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SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT		ATTORNEY DOCKET NO.
08/381,471	01/31/95	DELLABONA	M	4860.P1359

24M1/1024

BLAKELY SOKOLOFF TAYLOR AND ZAFMAN
12400 WILSHIRE BOULEVARD
7TH FLOOR
LOS ANGELES CA 90025

EXAMINER	
ART UNIT	PAPER NUMBER
2415	5

DATE MAILED: 10/24/96

Please find below a communication from the EXAMINER in charge of this application.

Commissioner of Patents

PTOL-90 (Rev. 6/84)

1 - PATIENT APPLICATION FILE COPY

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This is a communication from the examiner in charge of your application.
COMMISSIONER OF PATENTS AND TRADEMARKS

OFFICE ACTION SUMMARY

☐ Responsive to communication(s) filed on ____________.

☐ This action is **FINAL**.

☐ Since this application is in condition for allowance except for formal matters, **prosecution as to the merits is closed** in accordance with the practice under *Ex parte Quayle*, 1935 D.C. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire 3 month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claims

☑ Claim(s) 1 - 29 is/are pending in the application.

Of the above, claim(s) ____________ is/are withdrawn from consideration.

☐ Claim(s) ____________ is/are allowed.

☑ Claim(s) 1-6, 9, 11-16, 19, and 21-25 is/are rejected.

☑ Claim(s) 7, 8, 10, 17, 18, 20, and 26-29 is/are objected to.

☐ Claims ____________ are subject to restriction or election requirement.

Application Papers

☑ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☐ The drawing(s) filed on ____________ is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on ____________ is ☐ approved ☐ disapproved.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) ____________.

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: ____________.

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☑ Notice of Reference Cited, PTO-892

☑ Information Disclosure Statement(s), PTO-1449, Paper No(s). ____________

☐ Interview Summary, PTO-413

☑ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

-- SEE OFFICE ACTION ON THE FOLLOWING PAGES --

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. § 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless --
>
> (e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent.

2. Claims 1 - 6, 9, 11 - 16, 19, and 21 - 25 are rejected under 35 U.S.C. § 102(e) as being anticipated by Calder *et al.*

Calder's design uses and method of inputting data, a method for moving a cursor on a display screen (lines 20 - 24, col 2), and a method for detecting contact from the inputting device (line 47, col 3 - line 9, col 4). This device also contains a method of determining the intervals between contacts and updating the 'button state variable' as a result of this information (lines 41 - 47, col 4) as received from a touch panel for simulating a mechanical switch (claims 1, 11, and 12) and bus architecture (claim 21). This design also detects for cursor movement (lines 5 - 24, col 6) (claim 2). Calder's device also reacts to a contact of less than the predetermined time interval (lines 25 - 33, col 6) (claims 3, 13 and 22) or to a contact greater than the predetermined time interval (claims 4, 14 and

23) and allows for cursor movement (lines 34 - 41, col 6) (claims 5, 15 and 24). This device also allows the user to double click on icons (lines 41 - 68, col 6) (claims 6, 9, 16, 19, and 25).

3. Claims 7, 8, 10, 17, 18, 20 and 26 - 29 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

The device described in claims 7, 10, 17, 20, 26, and 29 where the circuitry allows for a click & drag & stick for controlling the cursor on the touch-sensitive input device was not taught or suggested in any of the prior art made of record. Therefore, claims 8, 18, 27 and 28 where the circuitry allows for a click & drag & disengage stick for controlling the cursor was also not taught or suggested in any of the prior art made of record.

4. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

5. Any inquiry concerning this communication or earlier communications from the Examiner should be directed to John Suraci, whose telephone number is (703) 305-4009, and whose normal working hours are Monday - Thursday, 6:30 - 5:30 ET. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark Powell, can be reached on (703) 305-9703.

RAYMOND J. BAYERL
PRIMARY EXAMINER
ART UNIT 2415

FORM PTO-892 (REV. 2-92) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

NOTICE OF REFERENCES CITED

SERIAL NO.	GROUP ART UNIT	ATTACHMENT TO PAPER NUMBER
08/381,471	2415	5

APPLICANT(S): Dellabona et al

U.S. PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	NAME	CLASS	SUB-CLASS	FILING DATE IF APPROPRIATE
	A	5432531	7/1995	Calder et al	345	145	7/1991
	B	5305017	4/1994	Gerpheide	345	174	
	C	5404458	4/1995	Zetts	345	173	2/1994
	D	5559943	9/1996	Cyr et al	345	145	6/1994
	E						
	F						
	G						
	H						
	I						
	J						
	K						

FOREIGN PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	COUNTRY	NAME	CLASS	SUB-CLASS	PERTINENT SHTS. DWG	PERTINENT PP. SPEC.
	L								
	M								
	N								
	O								
	P								
	Q								

OTHER REFERENCES (Including Author, Title, Date, Pertinent Pages, Etc.)

R

S

T

U

EXAMINER	DATE
John Suraci	10/21/96

* A copy of this reference is not being furnished with this office action. (See Manual of Patent Examining Procedure, section 707.05 (a).)

Form PTO 948 (Rev. 10-94) U.S. DEPARTMENT OF COMMERCE - Patent and Trademark Office Application No. 381471

NOTICE OF DRAFTSPERSON'S PATENT DRAWING REVIEW

PTO Draftpersons review all originally filed drawings regardless of whether they are designated as formal or informal. Additionally, patent Examiners will review the drawings for compliance with the regulations. Direct telephone inquiries concerning this review to the Drawing Review Branch, 703-305-8404.

The drawings filed (insert date) 1-31-95, are
A.______ not objected to by the Draftsperson under 37 CFR 1.84 or 1.152.
B. X objected to by the Draftsperson under 37 CFR 1.84 or 1.152 as indicated below. The Examiner will require submission of new, corrected drawings when necessary. Corrected drawings must be submitted according to the instructions on the back of this Notice.

1. DRAWINGS. 37 CFR 1.84(a): Acceptable categories of drawings: Black ink. Color.
   ___ Not black solid lines. Fig(s)______
   ___ Color drawings are not acceptable until petition is granted. Fig(s)______
2. PHOTOGRAPHS. 37 CFR 1.84(b)
   ___ Photographs are not acceptable until petition is granted. Fig(s)______
   ___ Photographs not properly mounted (must use brystol board or photographic double-weight paper). Fig(s)______
   ___ Poor quality (half-tone). Fig(s)______
3. TYPE OF DRAWINGS. 37 CFR 1.84(c)
   ___ Chemical or mathematical formula not labeled as separate figure. Fig(s)______
   ___ Group of waveforms not presented as a single figure, using common vertical axis with time extending along horizontal axis. Fig(s)______
   ___ Individuals waveform not identified with a separate letter designation adjacent to the vertical axis. Fig(s)______
4. TYPE OF PAPER. 37 CFR 1.84(e)
   ___ Paper not flexible, strong, white, smooth, nonshiny, and durable. Sheet(s)______
   ___ Erasures, alterations, overwritings, interlineations, folds, cracks, creases, and mutilations not accepted. Fig(s)______
   ___ Mylar, velum paper is not acceptable (too thin). Fig(s)______
5. SIZE OF PAPER. 37 CFR 1.84(f): Acceptable sizes:
   21.6 cm. by 35.6 cm. (8 1/2 by 14 inches)
   21.6 cm. by 33.1 cm. (8 1/2 by 13 inches)
   21.6 cm. by 27.9 cm. (8 1/2 by 11 inches)
   21.0 cm. by 29.7 cm. (DIN size A4)
   ___ All drawing sheets not the same size. Sheet(s)______
   ___ Drawing sheet not an acceptable size. Sheet(s)______
6. MARGINS. 37 CFR 1.84(g): Acceptable margins:

Paper size

	21.6 cm. X 35.6 cm. (8 1/2 X 14 inches)	21.6 cm X 33.1 cm. (8 1/2 X 13 inches)	21.6 cm. X 27.9 cm. (8 1/2 X 11 inches)	21.0 cm. X 29.7 cm. (DIN Size A4)
T	5.1 cm. (2")	2.5 cm. (1")	2.5 cm. (1")	2.5cm
L	.64 cm. (1/4")	.64 cm. (1/4")	.64 cm. (1/4")	2.5 cm.
R	.64 cm. (1/4")	.64 cm. (1/4")	.64 cm. (1/4")	1.5 cm.
B	.64 cm. (1/4")	.64 cm. (1/4")	.64 cm. (1/4")	1.0 cm.

Margins do not conform to chart above.
Sheet(s) 4-9, 11
X Top (T) ___ Left (L) ___ Right (R) ___ Bottom (B)

7. VIEWS. 37 CFR 1.84(h)
   REMINDER: Specification may require revision to correspond to drawing changes.
   ___ All views not grouped together. Fig(s)______
   ___ Views connected by projection lines or lead lines. Fig(s)______
   Partial views. 37 CFR 1.84(h) 2
   X View and enlarged view not labled separatly or properly. Fig(s) 5, 7, 11
   Sectional views. 37 CFR 1.84 (h) 3
   ___ Hatching not indicated for sectional portions of an object. Fig(s)______
   ___ Cross section not drawn same as view with parts in cross section with regularly spaced parallel oblique strokes. Fig(s)______
8. ARRANGEMENT OF VIEWS. 37 CFR 1.84(i)
   ___ Words do not appear on a horizontal, left-to-right fashion when page is either upright or turned so that the top becomes the right side, except for graphs. Fig(s)______
9. SCALE. 37 CFR 1.84(k)
   ___ Scale not large enough to show mechanism with crowding when drawing is reduced in size to two-thirds in reproduction. Fig(s)______
   ___ Indication such as "actual size" or scale 1/2" not permitted. Fig(s)______
10. CHARACTER OF LINES, NUMBERS, & LETTERS. 37 CFR 1.84(l)
    X Lines, numbers & letters not uniformly thick and well defined, clean, durable, and black (except for color drawings). Fig(s) 3
11. SHADING. 37 CFR 1.84(m)
    X Solid black shading areas not permitted. Fig(s) 10
    ___ Shade lines, pale, rough and blurred. Fig(s)______
12. NUMBERS, LETTERS, & REFERENCE CHARACTERS. 37 CFR 1.84(p)
    X Numbers and reference characters not plain and legible. 37 CFR 1.84(p)(1) Fig(s) 3, 5, 7, 11A-11J
    ___ Numbers and reference characters not oriented in same direction as the view. 37 CFR 1.84(p)(1) Fig(s)______
    ___ English alphabet not used. 37 CFR 1.84(p)(2) Fig(s)______
    X Numbers, letters, and reference characters do not measure at least .32 cm. (1/8 inch) in height. 37 CFR(p)(3) Fig(s) 5, 7, 11A-11J
13. LEAD LINES. 37 CFR 1.84(q)
    ___ Lead lines cross each other. Fig(s)______
    ___ Lead lines missing. Fig(s)______
14. NUMBERING OF SHEETS OF DRAWINGS. 37 CFR 1.84(t)
    ___ Sheets not numbered consecutively, and in Arabic numerals, beginning with number 1. Sheet(s)______
15. NUMBER OF VIEWS. 37 CFR 1.84(u)
    ___ Views not numbered consecutively, and in Arabic numerals, beginning with number 1. Fig(s)______
    ___ View numbers not preceded by the abbreviation Fig. Fig(s)______
16. CORRECTIONS. 37 CFR 1.84(w)
    ___ Corrections not made from prior PTO-948. Fig(s)______
17. DESIGN DRAWING. 37 CFR 1.152
    ___ Surface shading shown not appropriate. Fig(s)______
    ___ Solid black shading not used for color contrast. Fig(s)______

COMMENTS:

ATTACHMENT TO PAPER NO.______ REVIEWER SF DATE 3-16-95

PTO Copy

REMINDER

Drawing changes may also require changes in the specification, e.g., if Fig. 1 is changed to Fig. 1A, Fig. 1B, Fig. 1C, etc., the specification, at the Brief Description of the Drawings, must likewise be changed. Please make such changes by 37 CFR 1.312 Amendment at the time of submitting drawing changes.

INFORMATION ON HOW TO EFFECT DRAWING CHANGES

1. Correction of Informalities--37 CFR 1.85

File new drawings with the changes incorporated therein. The application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application, should be placed on the back of each sheet of drawings in accordance with 37 CFR 1.84(c). Applicant may delay filing of the new drawings until receipt of the Notice of Allowability (PTOL-37). Extensions of time may be obtained under the provisions of 37 CFR 1.136. The drawing should be filed as a separate paper with a transmittal letter addressed to the Drawing Review Branch.

2. Timing of Corrections

Applicant is required to submit **acceptable** corrected drawings within the three-month shortened statutory period set in the Notice of Allowability (PTOL-37). If a correction is determined to be unacceptable by the Office, applicant must arrange to have acceptable correction resubmitted within the original three-month period to avoid the necessity of obtaining an extension of time and paying the extension fee. Therefore, applicant should file corrected drawings as soon as possible.

Failure to take corrective action within set (or extended) period will result in **ABANDONMENT** of the Application.

3. Corrections other than Informalities Noted by the Drawing Review Branch on the Form PTO 948

All changes to the drawings, other than informalities noted by the Drawing Review Branch, **MUST** be approved by the examiner before the application will be allowed. No changes will be permitted to be made, other than correction of informalities, unless the examiner has approved the proposed changes.

345-145 AU 2609 EX
07/11/95 XR 5,432,531

US005432531A

United States Patent [19]

Calder et al.

[11] Patent Number: 5,432,531

[45] Date of Patent: Jul. 11, 1995

[54] COORDINATE PROCESSOR FOR A COMPUTER SYSTEM HAVING A POINTING DEVICE

[75] Inventors: Gary J. Calder, Eastleigh; Gavin D. Beardall, Alresford, both of England

[73] Assignee: International Business Machines Corporation, Armonk, N.Y.

[21] Appl. No.: 772,503

[22] Filed: Oct. 7, 1991

[30] Foreign Application Priority Data

Dec. 14, 1990 [GB] United Kingdom 90313657

[51] Int. Cl.⁶ G09G 3/02

[52] U.S. Cl. 345/173; 345/145

[58] Field of Search 345/173, 174, 175, 176, 345/177, 178, 157, 156, 162, 172; 178/18, 19

[56] References Cited

U.S. PATENT DOCUMENTS

4,914,624 4/1990 Dunthorn 364/900
5,119,075 6/1992 Smith 345/173

FOREIGN PATENT DOCUMENTS

0156593 3/1985 European Pat. Off. G06K 11/06
2152250 7/1985 United Kingdom G06F 3/033

Primary Examiner—Ulysses Weldon

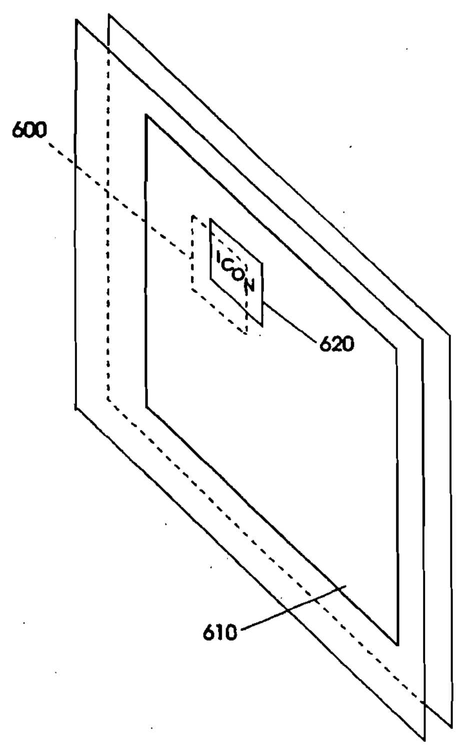
Assistant Examiner—Xiao M. Wu

Attorney, Agent, or Firm—Martin J. McKinley; Joseph C. Redmond

[57] ABSTRACT

A coordinate processor for a computer system having an absolute position pointing device (10) such as a touch sensitive display screen comprises stimulus detection means (200) for detecting a tactile stimulus of an absolute position pointing device (10) and directed to a point within a data display area (610) of a computer system. The processor further comprises coordinate locking means (210-320) for locking a current cursor position to the point within the display area corresponding to the tactile stimulus in response to said stimulus exceeding a predetermined threshold value. The processor permits the computer system to distinguish a stimulus of the pointing device (10) for repositioning the cursor within the data display area (610) from a stimulus of the pointing device (10) for issuing a button click command to the computer system. The processor may be embodied in an electronic logic circuit within a pointing device adapter portion of the computer system. Equally, the coordinate processor may be in the form of a central processing unit operating under the control of a computer program.

12 Claims, 5 Drawing Sheets



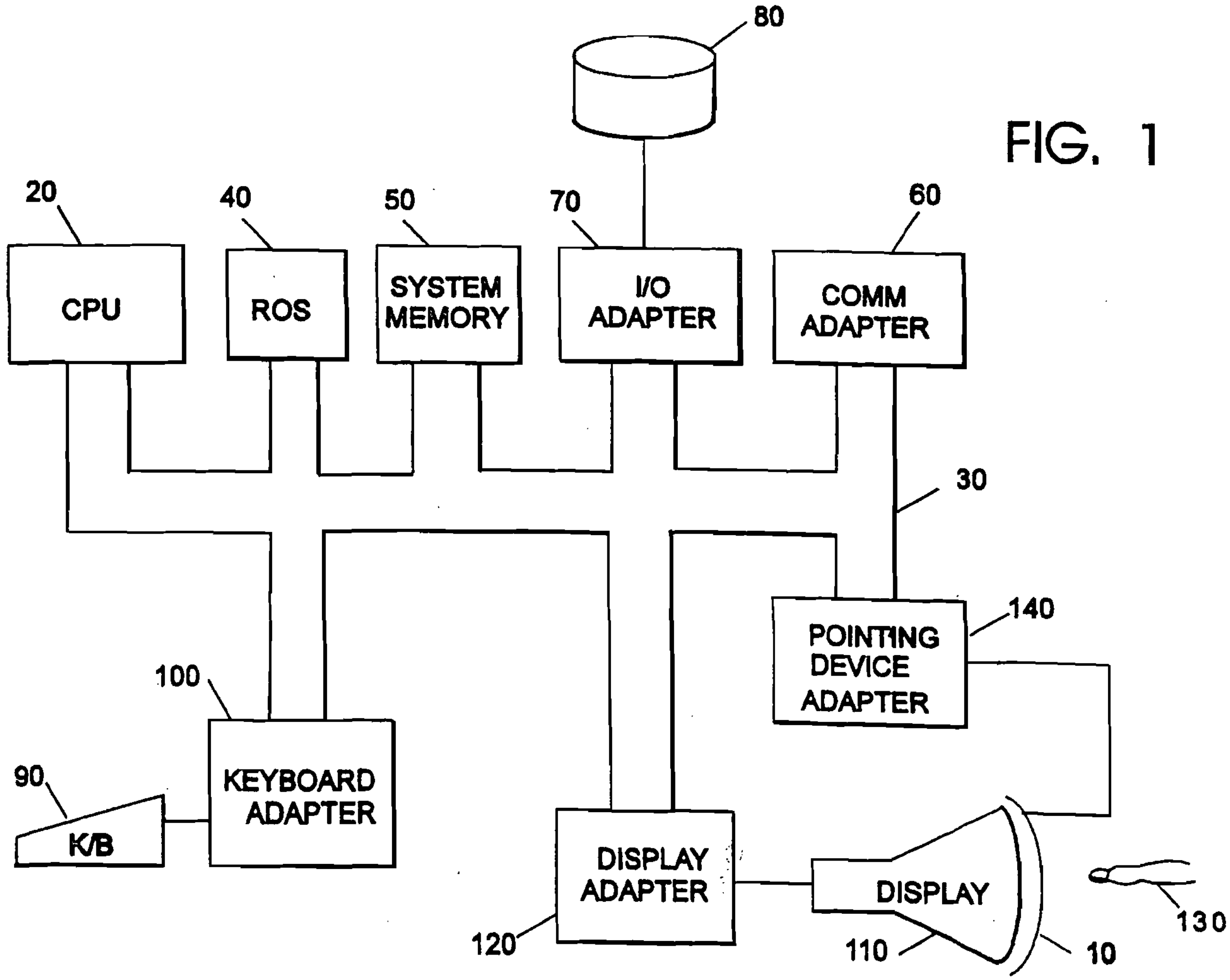

80
20
40
50
70
60
CPU
ROS
SYSTEM MEMORY
I/O ADAPTER
COMM ADAPTER
30
140
POINTING DEVICE ADAPTER
100
90
K/B
KEYBOARD ADAPTER
DISPLAY ADAPTER
120
DISPLAY
110
10
130

FIG. 1

FIG. 2

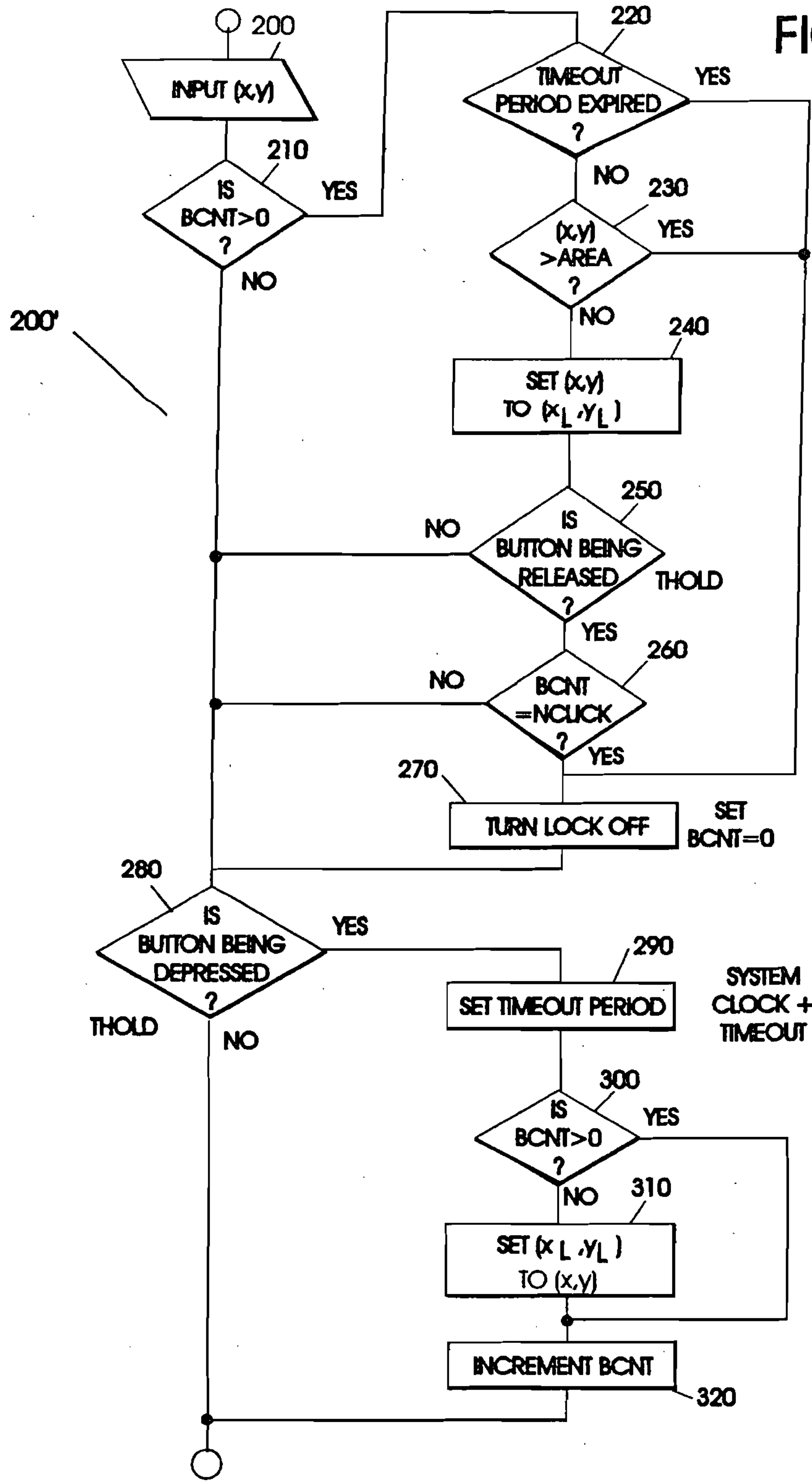

200
INPUT (x,y)
210
IS BCNT>0 ?
YES
NO
220
TIMEOUT PERIOD EXPIRED ?
YES
NO
230
(x,y) >AREA ?
YES
NO
240
SET (x,y) TO (xL,yL)
200'
250
IS BUTTON BEING RELEASED ?
NO
THOLD
YES
260
BCNT =NCLICK ?
NO
YES
270
TURN LOCK OFF
SET BCNT=0
280
IS BUTTON BEING DEPRESSED ?
YES
THOLD
NO
290
SET TIMEOUT PERIOD
SYSTEM CLOCK + TIMEOUT
300
IS BCNT>0 ?
YES
NO
310
SET (xL,yL) TO (x,y)
INCREMENT BCNT
320

FIG. 3

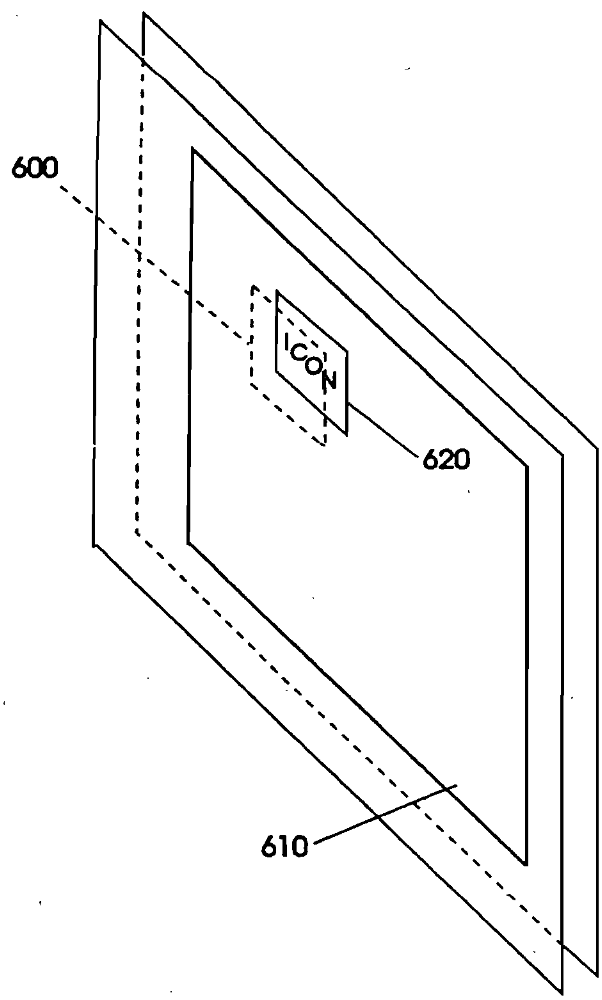
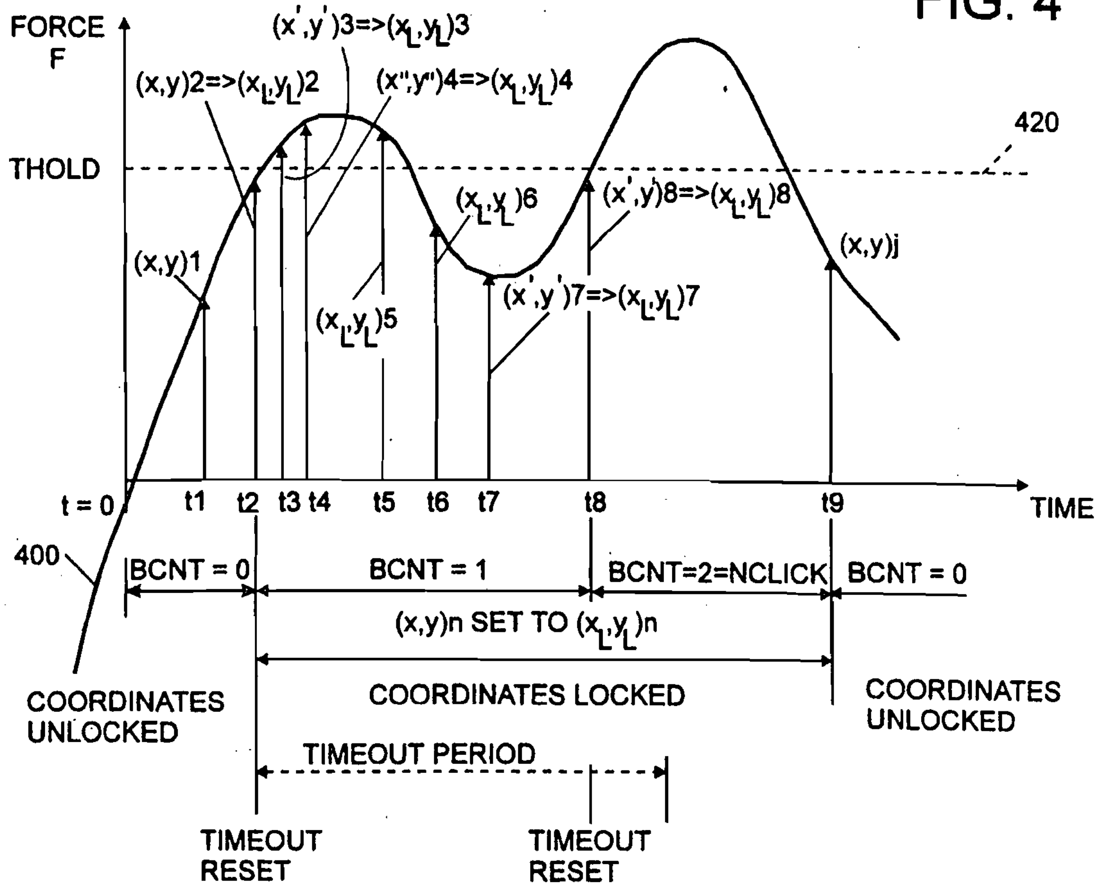


FIG. 4


FORCE
F
THOLD
(x,y)1
(x,y)2=>(xL,yL)2
(x',y')3=>(xL,yL)3
(x",y")4=>(xL,yL)4
(xL,yL)5
(xL,yL)6
(x',y')7=>(xL,yL)7
(x',y')8=>(xL,yL)8
(x,y)j
420
400
t = 0
t1
t2
t3
t4
t5
t6
t7
t8
t9
TIME
BCNT = 0
BCNT = 1
BCNT=2=NCLICK
BCNT = 0
(x,y)n SET TO (xL,yL)n
COORDINATES UNLOCKED
COORDINATES LOCKED
COORDINATES UNLOCKED
TIMEOUT PERIOD
TIMEOUT RESET
TIMEOUT RESET

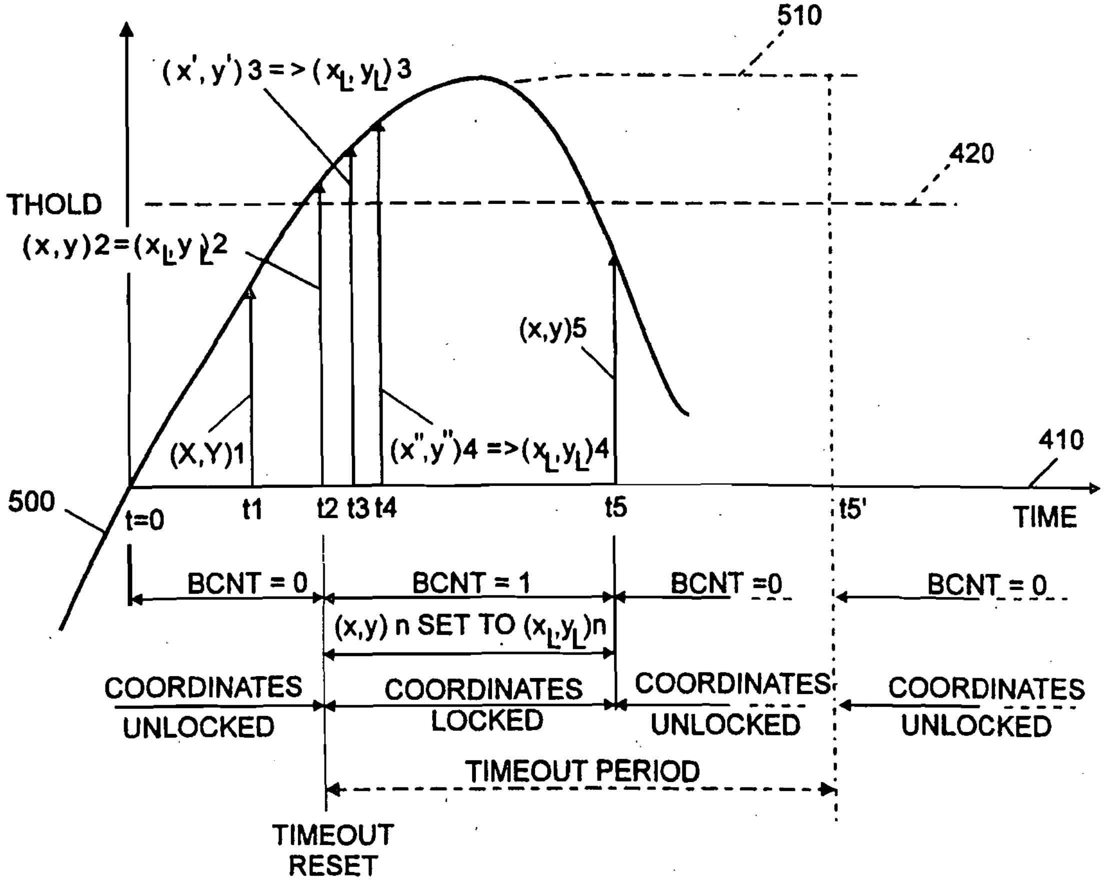

510
(x', y') 3 => (xL, yL) 3
420
THOLD
(x,y)2=(xL,yL)2
(x,y)5
(X,Y)1
(x",y")4 =>(xL,yL)4
410
500
t=0
t1
t2 t3 t4
t5
t5'
TIME
BCNT = 0
BCNT = 1
BCNT =0
BCNT = 0
(x,y) n SET TO (xL,yL)n
COORDINATES UNLOCKED
COORDINATES LOCKED
COORDINATES UNLOCKED
COORDINATES UNLOCKED
TIMEOUT PERIOD
TIMEOUT RESET

FIG. 5

COORDINATE PROCESSOR FOR A COMPUTER SYSTEM HAVING A POINTING DEVICE

FIELD OF INVENTION

The present invention generally relates to apparatus and methods for computer input devices, and more particularly to a coordinate processor for a computer system having a pointing device such as a touch sensitive display screen.

DESCRIPTION OF PRIOR ART

Many widely available computer systems such as the IBM PS/2 Model 70 (IBM and PS/2 are trademarks of IBM Corporation) are capable of receiving and processing data generated by a pointing device such as a mouse, tracker ball or touch sensitive display screen. The pointing device enables a user of the computer system to move, with a simple hand movement, a cursor between points within a data display area of a visual display unit.

A relative displacement pointing device such as a mouse or tracker ball provides the computer system with a vector which identifies the location within the data display area to which the cursor is to be moved relative to the current location of the cursor. The vector is generated by manipulating of the pointing device to achieve a desired cursor movement.

An absolute position pointing device such as a touch sensitive display screen provides the computer system with two dimensional coordinates identifying a point within the data display area to which the cursor is to be moved. In a touch sensitive display screen, the coordinates are generated by touching the screen at the point to which the cursor is to be moved.

In general, relative displacement pointing devices are also provided with at least one manually operable push button. The button can be operated by the user in a number of different modes and the computer system can be configured to respond differently to each mode of operation of the button. For example, the computer system may be configured to manipulate a window of displayed data within the data display area when the button is depressed as the pointing device is moved. Equally, the computer system may be programmed to perform another task when the cursor is placed on an icon representing the task within the display area and the button is depressed and released in rapid succession or "clicked". The computer system may also be configured to perform yet another task when the cursor is placed on an icon and the button is clicked twice or "double-clicked".

Touch screens are not generally provided with a manually operable push button. A button click command may however be issued via a touch screen by applying an corresponding sequence of touch stimuli to the touch screen within a predetermined time period. However, it will be appreciated that if each stimulus in the sequence is applied to a different point within a target area of the screen, then the computer system may fail to distinguish the button click command from a request to move the cursor from one point to another. In general therefore, absolute position pointing devices have been thought of as unsuitable for issuing button click commands. Many commercially available application software packages have therefore been written with relative displacement pointing devices in mind. Such packages can therefore be wholly, or at least partially, incompatible with computer systems having absolute position pointing devices.

SUMMARY OF THE INVENTION

An aim of the present invention is therefore to provide a coordinate processor which enables a computer system comprising an absolute position pointing device to operate in the same manner as a computer system having a relative displacement pointing device.

In accordance with the present invention, there is now provided a coordinate processor comprising: stimulus detection means for detecting a tactile stimulus of an absolute position pointing device and directed to a point within a data display area of a computer system; characterised in that the processor further comprises: coordinate locking means for locking a current cursor position to the point within the display area corresponding to the tactile stimulus in response to said stimulus exceeding a predetermined threshold value.

This advantageously enables the computer system to distinguish between cursor movement commands and button click commands issued via an absolute position pointing device without requiring a separate, manually operable push button. An operator of such a computer system can therefore fully exploit application software packages designed for operation with relative displacement pointing device without any perceptible degradation in performance of the computer system. Specifically, the coordinate processor enables the computer system to lock the position of the cursor onto a particular coordinate when a stimulus which may signal a button click command is detected. If however, a button click command is not subsequently detected, the cursor is automatically unlocked.

Preferably, the coordinate locking means further comprises first reset means for releasing the cursor for movement within the data display area upon detection of a predetermined button click command.

The coordinate locking means of a preferred embodiment of the present invention further comprises second reset means for releasing the cursor for movement within the data display area upon expiry of a predetermined timeout period.

In addition, the coordinate locking means preferably further comprises third reset means for releasing the cursor for movement within the data display area upon detection of a subsequent tactile stimulus of the pointing device directed to a point outside a predetermined subarea of the data display area. Preferably, the subarea is predetermined by the computer system to be commensurate in size with an graphical icon generated within the display area by the computer system.

Viewing the present invention from a second aspect, there is now provided a coordinate processor comprising: stimulus detection means for detecting a stimulus applied to an absolute position pointing device and directed to a point within a data display area defined by a computer system; characterised in that the processor further comprises: command distinguishing means responsive to the stimulus detection means to distinguish a stimulus of the pointing device for repositioning a cursor within the data display area from a stimulus of the pointing device for issuing a button click command to the computer system.

Preferably, the command distinguishing means can be manually preset to identify either a tactile stimulus of the pointing device for issuing a single button click command to the computer system, or a tactile stimulus of the pointing device for issuing a multiple button click command to the computer system.

In a preferred embodiment of the present invention to be described later, there is provided a coordinate processor comprising: first receiver means for receiving from an absolute position pointing device an input two dimensional coordinate data value corresponding to a point within a data display area of a computer system and generated by the pointing device in response to a stimulus manually applied to the pointing device; second receiver means for receiving from the pointing device a force data value corresponding to the input coordinate value and generated by the pointing device in response to the stimulus; characterised in that the processor further comprises: coordinate locking means for setting a lock coordinate data value to the input coordinate data value in response to the force data value exceeding a predetermined threshold value; coordinate setting means for setting one or more further input coordinate force data values to the lock coordinate data value in response to any one of the further input coordinate data values falling within a predetermined range of coordinate data values during a predetermined time period; first reset means for resetting the lock coordinate data value in response to at least one discrete stimulus of the pointing device generating a force data value greater than the predetermined threshold value.

DESCRIPTION OF DRAWINGS

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

FIG. 1 is a block diagram of a computer system comprising an absolute position pointing device in the form of a touch-sensitive visual display screen.

FIG. 2 is a block diagram of a coordinate processor of the present invention in the form of a flow chart.

FIG. 3 is a front view of a touch sensitive display screen displaying an icon within a data display area.

FIG. 4 is a waveform diagram corresponding to tactile stimuli representative of a double click command.

FIG. 5 is a waveform diagram corresponding to a tactile stimulus representative of a single click command.

DESCRIPTION OF PREFERRED EMBODIMENT

FIG. 1 illustrates an example of a computer system for processing input data from an absolute position pointing device. The system comprises a central processing unit (CPU) 20 for executing programmed instructions involving the input data. A bus architecture 30 communicates data between the CPU and other components of the computer system. A read only memory (ROS) 40 provides secure data storage. A random access system memory 50 provides temporary data storage. Data communication with other computer systems (not shown) is provided by a communications (COMM) adapter 60. An input/output (I/O) adapter 70 permits data communication between the bus architecture and a peripheral device such as a hard disk file 80. A visual output from the computer system in the form of a data display area is generated on a display device 110 by a display adapter 120. A user can operate the computer system using a keyboard 90 linked to the bus architecture via a keyboard adapter 100. By way of alternative to keyboard 90, an absolute position pointing device in the form of a touch sensitive display screen 10 is superimposed on display device 110. The touch screen 10 is responsive to a touch stimulus 130 applied by the user to issue a command to the computer system. The command may instruct the computer system to move a cursor between points within the data display area. Alternatively, the touch screen may be employed to issue a button click command instructing the computer system to an operation corresponding to the current position of the cursor in the display area.

The touch screen 10 is resolved by digitising circuitry (not shown) in a pointing device adapter 140 into a two dimensional array of discrete coordinate points. A touch stimulus applied to any one of the coordinate points is detected by a sensor array (not shown) in the touch screen 10. The sensor array generates an analog signal proportional to the force imparted to the touch screen by the stimulus. The signal is digitised by a sampling analogue to digital convertor (ADC) circuit (not shown) in the touch screen 10 to produce a input data value. The input data value, together with the coordinates to which it relates, are transmitted from the touch screen to the pointing device adapter 140. The input data value corresponding to each set of coordinates is typically refreshed by the ADC circuit sixty times a second. The pointing device adapter 140 connected to the bus architecture 30 passes each set of coordinates and the corresponding input data value to the bus architecture 30.

Referring now to FIG. 2, a coordinate processor 200' of the present invention distinguishes stimuli applied to the touch screen 10 to issue button click commands from stimuli to move the cursor within the display area. It will be appreciated that the coordinate processor of the present invention may be embodied in a hardwired electronic logic circuit within the pointing device adapter 140 or the touch screen 10. However, it will also be appreciated that, in other preferred embodiments of the present invention, the coordinate processor may be in the form of a processing unit such as CPU 20 operating under the control of a computer program.

The coordinate processor comprises an input stage 200. The input stage 200 sequentially reads the sampled input data value corresponding to each set of coordinates (x,y) of the touch screen 10 in turn. The coordinate processor increments a running total of button clicks BCNT each time a button click is detected. Initially BCNT is zero.

A count detect stage 210 checks BCNT for each input data value (x,y)n received from input stage 200. If BCNT corresponding to coordinates (x,y) is zero, then a depress detect stage 280 determines whether or not the corresponding input data value has increased above a predetermined button threshold value, THOLD.

If no such increase is detected, coordinates (x,y) are passed from coordinate processor to the computer system to control the positioning of the cursor within the display area. The next input data value is then received by input stage 200.

If, however, the input data value has increased over and above THOLD, then a timer stage 290 sets a timeout period, TIMEOUT which is equal to a current system clock value plus a predetermined value. In a preferred embodiment of the present invention, the timeout period can be manually adjusted about a nominal preset centre value of 500 ms. Another count detect stage 300 then determines again whether or not BCNT is zero.

If BCNT is zero, then a coordinate locking stage **310** sets a pair of lock coordinates (xL,yL) to coordinates (x,y).

If BCNT is not zero, the lock coordinates (xL,yL) retain their existing values. In either case, coordinates (x,y) are then passed to the computer system to control cursor positioning. A counter **320** then increments BCNT and the next input data value (x',y')n corresponding to coordinates (x',y') is received by input stage **200**.

If count detect stage **210** determines that BCNT is greater than zero for input data value (x',y')n, timer stage **220** indicates whether or not the timeout period has been exceeded.

If the timeout period has been exceeded, then a reset stage **270** resets BCNT to zero before (x',y')n is passed to depress detect stage **280**.

If the timeout period has not been exceeded, then an location check stage **230** determines whether or not coordinates (x',y') are outside a predetermined coordinate locking area, AREA, of the data display area. If coordinates (x',y') are outside AREA, then reset stage **270** resets BCNT before the (x',y')n is passed to depress detect stage **280**.

If coordinates (x',y') are within AREA, then a lock stage **240** replaces coordinates (x'y') corresponding to input data value (x',y')n with the lock coordinates (xL,yL). Release detect stage **250** then detects whether or not input data value (x',y')n has decreased to below THOLD. If no such decrease is detected, then input data value (x',y')n, now corresponding to lock coordinates (xL,yL), is passed to depress detect stage **280**. The cursor position is now locked to the lock coordinates (xL,yL).

If input data value (x',y')n has decreased over and below THOLD, then count detect stage **260** determines whether or not BCNT is equal to a predetermined click value, NCLICK.

In a particularly preferred embodiment of the present invention, NCLICK can be manually selected by the operator to detect different button click commands. For example, setting NCLICK to two configures the coordinate processor to detect both double and single click commands. Alternatively, setting NCLICK to one configures the cooordinate processor to detect only single click commands.

If BCNT is equal to NCLICK, the button click command has been detected. BCNT is therefore reset to zero and input data value (x',y')n is passed to depress detect stage **280**. The next input data value, (x'',y'')n corresponding to coordinates (x'',y''), is then received by input stage **200**.

In a preferred embodiment of the present invention, predetermined values TIMEOUT, AREA, THOLD, and NCLICK are supplied to the coordinate processor by CPU **20** under the control of an application software program. In particular, with reference to FIG. **3**, AREA is preferably selected to represent an area **600** of size and location commensurate with an icon **620** representing graphically, within the data display area **610**, a push button or the like. Preferably, the computer system is configured by the software so that the operator can select a particular program option by issuing a click command via touch screen **10** at the position of the icon within the display area.

Referring now to FIG. **4**, a double click command can be represented in the form of a curve **400** of tactile force applied to touch screen **10** with respect to time. Button threshold THOLD is represented by reference line **420**. Initially, BCNT is set to zero, NCLICK is set to 2, and TIMEOUT, AREA, and THOLD are set to appropriate values by the application software.

Initial tactile contact with touch screen **10** is made at time t0 where curve **400** is coincident with reference line **410**.

At time t1, input data value (x,y)**1** at coordinates (x,y) is lower than THOLD. However, at time t2, input data value (x,y)2 at coordinates (x,y) is greater than than THOLD. Depress detect stage **280** therefore indicates that the button is being depressed, and the timeout period is initialised by timer stage **290**. Lock coordinates (xL,yL) are now set to coordinates (x,y). BCNT is incremented to indicate that the position of the cursor within the display area are now locked to the lock coordinates (xL,yL). Therefore, if the next force data values (x',y')3 at time t3 and (x'',y'')4 at time t4, correspond to coordinates (x',y') and (x'',y'') within the confines of AREA, then coordinates (x'y') and (x'',y'') are both replaced by lock coordinates (xL,yL).

It will be appreciated that if either (x',y') or (x'',y'') fall outside AREA then BCNT would reset to zero thereby unlocking the cursor position.

At time t5, input data value (x,y)5 is just greater than THOLD. However, at time t6, input data value (x,y)6 is lower than THOLD. Release detect stage **260** therefore indicates that the button is being released. However, BCNT does not equal NCLICK. BCNT is therefore not reset to zero. Therefore coordinates (x',y') corresponding to input data value (x',y')7 at time t7 are also replaced by lock coordinates (xL,yL). The cursor position is therefore still locked.

At time t8, input data value (x',y')8 is greater than THOLD. The timeout period is therefore initialised again by time stage **290**. BCNT is incremented to indicate that a second button click has been detected. Lock coordinates (xL,yL) remain set to coordinates (x,y) originally corresponding to input data value (x,y)2. The cursor therefore remains locked to (x,y) within the display area.

At time t9, input data value (x,y)9 is lower than THOLD. Therefore release detect stage **250** indicates that the button is being released. BCNT is now equal to NCLICK indicating that a double click command has been detected. BCNT is now reset to zero to unlock the cursor position. The next touch stimulus producing a input data value greater than THOLD will therefore refresh lock coordinates (xL,yL).

It will be appreciated that BCNT will also be reset to zero if it is maintained at a value greater than zero for a period greater than the timeout period. Similarly, BCNT will be be reset to zero if any input stimulus is applied at a coordinate outside AREA.

A coordinate processor of the present invention therefore permits the operator to issue a double click command to a computer system via a touch sensitive display screen by locking the cursor position to a position within the display area at which an applied touch stimulus is of a magnitude exceeding a threshold value. The cursor position is unlocked when the prescribed number of clicks identifying the command is detected. Alternatively, the cursor position is unlocked if a subsequent stimulus is applied to the touch screen outside a predetermined area of the touch screen. Furthermore, the cursor position is also unlocked if the delivery of the command extends beyond a predetermined timeout period. It will therefore be appreciated that the coordinate processor of the present invention provides the operator of the computer system with freedom at all times to move the cursor to any point within the display area. Simultaneously however, the coordinate processor of the present invention enables the operator to issue via the touch screen a button click command to the computer system which is independent of any cursor movement command.

Referring now to FIG. **5**, a single click command can be represented in the form of a curve **500** of tactile force applied to the touch screen **10** with respect to time. Button threshold THOLD is represented by reference line **420**. Initially, BCNT is set to zero and NCLICK is set to 1. TIMEOUT, AREA, and THOLD are set to appropriate values by an application software program.

Initial tactile contact is made with the touch screen **10** at time t0 where curve **500** is coincident with reference line **410**.

At time t**1**, input data value (x,y)**1** corresponding to coordinates (x,y) is lower than THOLD.

At time t**2** however, input data value (x,y)**2** corresponding to coordinates (x,y) is greater than THOLD. Depress detect stage **280** therefore indicates that the button is being depressed and the timeout period is initialised by timer stage **290**. Lock coordinates (xL,yL) are now set to coordinates (x,y) and BCNT is incremented. The cursor position is now locked to coordinates (x,y).

If coordinates (x',y') and (x",y"), corresponding to force data values (x',y')**3** at time t**3** and (x",y")**4** at time t**4**, are within the confines of AREA, then (x',y') and (x",y") are both replaced by lock coordinates (xL,yL). The cursor position is therefore locked at coordinates (x,y).

If either (x',y') or (x",y") are outside AREA then BCNT will be reset to zero and the next input data value to exceed THOLD will refresh lock coordinates (xL,yL) and relock the cursor position.

At time t**5**, input data value (x,y)**5** is lower than THOLD. Therefore, release detect stage **260** indicates that the button is being released. BCNT now equals NCLICK indicating that the single click command has been detected. BCNT is now reset to zero. Therefore, the next input data value to exceed THOLD will refresh lock coordinates (xL,yL).

It will now be appreciated that a coordinate processor of the present invention also enables the operator of the computer system to issue a single click command to the a computer system via a touch sensitive display screen. In addition however, a coordinate processor of the present invention also enables the operator to issue cursor movement command to the computer system through the touch screen independently of button click commands.

Specifically, the coordinate processor of the present invention locks the cursor position to a point on the touch screen at which an applied touch stimulus has a magnitude exceeding a threshold value. The cursor position is unlocked when the button click command is detected, or if a subsequent stimulus is outside a predetermined area of the touch screen. The cursor position is also unlocked if the delivery of the command extends beyond a predetermined timeout period. It will therefore be appreciated that the cursor may be freely moved to any point within the display area depending on whether or not the operator wishes to complete delivery of the button click command.

Curve **510** illustrates a continuous tactile stimulus of the touch screen applied initially at time t**0**. BCNT is initially set to zero.

At time t**1**, input data value (x,y)**1** corresponding to coordinates (x,y) is lower than THOLD. However, at t**2**, input data value (x,y)**2** corresponding to coordinates (x,y) is greater than THOLD. Therefore, depress detect stage **280** indicates that the button is being depressed and the timeout period is initialised.

Lock coordinates (xL,yL) are now set to coordinates (x,y) and BCNT is incremented. The cursor position is now locked to (x,y).

At time t**5**, input data value (x,y)**5** is not below THOLD. Therefore, if no stimulus has been applied to the touch screen outside AREA at time t**5**, BCNT is not reset. The cursor position remains locked to coordinates (x,y).

At time t**5**' however, the timeout period expires. BCNT is therefore reset to zero. The cursor position is therefore unlocked. The next touch stimulus exceeding THOLD will thus refresh lock coordinates (xL,yL).

A coordinate processor for a computer system having touch sensitive display screen has now been described by way of example of the present invention. It will however be appreciated that the present invention is equally applicable to other absolute position pointing devices such as, for example, tablets.

Applicants claim:

1. A coordinate processor for distinguishing between cursor movement commands for a display and button click commands for a relative displacement pointing device comprising:

stimulus detection means (**200**) for detecting a single tactile stimulus of an absolute position pointing device (**10**) exceeding a force threshold within a preselected time period and directed to a point within a data display area (**610**) of a computer system for forming a pushbutton within a subarea of the display area at the point of the stimulus;

characterized in that the processor further comprises:

coordinate locking means (**210–320**) for locking a current cursor position to the point within the display area corresponding to the tactile stimulus in response to said stimulus exceeding a predetermined threshold value;

command distinguishing means responsive to the stimulative detection means to distinguish a stimulus of the pointing device for repositioning the cursor within the data display area from a stimulus of the pointing device for issuing a button click command to the computer system;

means for issuing one or more button click commands;

means for counting button click commands to lock the cursor position when a prescribed number of clicks identifying the command is detected; and

means for comparing the counted click commands to a present number for release of the cursor when the counted clicks equal the present number.

2. A processor as claimed in claim **1** wherein the coordinate locking means (**210–320**) further comprises:

first reset means (**260,270**) for releasing the cursor for movement within the data display area (**610**) upon detection of a predetermined button click command.

3. A processor as claimed in claim **2** wherein the coordinate locking means (**210–320**) further comprises:

second reset means (290,220,270) for releasing the cursor for movement within the data display area (610) upon expiry of a predetermined timeout period.

4. A processor as claimed in claim 3 wherein the coordinate locking means (210–320) further comprises: third reset means (230,270) for releasing the cursor for movement within the data display area (610) upon detection of a subsequent tactile stimulus of the pointing device (10) directed to a point outside a predetermined subarea (600) of the data display area (610).

5. A processor as claimed in claim 4 wherein the subarea (600) is predetermined by the computer system to be commensurate in size with a graphical icon (620) generated within the display area (610) by the computer system.

6. A processor as claimed in claim 5, wherein the coordinate locking means (210–320) can be manually preset to identify a tactile stimulus of the pointing device (10) for issuing a single button click command to the computer system.

7. A coordinate processor as claimed in claim 6 wherein the coordinate locking means (210–320) can be manually preset to identify a tactile stimulus of the pointing device (10) for issuing a multiple click command to the computer system.

8. A processor as claimed in claim 5 wherein the coordinate locking means (210–320) is responsive to a digital input value corresponding to the force of the tactile stimulus.

9. A processor as claimed in claim 5 wherein the absolute pointing device (10) is a touch sensitive display screen (10).

10. A method of operating an absolute position pointing device as a relative displacement pointing device in a computer system including a coordinate processor (200'), a display area (610) and a touch screen (10) using a single tactile stimulus exceeding a force threshold within a preselected time period to form a pushbutton within a sub area (600) of the display area (610) at the point of the stimulus, comprising the steps of:

a) supplying predetermined values of TIMEOUT, AREA, THOLD, NCLICK to an input (200) for installation in signal processing elements (220), (230), (260), (280), respectively;
b) setting a button click counter (210) to zero "0" for button clicks BCNT;
c) setting and storing a predetermined number of clicks and comparing the counted clicks with the predetermined number for release of a cursor when the counted clicks equal the predetermined number;
d) sequentially sampling an input signal (400), (500) definitive of tactile contact and location on a touch screen (10) in terms of signal magnitude; orthogonal coordinates x, y, and time periods **1** . . . j, where j is the last sample in signal (400), (500);
e) passing the input signal to element (280) if BCNT in counter (210) is zero; the element (280) comparing the signal magnitude at n=1 to a signal threshold THOLD;
f) passing the input signal to a timer stage (220), if BCNT is greater than 0 in counter (210)|x, y|n=1, the timer stage (220) indicating whether the time out period has been exceeded; if exceeded and a predetermined number of clicks have been counted, a reset stage (270) resets BCNT to 0 in elements (210) and (310) before passing the coordinates to element (280) for processing in accordance with steps d and e; and
g) processing succeeding process signal input sample |x', y'|n=j in accordance with steps e) through f).

11. The method of claim 10 wherein step e) comprises the steps of:

e1) if the signal magnitude is less than THOLD, the x, y coordinates at n=1 are passed to the computer system to control the position of a cursor within a display area (600) of a display (110): and
e2) if the signal magnitude exceeds THOLD, a timer stage(290) sets a timeout period for a coordinate locking stage (310) which sets a pair of lock coordinates (x1,y1) for coordinates |x, y|n=1 which are passed to the cursor.

12. The method of claims 10 or 11 wherein step f) comprises the steps of:

f1) if the timeout period in element (220) has not been exceeded, a location check stage (230) determines whether coordinates |(x, y)| n=1 are outside the AREA (600); if the coordinates are within the AREA, the |x,y|n=1 are replaced by coordinates |x1, y1| in an element (240) and supplied to a release stage (250);
f2) the release stage (250) detects whether the signal magnitude is below THOLD, if above THOLD, the signal is passed to element (280) for processing per d and e; if below THOLD, the signal is passed to a count detect stage (260); and
f3) the count detect stage (260) determines whether BCNT is equal to NCLICK; if equal, BCNT is reset to 0 by element (270) and the coordinates |x, y,|n=1 are passed to element (280) or if not equal, the coordinates |x, y,|n=1 are passed to element (280) which processes the coordinates per steps d and e.

* * * * *

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United States Patent [19]

Gerpheide

[11] Patent Number: 5,305,017

[45] Date of Patent: *Apr. 19, 1994

[54] METHODS AND APPARATUS FOR DATA INPUT

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[21] Appl. No.: 914,043

[22] Filed: Jul. 13, 1992

Related U.S. Application Data

[63] Continuation of Ser. No. 754,329, Sep. 4, 1991, which is a continuation of Ser. No. 394,566, Aug. 16, 1989.

[51] Int. Cl.[5] G09G 3/02

[52] U.S. Cl. 345/174; 345/168

[58] Field of Search 340/706, 709, 710, 712; 341/20, 23; 178/18, 19; 345/173, 174, 168

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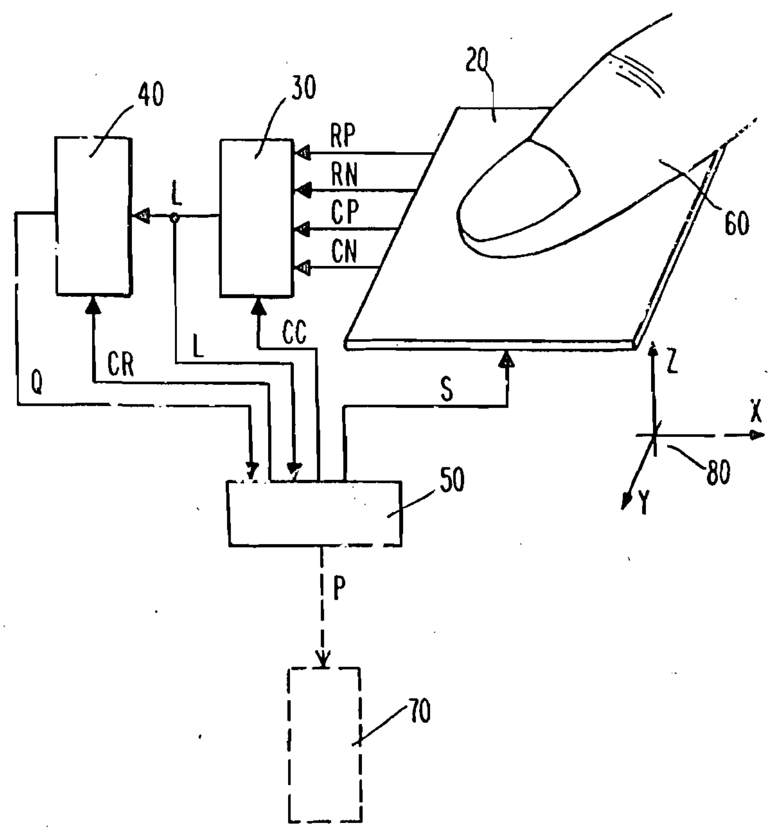
Primary Examiner—Ulysses Weldon
Assistant Examiner—M. Fatahiyar
Attorney, Agent, or Firm—Thorpe North & Western

[57] ABSTRACT

Methods and apparatus for data input. Devices are provided in accordance with this invention which utilize capacitive coupling of an object to the device to sense the object's position. The devices are comprised of a plurality of electrode strips which form virtual electrodes. The virtual electrodes are selectively connected to form virtual dipole electrodes which are responsive to the object's position.

17 Claims, 13 Drawing Sheets



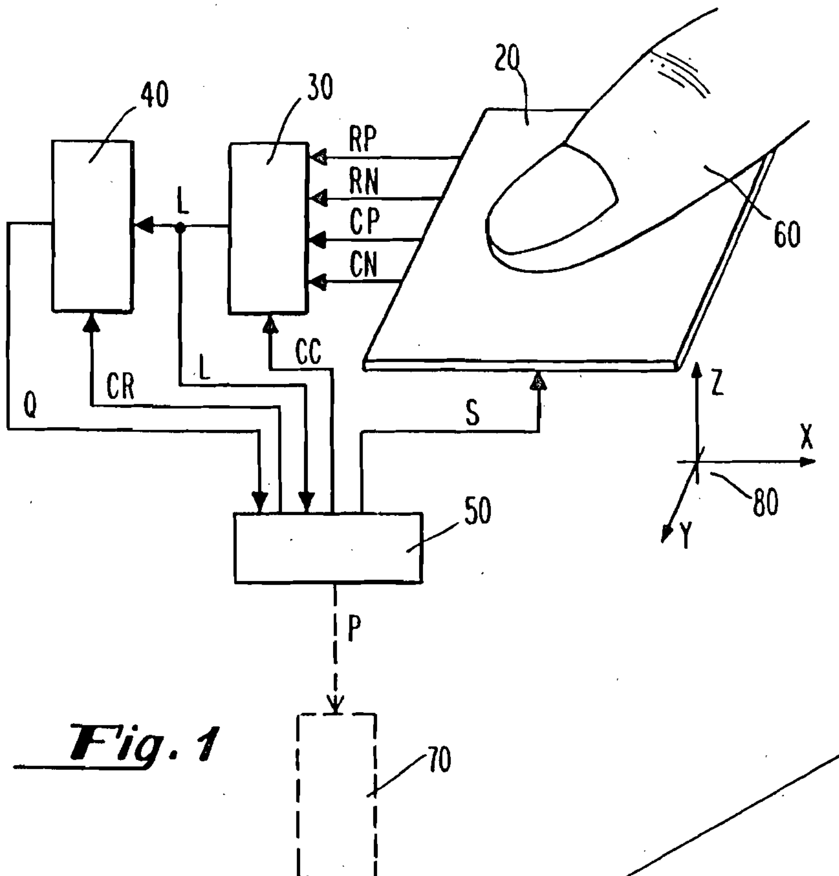


Fig. 1

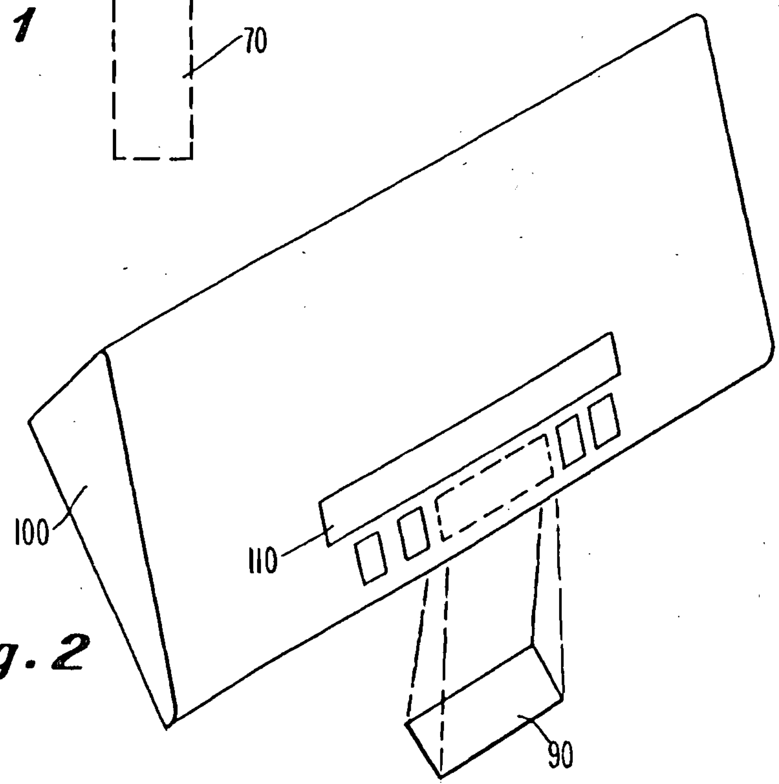
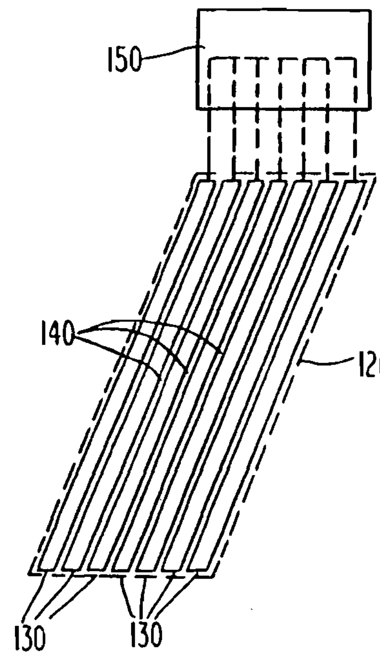


Fig. 2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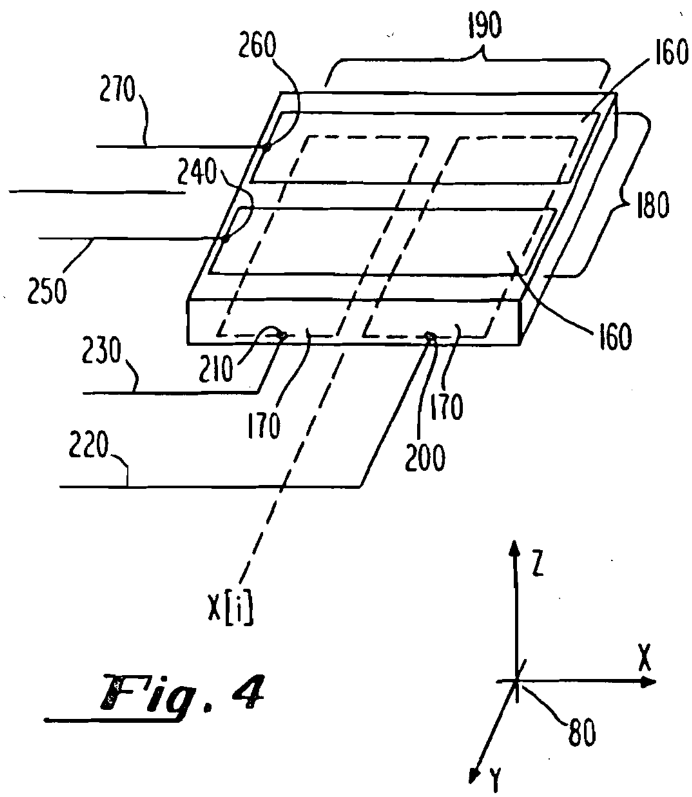
130

Fig. 3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230
210
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170
220
200
X[i]
Z
X
80
Y

Fig. 4

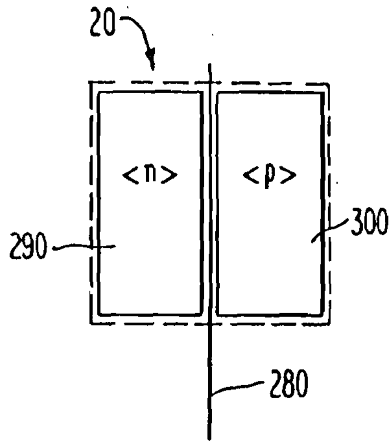


Fig. 5(a)

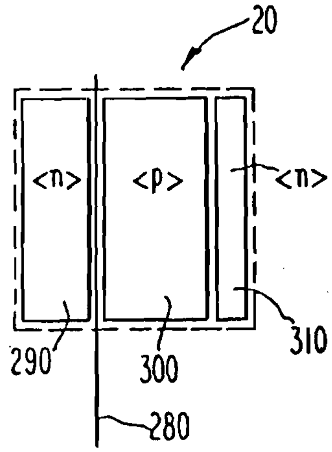


Fig. 5(b)

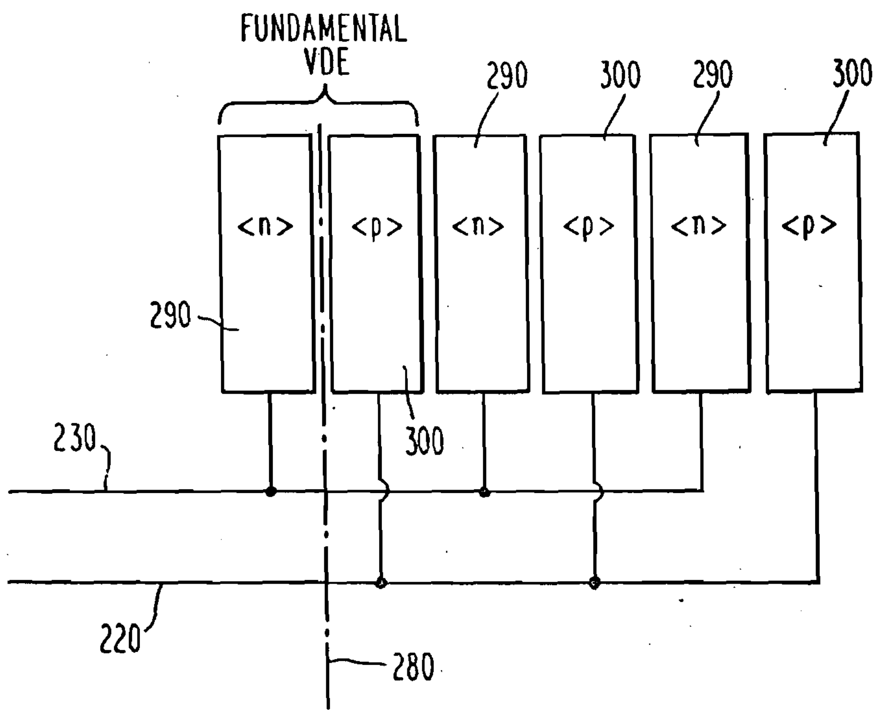
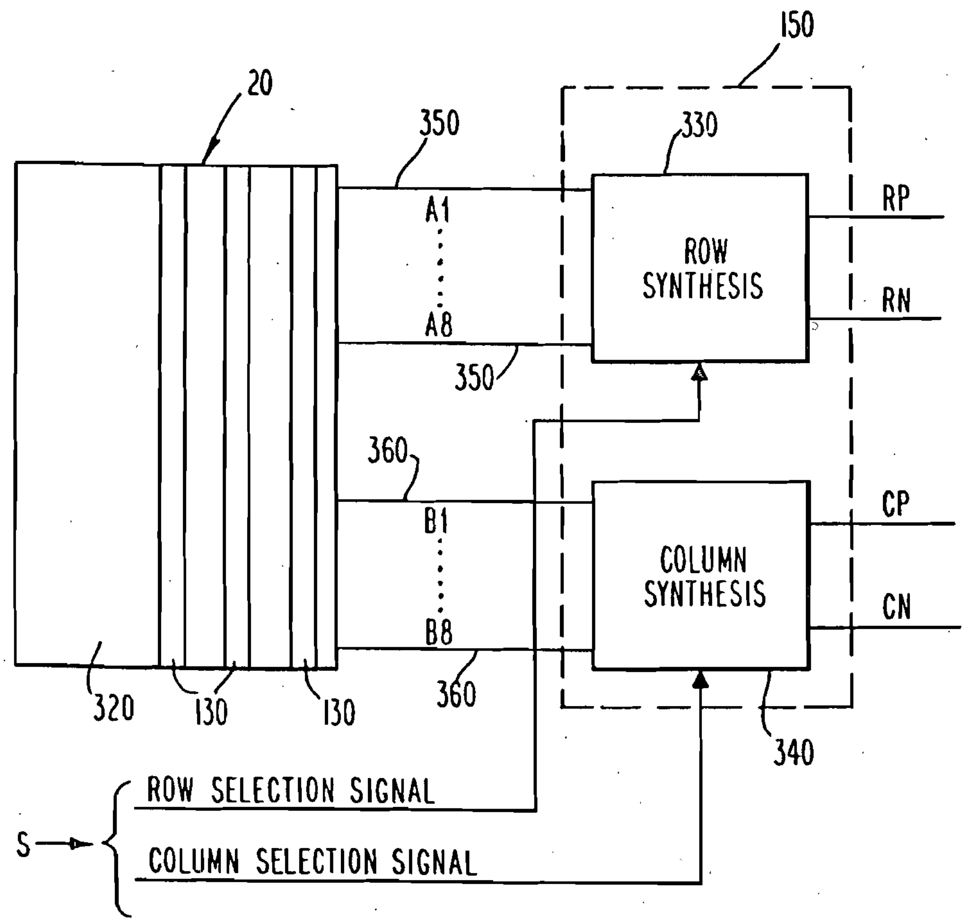


Fig. 6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330
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RP
RN
A8
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360
B1
COLUMN SYNTHESIS
CP
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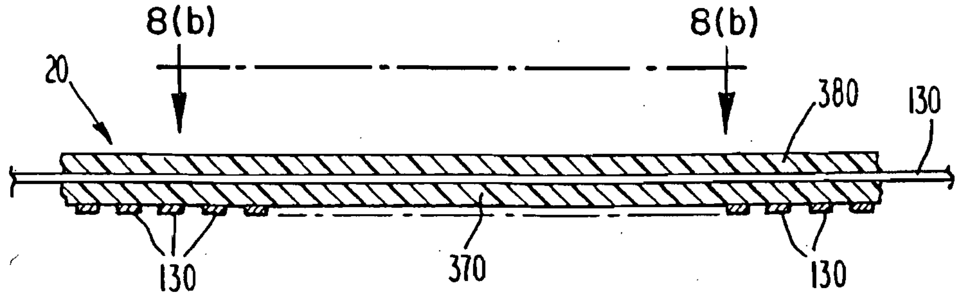
B8
360
320
130
130
340
ROW SELECTION SIGNAL
S
COLUMN SELECTION SIGNAL

Fig. 7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8(b)
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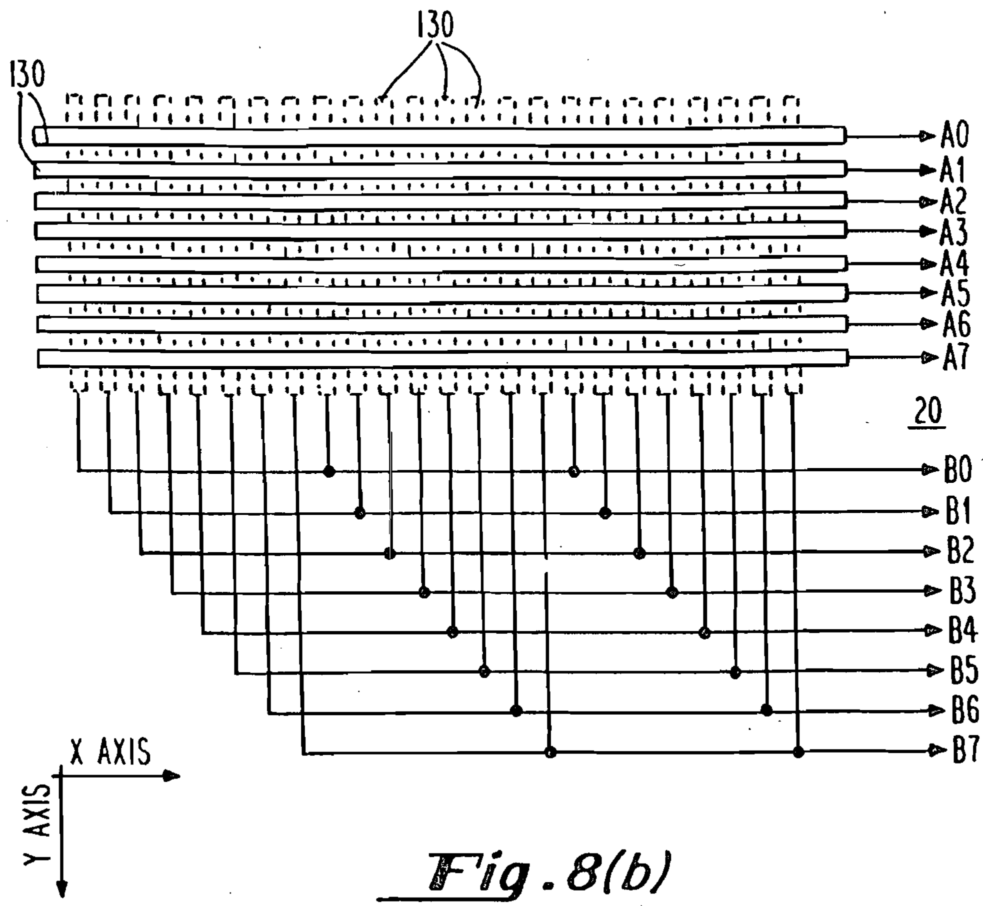
Fig. 8(a)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130
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A2
A3
A4
A5
A6
A7
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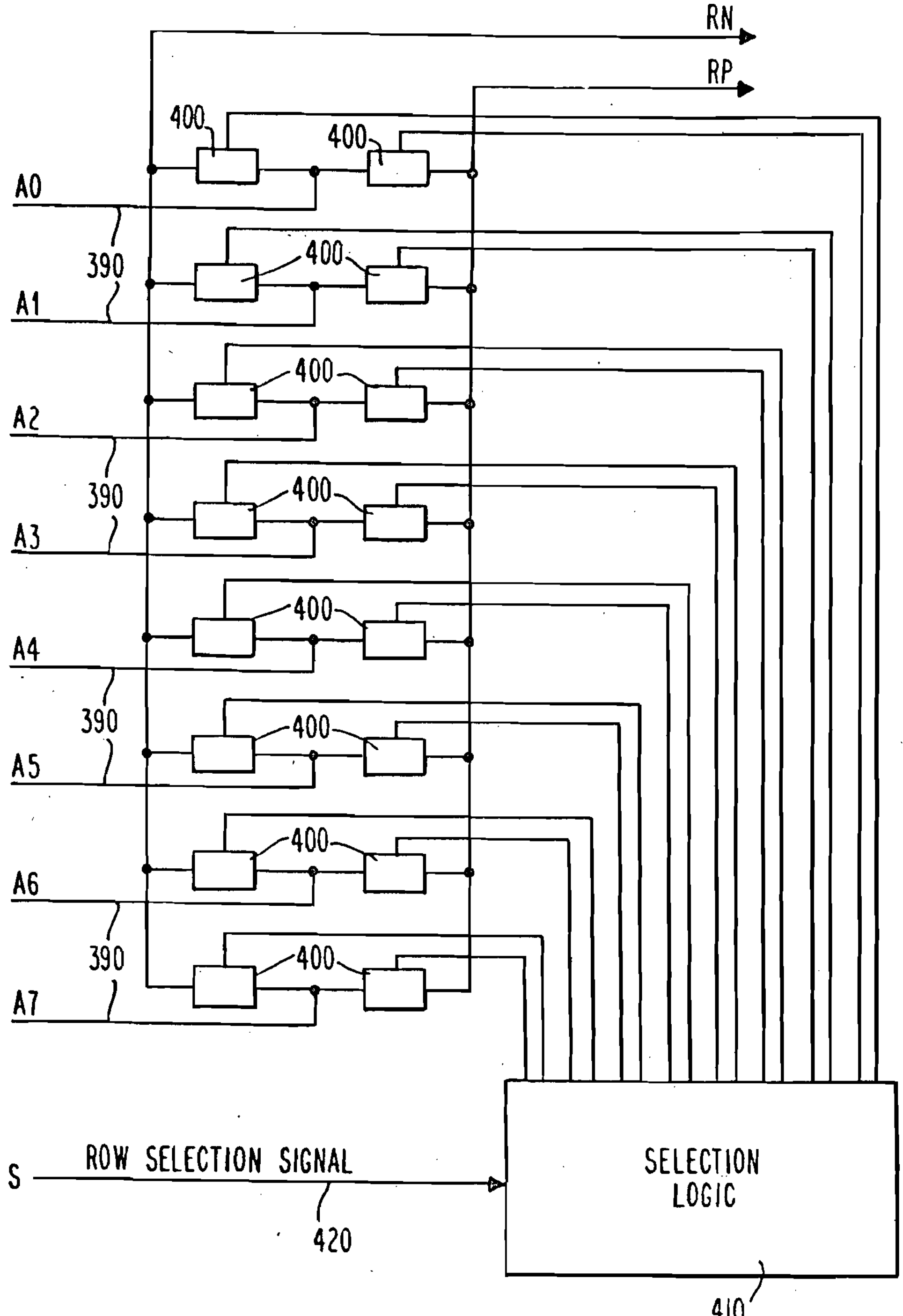
B1
B2
B3
B4
B5
B6
B7
X AXIS
Y AXIS

Fig. 8(b)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RP
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A0
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A1
A2
A3
A4
A5
A6
A7
S
ROW SELECTION SIGNAL
420
SELECTION
LOGIC
410

Fig. 9

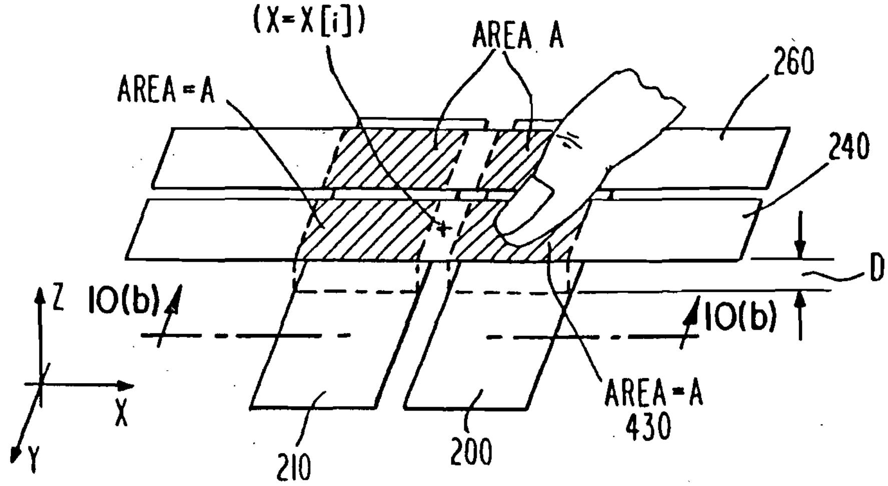

Fig. 10(a)

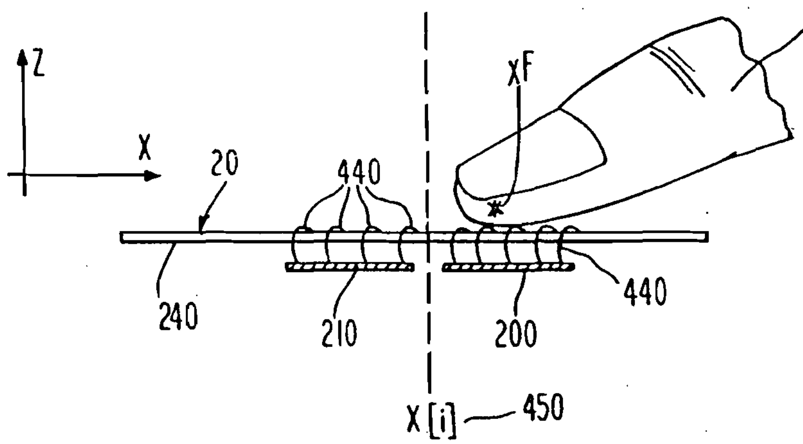

Fig. 10(b)

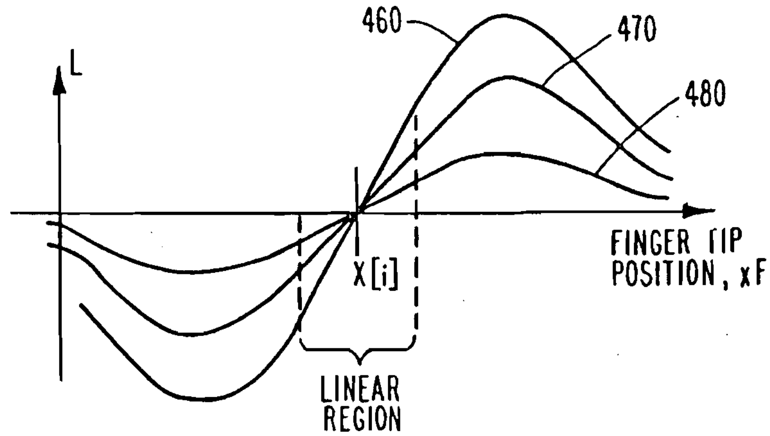
460
470
480
L
FINGER TIP
POSITION, xF
X[i]
LINEAR
REGION

Fig. 11

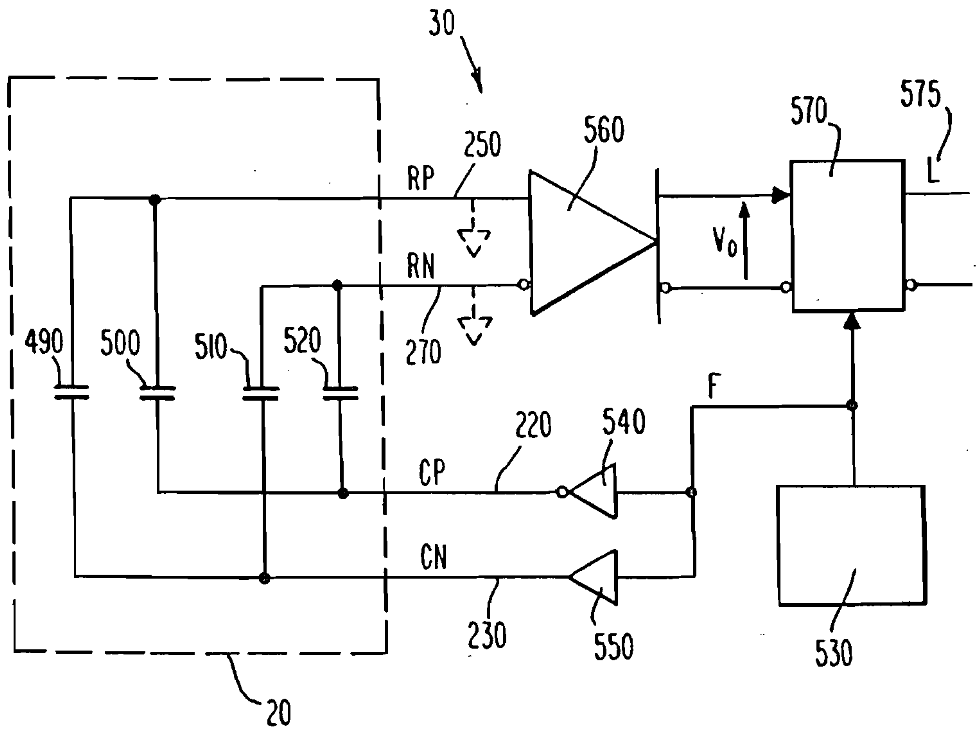
30
250
560
570
575
RP
L
Vo
RN
490
500
510
520
270
F
220
540
CP
CN
230
550
530
20

Fig. 12

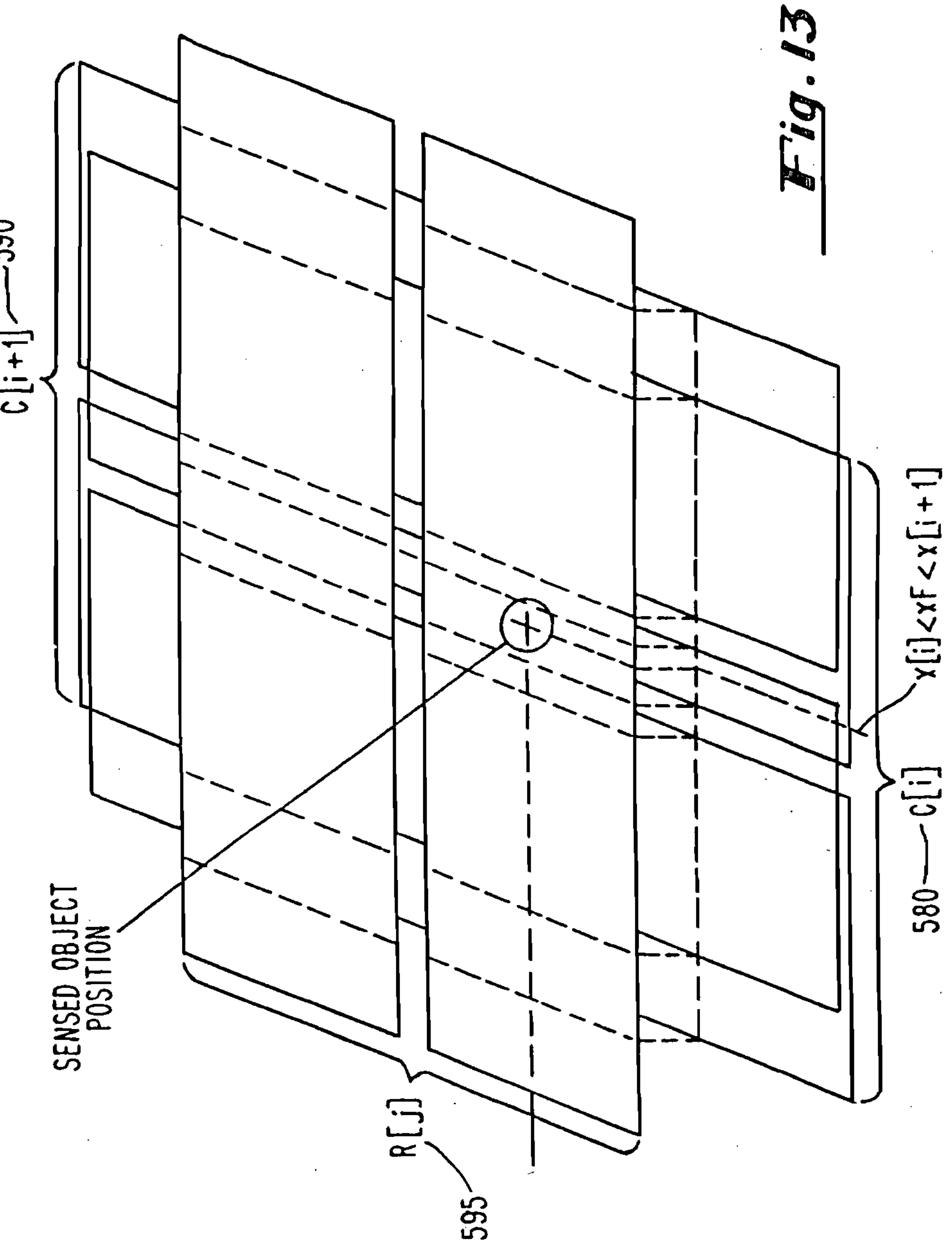

Fig. 13

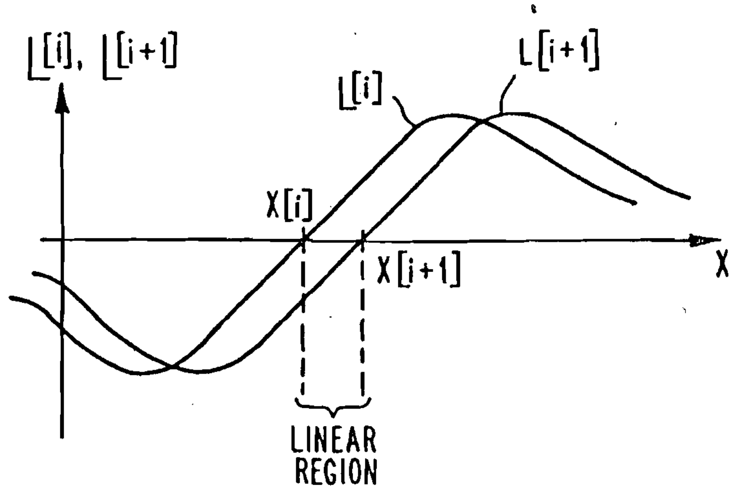
L[i], L[i+1]
L[i]
L[i+1]
X[i]
X[i+1]
X
LINEAR REGION

Fig. 14

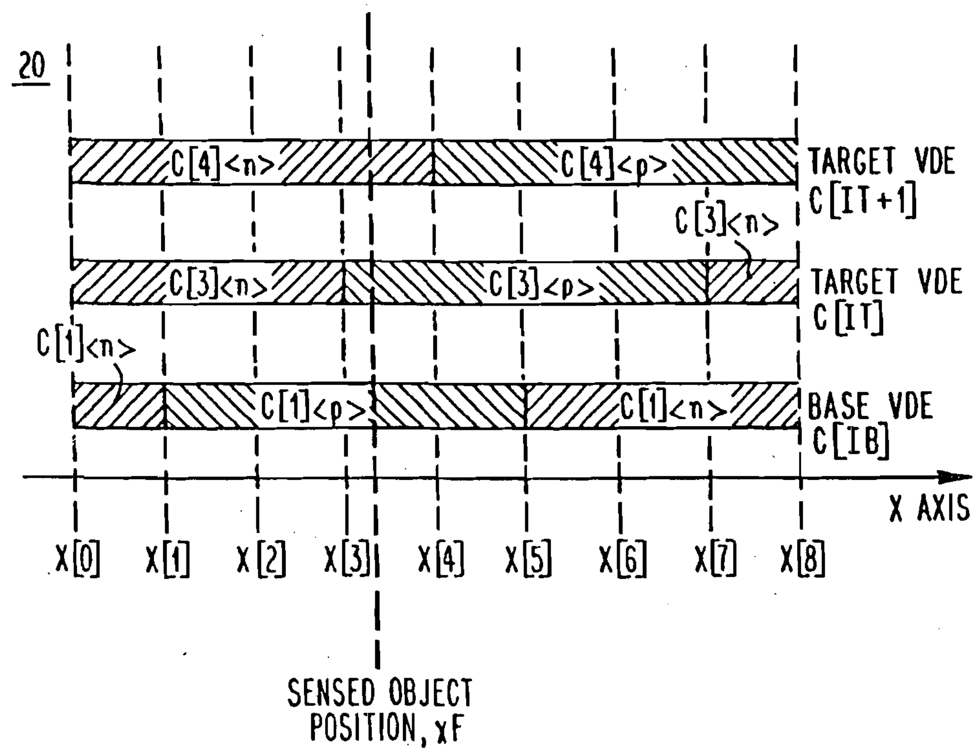
20
C[4]<n>
C[4]<p>
TARGET VDE C[IT+1]
C[3]<n>
C[3]<n>
C[3]<p>
TARGET VDE C[IT]
C[1]<n>
C[1]<p>
C[1]<n>
BASE VDE C[IB]
X AXIS
X[0] X[1] X[2] X[3] X[4] X[5] X[6] X[7] X[8]
SENSED OBJECT POSITION, xF

Fig. 15

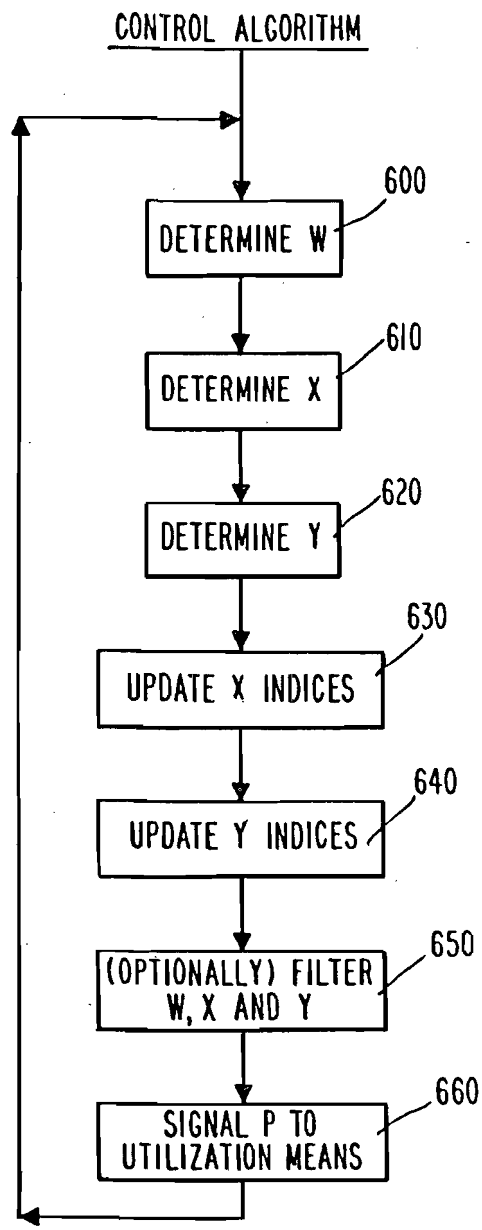
CONTROL ALGORITHM
DETERMINE W
600
DETERMINE X
610
DETERMINE Y
620
UPDATE X INDICES
630
UPDATE Y INDICES
640
(OPTIONALLY) FILTER W, X AND Y
650
SIGNAL P TO UTILIZATION MEANS
660

Fig. 16

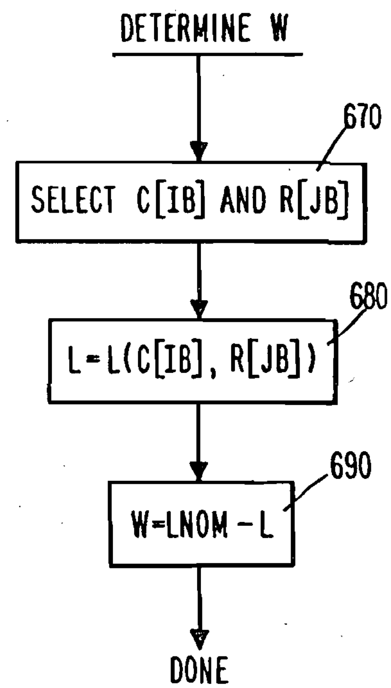
DETERMINE W
SELECT C[IB] AND R[JB]
670
L=L(C[IB], R[JB])
680
W=LNOM - L
690
DONE

Fig. 17

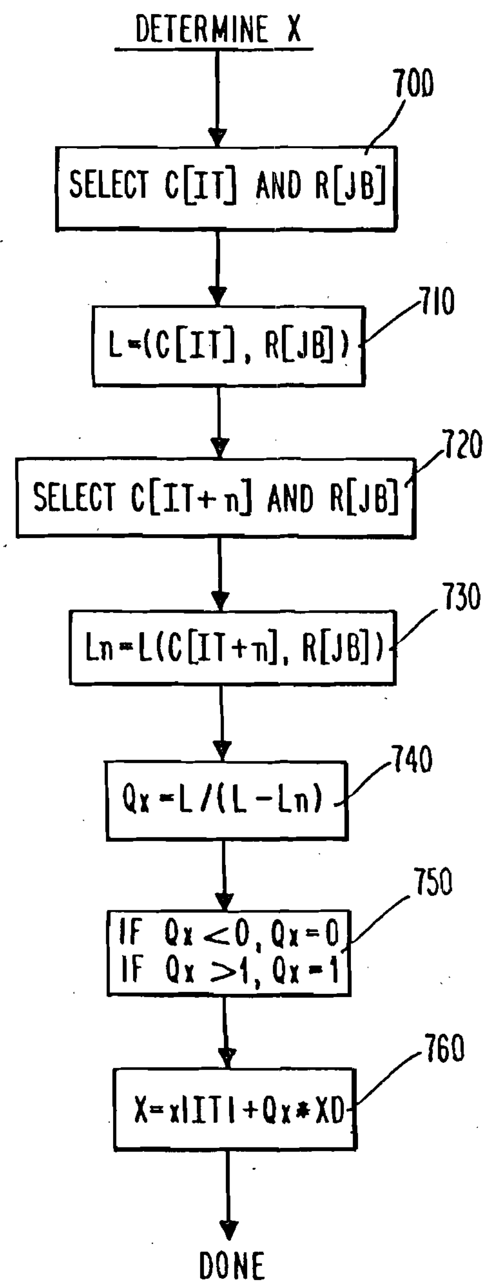
DETERMINE X
700
SELECT C[IT] AND R[JB]
710
L=(C[IT], R[JB])
720
SELECT C[IT+n] AND R[JB]
730
Ln=L(C[IT+n], R[JB])
740
Qx=L/(L-Ln)
750
IF Qx<0, Qx=0
IF Qx>1, Qx=1
760
X=x[IT]+Qx*XD
DONE

Fig. 18

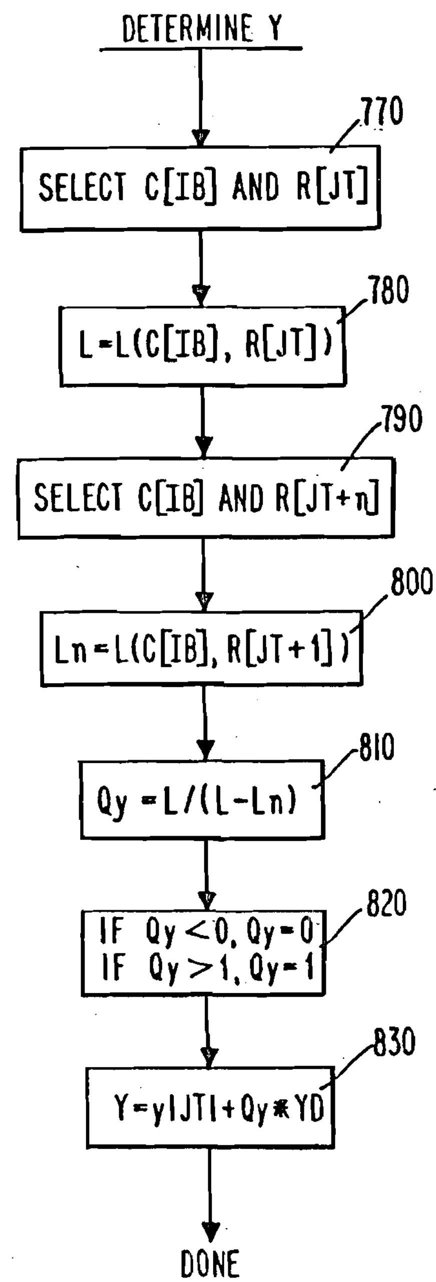
DETERMINE Y
770
SELECT C[IB] AND R[JT]
780
L=L(C[IB], R[JT])
790
SELECT C[IB] AND R[JT+n]
800
Ln=L(C[IB], R[JT+1])
810
Qy=L/(L-Ln)
820
IF Qy<0, Qy=0
IF Qy>1, Qy=1
830
Y=y[JT]+Qy*YD
DONE

Fig. 19

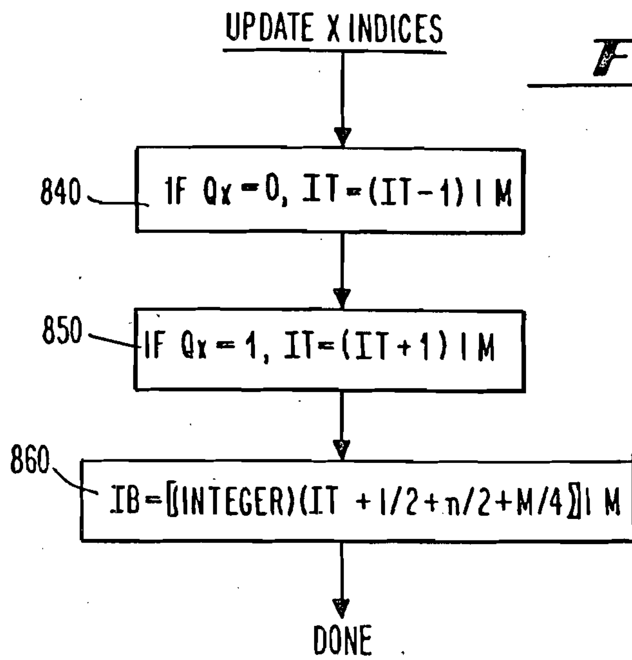
UPDATE X INDICES
840
IF Qx=0, IT=(IT-1) I M
850
IF Qx=1, IT=(IT+1) I M
860
IB=[(INTEGER)(IT +1/2+n/2+M/4)] I M
DONE

Fig. 20

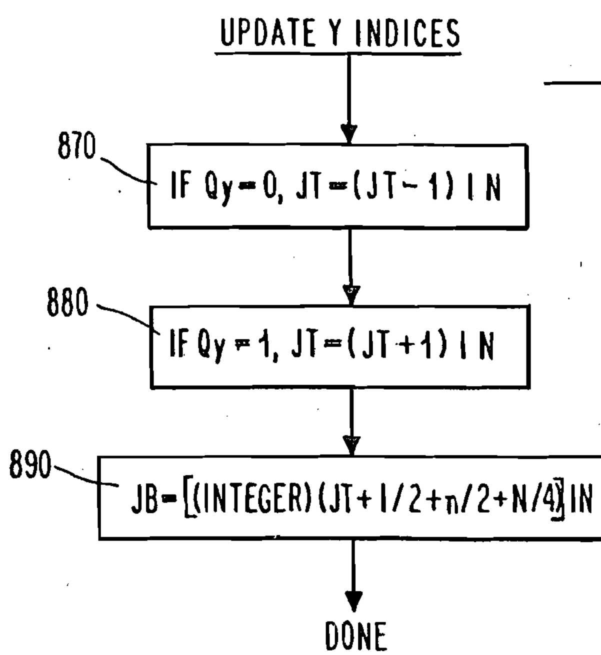
UPDATE Y INDICES
870
IF Qy=0, JT=(JT-1) I N
880
IF Qy=1, JT=(JT+1) I N
890
JB=[(INTEGER)(JT+1/2+n/2+N/4)] I N
DONE

Fig. 21

METHODS AND APPARATUS FOR DATA INPUT

This application is a continuation of U.S. application Ser. No. 07/754,329, filed Sep. 4, 1991, which is a continuation of prior application Ser. No. 07/394,566, filed on Aug. 16, 1989, by George E. Gerpheide for METHODS AND APPARATUS FOR DATA INPUT.

FIELD OF THE INVENTION

This invention relates generally to methods and apparatus for data input. More specifically, this invention relates to touch sensitive input devices for data input to computers and other instruments.

BACKGROUND OF THE INVENTION

Input devices for computers are well known in the art. There are several types of input devices, such as the familiar "mouse", which have been utilized and are generally useful in providing "user friendly" computer systems for both technical and non-technical applications. The popularity which these devices have achieved in the art can be given large credit for fostering the explosive growth of the personal computer industry since they provide a simple means for users to input data to computers for users.

Currently, about 95% of all input devices or "pointing devices" are mice. A mouse generally requires a free-rolling surface on which it can interface. Depending upon the particular mouse which is used, the device couples to the free-rolling surface and translates movement across the surface as an input to a computer. Thus, the mouse is unsuitable for any input application which cannot provide space for a rolling surface. The current and growing popularity of "laptop" computers thus has created a significant problem for mouse type technologies which require a rolling surface. Laptops are generally used in small confined areas such as, for example, airplanes, where there is insufficient room for a rolling surface. Therefore, a long-felt need in the art exists for non-mouse pointing solutions for computers and other instruments.

A further long-felt need in the art exists for input and pointing devices which are simple to use and which can be easily integrated with current computers. This long-felt need has not been solved by previous mechanical ball or shaft rolling technologies, such as, for example, track balls. Furthermore, new pointing devices should be reliable and rugged, with the ability to be transported to a variety of locations. Current track ball devices do not satisfy these long-felt needs and are also quite cumbersome since they require practiced dexterity by the user as he interacts with the device.

Other types of pointing or input devices have been employed in the art. U.S. Pat. No. 3,886,311, Rodgers et al., discloses a writing pen for detecting time varying electrostatic field components. The writing pen disclosed in Rodgers et al. is used in conjunction with a writing tablet which generates an electrostatic field. The Rodgers et al. patent discloses an X-Y grid having a writing surface overlaying the grid and an active stylus which writes on the grid in the same manner as a ball point pen. See column 2, lines 63, through column 3, line 7.

Other examples of stylus-type or "tablet" input devices are disclosed in U.S. Pat. No. 4,672,154, also to Rodgers et al. The second Rodgers et al. patent discloses a cordless stylus which emits a directional electric field from the tip of a conductive pen cartridge. The pen tip is capacitively coupled to a digitizer tablet having an X-Y coordinate system. The pointing device disclosed in the second Rodgers et al. patent may also function as a mouse. See column 1, lines 65 through 68. Both the stylus embodiment and the mouse embodiment disclosed in the second Rodgers et al. patent are both active devices which emit electrostatic fields that interface with the digitizer tablet.

The Rodgers et al. patents disclose digitizing styluses and mouse pointing devices which require a separate rolling surface. Furthermore, both of these patents disclose devices which are active and emit electrostatic fields to interact with the digitizing tablet in order to input data to a computer. Since the devices disclosed in both Rodgers et al. patents are active, the stylus is either attached to the tablet by a wire or contains a replaceable power source such as a battery. In either case, the user is required to grasp a bulky item in order to use the device. Thus, the devices disclosed in the Rodgers et al. patents do not satisfy a long-felt need in the art for pointing and input devices which can be conveniently and efficiently used for a variety of portable and desktop applications.

It has been known in the art to use tactile sensing devices to provide data input. See U.S. Pat. No. 4,680,430, Yoshikawa et al. The Yoshikawa et al. patent discloses a coordinate detecting apparatus for determining the coordinate position data of a point on a plane indicated by the touch of a finger tip or other load. Yoshikawa et al. teaches an analog type apparatus which uses a resistive film through which the coordinate position of a point is detected. The point's coordinate position is indicated by applying a load impedance to the position. See column 3, lines 8 through 22.

Tactile devices such as those disclosed in Yoshikawa et al. exhibit a significant disadvantage since they require electrical contact between the finger tip and the device. When individuals possess long fingernails or have other objects about the fingers and hands, good electrical contact is prevented and the device does not function properly.

Other analog tactile devices also exist in the art. See, e.g., U.S. Pat. No. 4,103,252, Bobick. The Bobick patent discloses electrodes located on the boundaries of a sensing region. Human touch on an edge of an electrode produces a capacitive charge to vary the time constant of an RC network which is part of an oscillator. The variation in capacitance of the sensor changes the time constant of the RC network and results in a change in frequency in the output signal of the oscillator. See column 2, lines 8–20.

U.S. Pat. No. 4,736,191, Matzke, discloses a touch activated control device comprising individual conductive plates which form sectors of a circle. A user's touch on the dielectric layer overlaying the plates is detected by individually charging and discharging each of the sectors in the plates in a sequential manner to determine the increased capacitance of the sector. See column 2, lines 26 through 40.

Display devices which are touch sensitive have also been utilized in the art. See U.S. Pat. No. 4,476,463, Ng et al. The Ng et al. patent discloses a display device which locates a touch anywhere on a conductive display faceplate by measuring plural electrical impedances of the faceplate's conductive coating. The impedances are at electrodes located on different edges of the faceplate. See column 2, lines 7 through 12. The touch sensitive devices disclosed in Ng et al. are generally designed to overlay a computer display and provide positioning information.

The tactile input devices disclosed in the Bobick, Matzke et al. and Ng et al. patents do not satisfy a long-felt need in the art for tactile input devices which accurately and efficiently provide data input for computers and other instrumentation. The devices disclosed in the aforementioned patents fail to satisfy this long-felt need since they effectively only measure position as a fraction of the distance between electrodes located on the boundaries of a sensing region. This leads to measurement inaccuracies since the distance between electrodes is relatively large, thereby causing small errors in the measured fraction to result in large position errors.

Still other tactile sensing devices utilize a grid of electrodes to digitally determine an object's position somewhere on the grid. See U.S. Pat. No. 4,550,221, Mabusth, and U.S. Pat. No. 4,639,720, Rympalski et al. The Mabusth patent discloses a touch sensitive control device which translates touch location to output signals and which includes a substrate that supports first and second interleaved, closely spaced, non-overlapping conducting plates. The plates are aligned in rows and columns so that edges of each plate of an array are proximate to, but spaced apart from, the edges of plates of the other array. The first and second arrays are periodically connected in a multiplexed fashion to a capacitance measuring circuit which measures the change in capacitance in the arrays. In effect, the Mabusth patent discloses a grid of pixels which are capacitively coupled.

Similarly, the Rympalski et al. patent discloses an electronic sketch pad which contains a graphics input pad having an array of transparent capacitive pixels, the capacitance characteristics of which are changed in response to the passing of a conductive tipped stylus over the surface of the pad. The change in capacitance is sensed by buffers disposed along the columns of the pixel matrix as the rows are scanned at a prescribed scanning rate.

Neither the Mabusth patent nor the Rympalski et al. patent satisfy a long-felt need in the art for tactile input devices which exhibit good position resolution of an object. Since the aforementioned patents teach devices which utilize a grid of electrodes and which operate in a "binary" mode, i.e., measure position by examining each electrode and determining that an object is located or is not located at a point on the grid, the resolution of the position measurement is limited to, at best, a few times the grid resolution. This requires an extremely fine pattern of electrodes to achieve acceptable position resolution. However, a fine pattern of electrodes is extremely expensive and, in most cases, not practical. Therefore, the Mabusth and Rympalski et al. patents do not satisfy a long-felt need in the art for tactile sensing devices which can input data to computers or other instruments.

SUMMARY OF THE INVENTION

The aforementioned long-felt needs are met by methods and apparatus provided in accordance with this invention. An apparatus for data input is provided. The apparatus comprises pad means for sensing at least one object's position, the pad means having electrical balances responsive to the object's position, and measurement means operatively coupled to the pad means for measuring the electrical balances in the pad means.

Methods of measuring an object's position are further provided in accordance with the present invention. The methods comprise the steps of providing an electrically sensitive pad comprising insulator means having first and second sides for providing an insulating substrate to the apparatus, first electrode means electrically coupled to the first side of the insulator means for establishing an electromagnetic field, second electrode means electrically coupled to the second side of the insulator means for further establishing the electromagnetic field in cooperation with the first electrode means, synthesis means operatively coupled to the first electrode means and the second electrode means for selecting first electrode means and second electrode means to repeatedly synthesize virtual dipole electrodes. The steps of the methods further comprise measuring electrical balances between the plurality of first electrode means and the second electrode means, calculating the object's coarse position based on at least one target index, calculating the object's fine position based on the measured balances between the plurality of first electrode and second electrode means, and calculating the object's net position.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a touch sensitive control device provided in accordance with this invention.

FIG. **2** shows a touch sensitive control device provided in accordance with this invention interfaced with a computer keyboard.

FIG. **3** illustrates synthesis of virtual electrodes.

FIG. **4** shows synthesis of virtual dipole electrodes from virtual electrodes.

FIG. **5**(*a*) illustrates a simple virtual dipole electrode.

FIG. **5**(*b*) illustrates a simple virtual dipole electrode wrapped around.

FIG. **6** illustrates cyclic virtual dipole electrodes.

FIG. **7** is a block diagram of a virtual electrode pad and row and column synthesis circuitry.

FIG. **8**(*a*) shows an elevation view of a virtual electrode pad provided in accordance with this invention.

FIG. **8**(*b*) is a plan view of a virtual electrode pad taken along the **8**(*b*) line of FIG. **8**(*a*).

FIG. **9** is a block diagram of row and column synthesis circuitry.

FIG. **10**(*a*) illustrates object position sensing with a touch sensitive control device provided in accordance with this invention.

FIG. **10**(*b*) shows object position sensing taken along the **10**(*b*) line of FIG. **10**(*a*).

FIG. **11** is a graph of electrical balance versus position for a sensed object.

FIG. **12** illustrates a preferred embodiment of the electrical balance measurement circuit of FIG. **1**.

FIG. **13** is a virtual dipole electrode pad on which a single row virtual dipole electrode and two column virtual dipole electrodes are synthesized.

FIG. **14** is a graph of balances versus object position for the arrangement of FIG. **13**.

FIG. **15** shows target and base virtual dipole electrode extent with indices updated reflecting sensed object position.

FIG. **16** is a preferred embodiment of a flow chart of a control algorithm provided in accordance with this invention.

FIG. **17** is a flow chart to determine the proximity of an object to a virtual dipole electrode pad.

FIG. 18 is a flow chart to determine the x position of an object.

FIG. 19 is a flow chart to determine the y position of an object.

FIG. 20 is a flow chart to accomplish x position index updating.

FIG. 21 is a flow chart to accomplish y position index updating.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings wherein like numerals refer to like elements, FIG. 1 is a touch sensitive input device provided in accordance with this invention, comprised of a virtual electrode pad 20, electrical balance measurement circuit 30, balance ratio determination circuit 40, and control circuit 50. In preferred embodiments, virtual electrode pad 20 is in the shape of a sheet. In further preferred embodiments, the virtual electrode pad 20 is capable of forming "virtual electrodes" at various positions on its top and bottom surfaces. The electrodes are denoted as "virtual electrodes" since separate conductive strips on the two sides of pad 20 are used to form single elements denoted "virtual electrodes." The virtual electrodes are connected to electronic circuitry capable of measuring the electrical balance between selected top virtual electrodes and selected bottom virtual electrodes.

In still further preferred embodiments, balance ratio determination circuit 40 is provided to determine the ratio of one balance measurement to another. Control circuit 50 selects appropriate electrodes for balance measurement and ratio determination. The control circuit 50 responds to balance ratios to calculate position information of the sensed object 60. This information may include position along 1 or 2 axes parallel to the electrode pad surface. Additional "proximity" information along an axis perpendicular to the surface of electrode pad 20 may also be determined from an appropriate balance measurement.

Position information determined by control circuit 50 is provided to a utilization means 70 which may be any of a variety of electronic or computer devices.

A finger 60 is shown located with its tip in close proximity to the top surface of electrode pad 20. The position of the finger tip over some region in the x and y directions may be sensed, as may its proximity in the z direction by virtual electrode pad 20. The sensed object 60 could also be a thumb tip, or any other conductive object. The coordinate axis 80 is shown for reference.

Referring to FIG. 2, a touch sensitive input device 90 provided in accordance with the present invention may provide information indicative of an operator's finger position to a computer, as an alternative to the function commonly performed by a computer mouse. An operator may draw, select commands, or manipulate graphically portrayed objects on a computer with touch sensitive input devices provided in accordance with this invention. The device 90 may be a separate pad which could be held in the hand, placed on a desktop, or in preferred embodiments built into a computer keyboard 100 positioned below the space bar 110 so an operator can manipulate it with his or her thumbs. In other preferred embodiments, the electrodes and insulator might be constructed from transparent materials for attachment to the viewing surface of a computer display screen.

The device 90 provides finger position information to any type of electronically controlled equipment. An operator could control the volume of a stereo, temperature of an oven, time for a cycle of an appliance, selection of a vending machine item, a "video game" electronic entertainment game, or the functions of electronic test or measuring equipment, for example, an oscilloscope. If a 1-axis form of the device is desired for an application, the electrode pad may be of a straight linear geometry. It could also be circular or cylindrical, having an operation like a common dial or potentiometer knob.

In preferred embodiments, the sensed object may be any substantially conductive object. With an electrode pad constructed on an appropriate scale, the device could sense the position of a nearby hand, person, automobile, or piece of machinery. The touch sensitive control devices provided in accordance with this invention could be further adapted for use as an "electronic blackboard."

Referring to FIG. 3, virtual electrode 120 is comprised of a number of electrode strips 130 deployed over an area. An electrode strip is a sheet conductive region. The strips are separated by insulating spaces 140 but are electrically connected together by electrode synthesis circuit 150. The area over which the connected strips 130 are deployed, including the area between strips 140, is defined as the area of the virtual electrode.

As defined and used throughout, the notation A B means A modulo B, that is, the remainder when A is divided by B. Square brackets are used to enclose indices, typically selecting one of a number of similar objects or points. For example, C[i] denotes the "i-th column". All indices are to be taken with respect to an understood row or column modulus. For example, if there are M "columns", then C[i+1] is to be interpreted as C[(i+1) M].

FIG. 4 shows a preferred embodiment of virtual electrode pad 20 with two "row" virtual electrodes 160 on the top side of the sheet and two "column" virtual electrodes 170 on the bottom side. In further preferred embodiments, each virtual electrode is rectangular in shape. The virtual electrodes have a "length" and a "width". The width of the row electrodes 160 are in the y direction with respect to the coordinate system 80, while the width of the column electrodes 170 are in the x direction. The two row virtual electrodes 160 form a row "virtual dipole electrode" (VDE) labelled R[j] at 180. A column VDE labelled C[i] at 190 is also formed.

In still further preferred embodiments, a VDE consists of two virtual electrodes of equal area located along side each other. A virtual electrode extending to the pad edge may "wrap around" to the opposite side's edge. The component virtual electrodes of the VDE are referred to as the "positive" and "negative" halves of the VDE. The location (along the axis in the width direction in the present example is greater for the positive half than for the negative half of the VDE. The positive half of C[i] is denoted by C[i]<p> at 200 and the negative half by C[i]<n> at 210. C[i]<p> is connected to wire CP at 220 and C[i]<n> to wire CN at 230. Similarly, R[j]<p> at 240 is connected to RP at 250 and R[j]<n> 260 to RN at 270.

The "location" of a VDE is defined as the coordinate in the width direction of a location line, i.e., equidistant between the two component virtual electrodes. Column VDEs C[0] . . . C[M−1] are located at x[0] . . . x[M−1], respectively. Row VDEs R[0] . . . R[N−1] are located at y[0] . . . y[N−1], respectively. The "VDE spacing" is the distance between adjacent row (or column, as appropriate) VDE locations. Typically, VDE width is greater than VDE spacing and therefore VDEs may overlap at adjacent locations.

Referring to FIGS. 5(*a*) and 5(*b*), a preferred embodiment of two simple column VDEs as described above is shown. There is a single location line **280** with a negative VDE half **290** on the left and a positive half **300** on the right. Each VDE covers essentially the entire virtual electrode pad **20**. In FIG. 5(*b*), the location line is not in the center of the pad. The <n> virtual electrode **290** extends to the left edge of the pad and wraps around to the right edge at **310**. In other preferred embodiments, a VDE may have only a positive half wherein the area of the negative half and any mutual capacities to the negative half are defined to be zero.

FIG. 6 illustrates another preferred embodiment of a VDE called a "cyclic" column VDE. A cyclic VDE consists of a "fundamental" VDE and additional VDEs located periodically along the axis. All the <n> virtual electrodes **290** are electrically connected together to the CN wire **230**. Similarly, all <p> virtual electrodes **300** are connected to CP at **220**. The number of component VDEs (including the fundamental VDE) in a cyclic VDE is defined as the "multiplicity". The multiplicity is three for the example shown. The location **280** of the fundamental VDE is taken to be the location of the entire cyclic VDE. This location has the lowest coordinate of all the component VDEs. Simple and cyclic row VDEs are analogous to the column VDEs described here.

Simple VDEs can be considered to be a special case of cyclic VDEs having multiplicity equal to one. The advantage of using higher multiplicity is increased accuracy compared to a virtual electrode pad of the same size and same number of cyclic VDEs but lower multiplicity. Assume the former has multiplicity A and the latter multiplicity B, where A is greater than B. The VDE spacing of the former will be the fraction B/A of the latter. Greater accuracy can be realized with the former due to the smaller VDE spacing.

Multiplicity greater than one implies the sensed object's absolute position can not be determined unambiguously. Position can be determined relative to the location of one component VDE, but there is no way to determine which component VDE. In many cases only relative position (that is, a change in position) needs to be sensed. With multiplicity greater than one, position should be measured frequently enough that the sensed object never moves more than half the VDE spacing from one measurement to the next. In this fashion, relative position change can be unambiguously determined. A multiplicity of one may be used if absolute position must be measured. Another solution is to use two different periodic VDEs with different VDE spacings.

Referring to FIG. 7, virtual electrode pad **20** comprises a substrate **320** and a plurality of electrical strips **130** on both sides of the substrate **320**. In preferred embodiments, substrate **320** is an insulator. Electrode synthesis circuit **150** comprises row synthesis circuit **330** and column synthesis circuit **340**. In further preferred embodiments, electrode pad **20** is connected to row synthesis circuit **330** through lines **A1** through **A8**, shown generally at **350**. Similarly, electrode pad **20** is connected to column synthesis circuit **340** through lines **B1** through **B8**, shown generally at **360**. In still further preferred embodiments, there are eight electrode strips on the top side of pad **20**.

On command from control means **50**, the electrode synthesis circuit **150** connects selected electrode strips to wires CN, CP, RN and RP to form one row and one column VDE on respective sides of the virtual electrode pad. A signal, S, from control means **50** is input to row synthesis circuit **330** and column synthesis circuit **340** and commands the virtual electrode pad **20** to select one row VDE and one column VDE. The location of each VDE is varied according to the requirements of a control algorithm. Both halves of each VDE are connected to the electrical balance measurement means **30**. This connection is via wires RN and RP connected to the positive and negative halves, respectively, of the row VDE; and via wires CN and CP connected to the positive and negative halves of the column VDE. In preferred embodiments, the electrical measurement accomplished is a capacitive measurement between the electrode strips.

FIGS. 8(*a*) and 8(*b*) show virtual electrode pad **20**. Referring to FIG. 8(*a*), flat electrode strips **130** are present on the top and bottom of separator insulating substrate, shown generally at **370**. On the top surface of electrode pad **20** is a thin overlay insulator **380** which prevents a sensed object from making electrical contact with electrode strips **130** and substrate **370**. It also protects the electrode strips from corrosion and wear.

In further preferred embodiments, pad **20** has overall dimensions of about 1.0 inch high by 3.5 inches wide by 0.08 inch thick. Overlay insulator **380** is a 0.02 inch thick MYLAR sheet, and separator insulator **370** is a 0.06 inch thick epoxy-glass printed circuit board material. Electrode strips **30** are 0.04 inch wide copper traces on 0.2 inch centers fabricated on both sides of the separator insulator using standard printed circuit board techniques. Dimensions may be varied considerably while still achieving good functionality. The width of the traces, spacing between the traces, and thickness of the circuit board insulator and overlay insulator may be selected for the particular application and object being sensed. The above-mentioned dimensions give good results for a human finger tip.

Referring to FIG. 8(*b*), there are eight electrode strips on the top side of the separator insulator **370** perpendicular to the y axis. Wires labelled **A0** through **A7** are attached to these 8 electrode strips. In still further preferred embodiments, there are twenty-four electrode strips on the bottom of separator insulator **370** perpendicular to the x axis. The twenty-four electrode strips are connected to wires labelled **B0** through **B7** as shown. Connection of three column electrode strips to each column wire is consistent with multiplicity of three. The multiplicity is one for the rows.

FIG. 9 illustrates a preferred embodiment of an implementation of row virtual electrode synthesis circuit **330**. Each electrode strip wire **A0** through **A7**, shown generally at **390**, is connected to a pair of electronic switches at **400**. In preferred embodiments, electronic switches **400** are CMOS analog switches. One or the other switch of each pair is electrically conducting. The electrically conducting switch connects the associated electrode strip to either wire RN or RP, depending on whether that strip is to be part of a VDE negative or positive half.

Each switch **400** is controlled by the selection logic block shown at **410**. The selection logic block **410** responds to the row selection signal **420** which is a component of signal S. The following selection table shows selection logic for synthesis of all possible row VDEs in the pad of FIG. 8.

SELECTION TABLE

	Selection Signal							
	R[0]	R[1]	R[2]	R[3]	R[4]	R[5]	R[6]	R[7]
A0:	RP	RN	RN	RN	RN	RP	RP	RP
A1:	RP	RP	RN	RN	RN	RN	RP	RP
A2:	RP	RP	RP	RN	RN	RN	RN	RP
A3:	RP	RP	RP	RP	RN	RN	RN	RN
A4:	RN	RP	RP	RP	RP	RN	RN	RN
A5:	RN	RN	RP	RP	RP	RP	RN	RN
A6:	RN	RN	RN	RP	RP	RP	RP	RN
A7:	RN	RN	RN	RN	RP	RP	RP	RP

In this way, one of eight possible VDEs, R[0] through R[7], are selected to be synthesized from electrode strips on the pad. The circuitry for columns may be identical to that for rows.

The pad dimensions, number of electrode strips to form a VDE, and multiplicity of VDEs along each axis may be varied. Some electrode strips can be unconnected when synthesizing a VDE. This provides additional spacing between VDE halves. The pad might be formed into a sphere, cup, cylinder, section of any of these, or other non-planar shape. The axes on the two sides of the pad need not be orthogonal. Axis systems other than rectangular coordinates might be used. With a radial coordinate system, "ring" virtual electrodes (directly analogous to the row virtual electrodes described above) would be shaped as rings while "wedge" virtual electrodes (directly analogous to the column virtual electrodes described above) would be shaped in a "pie-section."

The electrical balance measurement circuit 30 measures an electrical quantity between virtual row and column electrodes in the virtual electrode pad 20 defined as the "balance." Referring to FIG. 1, the electrical balance measurement circuit is connected to pad 20 by wires RP, RN, CP, and CN. In preferred embodiments, the electrical balance measurement circuit measures the capacitive balance between the virtual row and column electrodes. Thus, the terms electrical balance measurement and capacitive balance measurement are used interchangeably throughout.

It will be recognized by those with skill in the art that other electrical quantities responsive to a sensed object position such as, but not limited to, inductance, could be measured with input devices provided in accordance with this invention. Thus, the term "electric field" as used throughout is herein defined to mean any electromagnetic field, including electrostatic and magnetic fields. The capacitive balance measurement circuit outputs a signal which is responsive to the capacitive balance. This signal is utilized by the balance ratio determination circuit 40 and by the control circuit 50. The output signal might be a voltage utilized directly in an analog voltage form, or might be converted to digital form by an analog-to-digital converter.

To understand capacitive balance as it is used throughout, first define M(A,B) to denote the well-known mutual capacitance between virtual electrodes A and B when all other electrodes in the pad are grounded. M(C[i]<p>, R[j]<n>), for example, denotes the mutual capacitance between the positive half of VDE C[i] and the negative half of VDE R[j]. Then define the capacitive balance between VDEs C[i] and R[j],L(C[i],R[j]) to be given by:

$$L(C[i],R[j])=Kfg*k\{M(C[i]<p>,R[j]<n>)-M(C[i]<p>,R[j]<p>)+M(C[i]<n>,R[j]<p>)-M(C[i]<n>,R[j]<n>)\}.$$

Kfg is a constant scale factor which, in a preferred embodiment, depends on reference signal amplitude and amplifier gain of the electrical balance measurement circuit 30. Balance is a useful electrical quantity because it is indicative of the position of a conductive object, as described herein.

Referring to FIG. 10(*a*), sensed object 60 is above the virtual electrode pad 20 with VDEs synthesized appropriate to the object's x position. The location of the object is at coordinates (xF, yF, zF). The object's position is related to a weighted average location of all points on the surface of the object, with greater weight given to those points closer to pad 20. A row VDE, R[j], is located with its positive half R[j]<p> 240 roughly centered in the y direction underneath the sensed object.

A column VDE, C[i], is located at x[i] near the x position of the sensed object. R[j] is called the "base" VDE and C[i] is the "target" VDE with respect to this measurement. The row and column VDEs are connected to RN and RP, and CN and CP, respectively. The separator insulator between base and target has a thickness D. The overlap between C[i]<p> and R[j]<p> is of an area, A, shown at 430, which equals the area of each of the other three overlaps between the C[i] and R[j] electrode halves.

FIG. 10(*b*) illustrates this situation from a side view along the x axis. Finger tip 60 is shown as a representative sensed object positioned at xF. As is well known from the theory of parallel plate capacitors, M(C[i]<p>,R[j]<p>)=A*E/D, approximately, where E is the dielectric constant of the separator insulator. The same expression applies for each of the other three mutual capacities between the C[i] and R[j] electrode halves. All four mutual capacities are approximately equal. These approximations neglect an addition to A*E/D due to coupling of fringe electrostatic field lines shown at 440. If there were no finger tip present, the fringe field for all four would be equal. This balance would result in the exact equality:

$$L(C[i],R[j])=0.$$

A conducting object, such as finger tip 60, in close proximity upsets this balance. The finger tip, shown here positioned at xF>x[i] at 450, intercepts more of the fringe field of C[i]<p> than of C[i]<n> resulting in the inequality:

$$M(C[i]<p>,R[j]<p>)<M(C[i]<p>,R[j]<n>).$$

The finger tip does not substantially influence the fields coupled to R[j]<n> since the finger tip's y position is over R[j]<p> instead of R[j]<n>. Thus:

$$M(C[i]<n>,R[j]<p>)=M(C[i]<n>,R[j]<n>).$$

The net effect is that

$$L(C[i],R[j])>0$$

for the finger tip positioned at $xF > x[i]$. By similar analysis, for $xF = x[i]$, balance is preserved and $L(C[i],R[j]) = 0$. Similarly, for $xF < x[i]$, $L(C[i],R[j]) < 0$.

FIG. 11 plots the balance L, between the base and target VDEs for the situation of FIGS. 10(*a*) and 10(*b*) as a function of finger tip position xF. Plot **460** is for the case of the finger tip centered over the base VDE positive half ($yF = y0$), and as close to the pad as is possible ($zF = z0$). This case gives the largest magnitude change with position. Other plots **470** and **480** illustrate different y or greater z. The magnitude of the change is less in these cases since the finger intercepts fewer fringe field lines. In all cases, there is a region of xF around $xF = x[i]$ where L is essentially a linear function of xF. This means that $L = K(yF,zF)*(xF - x[i])$ for some slope K which is dependent on yF, zF, and Kfg, as well as electrode, and sensed object geometries.

FIG. 12 is a block diagram of a preferred embodiment of electrical balance measurement circuit **30**. Also shown is a simplified electrical model of virtual electrode pad **20** connected to the capacitive balance measurement circuit **30** via wires RP **250**, RN **270**, CP **220**, and CN **230**. This model consists of 4 capacitors representing the mutual capacities $M(C<n>,R<P>)$ **490**, $M(C<p>,R<p>)$ **500**, $M(C<n>,R<n>)$ **510** and $M(C<p>,R<n>)$ **520** between halves of the base and target VDEs. The reference signal source **530** generates an alternating current (AC) reference signal, F, with a frequency substantially higher than the frequency at which position measurements are to be made.

In preferred embodiments, this frequency is about 140 KHz. For human finger tip sensing, frequencies from 20 KHz to 500 KHz will give acceptable results. Possible wider frequency ranges are possible when other objects are sensed. The reference signal **530** goes to a pair of drivers. One driver **540** is an inverting type and drives the positive half of the synthesized column VDE via wire CP. The other driver **550** is a non-inverting type and drives the negative half via wire CN. CN **230** is thus driven with an in-phase version of F while CP **220** is driven with negative F (−F).

Wires RP **250** and RN **270** connect the positive and negative halves of the row VDE to non-inverting and inverting inputs, respectively, of a differential charge amplifier **560**. Differential charge amplifier **560** maintains RP and RN at an AC virtual ground so that the AC voltage across each mutual capacitance 500 or 520 is −F and the AC voltage across each mutual capacitance **490** or **510** is +F. The amount of charge coupled onto RP is $F*M(C<n>,R<p>) - F*M(C<p>,R<p>)$. The amount onto RN is $F*M(C<n>,R<n>) - F*M(C<p>,R<n>)$.

The charge amplifier **560** produces an AC differential output voltage, Vo, equal to a gain factor, G, times the charge coupled onto RP minus that on RN. This yields the following relationship:

$$Vo = (F*G)*\{M(C<n>,R<p>) - M(C<p>,R<p>) + M(C<p>,R<n>) - M(C<n>,R<n>)\} = L(C,R).$$

Vo is the balance between C and R, denoted herein as L(C,R). Both G and the magnitude of F are constant scale factors. The product (F*G) is the scale factor, Kfg, in the above definition of the balance, L.

In preferred embodiments, Vo feeds into a double balanced synchronous detector **570** for measurement. The detector **570** also uses input signal F as a reference. Detector **570** recovers the amplitude of a signal synchronized to reference signal F in the presence of electrical noise signals having much greater amplitude. This noise rejection is important since the amount of charge coupled across the mutual capacitances **490**, **500**, **510** and **520** of virtual electrode pad **20** may be very small in magnitude. The output of the charge amplifier **560** therefore consists of a significant noise component, N, in addition to the desired signal. The output of charge amplifier **560** can thus be written as:

$$Vo' = Vo + N = L(C,R) + N.$$

The output of the detector **570** is a signal proportional to the component of Vo which is synchronous with the reference signal F. Since the noise N is not synchronized to F, it does not affect the detector output signal **575**, which is therefore a direct measurement of L(C,R). The signal L at **575** can be encoded by any of a number of well known means, for example, in digital format or with a single ended or double ended voltage, current, or charge. The use of double balanced detector **570** minimizes noise and inaccuracy. In further preferred embodiments, a single balanced detector may be used.

Referring to FIG. 13, virtual electrode pad **20** has two column VDEs, C[i] **580** and C[i+1] **590** at adjacent locations, formed on the bottom side of the pad. A row VDE, R[j] **595** is formed on the top side. The position of a sensed object is also indicated, although the object itself is not shown. The object's x position, xF, is between the locations of the two column VDEs, x[i] and x[i+1].

FIG. 14 illustrates the variation of two balances measured in the pad **20** of FIG. 13. Each balance varies with the xF position of a sensed object. L[i] is the balance between base R[j] and target C[i]. L[i+1] is the balance between R[j] and C[i+1]. FIG. 11 showed the general linear nature of capacitive balance L, responsive to the object's xF position. The slope, K, of the general response varies with object yF and zF position and also includes the effect of the scale constant Kfg described above. Both L[i] and L[i+1] in FIG. 14 are essentially linear over the region between x[i] and x[i+1]. The slope constant, K, is essentially the same for both measurements. The measurements are expressed as:

$$L[i] = K*(xF - x[i]), \text{ and}$$

$$L[i+1] = K*(xF - x[i+1]).$$

In preferred embodiments, a balance ratio, Q[i], can be defined as:

$$Q[i] = L[i]/(L[i] - L[i+1]).$$

Other expressions for Q[i] may be developed which are functionally equivalent. From the above expressions for L, Q[i] can be rewritten as:

$$Q[i] = (xF - x[i])/(x[i+1] - x[i]).$$

Q[i] varies linearly from a value of zero for an object at $xF = x[i]$ up to one at $xF = x[i+1]$. Algebraic rearrangement gives an expression for position xF as:

$$xF = Q[i]*(x[i+1] - x[i]) + x[i].$$

It is advantageous to calculate Q[i] so the position xF can be determined independently of yF or zF. The balance ratio Q[i], is calculated by balance ratio determination circuit **40** using successive capacitive balance measurements L[i] and L[i+1].

The discussion regarding FIGS. **13** and **14** and the definition of balance ratios all contemplated a preferred embodiment in which two adjacent VDEs, with indices [i] and [i+1] are used to develop a balance ratio. Two non-adjacent VDEs, e.g., with indices [i] and [i+n] could also be used wherein n is considered an index offset.

Referring again to FIG. **1**, control circuit **50** accepts balance measurements, L, and ratios, Q, from balance measurement circuit **30** and ratio determination circuit **40**. Control circuit **50** generates a selection signal, S, which is provided to virtual electrode pad **20**. Signal S contains row and column selection components. In preferred embodiments, control circuit **50** is a microprocessor, microcontroller, or other digital logic circuitry.

Control signal S specifies one row VDE and one column VDE to be formed on pad **20** at any particular moment. Thus, the control circuit specifies or selects the particular column and row VDE at given times. Control circuit **50** also provides signals to balance measurement circuit **30** and balances ratio determination circuit **40** directing these two components to perform measurements and calculations. It also provides position signals, P, to utilization means **70**.

As herein defined, the object's "coarse" position means position with resolution equal to the distance between adjacent VDEs. The object's "fine" position means position with resolution some number of times greater than the coarse position. The particular multiple of the coarse resolution is a function of the capacitive balance measurement resolution, balance ratio determination resolution, and the degrading effects of electronic noise. In preferred embodiments, this multiple is 128.

Assume that one of M column VDEs and one of N row VDEs can be selected from the pad **20**. In preferred embodiments, M=8 and N=8. Each VDE covers the entire surface of the pad by wrapping around as described and shown in FIG. **5**(*b*).

Assume i and j are VDE indices taken from what may be called the set of "normal" indices. Row VDE R[i+N/2] is the same as R[i] with positive and negative halves interchanged. Similarly C[j+M/2] is an interchanged version of C[j]. Interchanging positive with negative halves of both the row and the column VDEs does not effect a balance measurement. This will be appreciated by recalling the definition of balance, L. Since operation is based on balance measurements, all normal column and row indices can be consistently increased by M/2 and N/2, respectively, to give alternate indices. Alternate indices correspond to coarse positions which are consistently offset by M/2 times the column VDE spacing and N/2 times the row VDE spacing.

In further preferred embodiments, it is not possible to determine if normal or alternate indices are being used at any particular time, but the type of indices being used will not switch while a sensed object remains in proximity to the pad. In still further preferred embodiments, position change is the same with normal and alternate indices. Fortunately, in many applications only a change in position is important. If absolute position must be determined, an additional measurement, L', that is sensitive to interchanging positive and negative halves can be defined by the expression:

$$L'(C[i],R[j]) = Kfg^{*}\{M(C[i]<p>,R[j]<n>)+M(C[i]<p>,R[j]<p>)-M(C[i]<n>,R[j]<p>)-M(C[i]<n>,R[j]<n>)\}.$$

Measurement circuitry to determine L' is a variation of the circuitry used for determining L. The control means may be adapted to use L' and distinguish normal indices from alternate indices in preferred embodiments.

A goal of the control circuit is to perform repeated updating of base indices, IB and JB, and target indices, IT and JT, such that the sensed object position is roughly centered within the positive halves of VDEs C[IB] and R[JB], and located in intervals x[IT] to x[IT+1] and y[JT] to y[JT+1]. This relates to the coarse position of the object.

Referring to FIG. **15**, one possible xF object position and the extent of appropriate column VDEs is shown. In this example, IB=1 and IT=3. Position xF is located between x[3] and x[4], the respective locations of target VDEs C[3] and C[4]. Furthermore, xF is roughly centered within the positive half of base VDE C[1]. An example for the y position and row VDEs is analogous.

Referring to FIG. **16**, a flow chart of a preferred embodiment of an algorithm executed by the control means is shown. At step **600**, the control means determines the proximity, W, of the sensed object to the pad generally in the z direction. The object's position is determined at step **610** and the object's y position is determined at step **620**. The control means updates the x indices IB and IT at step **630** and the y indices JB and JT at step **640**.

Signal filtering to reduce noise in the reported position, to vary the rate of reporting depending on position change activity, or to eliminate spurious position change or inaccuracies as the sensed object passes through the proximity threshold transition, is performed at step **650**. Signal P is sent to a utilization means at step **660**. One component of P indicates the proximity W, or closeness of contact, between the object to be sensed and the pad. If the proximity is sufficiently close, then other components of P indicate the x and y position of the object. This information could be coded in a variety of ways, for example, as absolute position, or relative position, that is, the change in the object's position since the last signal.

The value of W as determined at step **600** above may be used to determine if an object is in sufficiently close proximity to the pad that the x and y position determined in steps **610** and **620** is meaningful. This is done by comparing W to some threshold value Wth>0. If W>Wth then the object is sufficiently close so that position information is meaningful. If W≦Wth then the object is not close and the position information is not meaningful. The value Wth can be determined empirically by locating the object to be sensed at a proximity slightly more distant than that at which position sensing is desired to occur. The value of W determined with this arrangement is a suitable value for Wth.

In preferred embodiments, the control means makes one complete cycle through this algorithm every 5.5 milliseconds. Other periods may be achieved with no significant change in operation. The period may be further adapted for the particular utilization means used by the system. If the pad multiplicity is greater than one, the period should be sufficiently short to ensure that the sensed object never moves more than half the fundamental VDE width during one period.

Referring to FIG. 17, a flow chart for determining W is shown. At step 670, a column VDE is selected corresponding to index IB, and a row VDE is selected corresponding to JB. At step 680, the capacitive balance measurement means is directed to measure the balance L between the row and column VDEs which have been selected. At step 690, the proximity is determined and defined to be a constant equal to LNOM minus L. LNOM is set such that W equals zero when no object is present to be sensed. W increases as the object comes into closer proximity with the pad.

FIG. 18 details determination of the object's x position. At step 700, a column VDE corresponding to index IT is selected and a row VDE corresponding to JB is selected. At step 710, the capacitive balance measurement circuit is directed to measure the balance L, between C[IT] and R[JB]. Selection of a column VDE corresponding to index IT+n and a row VDE corresponding to JB is accomplished at 720. The number n is a target index offset. In preferred embodiments, n=1. In other preferred embodiments, n may have an integer value greater than one.

At step 730, the capacitive balance measurement circuit measures the balance Ln between C[IT+n] and R[JB]. At step 740, the balance ratio determination circuit calculates Qx=L/(L−Ln) where L and Ln are the two balances previously measured.

Qx is limited at step 750 to be in the range of zero through one, inclusive. If Qx is less than zero, it is set to zero. If Qx is greater than one, it is set to one.

At step 760, the X position=x[IT]+Qx*XD is calculated. XD is the distance between column VDE locations x[IT] and x[IT+n]. The calculation for X interpolates a position between these two column VDE locations.

Referring to FIG. 19, determination of the object's Y position is shown. At step 770, a column VDE corresponding to index IB is selected, and a row VDE corresponding to JT is selected. At step 780, the capacitive balance L between C[IB] and R[JT] is measured. Selection of a column VDE corresponding to index IB and a row VDE corresponding to JT+n is accomplished at step 790.

At step 800, the capacitive balance measurement means measures the balance Ln, between C[IB] and R[JT+n]. The balance ratio determination means calculates Qy=L/(L−Ln) at step 810 where L and Ln are the two balances just measured. At step 820, Qy is limited to the range of zero through one, inclusive. If Qy is less than zero, it is set to zero. If Qy is greater than one, is set to one.

At step 830, the object's y position=y[JT]+Qy*YD is calculated. YD is the distance between row VDE location y[IT] and y[IT+n]. The calculation for y position interpolates a position between the two row VDE locations.

Referring to FIG. 20, the X indices are updated. At step 840, the Qx ratio is tested. If Qx equals zero, the sensed x position is at, or possibly to the left of, C[IT]. In this case, one is subtracted from the current IT. The result is taken modulo M, where M is the number of column VDEs. This updates IT corresponding to the next column to the left.

At step 850, Qx is again tested. If Qx equals one, the sensed x position is at, or possibly to the right of, C[IT+n]. In this case, one is added to IT, modulo M. This updates IT to the right.

At step 860, the value $IT+\frac{1}{2}+n/2+M/4$ is rounded to the nearest integer. The rounded value is taken modulo M and assigned to IB. This ensures that the positive half of C[IB] is nearly centered over the region between the updated x[IT] and x[IT+n].

Referring to FIG. 21, the Y indices are updated. At step 870, the Qy ratio is tested. If Qy equals zero, the sensed Y position is at, or possibly below, R[JT]. In this case, one is subtracted from the current JT. The result is taken modulo N, where N is the number of row VDEs. This updates JT corresponding to the next row below.

Qy is again tested at step 880. If Qy equals one, the sensed Y position is at, or possibly above, R[JT+n]. In this case, one is added to JT, modulo N. This updates JT to the next row above. At step 890, the value $JT+\frac{1}{2}+n/2+N/4$ is rounded to the nearest integer. The rounded value is taken modulo N and assigned to IB. This ensures that the positive half of R[IB] is nearly centered over the region between the updated y[JT] and y[JT+n]. In preferred embodiments, a fractional number $A+\frac{1}{2}$ is rounded down to the integer A. In further preferred embodiments, $A+\frac{1}{2}$ is rounded up to A+1.

The circuitry to accomplish the above-referenced flow charts can be implemented in a variety of ways. All or part of the circuitry might be contained in one or more Application Specific Integrated Circuits (ASICs). In preferred embodiments, the circuitry may be implemented using standard integrated circuits, microprocessors, microcomputers, or other electronic components.

There have thus been described certain preferred embodiments of methods and apparatus provided in accordance with this invention to sense an object's position. While preferred embodiments have been disclosed, it will be recognized by those with skill in the art that modifications are within the spirit and scope of the invention. The appended claims are intended to cover all such modifications.

What is claimed is:

1. Apparatus for data input through sensing the position of a passive object relative to the apparatus comprising:

pad means for sensing the object's position, the pad means having

a plurality of first electrode strips spaced apart in a first array,

one or more second electrode strips disposed in proximity to the first electrode strips to cross thereover for establishing electric fields, including fringe electric fields, between the second electrode strip and selected first electrode strips, to thereby develop capacitive balances in the pad means,

wherein the object perturbs a fringe electric field when the object comes in proximity to the pad means, thereby changing the capacitive balances; and

measurement means operatively coupled to the pad means for measuring the capacitive balances in the pad means to thereby determine the position of the object relative to the pad means, said measurement means including

synthesis means responsive to control signals for selecting first electrode strips which, along with the second electrode strip, will develop electric fields, control means for supplying control signals to the synthesis means to designate the selected first electrode strips,

means for causing development of electric fields between the selected first electrode strips and the second electrode strip, and

means for detecting the changes in capacitive balances in the pad means and the locations of such changes.

2. The apparatus recited in claim 1 wherein the pad means further comprises:

insulator means having first and second sides electrically interfaced with the plurality of first electrode strips on the first side for providing an insulating substrate for the pad means; and

said second electrode strip being interfaced with the insulator means on the second side.

3. The apparatus recited in claim 2 wherein said pad means further comprises a plurality of second electrode strips spaced apart in a second array to extend at an angle to the direction in which the first electrode strips extend so that each electrode strip in the first array intersects each electrode strip in the second array at an intersecting location, and wherein the causing means includes means for supplying signals to selected electrode strips in the first array and second array to thereby establish electric fields between the selected electrode strips of the first array and the selected strips of the second array at intersecting locations.

4. The apparatus recited in claim 3 wherein said causing means further includes means for supplying signals to selected pairs of electrode strips in the first array to thereby form selected virtual dipole electrodes in the first array, and to selected pairs of electrode strips in the second array to thereby form selected virtual dipole electrodes in the second array, each virtual dipole electrode having a positive half electrode strip and a negative half electrode strip such that electric fields are established between selected halves of one polarity in the first array, and selected halves of the opposite polarity in the second array.

5. The apparatus recited in claim 4 wherein said detecting means comprises

means for successively calculating capacitive balances between selected halves of virtual dipole electrodes in the first array and halves of virtual dipole electrodes in the second array,

means for calculating capacitive balance ratios for selected pairs of calculated capacitive balances, and

means for calculating the position of the object relative to the pad means from the calculated capacitive balance ratios and the locations of the virtual dipole electrodes producing the calculated capacitive balances.

6. The apparatus recited in claim 1 wherein the apparatus is mounted to a keyboard input device of a computer.

7. The apparatus recited in claim 6 wherein the object is electrically passive.

8. Apparatus for sensing an object's position, the apparatus adapted to respond to the object's distortion of an electric field comprising:

insulator means having first and second sides for providing an insulating substrate to the apparatus;

a plurality of first electrode means disposed on the first side of the insulator means;

a plurality of second electrode means disposed on the second side of the insulator means for establishing electric fields in cooperation with the first electrode means;

balance measurement means for measuring capacitive balances among selected ones of the first electrode means and second electrode means;

synthesis means operatively coupled to the first electrode means and the second electrode means and responsive to control signals for selecting certain ones of the first electrode means and second electrode means to repeatedly synthesize virtual dipole electrodes, among which capacitive balances are to be measured by the balance measuring means;

control means operatively coupled to the synthesis means for supplying control signals to the synthesis means to thereby specify which of the first electrode means and second electrode means are selected by the synthesis means; and

balance ratio determination means operatively coupled to the balance measuring means for determining electrical balance ratios among the virtual dipoled electrodes.

9. The apparatus recited in claim 8 further comprising dielectric insulating means overlaying the first electrode means for preventing the object from making contact with the first electrode means.

10. The apparatus recited in claim 8 wherein the apparatus is mounted to a keyboard data input device of a computer.

11. A method of measuring an object's position comprising the steps of:

providing an electrically sensitive pad comprising:

insulator means having first and second sides for providing an insulating substrate to the apparatus;

first electrode means electrically coupled to the first side of the insulator means for establishing an electric field;

second electrode means electrically coupled to the second side of the insulator means for further establishing the electric field in cooperation with the first electrode means;

synthesis means operatively coupled to the first electrode means and the second electrode means for selecting first electrode means and second electrode means to repeatedly synthesize virtual dipole electrodes, the virtual dipole electrodes being adapted to develop an electrical balance responsive to the object's distortion of

the electric field;

measuring electrical balances between the first electrode means and the second electrode means;

calculating the object's coarse position based on at least one target index;

calculating the object's fine position based on the measured balances between the first electrode means and the second electrode means; and

calculating the object's net position based on the object's calculated coarse and fine positions.

12. The method recited in claim 11 wherein the object's net position is the sum of the object's coarse position and the object's fine position.

13. The method recited in claim 12 further comprising the step of updating the target index.

14. The method recited in claim 13 wherein the step of calculating the object's fine position further comprises:

calculating a first electrical balance between a first upper virtual dipole electrode defined by the first electrode means and a lower virtual dipole electrode defined by the second electrode means, the first upper and lower virtual dipole electrodes being determined by the target index;

calculating a second electrical balance between a second upper virtual dipole electrode defined by the first electrode means and a lower virtual dipole electrode defined by the second electrode means, the second upper virtual dipole electrode being determined by a target index offset;

calculating an electrical balance ratio between the first and second electrical balances; and

calculating the object's fine position based on the electrical balance ratio and the position of the virtual dipole electrodes.

15. The method recited in claim **14** wherein the steps of calculating the first and second electrical balances further comprises measuring capacitances between the first electrode means and the second electrode means and algebraically summing the capacitance values between the electrode means.

16. The method recited in claim **15** wherein the electrical balance ratio follows the relationship:

$$Q = \frac{L1}{L1 - LN},$$

where

Q=electrical balance ratio,

L1=the first electrical balance, and

LN=the second electrical balance.

17. The method recited in claim **16** wherein the object's fine position is calculated according to the following relationship:

$$\text{Fine position} = (XN - X)^{*}Q,$$

where

X=a location of the first upper virtual dipole electrode, and

XN=a location of the second upper virtual dipole electrode.

* * * * *

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Zetts

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[54] **RECOGNIZING THE CESSATION OF MOTION OF A POINTING DEVICE ON A DISPLAY BY COMPARING A GROUP OF SIGNALS TO AN ANCHOR POINT**

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[58] **Field of Search** 395/140, 141, 142, 143, 395/147, 162; 345/145, 156, 157, 158, 159, 160, 161, 162, 163, 164, 167, 173, 179, 180; 364/927.5, 927.61, 929.12, 929.3

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4,409,836	10/1983	Comroe et al.	73/504
4,587,630	5/1986	Straton et al.	364/900
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4,886,941	12/1989	Davis et al.	340/710
4,899,138	2/1990	Araki et al.	340/712
4,903,012	2/1990	Ohuchi	340/709
5,025,411	6/1991	Tallman et al.	364/900
5,027,109	6/1991	Donovan et al.	340/706
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63-311426	4/1987	Japan .
62-080724	12/1988	Japan .

Primary Examiner—Thomas C. Lee
Assistant Examiner—Moustafa Mohamed Meky
Attorney, Agent, or Firm—George E. Grosser; Joseph C. Redmond, Jr.

[57] **ABSTRACT**

A method and apparatus for efficiently distinguishing between different types of input signals simulated by a pointing device coupled to a multi-tasking computer system. The pointing device may be a stylus, finger or other device that moves across the surface of a touch screen or the like to generate positional information. Depending on the response of a delay timer, the motion of the pointing device is recognized by software application programs as input information either from a mouse or from a gesture or a handwriting input mode. If motion cessation across the screen is detected with a predetermined time-delay period, the system accepts the input information in a mouse-emulating mode. If motion is detected within the predetermined time-delay period, the timer is reset. Thus, the system overhead associated with managing the timer can be reduced because the timer is periodically reset and need not be reset after each movement of the pointing device as in the prior art. The periodic resetting can be based on intervals of n points generated by a moving pointing device, or n real-time units relative to a given point generated by the pointing device.

16 Claims, 11 Drawing Sheets

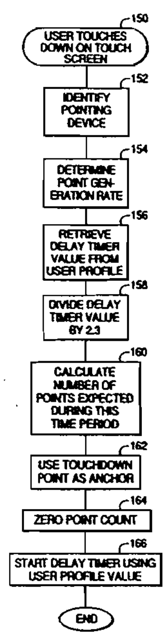
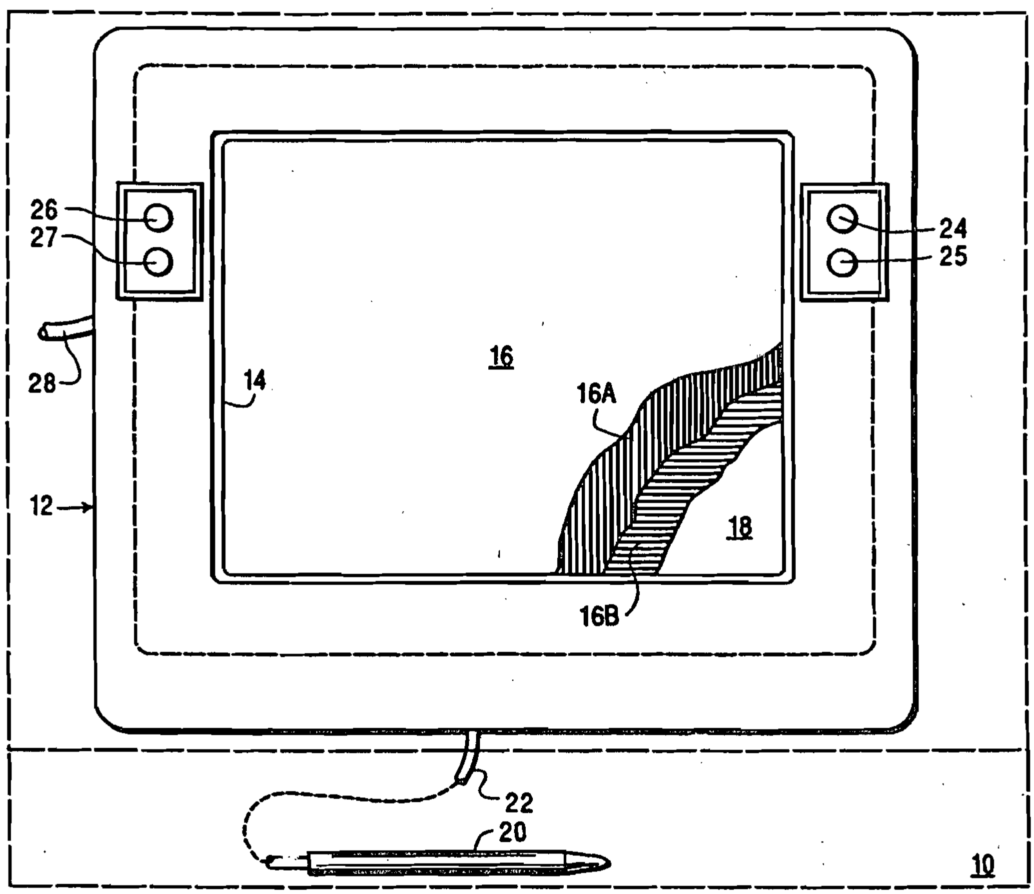


FIG. 1



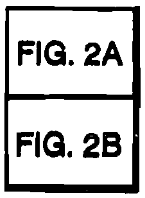
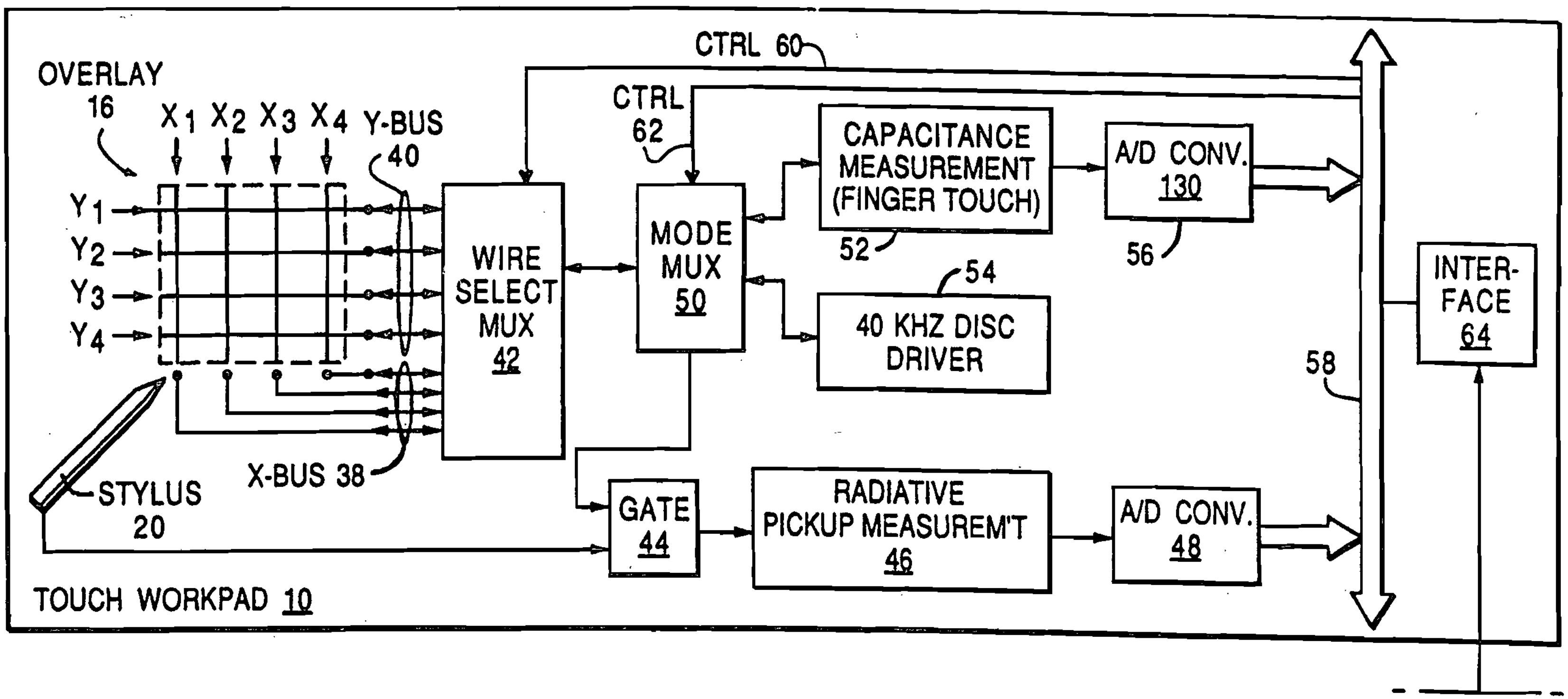


FIG. 2A
FIG. 2B

FIG. 2

FIG. 2A


CTRL 60
OVERLAY 16
CTRL 62
X1 X2 X3 X4
Y-BUS 40
Y1
Y2
Y3
Y4
WIRE SELECT MUX 42
MODE MUX 50
CAPACITANCE MEASUREMENT (FINGER TOUCH)
52
A/D CONV. 130
56
54
40 KHZ DISC DRIVER
58
INTER-FACE 64
STYLUS 20
X-BUS 38
GATE 44
RADIATIVE PICKUP MEASUREM'T 46
A/D CONV. 48
TOUCH WORKPAD 10

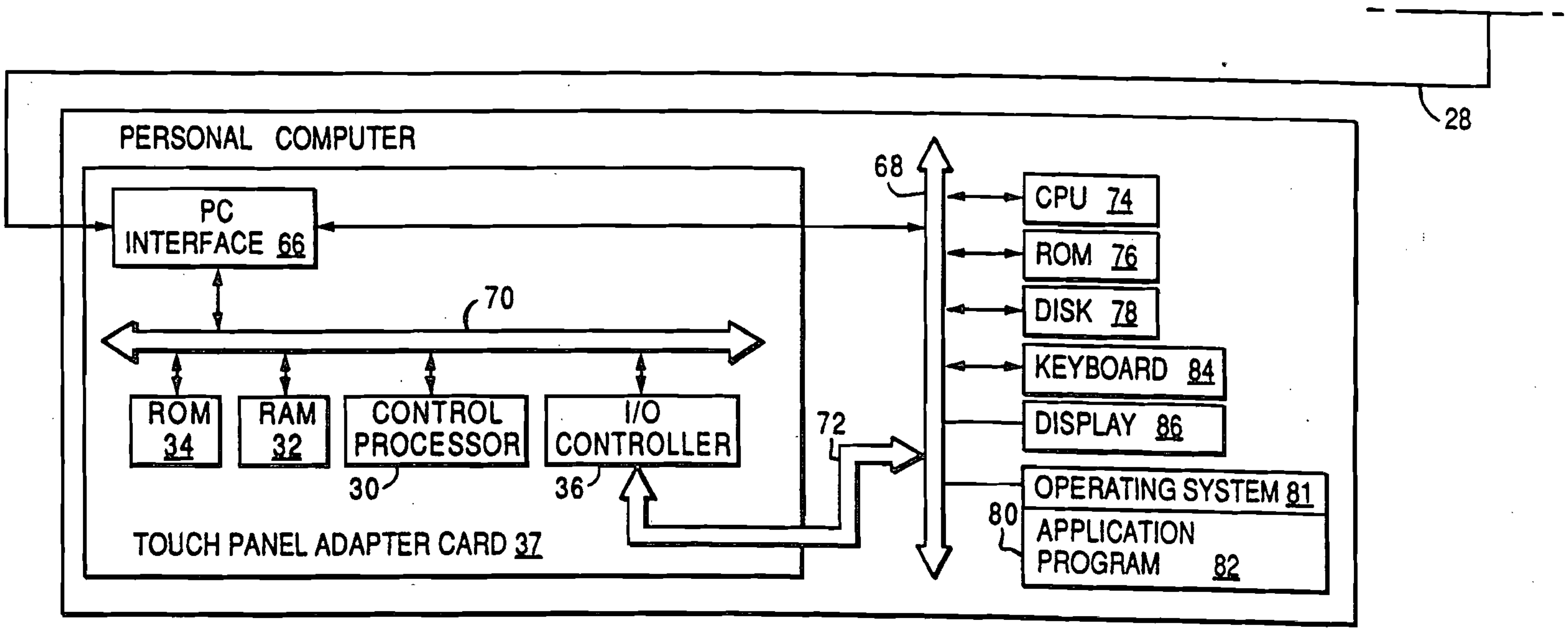

PERSONAL COMPUTER
PC INTERFACE 66
70
ROM 34
RAM 32
CONTROL PROCESSOR
30
I/O CONTROLLER
36
TOUCH PANEL ADAPTER CARD 37
72
68
CPU 74
ROM 76
DISK 78
KEYBOARD 84
DISPLAY 86
OPERATING SYSTEM 81
APPLICATION PROGRAM 82
80
28

FIG. 2B

FIG. 3

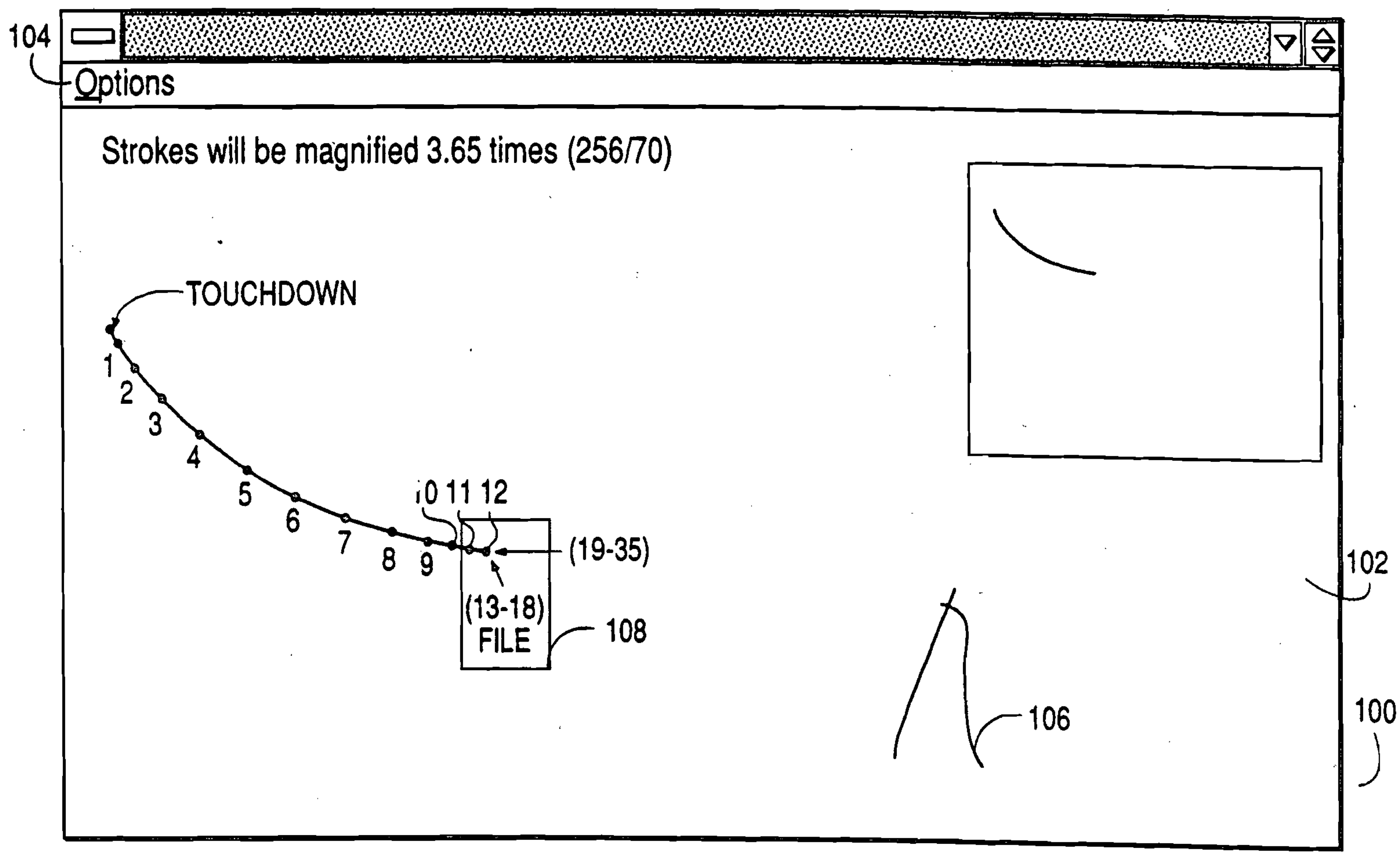
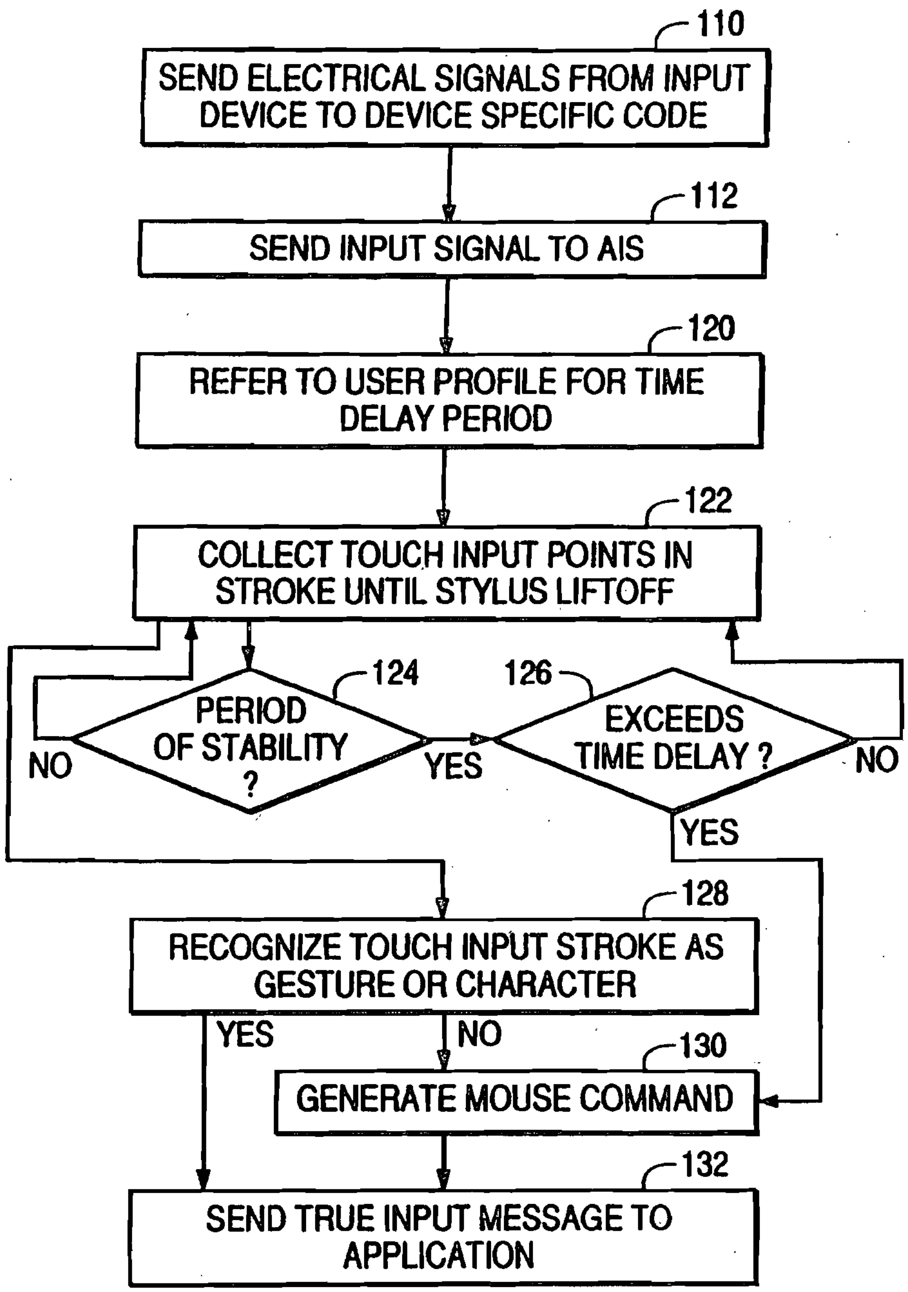

104
Options
Strokes will be magnified 3.65 times (256/70)
TOUCHDOWN
1
2
3
4
5
6
7
8
9
10 11 12
(19-35)
(13-18)
FILE
108
102
106
100

FIG. 4


110
SEND ELECTRICAL SIGNALS FROM INPUT DEVICE TO DEVICE SPECIFIC CODE
112
SEND INPUT SIGNAL TO AIS
120
REFER TO USER PROFILE FOR TIME DELAY PERIOD
122
COLLECT TOUCH INPUT POINTS IN STROKE UNTIL STYLUS LIFTOFF
124
PERIOD OF STABILITY ?
NO
YES
126
EXCEEDS TIME DELAY ?
NO
YES
128
RECOGNIZE TOUCH INPUT STROKE AS GESTURE OR CHARACTER
YES
NO
130
GENERATE MOUSE COMMAND
132
SEND TRUE INPUT MESSAGE TO APPLICATION

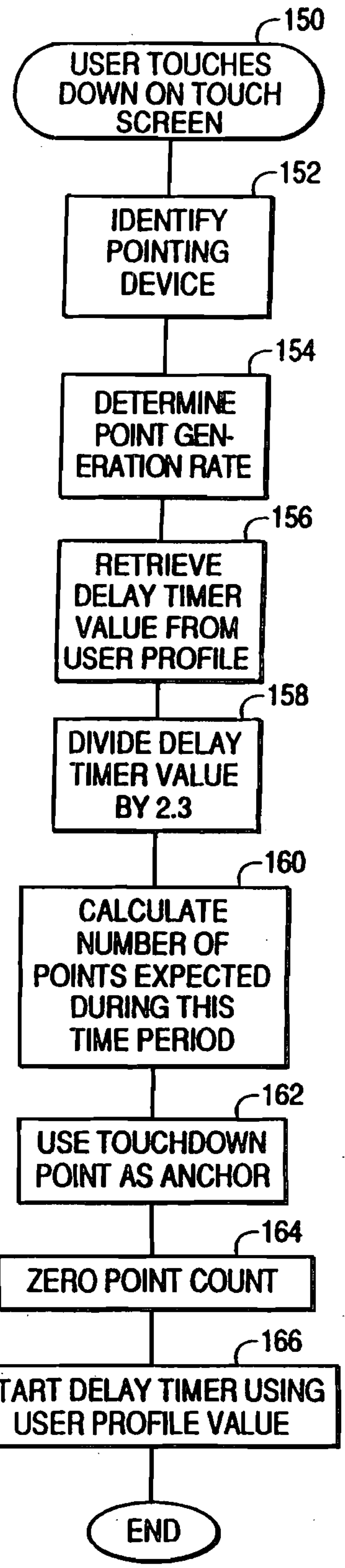

150
USER TOUCHES DOWN ON TOUCH SCREEN
152
IDENTIFY POINTING DEVICE
154
DETERMINE POINT GENERATION RATE
156
RETRIEVE DELAY TIMER VALUE FROM USER PROFILE
158
DIVIDE DELAY TIMER VALUE BY 2.3
160
CALCULATE NUMBER OF POINTS EXPECTED DURING THIS TIME PERIOD
162
USE TOUCHDOWN POINT AS ANCHOR
164
ZERO POINT COUNT
166
START DELAY TIMER USING USER PROFILE VALUE
END

FIG. 5A-1

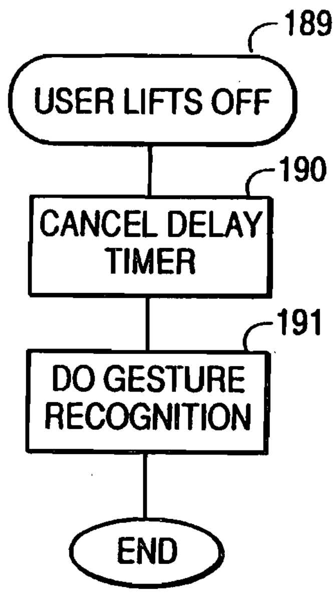


FIG. 5A-2

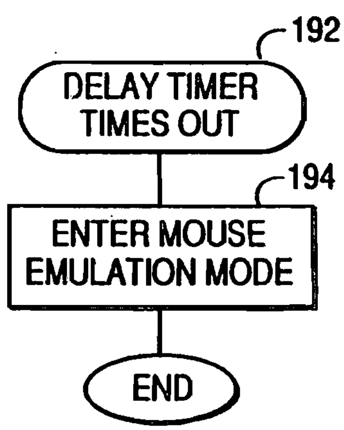


FIG. 5A-3

FIG. 5B

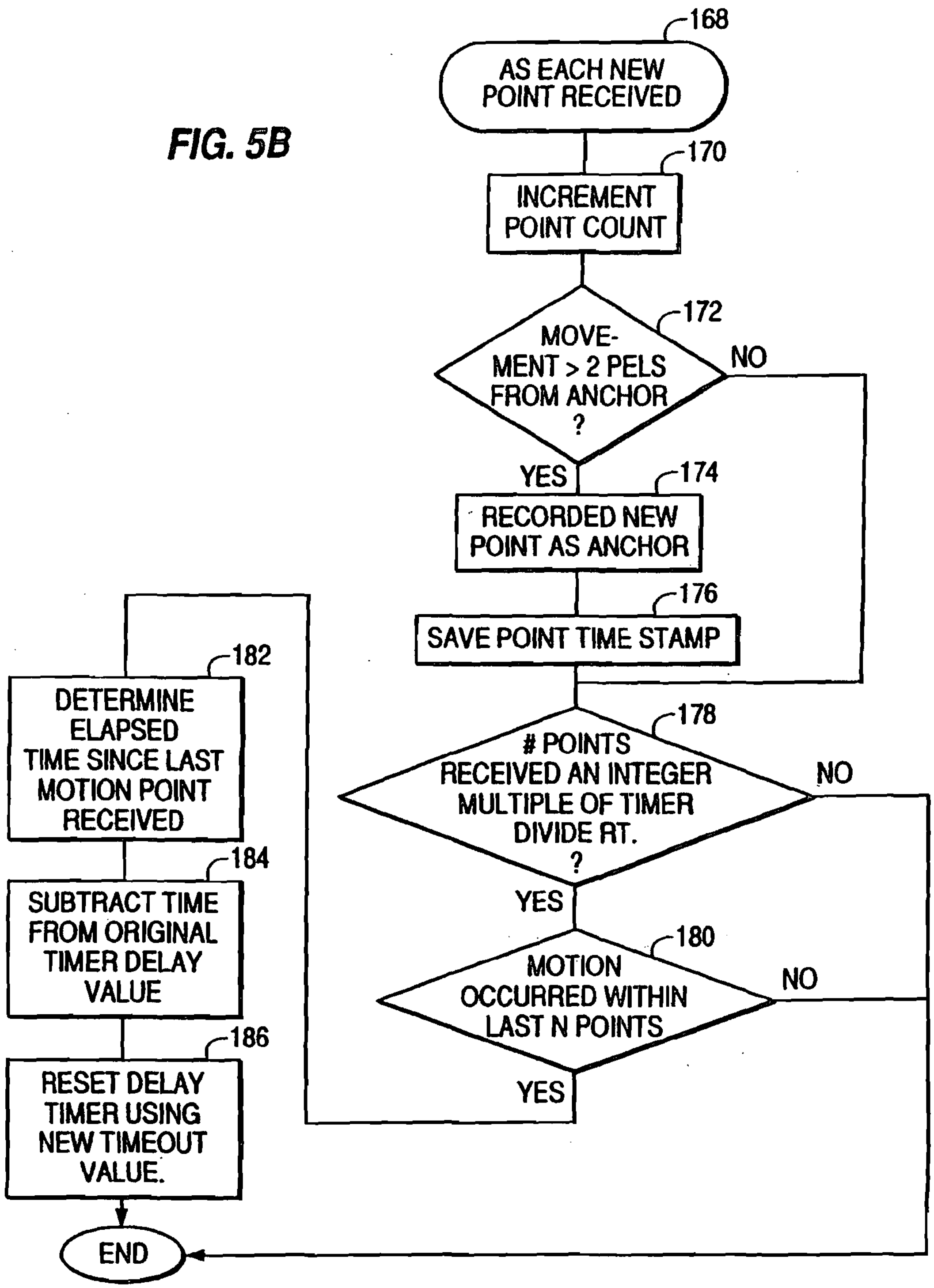

168
AS EACH NEW POINT RECEIVED
170
INCREMENT POINT COUNT
172
MOVE-MENT > 2 PELS FROM ANCHOR ?
NO
YES
174
RECORDED NEW POINT AS ANCHOR
176
SAVE POINT TIME STAMP
178
POINTS RECEIVED AN INTEGER MULTIPLE OF TIMER DIVIDE RT. ?
NO
YES
180
MOTION OCCURRED WITHIN LAST N POINTS
NO
YES
182
DETERMINE ELAPSED TIME SINCE LAST MOTION POINT RECEIVED
184
SUBTRACT TIME FROM ORIGINAL TIMER DELAY VALUE
186
RESET DELAY TIMER USING NEW TIMEOUT VALUE.
END

FIG. 6

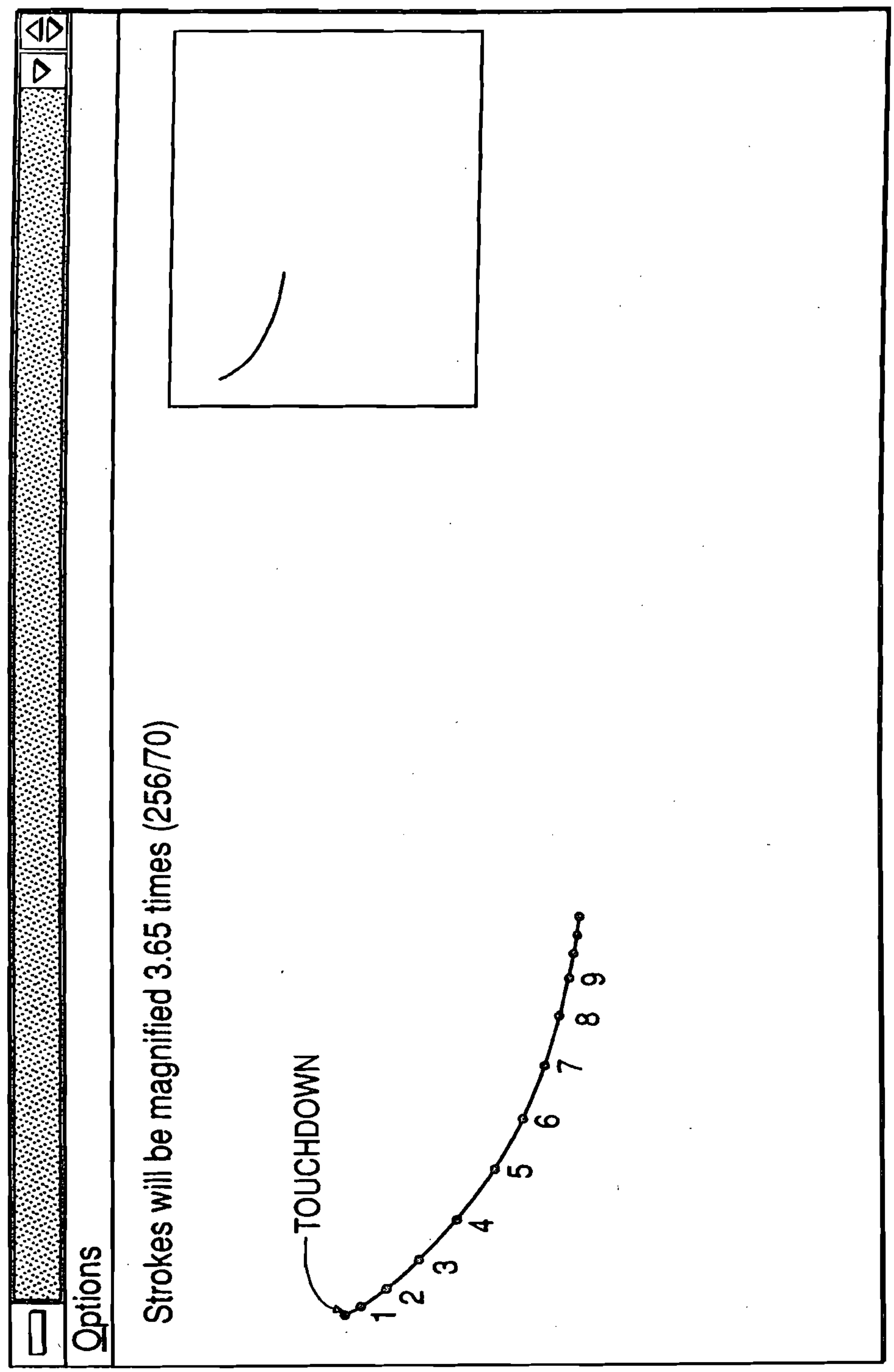
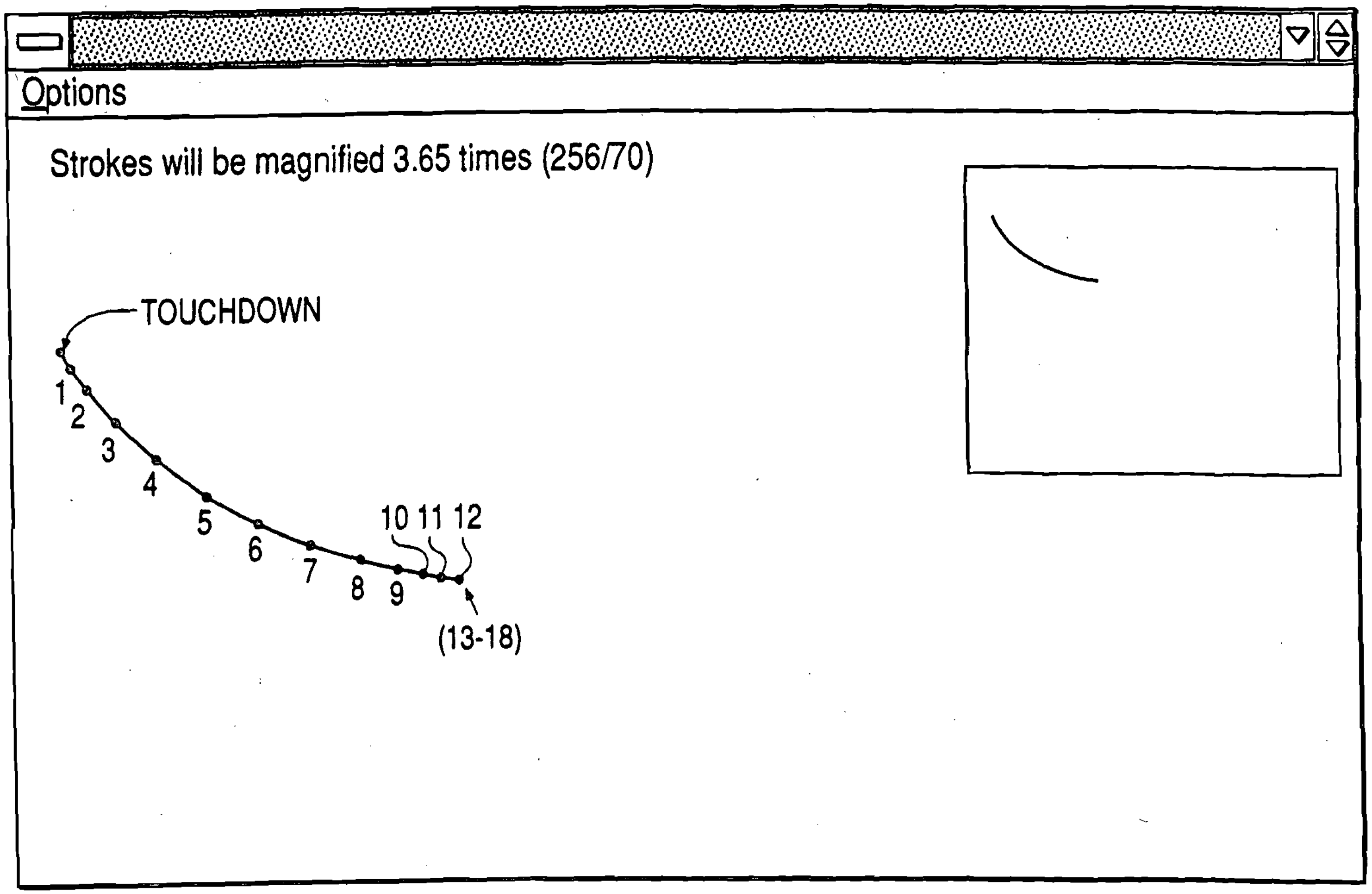
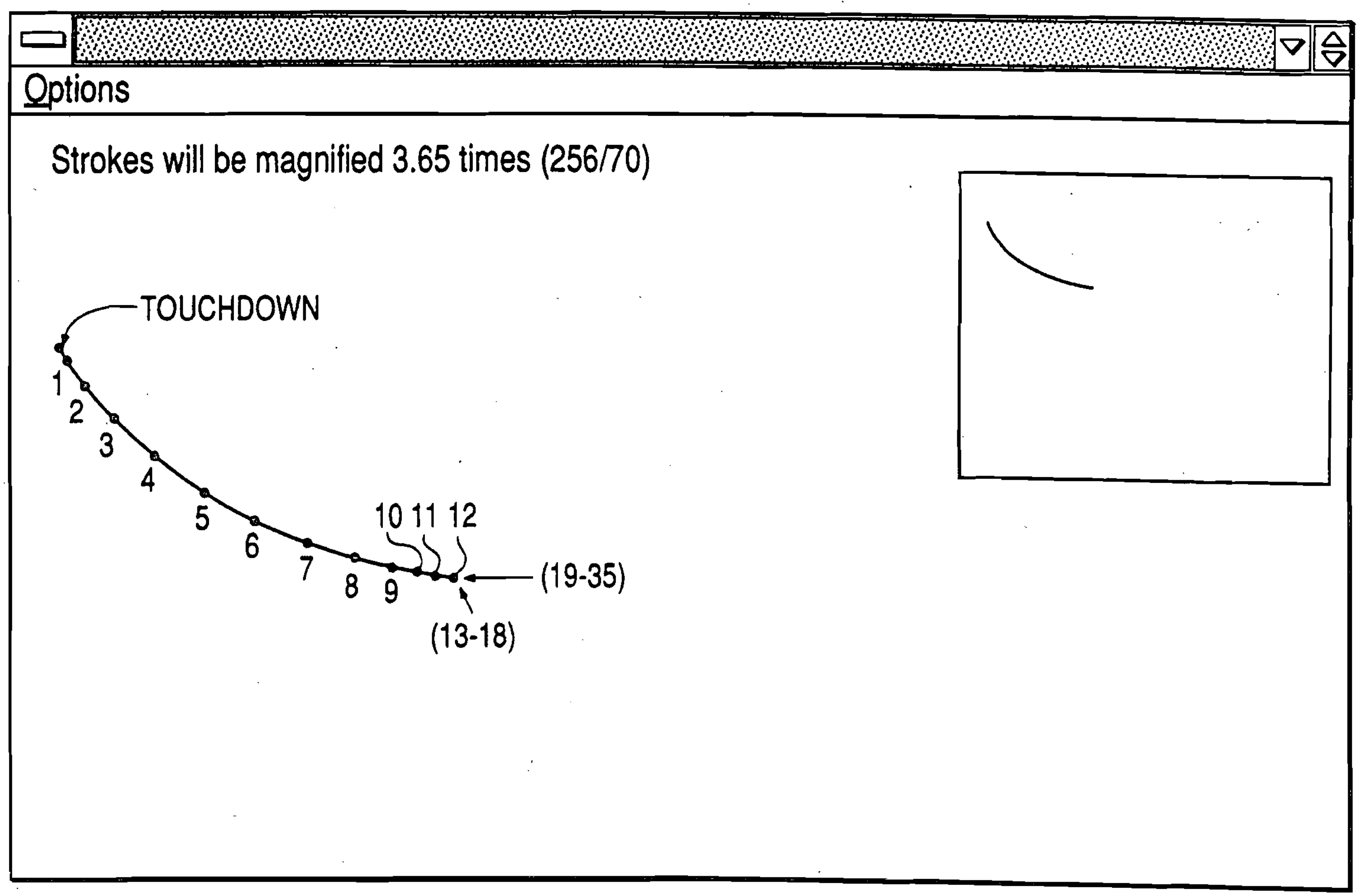

Options
Strokes will be magnified 3.65 times (256/70)
TOUCHDOWN
1
2
3
4
5
6
7
8
9

FIG. 7



Options
Strokes will be magnified 3.65 times (256/70)
TOUCHDOWN
1
2
3
4
5
6
7
8
9
10
11
12
(13-18)

FIG. 8


Options
Strokes will be magnified 3.65 times (256/70)
TOUCHDOWN
1
2
3
4
5
6
7
8
9
10 11 12
(19-35)
(13-18)

RECOGNIZING THE CESSATION OF MOTION OF A POINTING DEVICE ON A DISPLAY BY COMPARING A GROUP OF SIGNALS TO AN ANCHOR POINT

This application is a continuation of U.S. patent application Ser. No. 07/774,488, filed Oct. 10, 1991, now abandoned.

TECHNICAL FIELD

This invention generally relates to input devices for a data processing system and, more particularly, a method and apparatus for reducing system overhead associated with distinguishing between input signals generated by different types of pointing devices. The invention has particular application in a multi-tasking computer system in which a single task is dedicated to controlling a timer used to distinguish between the input signals.

BACKGROUND ART

The use of a touch input device disposed over the viewing surface of a computer display to provide a "user friendly" means for the control of a data processing system is well known in the art. U.S. Pat. No. 5,025,411 to Tallman et al. discloses a typical input device in the form of a touch screen used to control the operation of a digital oscilloscope. U.S. Pat. No. 4,587,630 to Straton et al. discloses a programmable touch screen emulating a keyboard input device. U.S. Pat. No. 4,903,012 to Ohuchi discloses a touch screen for calibrating the coordinates of a computer system. Such devices are designed to allow an unsophisticated user to perform desired tasks on a computer system without extensive training. Human factor studies have shown that an input device which allows the user to input data directly on the computer display achieves greatest immediacy and accuracy between man and machine.

In current graphical user interfaces developed to aid man-machine interaction, there are many items, such as menu selections, icons or windows, which a user can most easily select by using a mouse or a finger. U.S. Pat. No. 4,886,941 to Davis et al. and Japanese Publications Nos. 62-80724 and 63-311426 describe prior art systems employing mouse-pointing devices as input devices for data processing systems. Some advanced softward applications allow a user to input complex control signals with a finger. U.S. Pat. No. 4,899,138 to Araki et al., for example, discloses a touch panel for providing control signals in accordance with the manner in which a finger touches the panel within a predetermined period of time (i.e., making a gesture).

A stylus has proven to be more effective in inputting information on a touch sensitive input device because of its greater precision. It is more convenient to utilize a touch input system which allows both a stylus and a finger to operate as input devices. One such system is described in commonly assigned U.S. Pat. No. 4,686,332 to Greanias et al., entitled "Combined Finger Touch and Stylus Detection System for Use on the Viewing Surface of a Visual Display Device," and which is hereby expressly incorporated herein by reference.

In a touch input device (e.g., a touch workpad) for a data processing system, where a touch sensor is disposed over a viewing surface of a display, input signals generated from a pointing device, such as a stylus or

finger, can be categorized either as a mouse input signal or as a gesture or handwriting input signal. Where such input signals are intended to emulate the behavior of a mouse and represent commands, such as mouse button down and mouse button up, the stylus or finger is respectively touched down and lifted off the surface. Where the input device allows the user to use a stylus and touch sensor to simulate pen and paper to create a handwriting input signal, alphanumeric characters can be entered into an appropriate application program. Where the input signal is part of a gesture, a series of such input signals resembling a geometric figure, such as a circle, a right-hand or a left-hand arrow, are indicative of an action to be taken by the computer system. As all three types of input signals may be emulated by the use of a stylus or finger as a touch input device, it would be advantageous to design a stylus- or finger-based operating system such that all three types of input signals may be simultaneously entered anywhere on the display.

In order to utilize all three types of input signals, they must be distinguished by the data processing system. One method of differentiating between the types of input signals is by timing. If the user, after initiating contact between a pointing device and the touch sensor, moves the pointing device to a desired position and stops motion for a predetermined time period without losing contact between the device and the touch sensor (hereinafter referred to as "lift-off"), the operating system will recognize an input signal at the desired position as a mouse command. For example, if the user stops moving the pointing device at a given position for 200 milliseconds, a mouse command at the given position is recognized. If, on the other hand, the user does not stop at any given position for the specified time delay period and instead lifts off the touch sensor, the input signals are selected as candidates for character or gesture recognition instead of mouse commands.

To detect the cessation of motion at a desired position, the operating system repeatedly resets a delay software timer each time a position point identified by an input signal generated by the pointing device is sufficiently offset from a previous position point. Repeatedly resetting the timer in this manner creates a large amount of processing overhead when the cessation detection is required in a multi-tasking system.

A multi-tasking computer system creates the illusion of concurrently running a plurality of computer processes, also known as jobs, tasks or threads. To create this illusion, an operating system switches a single processor between multiple threads. A timer thread is dedicated to managing the software timer. The timer thread cannot reset the timer until the processor saves all computations made while executing the current thread and switches back to the timer thread. As a result, a large amount of processing time is required to repeatedly reset the above-described timer.

SUMMARY OF THE INVENTION

It is an object of this invention to reduce the overhead associated with a delay timer which is reset each time an input signal, representing a point on a workpad, generated by a pointing device is sufficiently spaced from a previous input signal.

It is another object of this invention to maintain the accuracy of measurement of a period of cessation of a pointing device's motion while a timer is reset on every nth position point and the pointing device has stopped sometime between timer resets.

It is a further object of the invention to more efficiently identify an input signal generated by a pointing device in a multi-tasking computer system that dedicates a task or thread to managing a timer used to distinguish between types of input signals generated by a pointing device.

It is also an object of the invention to reduce in a data processing system the overhead associated with a delay timer by resetting the timer periodically when a point is generated from a pointing device within a given period of time starting from the time an initial point is generated.

These and other objects and features of the invention are accomplished by a method and apparatus which manage in the following manner a delay timer in an operating system of a computer receiving input from a pointing device. At touch-down time, the identity of the pointing device is established, and the rate at which points (represented by the input signals) are generated by the pointing device is determined. A timer reset divide rate is calculated such that the delay timer is reset on every nth point generated, even though motion of the pointing device may have been detected on the current point. Points are collected as the pointing device is moved across a touch-sensitive computer display. In the alternative, points are collected from a pointing device that causes a cursor to move across a display screen without requiring the screen to be touched by the pointing device, e.g., mouse, joystick, etc. In response to a determination that motion has occurred within the previous n points generated from the pointing device, the timer is reset with a predetermined time-delay period. If motion has occurred within the previous n points, but has ceased during the generation of the last several points, the timer is reset with an additional amount of time attributable to such last several points in order to maintain the accuracy of the timing. If it is determined that the motion of the pointing device ceased for the predetermined time-delay period, e.g., 200 milliseconds, an action is performed by the computer system. In the preferred embodiment, the action is a mouse command, such as a mouse button down or mouse button up, that is generated at the point where motion ceased. If the pointing device does not stop at any position for the predetermined time-delay period, but instead lifts off, the set of points generated by the pointing device is sent to a character- or gesture-recognition unit as candidates for character or gesture recognition.

In another embodiment of the invention a given point is generated from the pointing device and marked as a reference point. Each subsequently generated point is monitored with respect to a time period relative to the time the reference point was generated. When subsequent point is generated at a time period greater than a given time period, the delay timer is reset as in the embodiment above.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects, features and improvements will be better understood with reference to the following drawing figures.

FIG. 1 shows the front view of an overlay unit used for the detection of finger touch and stylus position. The unit is disposed over a flat panel display to form what is known as a "touch workpad."

FIG. 2 is an architectural diagram of the combined finger touch and stylus detection system.

FIG. 3 is a representation of a window displayed on the touch workpad in FIG. 1 and illustrating a stroke made by a pointing device that has been recognized as a mouse command.

FIG. 4 is a flow diagram illustrating the operation of the present invention to distinguish between stroke input signals intended to produce mouse commands, and stroke input signals intended to produce gesture or handwriting events.

FIG. 5A and 5B are flow diagrams illustrating the operation of the invention in reducing system overhead associated with resetting a delay timer to determine whether a cessation of motion has occurred.

FIGS. 6, 7, and 8 are representations of a window displayed on the touch workpad of FIG. 1 and depicting an inked stroke intended to produce a mouse command.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a touch workpad substantially similar to that described in co-pending application No. 07/351,227 to Arbeitman, et al., entitled "Flat Touch Screen Workpad for a Data Processing System," filed May 15, 1989, which is hereby expressly incorporated herein by reference. The workpad 10 comprises a housing 12 having a rectangular recessed window 14 which surrounds the edges of a rectangular touch overlay 16. The touch overlay 16 is transparent and is disposed on a liquid crystal display (LCD) 18. The overlay 16 consists of a laminate structure including several plastic substrate layers laminated together by means of adhesive layers. The overlay 16 also includes a first plurality of transparent X conductors 16A disposed in the vertical direction and a second plurality of transparent Y conductors 16B disposed in the horizontal direction. Several of the conductors in both the vertical and horizontal directions are positioned beyond the recessed window 14 to allow more accurate determination of the location of the stylus 20 or a finger on or near the overlay 16 at the edges of the display window 14.

The stylus 20 is connected to the touch workpad via cable 22. The stylus 20 acts as an antenna to pick up the signals radiated by the overlay 16, and provides much greater resolution than can be provided by a finger touch. Also on the bezel of the housing are four button switches 24–27 which can be used to change the mode in which the data from the workpad 10 is received. Workpad cable 28 connects the workpad 10 to the computer with which the user is communicating. The workpad cable 28 provides power to the workpad 10 as well as display signals to operate the LCD 18 and also touch signals to operate the overlay in both finger touch and stylus modes. In addition, the cable 28 is also the conduit to the computer for the measurement of the signal strength received by the stylus 20 and of the frequency change due to changes in capacitance of a finger touch.

FIG. 2 shows an architectural diagram of the finger touch and stylus detection system which is similar to that disclosed in FIG. 9 of U.S. Pat. No. 4,686,332. The touch control processor 30, random access memory 32, read only memory and the I/O controller 36 are on a touch panel adapter card 37 in a personal computer, while the rest of the touch electronics are integrated in the touch workpad 10. As discussed in connection with FIG. 1, the touch workpad 10 communicates with the personal computer and touch panel adapter card **37** via the workpad cable **28**. The vertical X conductors and the horizontal Y conductors are connected through the X bus **38** and the Y bus **40**, respectively, to the wire selection multiplexer **42**. The radiative pickup stylus **20** is connected through the gate **44** to the radiative pickup measurement device **46**. The wire selection multiplexer **42** is connected through the mode multiplexer **50** to the capacitance measurement device **52** which is used for capacitance finger touch detection. The wire selection multiplexer **42** is also connected through the mode multiplexer **50** to the 40 kHz oscillator driver **54** which is used to drive the X bus **38** and the Y bus **40** for the stylus detection operation. The mode multiplexer **50** also provides an enabling input to the gate **44** to selectively connect the output of the stylus **20** to the radiative pickup measurement device **46** for stylus detection operations. The output of the capacitance measurement device **52** is connected through the analog-to-digital converter **56** to the workpad bus **58**. The output of the radiative pickup measurement device **46** is connected through the analog-to-digital converter **48** to the bus **58**. The control input **60** of the wire selection multiplexer **42** is connected to the bus **58**. The control input **62** of the mode multiplexer **50** also is connected to the bus **58**.

The workpad bus **58** is connected via workpad interface **64** to the workpad cable **28** which is connected to interface **66** in the touch panel adapter card **37** of the personal computer (PC). The PC interface **66** communicates with the main system bus **68** and with the adapter card **70**. The I/O controller **36** has an I/O bus **72** which is connected to the main bus **68** of the PC. The I/O controller **36** is also connected to adapter card bus **70**. The adapter bus **70** also interconnects the control processor **30** with the read only memory (ROM) **34** and the random access memory (RAM) **32**. The personal computer includes standard devices known in the art such as a CPU **74**, ROM **76**, disk storage **78**, a memory **80** which stores operating system **81** and application programs **82**, a standard keyboard **84**, and a standard display **86**. The standard display **86** is typically a cathode ray tube (CRT), and in the preferred embodiment the display **86** is in addition to the liquid crystal display (LCD) **18** of workpad **10**.

The wire selection multiplexer **42** and the mode multiplexer **50** connect selected patterns of a plurality of the horizontal and vertical conductors in the overlay **16** to either the capacitance measurement device **52** or the 40 kHz oscillator driver **54**, in response to control signals applied over the control inputs **60** and **62** from the bus **58** by the control processor **30**. During finger touch operations, the capacitance measuring device **52** has its input coupled through the mode multiplexer **50** and the wire selection multiplexer **42** to selected single conductors in the horizontal and vertical conductor array in the overlay **16** in response to control signals from the control processor **30**. The output of the capacitance measurement device **52** is converted to digital values by the A/D converter **56** and is supplied over the bus **58** to the control processor **30**. The control processor **30** executes a sequence of stored program instructions to detect the horizontal array conductor pair and the vertical array conductor pair in the overlay **16** which are both being touched by the operator's finger.

The finger touch and stylus sensing modes operate independently of one another, the detection system cycling between the two modes until a finger touch or stylus is detected.

Commonly assigned, co-pending application No. 07/344,879, entitled "Advanced User Interface," filed Apr. 28, 1989, which is hereby expressly incorporated herein by reference, describes an operating system extension which allows alternative forms of input to be handled by conventional software applications which were not written to understand such alternative forms of input. For example, conventional applications are written to accept only keyboard and mouse input signals. A user could use the Advanced User Interface (AUI) to utilize a touch sensor without modifying any of the software application code. In accordance with the present invention, AUI is stored in RAM **80** with the operating system **81** and application programs **82**. In a preferred embodiment, this invention improves AUI by allowing it more efficiently to distinguish between mouse commands and gesture or character data.

FIG. **3** is a representation of the touch workpad of FIG. **1** showing an opened software application window **100**. The application is called "MAG.EXE." The work space area **102** is a typical feature of a window and is the area where most data for input of the application is generated. The action bar **104** contains a single selectable menu item, "options." If the user touches down with the pointing device (e.g., stylus, finger, etc.) on the "options" menu item, a pulldown menu will appear to allow him to select one of many available options.

The window also depicts the inked trail of a set of points representing a gesture **106** made by a pointing device. In this case, the gesture **106** is an "up arrow" which is one of many gestures which is recognizable by the AUI and which a user can use to cause the computer system to take one of many possible actions. One possible meaning for the "up arrow" gesture, when input in the work space area **102** of window **100**, would be to enlarge or to maximize the window **100**.

Also depicted in FIG. **3** is a long line **107** representing another trail of input points generated by a pointing device. For this series of points after touchdown, the user moved twelve points and then ceased further movement. As shown in FIG. **3**, the user did not move the pointing device from point **12** to point **35**. Thus, a timeout was created and program execution transferred to mouse emulation mode. Now an application command, such as a "file" command **108**, could be activated by recognizing the series of points as a "file" command generated by a mouse-pointing device and sent to the application program.

The present invention includes a computer module within the stylus or finger-based operating system extension (AUI) to differentiate between touch input signals intended to emulate a mouse command, such as a mouse button down, mouse move, or a mouse button up, and those touch input signals which are to be considered a gesture or character. This differentiation is done by using a time delay to differentiate between the two types of touch input signals. The AUI allows the user to touch the screen and move to the desired position before the application is notified of the command by placing all the points received from the touch sensor in a stroke buffer. The points stored in the stroke buffer are hereinafter referred to as "a stroke." Once the user reaches the desired position and stops moving for the set time delay, a mouse command is generated at the point at which the user has stopped. Since AUI recognizes the timeout as mouse emulation, rather than as a gesture command, the stroke buffer is not used and the application is passed a mouse command; in the preferred embodiment the command would be a mouse button down message. For example, if the user stops moving the pointing device at a desired position for 200 milliseconds, a mouse command, such as a mouse down button command, at the desired position is communicated to the application program. However, if the user starts to move the device again before the end of the set period of time, the command is not generated until the user once again stops (without lifting off) and pauses for the period of time delay. The time delay is typically defined in milliseconds (ms) and may be varied depending upon the screen area with which the user is interacting. The time delay may be specified by the user or may be altered by the application program which is utilizing the touch input signal.

If, on the other hand, the user does not stop at a particular point for the specified time delay period and instead lifts off the touch screen, the AUI selects the set of input points generated by the pointing device (the stroke) as candidate points for character or gesture recognition. In other words, the time delay provides a window in time in which gestures can be made. During this time, the AUI will only allow gestures to be made. If the user waits for the time delay period before lifting off, the points generated by the pointing device will not be candidates for a gesture. The stopping point coordinates (i.e., coordinates corresponding to the last point generated by the pointing device prior to detection of motion cessation) are then used for a mouse command. If the user lifts the pointing device before the time delay period expires, an attempt will be made to recognize the set of generated points as a gesture or character. If the points are not so recognized, however, the normal mouse emulation sequence will be generated. If the points are recognized, the AUI sends the appropriate commands to the appropriate application program.

The recognition of a circle gesture made by a pointing device on the face of the touch overlay **16** is described below with reference to FIG. 4.

A user, having determined that he wishes to invoke a software utility by making a gesture with a pointing device, draws a circle on the face of the touch sensor **16** and lifts the device off before the end of the set time delay. The touch sensor **16** generates a series of interrupts to a device driver for the touch workpad at **110** which passes a set of input signals to the AUI corresponding to the set of points in the circle at **112**.

When the AUI discovers the first touch input point (i.e., a touch-down of the pointing device on the touch sensor **16**), it looks up the time delay period selected by the user or programmer at **120**. At **122**, the touch input points generated by the pointing device are collected in a stroke buffer until the stylus lift-off event is detected. At **124**, as the touch input points are received by the AUI. A delay timer is reset every nth point to determine the period of stability or cessation of pointing device movement initiated by the user pausing on the touch sensor at **126**. If the user moves the pointing device before the time delay period has expired, the AUI continues to receive the touch input points in the stroke buffer at **122**. If, however, the pointing device is not moved within a period that exceeds the time delay, a mouse command is recognized and generated at **130**. In this example, the user does not pause before pointing device (e.g., the stylus **20**) is lifted, and therefore, the stroke is sent to a character recognition unit or gesture recognition unit for processing at **128**. If the touch input stroke has not been recognized as either a gesture or character, a mouse command would be generated at **130**.

If the input stroke has been recognized by the gesture recognition unit as a circle gesture, the AUI passes the circle gesture signal to the appropriate computer module **132**.

There is described below with reference to FIG. 5A and 5B, an operation of the invention to reduce system overhead associated with resetting a delay timer which is used to determine whether a cessation of motion of the pointing device has occurred.

Referring to FIG. 5A, the user first touches a pointing device down on the touch sensor in **150** and generates one point. In **152**, after the first point is collected by the AUI, the pointing device that generated that point is identified; that is, the pointing device is identified as a finger, stylus, mouse, etc. In **154**, the point generation rate is determined. Each pointing device generates points at different rates. The stylus, for example, generates 110 points per second, whereas the mouse generates 40 points per second. At **156**, the system refers to a user profile and retrieves a delay timer value. There is a different delay timer value for each pointing device. For example, the stylus timer delay is 200 ms, whereas the finger timer delay is 300 ms. In **158**, the delay timer value is divided by 2.3, an empirically derived constant, to yield 86 ms (i.e., 200 ms divided by 2.3 yields 86 ms). At **160**, the number of points expected during this 86 ms period is then calculated. With a stylus generating 110 points per second, there would be approximately 9 input points during the 86 ms period. The system records the touch-down point and uses it as an anchor. The term "anchor" implies that the next point generated by the pointing device must be a predetermined distance from the touch-down point to be considered a movement of the pointing device. The predetermined distance may be varied in accordance with the system resolution. At **164**, the point count is zeroed out. As the points are received, they are counted. In **166**, the delay timer is started using the retrieved value. At this point, setup initialization is completed.

At **188**, the user lifts the pointing device off the touch sensor. If the user lifts off, there will be no mouse emulation detected and the system categorizes the input points generated by the pointing device as a gesture or handwriting input and cancels the timer. In **192**, the delay timer times out. The delay timer timed out because the user stopped moving the pointing device for time in excess of the delay period and the system stopped resetting the timer. When that happens, the system enters mouse emulation mode.

In FIG. 5B, at **168**, each new point generated is collected from the touch sensor. For the stylus, the points are received at 110 points per second. At **170**, the point count is incremented. At **172**, the X–Y coordinates of the newest input point are examined to see if the point is more than two picture elements (pels) from the anchor or the previous input point. If so, the system classifies the pointing device as having movement. In **174**, the new point is recorded. The X–Y coordinates are used for the new anchor, and the timestamp of that point is saved. If there is no movement, the last two steps are omitted. At **178**, the number of points received up to this time is calculated. If the number is an integer multiple of the divide rate, the system proceeds to **180** to see if motion had occurred within the last n points. ("n" in this case is 9.) The divide rate for the stylus would be 9, so the system would check for multiples of 9 (e.g., 9, 18, 27, etc.). If motion has occurred, the elapsed time is determined from the time the last motion point was received. If there has been any elapsed time since the last motion point, the elapsed time is subtracted from the original timer value, e.g., 200 ms. At **186**, the timer delay is reset using the new timeout value which would be 200 ms minus the elapsed time between motion cessation and the nth point. In **178** and **180**, if either of those tests resulted in no, the system exits.

In FIG. **6**, there is shown a stroke consisting of a touch-down and a series of nine (9) points. As discussed previously, after 9 points are received from the stylus, the system checks to see if movement has occurred within the last 9 points. In the figure, the stylus movement has been relatively rapid. In actual use, the points are likely to be spaced more closely together.

In FIG. **6**, there has been motion within the last 9 points; the portion of the stroke from point **8** to point **9** has been inked. After the 9th point is received, the delay timer, which is waiting for a period of stability of 200 ms, is reset to zero and resumes waiting for the user to stop moving.

In FIG. **7**, the user has continued to move on to points **10**, **11** and **12**. Points **13–18** are shown in parenthesis. After the user moved to point **12**, he held the stylus stationary so that the last 6 points were generated in the same position as the 12th point. At point **18**, the system, again, determines if any motion occurred in the previous 9 points. Again, the answer is yes. Motion occurred on the first 3 points (**10–12**). However, on the last 6 points there was no motion, so the 200 ms timer is reset. To account for the absence of motion for the last 6 points, 54 ms, the timer is reset at the value of 200 ms minus 50 ms which equals 150 ms.

FIG. **8** shows that the user never did again move the stylus. The stylus remained stationary after point **12**, and points **19–35** show there was no movement so the timer is never reset. At point **35**, a timeout occurred because the user failed to move the pointing device for 200 ms. When the system detects a timeout, mouse emulation mode is entered to cause a mouse command input message to be produced.

The AUI system provides facilities for finger- and stylus-based user interface devices. When used with devices capable of tracking the movement of a user's finger or the movement of a stylus, AUI provides support for the handling of the resulting stroke information. These facilities include the visual tracing on the screen of ink flowing from the stylus, the delivery of the stroke information to application programs, and the delivery of the stroke information to recognition subsystems for further analysis.

AUI employs a user interface technique where mouse emulation for the pointing device (stylus, finger or mouse) is delayed until the user stops moving the pointing device. Any stroke completed (i.e., pointing device is lifted off touch sensor) before movement has stopped is classified as a gesture or handwriting input. After motion stops, it is assumed the user intends to emulate a mouse input, and a mouse emulation mode begins. To effect the detection of motion cessation, the user must touch down and hold the pointing device stationary for a timeout period. "Stationary" is defined as no change in position greater than n pels, where 'n pels' can be expressed in either display or sensor resolution units. In one preferred embodiment, a value of two display pels is used. Examples of typical timeout values are 200 ms for a stylus, 300 ms for finger touch, and 200 ms for a mouse. These values represent a trade-off between minimizing the delay to enter mouse emulation and making gestures easy to stroke without inadvertently timing out during the stroke.

The invention has particular application in a multitasking computer system. As described above, a single task or thread is typically dedicated to managing a delay timer used to determine motion cessation. In the prior art, for example, a stylus pointing device generates 110 points per second, one point every 9 ms. Thus, the prior art processor would need to switch to and from the timer thread every 9 ms when the stylus is in motion. As a result, 100% of the processing time of the system is taken up by managing the timer, assuming the processor takes 9 ms to process data for each point generated.

In accordance with the present invention, this timer thread needs to be reset only every nth point generated by the pointing device used with the computer system. Thus, the system processor does not have to waste processing time to switch between a currently executing thread to the timer thread after each point is generated by a moving pointing device.

To clarify the above description invention, the following pseudocode is provided to detail the logic flow:

```
when a user touches down
    identify stroke device
    determine point rate
    retrieve the delay timer value from user profile
    divide delay timer value by 2.3
    calculate number of points expected during this
        period
    clear point counter
    start delay timer
endwhen
when a new point is received from the sensor
    increment number of points received in the stroke
    if point shows movement greater than 2 pels from
        last motion point, record point and
        timestamp of point
    endif
    if number of stroke points is even multiple of
        time divide rate
        if motion had occurred during last n points
            determine elapsed time since last
                motion point received
            subtract this time from original delay
                timer value
            reset the delay timer using this new
                timeout value
        endif
    endif
endwhen
when user lifts off
    cancel delay timer
endwhen
when delay timeout occurs (asynchronously)
    enter mouse emulation mode
endwhen
```

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in detail may be made therein without departing from the spirit, scope and teaching of the invention. For example, the above embodiment assumed a steady generation of points was made by the pointing device such that the timer used to determine cessation of a moving pointing device could be periodically reset after n points were generated. However, in a system where the movement of the pointing device is sporadic and a steady stream of points are not generated by a moving pointing device, the timer can be reset periodically at timed intervals, e.g., 86 ms, in accordance with the following alternative embodiment of the invention.

In this embodiment, an initial point generated by the pointing device is used as an anchor point (as in the embodiment described above). All subsequent points are then monitored as to their time period of generation (hereinafter referred to as a "timestamp") relative to the anchor point was generated. When a point is generated with a timestamp greater than a given interval of time, e.g., 86 ms, the timer is reset and the point is used as the new anchor point. According to this embodiment of the invention, the timer is periodically reset at given time intervals when points are generated within the predetermined time-delay period, e.g., 200 ms. If no points are generated by the pointing device, and no movement thereof is detected, then a timeout occurs and a the system enters a mouse emulation mode (as described above).

The embodiments presented above are for purposes of example and illustration only and are not to be taken to limit the scope of the invention narrower than the scope of the appended claims.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent is:

1. A method for reducing the processing time required to recognize the cessation of motion of a moving pointing device in an information processing system, the method comprising the steps of:

determining that a pointing device is located in operative proximity to a display screen, in said information processing system;

generating a series of delay timers having a predetermined rate, while said pointing device is located in said operative proximity to said display screen, in said information processing system;

accessing a predetermined timer divide rate value 'n' from said information processing system, representing a predetermined plurality of 'n' of coordinate point signals, in said information processing system;

receiving a first point signal for said pointing device with respect to said display screen, and buffering said first point signal in a memory as an anchor point and starting a delay timer, in said information processing system;

receiving a plurality of n−1 succeeding point signals for said pointing device with respect to said display screen, and buffering said plurality of n+1 signals, in a memory in said information processing system;

computing whether said pointing device has moved with respect to said display screen by comparing at least one of said buffered plurality of n−1 point signals with said buffered anchor point, in said information processing system;

if said computing step determines that said pointing device has moved, then receiving a second plurality of n succeeding coordinate point signals for said pointing device with respect to said display screen, and buffering a first of said second plurality of n signals as a new anchor point while restarting the delay timer, in said information processing system;

if said computing step determines that said pointing device has not moved, then outputting a first output signal indicating cessation of motion of said pointing device;

if said determining step determines that said pointing device is not located in said operative proximity to said display screen, then outputting a second output signal indicating that said pointing device has been removed from said operative proximity to said display screen.

2. The method as recited in claim 1, which further comprises the steps of:

identifying the pointing device as one among several possible pointing devices; and

setting, in accordance with the identified pointing device, said predetermined delay timer value.

3. The method as recited in claim 1, wherein the pointing device is a finger moving across a touch sensor, and further comprising the step of canceling said delay timer when the finger is lifted off the touch sensor.

4. The method as recited in claim 1, wherein the information processing system enters a mouse emulation mode in response to said first output signal.

5. The method as recited in claim 1, further comprising the step of entering a gesture recognition mode when said second output signal is outputted.

6. A method for reducing the processing time required to recognize the cessation of motion of a moving pointing device in an information processing system, the method comprising the steps of:

determining that a pointing device is located in operative proximity to a touch sensor controlling a display screen, in said information processing system;

generating a series of delay timers having a predetermined rate, while said pointing device is located in said operative proximity to said touch sensor, in said information processing system;

accessing a predetermined timer divide rate value 'n' from said information processing system, representing a predetermined plurality of 'n' of coordinate point signals, in said information processing system;

receiving a first point signal for said pointing device with respect to said touch sensor, and buffering said first point signal in a memory as an anchor point and starting a delay timer, in said information processing system;

receiving a plurality of n−1 succeeding coordinate point signals for said pointing device with respect to said touch sensor,

and buffering said plurality of n−1 signals, in said memory in said information processing system;

computing whether said pointing device has moved with respect to said touch sensor by comparing at least one of said buffered plurality of n−1 point signals with said buffered anchor point, in said information processing system;

if said computing step determines that said pointing device has moved, then receiving a second plurality of n succeeding coordinate point signals for said pointing device with respect to said touch sensor, and buffering a first of said second plurality of n signals as a new anchor point while restarting the delay timer, in said information processing system;

if said computing step determines that said pointing device has not moved, then outputting a first output signal indicating cessation of motion of said pointing device; if said determining step determines that said pointing device is not located in said operative proximity to said touch sensor, then outputting a second output signal indicating that said pointing device has been removed from said operative proximity to said touch sensor.

7. The method as recited in claim 6, further comprising the step of identifying a type of said pointing device wherein said predetermined delay timer value is determined in accordance with the type identified.

8. The method recited in claim 6, wherein when motion of said pointing device has not been detected within a number of previous position points, said predetermined delay timer value is reduced in accordance with the number of previous position points.

9. The method recited in claim 6, wherein the system accepts information from said pointing device as gesture or character information in response to movement and removal of said pointing device from said touch sensor.

10. The method as recited in claim 6, further comprising the step of entering a gesture recognition mode when said second output signal is outputted.

11. A method for reducing the processing time required in a multi-tasking information processing system, to recognize the cessation of motion of a moving first pointing device that emulates a second pointing device in the system, the method comprising the steps of:

determining that a first pointing device is located in operative proximity to a display screen, in said information processing system;

generating a series of delay timers having a predetermined rate, while said pointing device is located in said operative proximity to said display screen, in said information processing system;

accessing a predetermined timer divide rate value 'n' from said information processing system, representing a predetermined plurality of 'n' of coordinate point signals, in said information processing system;

receiving a first point signal for said pointing device with respect to said display screen, and buffering said first point signal in a memory as an anchor point and starting a delay timer, in said information processing system;

receiving a plurality of $n-1$ succeeding point signals for said pointing device with respect to said display screen, and buffering said plurality of $n-1$ signals, in said memory in said information processing system;

computing whether said pointing device has moved with respect to said display screen by comparing at least one of said buffered plurality of $n-1$ point signals with said buffered anchor point, in said information processing system;

if said computing step determines that said pointing device has moved, then receiving a second plurality of n succeeding coordinate point signals for said pointing device with respect to said display screen, and buffering a first of said second plurality of n signals as a new anchor point while restarting the delay timer, in said information processing system;

if said computing step determines that said first pointing device has not moved, then outputting a first output signal indicating cessation of motion of said first pointing device and designating it as said second pointing device;

if said determining step determines that said first pointing device is not located in said operative proximity to said display screen, then outputting a second output signal indicating that said first pointing device has been removed from said operative proximity to said display screen.

12. A data processing system for reducing the processing time required to recognize the cessation of motion of a moving pointing device, comprising:

means for determining that a pointing device is located in operative proximity to a touch sensor controlling a display screen, in said data processing system;

means for generating a series of delay timers having a predetermined rate, while said pointing device is located in said operative proximity to said touch sensor, in said data processing system;

means for accessing a predetermined timer divide rate value 'n' from said information processing system, representing a predetermined plurality of 'n' of coordinate point signals, in said data processing system;

means for receiving a first point signal for said pointing device with respect to said touch sensor, and buffering said first point signal in a memory as an anchor point and starting a delay timer, in said data processing system;

said receiving means receiving a plurality of $n-1$ succeeding point signals for said pointing device with respect to said touch sensor, and buffering said plurality of $n-1$ signals, in a memory in said data processing system;

means for computing whether said pointing device has moved with respect to said touch sensor by comparing at least one of said buffered plurality of $n-1$ point signals with said buffered anchor point, in said data processing system;

if said computing step determines that said pointing device has moved, then receiving a second plurality of n succeeding coordinate point signals for said pointing device with respect to said touch sensor, and buffering a first of said second plurality of n signals as a new anchor point while restarting the delay timer, in said data processing system;

if said computing means determines that said pointing device has not moved, then said computing means outputs a first output signal indicating cessation of motion of said pointing device;

if said determining means determines that said pointing device is not located in said operative proximity to said touch sensor, then said computing means outputs a second output signal indicating that said pointing device has been removed from said operative proximity to said touch sensor.

13. The data processing system recited in claim 12, wherein the system accepts information from said pointing device as mouse input data in response to a recognition of motion cessation.

14. The data processing system recited in claim 12, wherein said touch sensor is a touch-sensitive display screen that displays information under control of said pointing device.

15. The data processing system recited in claim 12, wherein the system is a multi-tasking computer system that dedicates a single task to managing said computing by said computing means.

16. The data processing system recited in claim 12, wherein the system enters a gesture recognition mode when said second output signal is outputted.

* * * * *

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United States Patent [19]

Cyr et al.

[11] **Patent Number: 5,559,943**

[45] **Date of Patent: Sep. 24, 1996**

[54] **METHOD AND APPARATUS CUSTOMIZING A DUAL ACTUATION SETTING OF A COMPUTER INPUT DEVICE SWITCH**

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[21] Appl. No.: **266,177**

[22] Filed: **Jun. 27, 1994**

[51] **Int. Cl.**[6] **G06F 3/14**

[52] **U.S. Cl.** **395/155**; 345/145

[58] **Field of Search** 395/155, 161, 395/159, 157, 156, 154; 345/145

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Assistant Examiner—Crescelle N. dela Torre
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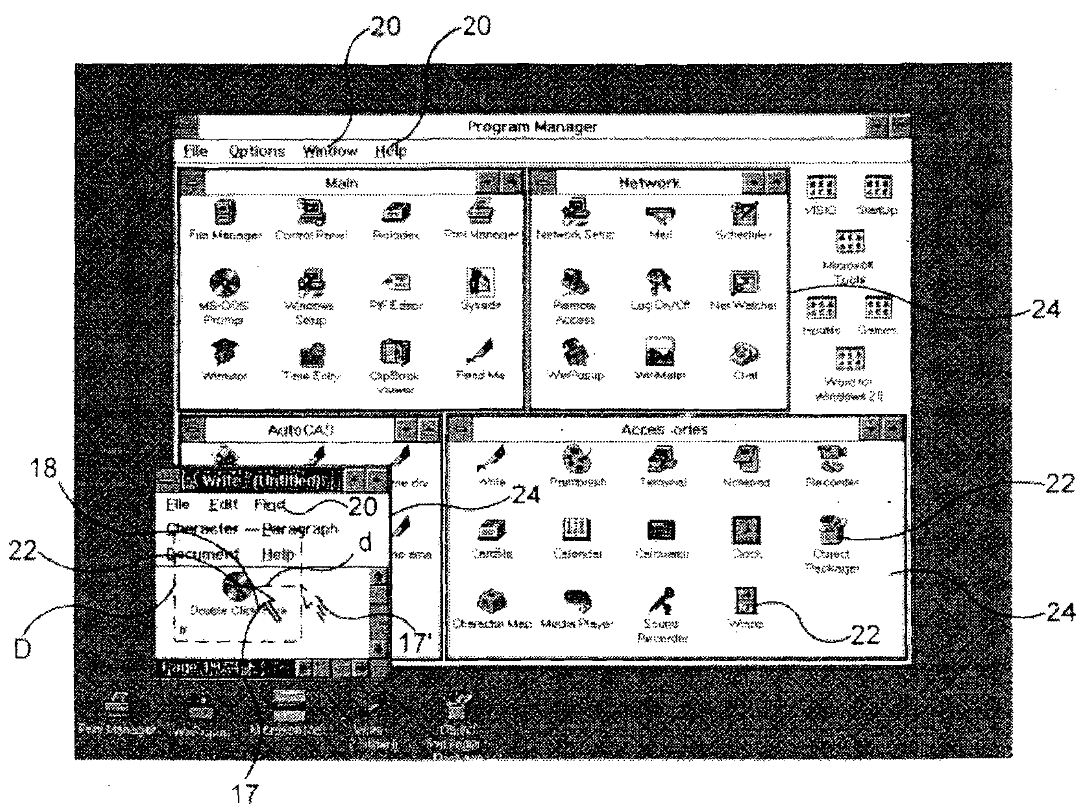
[57] **ABSTRACT**

A method and computer system present a user with a target icon on a computer screen and instruct the user to place a cursor thereon and twice actuate a mouse switch. The method measures the positions of the cursor on the screen during, and the time between, the two actuations by the user, and uses these measurements to customize, for the given user, the dual actuation speed and cursor movement area used to determine a double-click input command.

17 Claims, 3 Drawing Sheets



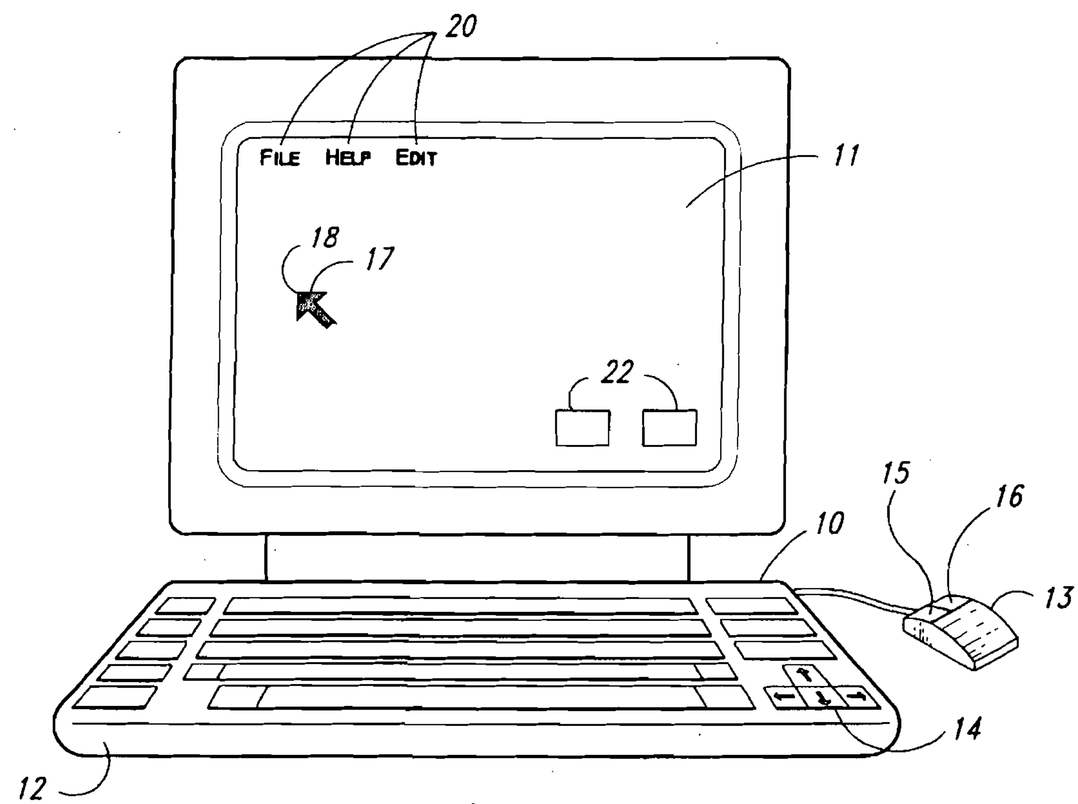


Fig. 1

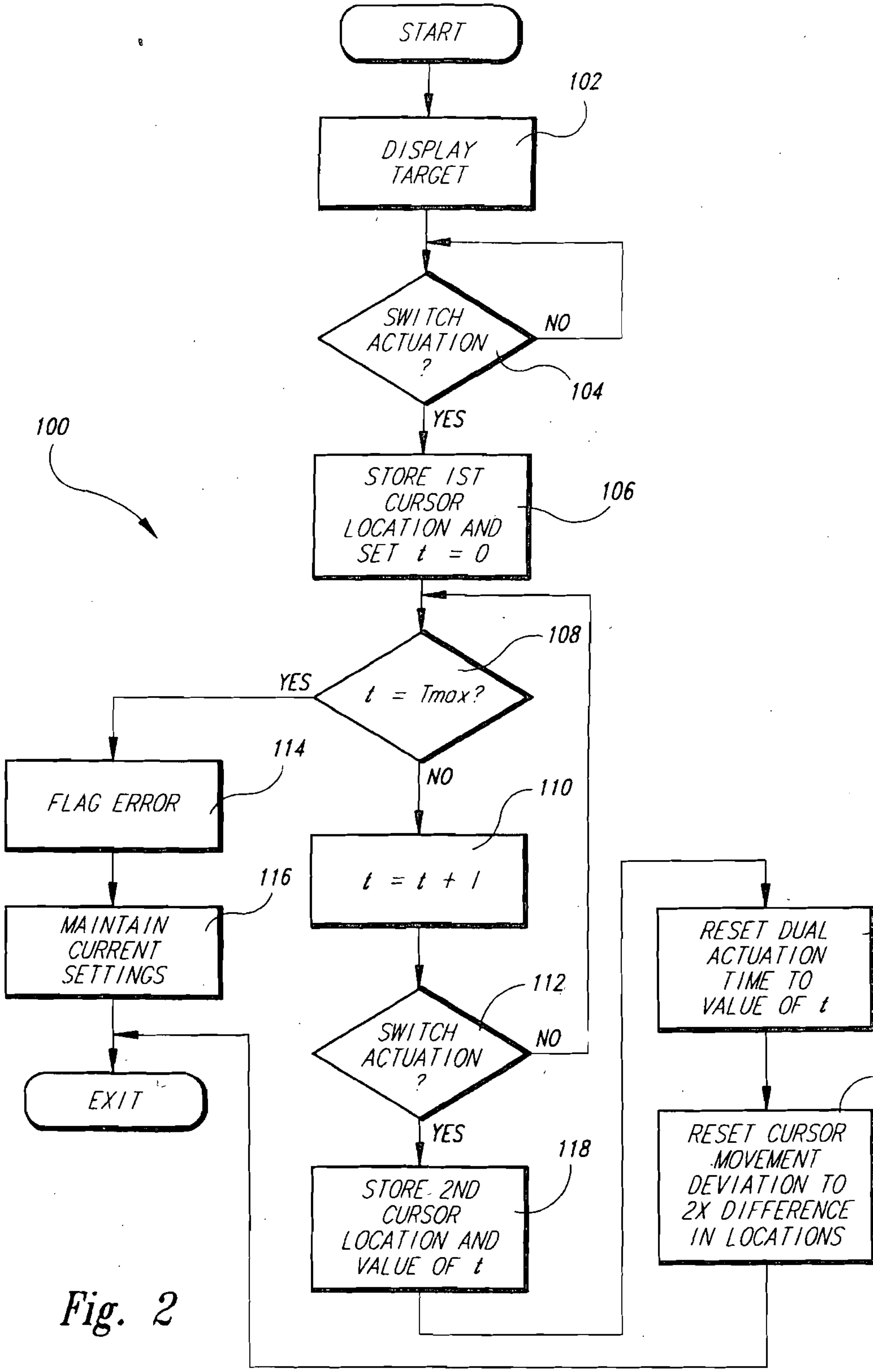

START
DISPLAY TARGET
102
SWITCH ACTUATION ?
NO
104
YES
100
STORE 1ST CURSOR LOCATION AND SET t = 0
106
108
YES
t = Tmax?
114
FLAG ERROR
NO
110
t = t + 1
120
RESET DUAL ACTUATION TIME TO VALUE OF t
116
MAINTAIN CURRENT SETTINGS
112
SWITCH ACTUATION ?
NO
122
EXIT
YES
118
RESET CURSOR MOVEMENT DEVIATION TO 2X DIFFERENCE IN LOCATIONS
STORE 2ND CURSOR LOCATION AND VALUE OF t

Fig. 2

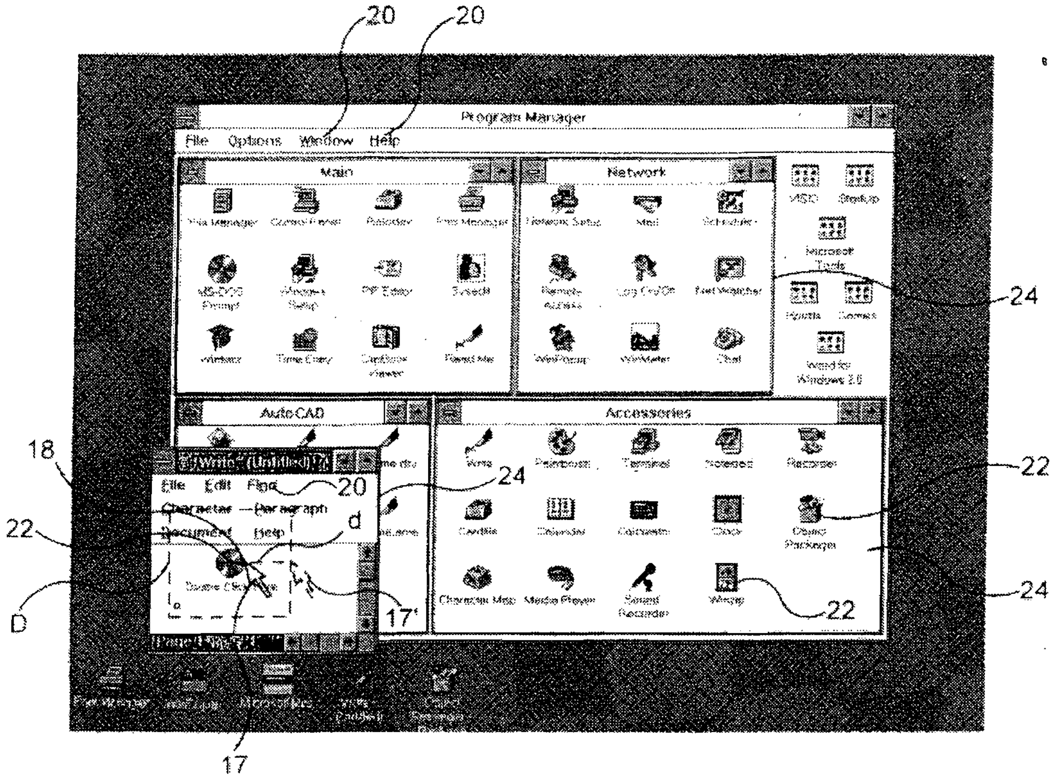

20
20
Program Manager
File
Options
Window
Help
Main
Network
AutoCAD
Accessories
Write - (Untitled)
Edit
Find
Character
Paragraph
Document
24
18
22
D
d
17'
17
22
24
22

FIG. 3

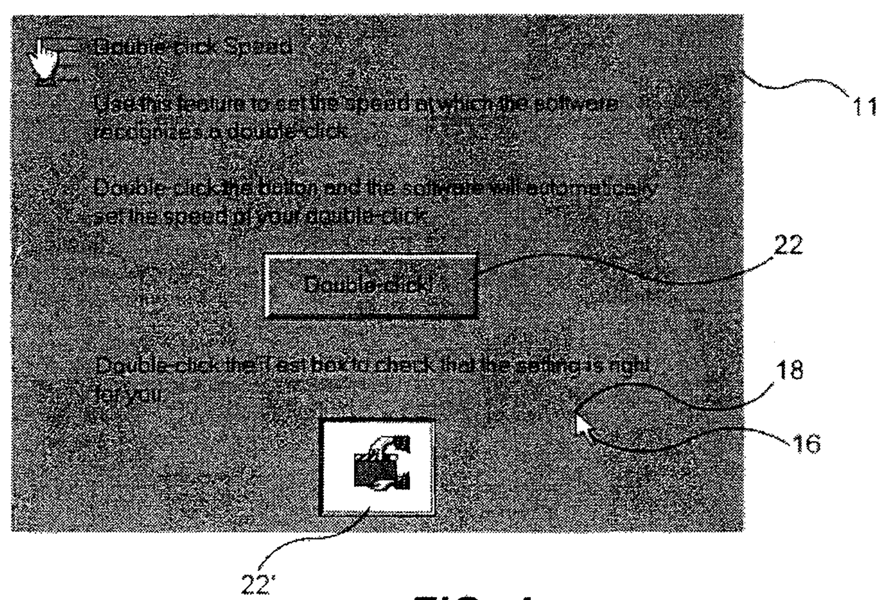

Double-click Speed
Use this feature to set the speed at which the software recognizes a double-click.
Double-click the button and the software will automatically set the speed of your double-click.
Double-click!
Double-click the Test box to check that the setting is right for you.
11
22
18
16
22'

FIG. 4