

EXHIBIT 4.16

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11677958	WESTERMAN ET AL.
	Examiner	**Art Unit**
	Koosha Sharifi	2629

SEARCHED

Class	Subclass	Date	Examiner
345	173-178	12/14/2009	ks
178	18.01,18.03,19.01,20.01	12/14/2009	ks
715	863	12/14/2009	ks

SEARCH NOTES

Search Notes	Date	Examiner
EAST	12/14/2009	ks

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

/K. S./ Examiner.Art Unit 2629	

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CONFIRMATION NO. 1844

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/677,958	02/22/2007 RULE	345	2629	10684-25086.04

APPLICANTS
Wayne Westerman, San Francisco, CA;
John G. Elias, Townsend, DE;

** **CONTINUING DATA** *************************
This application is a CON of 11/015,434 12/17/2004 PAT 7,339,580
which is a CON of 09/236,513 01/25/1999 PAT 6,323,846
which claims benefit of 60/072,509 01/26/1998

** **FOREIGN APPLICATIONS** *************************

** **IF REQUIRED, FOREIGN FILING LICENSE GRANTED** **
03/12/2007

		STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /KOOSHA SHARIFI-TAFRESHI/ Examiner's Signature	☐ Met after Allowance Initials	CA	45	35	3

ADDRESS

APPLE C/O MORRISON AND FOERSTER ,LLP
LOS ANGELES
555 WEST FIFTH STREET SUITE 3500
LOS ANGELES, CA 90013-1024
UNITED STATES

TITLE

Ellipse Fitting for Multi-Touch Surfaces

FILING FEE RECEIVED		
3760	FEES: Authority has been given in Paper No.____________ to charge/credit DEPOSIT ACCOUNT No.____________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ________________ ☐ Credit

Notice of References Cited	Application/Control No. 11/677,958	Applicant(s)/Patent Under Reexamination WESTERMAN ET AL.	
	Examiner Koosha Sharifi	Art Unit 2629	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-5,896,126	04-1999	Shieh, Johnny Meng-Han	345/173
*	B	US-5,825,352	10-1998	Bisset et al.	345/173
*	C	US-6,147,680	11-2000	Tareev, Aleksey A.	345/173
*	D	US-5,748,184	05-1998	Shieh, Johnny Meng-Han	345/173
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
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	P					
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NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
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	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

ALTERNATIVE TO PTO/SB/08A/B
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Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				**Application Number**	11/677,958
(Use as many sheets as necessary)				**Filing Date**	February 22, 2007
				First Named Inventor	Wayne C. WESTERMAN
				Art Unit	2629
				Examiner Name	R. Hjerpe
Sheet	1	of	3	Attorney Docket Number	106842508604

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1.	US-2002/0140668-A1	10-03-2002	Crawford	
	2.	US-2004/0146688-A1	07-29-2004	Treat	
	3.	US-2007/0070050-A1	03-29-2007	Westerman et al.	
	4.	US-2007/0070051-A1	03-29-2007	Westerman et al.	
	5.	US-2007/0070052-A1	03-29-2007	Westerman et al.	
	6.	US-2007/0078919-A1	04-05-2007	Westerman et al.	
	7.	US-2007/0081726-A1	04-12-2007	Westerman et al.	
	8.	US-2007/0268273-A1	11-22-2007	Westerman et al.	
	9.	US-2007/0268274-A1	11-22-2007	Westerman et al.	
	10.	US-2007/0268275-A1	11-22-2007	Westerman et al.	
	11.	US-2008/0041639-A1	02-21-2008	Westerman et al.	
	12.	US-2008/0042986-A1	02-21-2008	Westerman et al.	
	13.	US-2008/0042987-A1	02-21-2008	Westerman et al.	
	14.	US-2008/0042988-A1	02-21-2008	Westerman et al.	
	15.	US-2008/0042989-A1	02-21-2008	Westerman et al.	
	16.	US-2008/0128182-A1	06-05-2008	Westerman et al.	
	17.	US-2009/0021489-A1	01-22-2009	Westerman et al.	
	18.	US-5,471,578-A	11-28-1995	Moran et al.	
	19.	US-5,479,528-A	12-26-1995	Speeter	
	20.	US-5,548,667-A	08-20-1996	Tu	
	21.	US-5,589,856-A	12-31-1996	Stein et al.	
	22.	US-5,594,469-A	01-14-1997	Freeman et al.	
	23.	US-5,943,043-A	08-24-1999	Furuhata et al.	
	24.	US-6,255,604-B1	07-03-2001	Tokioka et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
	25.	EP-0 622 722-A2, A3, B1	11-02-1994	Xerox Corp.		
	26.	EP-0 817 000-A1, B1	01-07-1998	IBM Corp.		
	27.	WO-99/38149-A1	07-29-1999	Westerman et al.		

Examiner Signature	/Koosha Sharifi-tafreshi/	Date Considered	12/14/2009

*EXAMINER: Initial if information considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

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				Art Unit	2629
(Use as many sheets as necessary)				Examiner Name	R. Hjerpe
Sheet	2	of	3	Attorney Docket Number	106842508604

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	28.	CHANG, C-C. et al. (August 1, 1993). "A Hashing-Oriented Nearest Neighbor Searching Scheme," *Pattern Recognition Letters*, 14(8):625-630.	
	29.	CROWLEY, J.L. (March 1, 1997). "Vision for Man-Machine Interaction," *Robotics and Autonomous Systems*, 19(3-4):347-358.	
	30.	DAVIS, J. et al. (May 2, 1994). "Recognizing Hand Gestures," *European Conference on Computer Vision*, Stockholm, SE, 1:331-340.	
	31.	European Search Report mailed December 12, 2008, for EP Application No. 06016855.6 filed January 25, 1999, six pages.	
	32.	European Search Report mailed December 23, 2008, for EP Application No. 06016831.7 filed January 25, 1999, seven pages.	
	33.	European Search Report mailed January 9, 2009, for EP Application No. 06016832.5 filed January 25, 1999, four pages.	
	34.	HEAP, T. et al. (October 14, 1996). "Towards 3D Hand Tracking Using a Deformable Model," *Proceedings of the 2nd International Conference*, Killington, VT, USA, October 14-16, 1996, *Automatic Face and Gesture Recognition, IEEE Comput. Soc.*, pp. 140-145.	
	35.	International Search Report mailed December 28, 2005, for PCT Application No. PCT/US 05/03325, filed February 3, 2005, two pages.	
	36.	NIREI, K. et al. (August 5, 1996). "Human Hand Tracking from Binocular Image Sequences," *Proceedings of the 1996 IEEE IECON 22nd International Conference*, Taipei, Taiwan, August 5-10, 1996, *Industrial Electronics, Control, and Instrumentation* 1(5):297-302.	
	37.	Non-Final Office Action mailed September 21, 2007, for U.S. Patent Application No. 11/428,515, filed July 3, 2006, seven pages.	
	38.	Non-Final Office Action mailed September 24, 2007, for U.S. Patent Application No. 11/428,506, filed July 3, 2006, six pages.	
	39.	Non-Final Office Action mailed September 24, 2007, for U.S. Patent Application No. 11/428,521, filed July 3, 2006, six pages.	
	40.	Non-Final Office Action mailed January 28, 2008, for U.S. Patent Application No. 11/428,522, filed July 3, 2006, seven pages.	
	41.	Non-Final Office Action mailed February 4, 2008, for U.S. Patent Application No. 11/428,515, filed July 3, 2006, six pages.	
	42.	Non-Final Office Action mailed July 9, 2008, for U.S. Patent Application No. 11/428,521, filed July 3, 2006, 11 pages.	
	43.	Non-Final Office Action mailed September 2, 2008, for U.S. Patent Application No. 11/428,522, filed July 3, 2006, six pages.	
	44.	Non-Final Office Action mailed September 15, 2008, for U.S. Patent Application No. 11/428,506, filed July 3, 2006, eight pages.	
	45.	Non-Final Office Action mailed October 31, 2008, for U.S. Patent Application No. 11/428,515, filed July 3, 2006, seven pages.	
	46.	Non-Final Office Action mailed February 17, 2009, for U.S. Patent Application No. 11/428,522, filed July 3, 2006, six pages.	
	47.	Notice of Allowability mailed February 11, 2009, for U.S. Patent Application No. 11/428,521, filed July 3, 2006, five pages.	
	48.	US Patent Application No. 11/332,861 filed on 1/13/2006 which is a Reissue of 6,677,932.	

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(Use as many sheets as necessary)				Examiner Name	R. Hjerpe
Sheet	3	of	3	Attorney Docket Number	106842508604

	49.	WESTERMAN, W. (January 1, 1999). "Hand Tracking, Finger Identification, and Chordic Manipulation on a Multi-Touch Surface," Dissertation, University of Delaware, pp. 1-333.	

Examiner Signature	/Koosha Sharifi-tafreshi/	Date Considered	12/14/2009

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		First Named Inventor	Wayne Carl WESTERMAN
		Art Unit	2629
		Examiner Name	Bipin H. Shalwala
Sheet 1	of 2	Attorney Docket Number	106842508604 **Client Ref. No. P3950USC13**

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1.	US-2009/0160816-A1	06-25-2009	Westerman et al.	
	2.	US-5,270,711-A	12-14-1993	Knapp et al.	
	3.	US-5,856,824-A	01-05-1999	Shieh	
	4.	US-5,877,748-A	03-02-1999	Redlich	
	5.	US-5,917,476-A	06-29-1999	Czerniecki	
	6.	US-5,982,302-A	11-09-1999	Ure	
	7.	US-6,097,371-A	08-01-2000	Siddiqui et al.	

FOREIGN PATENT DOCUMENTS

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	8.	JP-02-056017-A	02-26-1990	Nippon Telegraph and Telephone Corp.	Translation of Abstract Only	
	9.	JP-02-304613-A	12-18-1990	Philips NV	Translation of Abstract Only	
	10.	JP-04-233619-A	08-21-1992	Philips NV	Translation of Abstract Only	
	11.	JP-07-129312-A	05-19-1995	Oki Electric Ind.Co. Ltd.	Translation of Abstract Only	

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NON PATENT LITERATURE DOCUMENTS

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	12.	Final Office Action mailed March 19, 2009, for U.S. Patent Application No. 11/428,506, filed July 3, 2006, seven pages.	
	13.	Non-Final Office Action mailed March 18, 2009, for U.S. Patent Application No. 11/428,515, filed July 3, 2006, 12 pages.	
	14.	Non-Final Office Action mailed April 2, 2009, for U.S. Patent Application No. 11/428,501, filed July 3, 2006, 11 pages.	
	15.	Non-Final Office Action mailed April 2, 2009, for U.S. Patent Application No. 11/428,503, filed July 3, 2006, 12 pages.	

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Sheet	2	of	2	Attorney Docket Number	106842508604 **Client Ref. No. P3950USC13**

	16.	Notice of Allowability mailed July 10, 2009, for U.S. Patent Application No. 11/428,521, filed July 3, 2006, four pages.	
	17.	RUBINE, D. (May 1992). "Combining Gestures and Direct Manipulation," CHI '92, pp. 659-660.	
	18.	U.S. Patent Application No. 12/342,027, filed on December 22, 2008, by Westerman et al. (copy not attached.)	
	19.	U.S. Patent Application No. 12/422,197, filed on April 10, 2009, by Westerman et al. (copy not attached.)	
	20.	U.S. Patent Application No. 12/422,205, filed on April 10, 2009, by Westerman et al. (copy not attached.)	
	21.	U.S. Patent Application No. 12/422,212, filed on April 10, 2009, by Westerman et al. (copy not attached.)	
	22.	U.S. Patent Application No. 12/422,222, filed on April 10, 2009, by Westerman et al. (copy not attached.)	
	23.	U.S. Patent Application No. 12/422,225, filed on April 10, 2009, by Westerman et al. (copy not attached.)	
	24.	U.S. Patent Application No. 12/434,439, filed on May 1, 2009, by Westerman et al. (copy not attached.)	
	25.	U.S. Patent Application No. 12/479,573, filed on June 5, 2009, by Westerman et al. (copy not attached.)	
	26.	U.S. Patent Application No. 12/479,617, filed on June 5, 2009, by Westerman et al. (copy not attached.)	
	27.	U.S. Patent Application No. 12/479,678, filed on June 5, 2009, by Westerman et al. (copy not attached.)	

Examiner Signature	/Koosha Sharifi-tafreshi/	Date Considered	12/14/2009

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	AA*	US-2002/0118848	08-29-2002	Karpenstein	
	AB*	US-2003/0006974	01-09-2003	Clough et al.	
	AC*	US-2003/0076301	04-24-2003	Tsuk et al.	
	AD*	US-2003/0076303	04-24-2003	Huppi	
	AE*	US-2003/0076306	04-24-2003	Zadesky et al.	
	AF*	US-2003/0095095	05-22-2003	Pihlaja	
	AG*	US-2003/0095096	05-22-2003	Robbin et al.	
	AH*	US-2003/0098858	05-29-2003	Perski et al.	
	AI*	US-2003/0206202	11-06-2003	Moriya	
	AJ*	US-2003/0234768	12-25-2003	Rekimoto et al.	
	AK*	US-2004/0263484	12-30-2004	Montysalo et al.	
	AL*	US-2005/0012723	01-20-2005	M. Pallakoff	
	AM*	US-2005/0052425	03-10-2005	Zadeski et al.	
	AN*	US-2005/0104867	05-19-2005	Westerman et al.	
	AO*	US-2005/0110768	05-26-2005	Marriott et al.	
	AP*	US-2006/0022955	02-02-2006	Kennedy	
	AQ*	US-2006/0022956	02-02-2006	Lengeling et al.	
	AR*	US-2006/0026521-A1	02-02-2006	Hotelling et al.	
	AS*	US-2006/0026535	02-02-2006	Hotelling et al.	
	AT*	US-2006/0026536	02-02-2006	Hotelling et al.	
	AU*	US-2006/0032680	02-16-2006	Elias et al.	
	AV*	US-2006/0033724	02-16-2006	Chaudhri et al.	
	AW*	US-2006/0053387	03-09-2006	Ording	
	AX*	US-2006/0066582	03-30-2006	Lyon et al.	
	AY*	US-2006/0085757	04-20-2006	Andre et al.	
	AZ*	US-2006/0097991-A1	05-11-2006	Hotelling et al.	
	AA1*	US-2006/0197753-A1	09-07-2006	Hotelling	
	AB1*	US-2006/0232567	10-19-2006	Westerman et al.	
	AC1*	US-2006/0238517	10-26-2006	King et al.	
	AD1*	US-2006/0238518	10-26-2006	Westerman et al.	
	AE1*	US-2006/0238519	10-26-2006	Westerman et al.	
	AF1*	US-2006/0238520	10-26-2006	Westerman et al.	
	AG1*	US-2006/0238521	10-26-2006	Westerman et al.	
	AH1*	US-2006/0238522	10-26-2006	Westerman et al.	
	AI1*	US-2007/0229464	10-04-2007	Hotelling et al.	
	AJ1*	US-2007/0236466	10-11-2007	Hotelling	
	AK1*	US-2007/0247429	10-25-2007	Westerman	
	AL1*	US-2007/0257890	11-08-2007	Hotelling et al.	
	AM1*	US-3,333,160	07-25-1967	Gorski	
	AN1*	US-3,541,541	11-17-1970	Engelhart	
	AO1*	US-3,662,105	05-09-1972	Hurst et al.	
	AP1*	US-3,798,370	03-19-1974	Hurst	
	AQ1*	US-4,246,452	01-20-1981	Chandler	
	AR1*	US-4,550,221	10-29-1985	Mabusth	
	AS1*	US-4,672,364	06-09-1987	Lucas	
	AT1*	US-4,672,558	06-09-1987	Beckes et al.	
	AU1*	US-4,692,809	09-08-1987	Beining et al.	

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	AV1*	US-4,695,827	09-22-1987	Beining et al.	
	AW1*	US-4,733,222	03-22-1988	Evans	
	AX1*	US-4,734,685	03-29-1988	Watanabe	
	AY1*	US-4,746,770	05-24-1988	McAvinney	
	AZ1*	US-4,771,276	09-13-1988	Parks	
	AA2*	US-4,788,384	11-29-1988	Bruere-Dawson et al.	
	AB2*	US-4,806,846	02-21-1989	Kerber	
	AC2*	US-4,898,555	02-06-1990	Sampson	
	AD2*	US-4,968,877	11-06-1990	McAvinney et al.	
	AE2*	US-5,003,519	03-26-1991	Noirjean	
	AF2*	US-5,017,030	05-21-1991	Crews	
	AG2*	US-5,178,477	01-12-1993	Gambaro	
	AH2*	US-5,189,403	02-23-1993	Franz et al.	
	AI2*	US-5,194,862	03-16-1993	Edwards	
	AJ2*	US-5,224,861	07-06-1993	Glass et al.	
	AK2*	US-5,241,308	08-31-1993	Young	
	AL2*	US-5,252,951	10-12-1993	Tannenbaum et al.	
	AM2*	US-5,281,966	01-25-1994	Walsh	
	AN2*	US-5,305,017	04-19-1994	Gerpheide	
	AO2*	US-5,345,543	09-06-1994	Capps et al.	
	AP2*	US-5,376,948	12-27-1994	Roberts	
	AQ2*	US-5,398,310	03-14-1995	Tchao et al.	
	AR2*	US-5,442,742	08-15-1995	Greyson et al.	
	AS2*	US-5,463,388	10-31-1995	Boie et al.	
	AT2*	US-5,463,696	10-31-1995	Beernink et al.	
	AU2*	US-5,483,261	01-09-1996	Yasutake	
	AV2*	US-5,488,204-A	01-30-1996	Mead et al.	
	AW2*	US-5,495,077	02-27-1996	Miller et al.	
	AX2*	US-5,513,309	04-30-1996	Meier et al.	
	AY2*	US-5,523,775	06-04-1996	Capps, S.	
	AZ2*	US-5,530,455	06-25-1996	Gillick et al.	
	AA3*	US-5,543,590	08-06-1996	Gillespie, et al.	
	AB3*	US-5,543,591	08-06-1996	Gillespie et al.	
	AC3*	US-5,563,632	10-08-1996	Roberts	
	AD3*	US-5,563,996	10-08-1996	Tchao	
	AE3*	US-5,565,658-A	10-15-1996	Gerpheide et al.	
	AF3*	US-5,579,036	11-26-1996	Yates, IV	
	AG3*	US-5,581,681	12-03-1996	Tchao et al.	
	AH3*	US-5,583,946	12-10-1996	Gourdol	
	AI3*	US-5,590,219	12-31-1996	Gourdol	
	AJ3*	US-5,592,566	01-07-1997	Pagallo et al.	
	AK3*	US-5,594,810	01-14-1997	Gourdol	
	AL3*	US-5,596,694	01-21-1997	Capps	
	AM3*	US-5,612,719	03-18-1997	Beernink et al.	
	AN3*	US-5,625,715	04-29-1997	Trew et al.	
	AO3*	US-5,631,805	05-20-1997	Bonsall	
	AP3*	US-5,633,955	05-27-1997	Bozinovic et al.	
	AQ3*	US-5,634,102	05-27-1997	Capps	
	AR3*	US-5,636,101	06-03-1997	Bonsall et al.	
	AS3*	US-5,642,108	06-24-1997	Gopher et al.	
	AT3*	US-5,644,657	07-01-1997	Capps et al.	

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /K.S./

ALTERNATIVE TO PTO/SB/08A/B
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Substitute for form 1449/PTO				Complete if Known	
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	AU3*	US-5,666,113	09-09-1997	Logan	
	AV3*	US-5,666,502	09-09-1997	Capps	
	AW3*	US-5,666,552	09-09-1997	Grayson et al.	
	AX3*	US-5,675,361	10-07-1997	Santilli	
	AY3*	US-5,677,710	10-14-1997	Thompson- Rohrlich	
	AZ3*	US-5,689,253	11-18-1997	Hargreaves et al.	
	AA4*	US-5,710,844	01-20-1998	Capps et al.	
	AB4*	US-5,729,250	03-17-1998	Bishop et al.	
	AC4*	US-5,730,165	03-24-1998	Philipp	
	AD4*	US-5,736,976	04-07-1998	Cheung	
	AE4*	US-5,741,990	04-21-1998	Davies	
	AF4*	US-5,745,116	04-28-1998	Pisutha-Amond	
	AG4*	US-5,745,716	04-28-1998	Tchao et al.	
	AH4*	US-5,746,818	05-05-1998	Yatake	
	AI4*	US-5,748,184	05-05-1998	Shieh	
	AJ4*	US-5,748,269	05-05-1998	Harris et al.	
	AK4*	US-5,764,222	06-09-1998	Shieh	
	AL4*	US-5,767,457	06-16-1998	Shieh	
	AM4*	US-5,767,842	06-16-1998	Korth	
	AN4*	US-5,790,104	08-04-1998	Shieh	
	AO4*	US-5,790,107-A	08-04-1998	Kasser et al.	
	AP4*	US-5,802,516	09-01-1998	Shwarts et al.	
	AQ4*	US-5,808,567	09-15-1998	McCloud	
	AR4*	US-5,809,267	09-15-1998	Moran et al.	
	AS4*	US-5,821,690	10-13-1998	Martens et al.	
	AT4*	US-5,821,930	10-13-1998	Hansen	
	AU4*	US-5,823,782	10-20-1998	Marcus et al.	
	AV4*	US-5,825,351	10-20-1998	Tam	
	AW4*	US-5,825,352-A	10-20-1998	Bisset et al.	
	AX4*	US-5,835,079	11-10-1998	Shieh	
	AY4*	US-5,854,625	12-29-1998	Frisch et al.	
	AZ4*	US-5,880,411-A	03-09-1999	Gillespie et al.	
	AB5*	US-5,898,434	04-27-1999	Small et al.	
	AC5*	US-5,920,309	07-06-1999	Bissett et al.	
	AD5*	US-5,923,319	07-13-1999	Bishop et al.	
	AE5*	US-5,933,134	08-03-1999	Shieh	
	AF5*	US-5,943,044	08-24-1999	Martinelli et al.	
	AG5*	US-6,002,389	12-14-1999	Kasser	
	AH5*	US-6,002,808	12-14-1999	Freeman	
	AI5*	US-6,020,881	02-01-2000	Naughton et al.	
	AJ5*	US-6,031,524	02-29-2000	Kunert	
	AK5*	US-6,037,882	03-14-2000	Levy	
	AL5*	US-6,050,825	04-18-2000	Nichol et al.	
	AM5*	US-6,052,339	04-18-2000	Frenkel et al.	
	AN5*	US-6,072,494	06-06-2000	Nguyen	
	AO5*	US-6,084,576	07-04-2000	Leu et al.	
	AP5*	US-6,107,997	08-22-2000	M.J. Ure	
	AQ5*	US-6,128,003	10-03-2000	Smith, et al.	
	AR5*	US-6,131,299	10-17-2000	Raab et al.	
	AS5*	US-6,135,958	10-24-2000	Mikula-Curtis et al.	
	AT5*	US-6,144,380	11-07-2000	Schwarts et al.	

la-1008936

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /K.S./

ALTERNATIVE TO PTO/SB/08A/B
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	AU5*	US-6,188,391-B1	02-13-2001	Seely, et al.	
	AV5*	US-6,188,391	02-13-2001	Seely et al.	
	AW5 *	US-6,198,515	03-06-2001	Cole	
	AX5*	US-6,208,329	03-27-2001	Ballare	
	AY5*	US-6,222,465	04-24-2001	Kumar et al.	
	AZ5*	US-6,239,790	05-29-2001	Martinelli et al.	
	AA6*	US-6,243,071	06-05-2001	Shwarts et al.	
	AB6*	US-6,246,862	06-12-2001	Grivas et al.	
	AC6*	US-6,249,606	06-19-2001	Kiraly et al.	
	AD6*	US-6,278,443-B1	08-21-2001	Amro et al.	
	AE6*	US-6,288,707	09-11-2001	Philipp	
	AF6*	US-6,289,326	09-11-2001	LaFleur	
	AG6*	US-6,292,178	09-18-2001	Bernstein et al.	
	AH6*	US-6,323,846-B1	11-27-2001	Westerman et al.	
	AI6*	US-6,323,849	11-27-2001	Westerman et al.	
	AJ6*	US-6,347,290	02-12-2002	Bartlett	
	AK6*	US-6,377,009	04-23-2002	Philipp	
	AL6*	US-6,380,931	04-30-2002	Gillespie et al.	
	AM6*	US-6,411,287	06-25-2002	Scharff et al.	
	AN6*	US-6,414,671	07-02-2002	Gillespie et al.	
	AO6*	US-6,421,234	07-16-2002	Ricks et al.	
	AP6*	US-6,452,514	09-17-2002	Philipp	
	AQ6*	US-6,457,355	10-01-2002	Philipp	
	AR6*	US-6,466,036	10-15-2002	Philipp	
	AS6*	US-6,515,669	02-04-2003	Mohri	
	AT6*	US-6,525,749	02-25-2003	Moran et al.	
	AU6*	US-6,535,200	03-18-2003	Philipp	
	AV6*	US-6,543,684	04-08-2003	White et al.	
	AW6*	US-6,543,947	04-08-2003	Lee	
	AX6*	US-6,570,557	05-27-2003	Westerman et al.	
	AY6*	US-6,593,916	07-15-2003	Aroyan	
	AZ6*	US-6,610,936	08-26-2003	Gillespie et al.	
	AA7*	US-6,624,833	09-23-2003	Kumar et al.	
	AB7*	US-6,639,577	10-28-2003	Eberhard	
	AC7*	US-6,650,319	11-18-2003	Hurst et al.	
	AD7*	US-6,658,994	12-09-2003	McMillan	
	AE7*	US-6,670,894	12-30-2003	Mehring	
	AF7*	US-6,677,932	01-13-2004	Westerman	
	AG7*	US-6,677,934	01-13-2004	Blanchard	
	AH7*	US-6,724,366	04-20-2004	Crawford	
	AI7*	US-6,757,002	06-29-2004	Oross et al.	
	AJ7*	US-6,803,906	10-12-2004	Morrison et al.	
	AK7*	US-6,842,672	01-11-2005	Straub et al.	
	AL7*	US-6,856,259	02-15-2005	Sharp	
	AM7*	US-6,888,536	05-03-2005	Westerman et al.	
	AN7*	US-6,900,795	05-31-2005	Knight, III et al.	
	AO7*	US-6,927,761	08-09-2005	Badaye et al.	
	AP7*	US-6,942,571	09-13-2005	McAllister et al.	
	AQ7*	US-6,965,375	11-15-2005	Gettemy et al.	
	AR7*	US-6,972,401	12-06-2005	Akitt et al.	

la-1008936

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /K.S./

ALTERNATIVE TO PTO/SB/08A/B
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	AS7*	US-6,977,666	12-20-2005	Hedrick	
	AT7*	US-6,985,801	01-10-2006	Straub et al.	
	AU7*	US-6,992,659	01-31-2006	Gettemy	
	AV7*	US-7,031,228	04-18-2006	Born et al.	
	AW7*	US-7,129,416	10-31-2006	Steinfeld, et al.	
	AX7*	US-7,339,580	03-04-2008	Westerman et al.	
	AY7*	US-RE40,153	03-18-2008	Westerman et al.	
	AZ7	US-2003/164820	09-04-2003	Kent	
	AA8	US-2003/132950	08-17-2003	Surucu et al.	
	AB8	US-5,883,619	03-1999	Ho et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
	BA	CA-1243096	10-11-1988	LAITRAM CORP		
	BB	EP-1014295	01-09-2002	TOKAI RIKA CO LTD		
	BC	WO-92/02000	02-06-1992	British Telecommunications Public Limited Company		√
	BD	EP-0288692	07-14-1993	IBM		
	BE	EP-0664504	01-24-1995	US WEST TECHNOLOGIES INC		
	BF	EP-0464908	09-04-1996	PHILIPS ELECTRONICS UK LTD; PHILIPS NV		
	BG	WO-97/018547	05-22-1997	Ure		
	BH	WO-97/023738	07-03-1997	Philipp		
	BI	WO-97/36225	10-02-1997	Synaptics Inc.		√
	BJ	WO-97/40744	11-06-1997	Philips Electronics N.V.		√
	BK	WO-98/14863	04-09-1998	PHILIPS ELECTRONICS NV; PHILIPS NORDEN AB		
	BL	WO-03/088176	10-23-2003	SYNAPTICS INC		
	BM	DE-10251296-A1	05-19-2004			
	BN	WO-WO06/023569	03-02-2006	FINGERWORKS INC		
	BO	GB-2330670 A	04-28-1999	Sony United Kingdom Limited		√

Examiner Signature	/Koosha Sharifi-tafreshi/	Date Considered	12/14/2009

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NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	CA	US Patent Application No. 10/654,108 filed on September 2, 2003 entitled "Ambidextrous	

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /K.S./

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		Mouse"	
	CB	US Patent Application No. 10/789,676 filed on February 27, 2004 entitled "Shape Detecting Input Device"	
	CC	"4-Wire Resistive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-4resistive.html generated August 5, 2005	
	CD	"5-Wire Resistive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-resistive.html generated August 5, 2005	
	CE	"A Brief Overview of Gesture Recognition" obtained from http://www.dai.ed.ac.uk/Cvonline/LOCA_COPIES/COHEN/gesture_overview.html, generated April 20, 2004	
	CF	"Capacitive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-capacitive.html generated August 5, 2005	
	CG	"Capacitive Position Sensing" obtained from http://www.synaptics.com/technology/cps.cfm generated August 5, 2005	
	CH	"Comparing Touch Technologies" obtained from http://www.touchscreens.com/intro-touchtypes.html generated October 10, 2004	
	CI	"Gesture Recognition" http://www.fingerworks.com/gesture_recognition.html	
	CJ	"GlidePoint®" obtained from http://www.cirque.com/technology/technology_gp.html generated August 5, 2005	
	CK	"How do touchscreen monitors know where you're touching?" obtained from http://www.electronics.howstuffworks.com/question716.html generated August 5, 2005	
	CL	"How does a touchscreen work?" obtained from http://www.touchscreens.com/intro-anatomy.html generated August 5, 2005	
	CM	"iGesture Products for Everyone (learn in minutes) Product Overview" FingerWorks.com	
	CN	"Infrared Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-infrared.html generated August 5, 2005	
	CO	"Mouse Emulation" FingerWorks obtained from http://www.fingerworks.com/gesture_guide_mouse.html generated August 30, 2005	
	CP	"Mouse Gestures in Opera" obtained from http://www.opera.com/products/desktop/mouse/index.dml generated August 30, 2005	
	CQ	"Mouse Gestures," Optim oz, May 21, 2004	
	CR	"MultiTouch Overview" FingerWorks obtained from http://www.fingerworks.com/multoverview.html generated August 30, 2005	
	CS	"Near Field Imaging Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-nfi.html generated August 5, 2005	
	CT	"PenTouch Capacitive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-pentouch.html generated August 5, 2005	
	CU	"Surface Acoustic Wave Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-saw.html generated August 5, 2005	
	CV	"Symbol Commander" obtained from http://www.sensiva.com/symbolcomander/, generated August 30, 2005	
	CW	"Tips for Typing" FingerWorks http://www.fingerworks.com/mini_typing.html generated August 30, 2005	
	CX	"Touch Technologies Overview" 2001, 3M Touch Systems, Massachusetts	
	CY	"Wacom Components - Technology" obtained from http://www.wacom-components.com/english/tech.asp generated on October 10, 2004	
	CZ	"Watershed Algorithm" http://rsb.info.nih.gov/ij/plugins/watershed.html generated August 5, 2005	

la-1008936

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /K.S./

ALTERNATIVE TO PTO/SB/08A/B
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	CA1	"FingerWorks - Gesture Guide - Application Switching," obtained from http://www.fingerworks.com/gesture_guide_apps.html, generated on 08/27/2004, 1-pg	
	CB1	"FingerWorks - Gesture Guide - Editing," obtained from http://www.fingerworks.com/gesure_guide_editing.html, generated on 08/27/2004, 1-pg	
	CC1	"FingerWorks - Gesture Guide - File Operations," obtained from http://www.fingerworks.com/gesture_guide_files.html, generated on 08/27/2004, 1-pg	
	CD1	"FingerWorks - Gesture Guide - Text Manipulation," obtained from http://www.fingerworks.com/gesture_guide_text_manip.html, generated on 08/27/2004, 2-pg	
	CE1	"FingerWorks - Gesture Guide - Tips and Tricks," obtained from http://www.fingerworks.com/gesture_guide_tips.html, generated 08/27/2004, 2-pgs	
	CF1	"FingerWorks - Gesture Guide - Web," obtained from http://www.fingerworks.com/gesture_guide_web.html, generated on 08/27/2004, 1-pg	
	CG1	"FingerWorks - Guide to Hand Gestures for USB Touchpads," obtained from http://www.fingerworks.com/igesture_userguide.html, generated 08/27/2004, 1-pg	
	CH1	"FingerWorks - iGesture - Technical Details," obtained from http://www.fingerworks.com/igesture_tech.html, generated 08/27/2004, 1-pg	
	CI1	"FingerWorks - The Only Touchpads with Ergonomic Full-Hand Resting and Relaxation!" obtained from http://www.fingerworks.com/resting.html, Copyright 2001, 1-pg	
	CJ1	"FingerWorks - Tips for Typing on the Mini," obtained from http://www.fingerworks.com/mini_typing.html, generated on 08/27/2004, 2-pgs	
	CK1	"iGesture Pad - the MultiFinger USB TouchPad with Whole-Hand Gestures," obtained from http://www.fingerworks.com/igesture.html, generated 08/27/2004, 2-pgs	
	CL1	Bier, et al., "Toolglass and Magic Lenses: The see-through interface" In James Kijiya, editor, Computer Graphics (SIGGRAPH '93 Proceedings), volume 27, pages 73-80, August 1993	
	CM1	BUXTON, W. et al. (July 22, 1985). "Issues and Techniques in Touch-Sensitive Tablet Input," *Proceedings ACM Siggraph*, pp. 215-224.	√
	CN1	CUTLER, L.D. et al. (April 27, 1997). "Two-Handed Direct Manipulation on the Responsive Workbench," *Proceedings of the 1997 Symposium on Interactive 3D Graphics*, Providence, RI, April 27-30, 1997, pp.107-114.	√
	CO1	DAVIS, J. et al. (October 31, 1994). "Determining 3-D Hand Motion," *Signals, Systems and Computers, 1994 Conference Record of the 28th Asilomar Conference on Pacific Grove*, CA, October 31 - November 2, 1994, Los Alamitos, CA, pp. 1262-1266.	√
	CP1	Douglas et al., The Ergonomics of Computer Pointing Devices (1997)	
	CQ1	European Search Report received in EP 1 621 989 *(@ Beyer Weaver & Thomas, LLP)* dated March 27, 2006	
	CR1	EVB ELEKTRONIK "TSOP6238 IR Receiver Modules for Infrared Remote Control Systems" dated 01/2004 1-pg	
	CS1	Fisher et al., "Repetitive Motion Disorders: The Design of Optimal Rate- Rest Profiles," Human Factors, 35(2):283-304 (Jun. 1993)	
	CT1	Fukumoto, et al., "ActiveClick: Tactile Feedback for Touch Panels," In CHI 2001 Summary, pages 121-122, 2001	
	CU1	Fukumoto and Yoshinobu Tonomura, "Body Coupled Fingering: Wireless Wearable Keyboard," *CHI 97*, pp. 147-154 (Mar. 1997)	
	CV1	Hardy, "Fingerworks" March 7, 2002; BBC World On Line	
	CW1	Hillier and Gerald J. Lieberman, *Introduction to Operations Research* (1986)	
	CX1	Jacob et al., "Integrality and Separability of Input Devices," *ACM Transactions on Computer-Human Interaction*, 1:3-26 (Mar. 1994)	
	CY1	Kinkley et al., "Touch-Sensing Input Devices," in CHI '99 Proceedings, pp 223-230, 1999	
	CA2	KIONX "KXP84 Series Summary Data Sheet" copyright 2005,dated 10/21/2005, 4-pgs	

la-1008936

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /K.S./

ALTERNATIVE TO PTO/SB/08A/B
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Sheet	8	of	9	Attorney Docket Number	106842508604

	CB2	Lee et al., "A Multi-Touch Three Dimensional Touch-Sensitive Tablet," in CHI '85 Proceedings, pages 121-128, 2000	
	CC2	Lee, "A Fast Multiple-Touch-Sensitive Input Device," Master's Thesis, University of Toronto (1984)	
	CD2	LEE, S.K. et al. (April 1985). "A Multi-Touch Three Dimensional Touch-Sensitive Tablet," *Proceedings of CHI: ACM Conference on Human Factors in Computing Systems*, pp. 21-25.	√
	CE2	Matsushita et al., "HoloWall: Designing a Finger, Hand, Body and Object Sensitive Wall," In Proceedings of UIST '97, October 1997	
	CF2	PAVLOVIC, V.I. et al. (July 1997). "Visual Interpretation of Hand Gestures for Human-Computer Interaction: A Review," *IEEE Transactions on Pattern Analysis and Machine Intelligence* 19(7):677-695.	√
	CG2	Quantum Research Group "QT510 / QWheel™ Touch Slider IC" copyright 2004-2005, 14-pgs	
	CH2	Quek, "Unencumbered Gestural Interaction," *IEEE Multimedia*, 3:36-47 (Winter 1996)	
	CI2	Radwin, "Activation Force and Travel Effects on Overexertion in Repetitive Key Tapping," *Human Factors*, 39(1):130-140 (Mar. 1997)	
	CJ2	Rekimoto "SmartSkin: An Infrastructure for Freehand Manipulation on Interactive Surfaces" CHI 2002, April 20-25, 2002	
	CK2	Rekimoto et al., "ToolStone: Effective Use of the Physical Manipulation Vocabularies of Input Devices," In Proc. Of UIST 2000, 2000	
	CL2	Rubine et al., "Programmable Finger-Tracking Instrument Controllers," *Computer Music Journal*, vol. 14, No. 1 (Spring 1990)	
	CM2	Rutledge et al., "Force-To-Motion Functions For Pointing," Human-Computer Interaction - INTERACT (1990)	
	CN2	Subatai Ahmad, "A Usable Real-Time 3D Hand Tracker," Proceedings of the 28th Asilomar Conference on Signals, Systems and Computers - Part 2 (of2), Vol. 2 (October 1994)	
	CO2	TEXAS INSTRUMENTS "TSC2003 / I2C Touch Screen Controller" Data Sheet SBAS 162, dated October 2001, 20-pgs	
	CP2	Wellner, "The Digital Desk Calculators: Tangible Manipulation on a Desk Top Display" IN ACM UIST '91 Proceedings, Pages 27-34, November 1991	
	CQ2	Williams, "Applications for a Switched-Capacitor Instrumentation Building Block" Linear Technology Application Note 3, July 1985, pp. 1-16	
	CR2	Yamada et al., "A Switched-Capacitor Interface for Capacitive Pressure Sensors" IEEE Transactions on Instrumentation and Measurement, Vol. 41, No. 1, February 1992, pp.81-86	
	CS2	Yeh et al., "Switched Capacitor Interface Circuit for Capacitive Transducers" 1985 IEEE	
	CT2	Zhai et al., "Dual Stream Input for Pointing and Scrolling," *Proceedings of CHI '97 Extended Abstracts* (1997)	
	CU2	Zimmerman et al., "Applying Electric Field Sensing to Human-Computer Interfaces," In CHI '85 Proceedings, Pages 280-287, 1995	
	CV2	International Search Report received in corresponding PCT application number PCT/US2006/008349 dated October 6, 2006	√
	CW2	International search report for PCT/US99/01454, mailed May 14, 1999.	√
	CX2	European supplementary search report for European Patent Application No. 99904228.6, mailed February 16, 2005.	√
	CY2	Supplementary European search report for U.S. patent Application No. 99904228.6, mailed July 8, 2005.	√
	CZ2	European examination report for European patent Application No. 99904228.6, mailed April 20, 2006.	√

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /K.S./

ALTERNATIVE TO PTO/SB/08A/B
(Based on PTO 08-08 version)

Substitute for form 1449/PTO				*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				**Application Number**	11/677,958
				Filing Date	February 22, 2007
				First Named Inventor	Wayne C. WESTERMAN
				Art Unit	2629
(Use as many sheets as necessary)				Examiner Name	R. Hjerpe
Sheet	9	of	9	Attorney Docket Number	106842508604

	CA3	European examination report for European Patent Application No. 99904228.6, mailed March 23, 2007.	√
	CB3	Extended European search report for European Patent Application No. 06016858.0, mailed December 21, 2007.	√
	CC3	Extended European search report for European Patent Application No. 06016856.4, mailed March 14, 2008.	√
	CD3	European examination report for European Patent Application No. 06016830.9, mailed August 6, 2008.	√
	CD4	European search report for European Patent Application No. 06016830.9 mailed December 3, 2007	√
	CD5	European examination report for European Patent Application No. 06016856.4 mailed September 16, 2008	√

Examiner Signature	/Koosha Sharifi-tafreshi/	Date Considered	12/14/2009

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English language Translation is attached.

la-1008936

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /K.S./

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/677,958	02/22/2007	Wayne Westerman	10684-25086.04	1844

69753 7590 02/02/2010

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EXAMINER	
SHARIFI-TAFRESHI, KOOSHA	

ART UNIT	PAPER NUMBER
2629	

MAIL DATE	DELIVERY MODE
02/02/2010	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Interview Summary	**Application No.** 11/677,958	**Applicant(s)** WESTERMAN ET AL.	
	Examiner Koosha Sharifi	**Art Unit** 2629	

All participants (applicant, applicant's representative, PTO personnel):

(1) *Amare Mengistu*.

(2) *Koosha Sharifi*.

(3) *Gregory Weaver*.

(4) _____.

Date of Interview: *27 January 2010*.

Type: a)☐ Telephonic b)☐ Video Conference
c)☒ Personal [copy given to: 1)☐ applicant 2)☒ applicant's representative]

Exhibit shown or demonstration conducted: d)☒ Yes e)☐ No.
If Yes, brief description: *keyboard*.

Claim(s) discussed: *1*.

Identification of prior art discussed: *Bisset et al.*.

Agreement with respect to the claims f)☐ was reached. g)☐ was not reached. h)☒ N/A.

Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: *The proposed amendment "mathematical fitting an ellipse" would overcome the art of record.*.

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)

THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN A NON-EXTENDABLE PERIOD OF THE LONGER OF ONE MONTH OR THIRTY DAYS FROM THIS INTERVIEW DATE, OR THE MAILING DATE OF THIS INTERVIEW SUMMARY FORM, WHICHEVER IS LATER, TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.

/K. S./
Examiner, Art Unit 2629

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:

- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:

1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

AMENDMENTS TO THE CLAIMS

1. (currently amended) A method of processing input from a touch-sensitive surface, the method comprising:

receiving at least one proximity image representing a scan of a plurality of electrodes of the touch-sensitive surface;

segmenting each proximity image into one or more pixel groups that indicate significant proximity, each pixel group representing proximity of a distinguishable hand part or other touch object on or near the touch-sensitive surface; and

mathematically fitting an ellipse to at least one of the pixel groups.

2. (original) The method of claim 1 further comprising transmitting one or more ellipse parameters as a control signal to an electronic or electromechanical device.

3. (original) The method of claim 2 wherein the one or more ellipse parameters is selected from the group consisting of position, shape, size, orientation, eccentricity, major radius, minor radius, and any combination thereof.

4. (original) The method of claim 3 wherein the one or more ellipse parameters are used to distinguish a pixel group associated with a fingertip from a pixel group associated with a thumb.

5. (original) The method of claim 1 wherein fitting an ellipse to a group of pixels comprises computing one or more eigenvalues and one or more eigenvectors of a covariance matrix associated with the pixel group.

6. (original) The method of claim 1 further comprising: tracking a path of at least one of the one or more pixel groups through a time-sequenced series of proximity images;

fitting an ellipse to the at least one of the one or more pixel groups in each of the time-sequenced series of proximity images; and tracking a change in one or more ellipse parameters through the time-sequenced series of proximity images.

7. (original) The method of claim 6 further comprising transmitting the change in the one or more ellipse parameters as a control signal to an electronic or electromechanical device.

8. (original) The method of claim 7 wherein the change in the one or more ellipse parameters is selected from the group consisting of position, shape, size, orientation, eccentricity, major radius, minor radius, and any combination thereof.

9. (original) The method of claim 6 wherein fitting an ellipse to the one pixel group comprises computing one or more eigenvalues and one or more eigenvectors of a covariance matrix associated with the pixel group.

10. (currently amended) A touch-sensing device comprising:

a substrate;

a plurality of touch-sensing electrodes arranged on the substrate;

electronic scanning hardware adapted to read the plurality of touch-sensing electrodes;

a calibration module operatively coupled to the electronic scanning hardware and adapted to construct a proximity image having a plurality of pixels corresponding to the touch-sensing electrodes; and

a contact tracking and identification module adapted to:

segment the proximity image into one or more pixel groups, each pixel group representing proximity of a distinguishable hand part or other touch object on or near the touch-sensitive surface; and

<u>mathematically</u> fit an ellipse to at least one of the one or more pixel groups.

11. (original) The touch-sensing device of claim 10 further comprising a host communication interface adapted to transmit one or more ellipse parameters as a control signal to an

electronic or electromechanical device.

12. (original) The touch-sensing device of claim 11 wherein the touch-sensing device is integral with the electronic or electromechanical device.

13. (original) The touch-sensing device of claim 11 wherein the one or more ellipse parameters comprise one or more parameters selected from the group consisting of position, shape, size, orientation, eccentricity, major radius, minor radius, and any combination thereof.

14. (original) The method of claim 13 wherein the one or more ellipse parameters are used to distinguish a pixel group associated with a fingertip from a pixel group associated with a thumb.

15. (original) The touch-sensing device of claim 10 wherein the contact tracking and identification module is adapted to compute one or more eigenvalues and one or more eigenvectors to fit the ellipse.

16. (original) The touch-sensing device of claim 10 wherein the contact tracking and identification module is further adapted to:

track a path of one or more pixel groups through a plurality of time-sequenced proximity images;

fit an ellipse to at least one of the one or more pixel groups in a first proximity image of the plurality of time-sequenced proximity images; and

track a change in one or more ellipse parameters associated with the fitted ellipse through two or more of the time-sequenced proximity images.

17. (original) The touch-sensing device of claim 16 further comprising a host communication interface adapted to transmit the change in at least one of the one or more ellipse parameters as a control signal to an electronic or electromechanical device.

18. (original) The touch-sensing device of claim 17 wherein the touch-sensing device is integral with the electronic or electromechanical device.

19. (original) The touch-sensing device of claim 17 wherein the change in one or more ellipse parameters used as a control input to an electronic or electromechanical device comprises one or more parameters selected from the group consisting of position, shape, size, orientation, eccentricity, major radius, minor radius, and any combination thereof.

20. (original) The touch-sensing device of claim 16 wherein the contact tracking and identification module is adapted to compute one or more eigenvalues and one or more eigenvectors to fit the ellipse.

21. (original) The touch-sensing device of any one of claims 10-12 and 16-18 wherein the touch-sensing device is fabricated on or integrated with a display device.

22. (original) The touch-sensing device of claim 21, wherein the display device comprises a liquid crystal display (LCD) or a light-emitting polymer display (LPD).

23. (original) A computer-readable medium having embodied thereon instructions executable by a machine to perform a method according to any of claims 1-9.

24. (original) A touch-sensing device comprising:

means for producing a proximity image representing a scan of a plurality of electrodes of a touch-sensitive surface, the proximity image having a plurality of pixels corresponding to the touch-sensing electrodes; and

means for segmenting the proximity image into one or more pixel groups, each pixel group representing a touch object on or near the touch-sensitive surface; and

means for fitting an ellipse to at least one of the pixel groups.

25. (original) The touch-sensing device of claim 24 wherein the touch object comprises at least a portion of a hand.

26. (original) The touch-sensing device of claim 24 wherein the touch object comprises at least a portion of one or more fingers.

27. (original) The touch-sensing device of claim 24 wherein the touch object comprises at least a portion of a body part.

28. (original) The touch-sensing device of claim 27 wherein the body part comprises one or more of a hand, a finger, an ear, or a cheek.

29. (original) The touch-sensing device of claim 24 further comprising means for transmitting one or more ellipse parameters as a control signal to an electronic or electromechanical device.

30. (original) The touch-sensing device of claim 27 wherein the touch-sensing device is integral with the electronic or electromechanical device.

31. (original) The touch-sensing device of claim 24 further comprising:

means for tracking a path of one or more pixel groups through a plurality of time-sequenced proximity images;

means for fitting an ellipse to at least one of the pixel groups in a plurality successive proximity images; and

means for tracking a change in one or more ellipse parameters through a plurality of time-sequenced proximity images.

32. (original) The touch-sensing device of claim 29 further comprising means for transmitting the change in the one or more ellipse parameters as a control signal to an electronic or

electromechanical device.

33. (original) The touch-sensing device of claim 32 wherein the touch-sensing device is integral with the electronic or electromechanical device.

34. (original) The touch-sensing device of any one of claims 24 and 29-33 wherein the touch-sensing device is fabricated on or integrated with a display device.

35. (original) The touch-sensing device of claim 34, wherein the display device comprises a liquid crystal display (LCD) or a light-emitting polymer display (LPD).

CERTIFICATE OF TRANSMISSION UNDER 37 CFR § 1.8

I hereby certify that this document is being electronically transmitted via the United States Patent and Trademark Office EFS-Web on February 24, 2010..

Signature: (Lisa D. Bronk)

VIA EFS
Docket No.: 106842508604
Client Ref. No.: P3950USC13
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Wayne WESTERMAN et al.

Application No.: 11/677,958

Confirmation No.: 1844

Filed: February 22, 2007

Art Unit: 2629

For: ELLIPSE FITTING FOR MULTI-TOUCH SURFACES

Examiner: Koosha Sharifi-Tafreshi

**STATEMENT OF SUBSTANCE OF INTERIVEW,
REQUEST FOR CORRECTED OFFICE ACTION,
AND
AMENDMENT IN RESPONSE TO NON-FINAL OFFICE ACTION**

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

INTRODUCTORY COMMENTS

This is in response to the non-final Office Action dated December 24, 2009, for which a response is due on March 24, 2010. Reconsideration and allowance of the pending claims, as amended, in light of the remarks presented herein are respectfully requested.

Amendments to the claims are reflected in the list beginning on page 2 of this paper.

A Request for Corrected Office Action begins on page 8 of this paper

Remarks/Arguments begin on page 10 of this paper.

VIA EFS WEB
Patent
Docket No. 106842508604
Client Reference No. P3950USC13

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Wayne WESTERMAN et al.

Serial No.: 11/677,958

Filing Date: February 22, 2007

For: ELLIPSE FITTING FOR MULTI-TOUCH SURFACES

Examiner: Koosha Sharifi-Tafreshi

Group Art Unit: 2629

Confirmation No.: 1844

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. § 1.97 & § 1.98

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Pursuant to 37 C.F.R. § 1.97 and § 1.98, Applicants submit for consideration in the above-identified application the documents listed on the attached Form PTO/SB/08a/b. Copies of foreign documents and non-patent literature are submitted herewith. The Examiner is requested to make these documents of record.

Applicants would like to draw the Examiner's attention to the fact that document no. 19 (EP-0 546 704) listed on the attached Form PTO/SB/08a/b is the English language counterpart of document no. 20 (JP-06-083523).

This Supplemental Information Disclosure Statement is submitted:

☐ With the application; accordingly, no fee or separate requirements are required.

☐ Before the mailing of a first Office Action after the filing of a Request for Continued Examination under § 1.114. However, if applicable, a certification under 37 C.F.R. § 1.97 (e)(1) has been provided.

☐ Within three months of the application filing date or before mailing of a first Office Action on the merits; accordingly, no fee or separate requirements are required. However, if applicable, a certification under 37 C.F.R. § 1.97 (e)(1) has been provided.

☒ After receipt of a first Office Action on the merits but before mailing of a final Office Action or Notice of Allowance.

- ☒ A fee is required. ~~Accordingly, a Fee Transmittal form (PTO/SB/17) is attached to this submission in duplicate.~~
- ☐ A Certification under 37 C.F.R. § 1.97(e) is provided above; accordingly; no fee is believed to be due.

☐ After mailing of a final Office Action or Notice of Allowance, but before payment of the issue fee.

- ☐ A Certification under 37 C.F.R. § 1.97(e) is provided above and a Fee Transmittal form (PTO/SB/17) is attached to this submission in duplicate.

Applicants would appreciate the Examiner initialing and returning the Form PTO/SB/08a/b, indicating that the information has been considered and made of record herein.

The information contained in this Supplemental Information Disclosure Statement under 37 C.F.R. § 1.97 and § 1.98 is not to be construed as a representation that: (i) a complete search has been made; (ii) additional information material to the examination of this application does not exist; (iii) the information, protocols, results and the like reported by third parties are accurate or enabling; or (iv) the above information constitutes prior art to the subject invention.

In the unlikely event that the transmittal form is separated from this document and the Patent and Trademark Office determines that an extension and/or other relief (such as payment of a fee under 37 C.F.R. § 1.17 (p)) is required, Applicants petition for any required relief including extensions of time and authorize the Commissioner to charge the cost of such petition and/or other fees due in connection with the filing of this document to **Deposit Account No. 03-1952** referencing 106842508604.

Dated: February 24, 2010

Respectfully submitted,

By: /Gregory S. Weaver, #53,751/

Gregory Weaver
Registration No.: 53,751
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555 West Fifth Street
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(213) 892-5399

REQUEST FOR CORRECTED OFFICE ACTION

The Office Action appears to contain an error that affects Applicants ability to reply, and therefore, Applicants respectfully request a corrected Office Action with a reset period for reply under MPEP § 710.06.

The Office Action indicates that Applicants have "**failed to further elect species from ... Species 1-4, and ... Species X, Y and Z and is required to [sic, do] this in response to this action.**" (Office Action, page 2 (emphasis in the Office Action).) However, the Office Action also indicates that the restriction requirement is "**still deemed proper and is therefore made FINAL.**" (Office Action, page 5 (emphasis in the Office Action).) According to 37 CFR § 1.143, because the Examiner made the requirement final, the Examiner has accepted Applicants' provisional election of claims as the invention elected:

> "In requesting reconsideration [of a restriction requirement] the applicant must indicate a provisional election of one invention for prosecution, which invention shall be the one elected in the event the requirement becomes final. The requirement for restriction will be reconsidered on such a request. If the requirement is repeated and made final, the examiner will at the same time act on the claims to the invention elected." (37 CFR § 1.143 (emphasis added).)

In other words, Rule 1.143 mandates that if the Examiner makes the requirement final, the Examiner *must* at the same time act on the provisionally elected claims as *the claims to the invention elected.* In line with the Rule, the Office Action does include a substantive examination of the claims provisionally elected by Applicants.[1] However, the Office Action's requirement that Applicants elect further species contradicts the Rule and results in an ambiguity that affects Applicants' ability to reply to the Office Action.

[1] The restriction requirement in the Office Action dated October 27, 2009 indicates "The species are independent or distinct because claims to the different species recite the mutually exclusive characteristics of such species" and "Currently, no claim is generic." (page 3 (emphasis added).) Therefore, the restriction requirement alleges that there are patentably distinct species claims. The acceptance of Applicants' provisional election of all claims (without amendment) and substantive examination of all claims is tantamount to an admission that the basis for requiring restriction is incorrect.

If the Examiner intends to maintain the restriction requirement, Applicants request a corrected Office Action correcting this contradiction, so that the record is clear whether or not there is a requirement that Applicants elect further species. Under MPEP § 710.06, the corrected Office Action is a non-final action with a reset period for reply.

Alternatively, Applicants note that regardless of the propriety of the restriction requirement when first asserted, there currently appears to be no rationale for maintaining the restriction requirement because all of the claims have been searched on the merits and, consequently, no search burden exists. Furthermore, although the Office Action asserts "searching for the mutually exclusive characteristics/features would be a search burden for the examiner because different searches with different keywords would be required for each of the mutually [sic, exclusive] characteristics/features as identified above" (Office Action, page 5 (emphasis added)), the Examiner's December 14, 2009 Search History (available on PAIR) does not appear to contain any search keywords that would distinguish between the alleged "mutually exclusive characteristic" of provisionally elected species A and any alleged mutually exclusive characteristic of another species of the restriction requirement. In other words, the search actually performed by the Examiner does not appear to take into account any of the alleged "mutually exclusive characteristics" of the species, listed on pages 2-4 of the Office Action, on which the restriction requirement is based. Thus, there is currently no search burden because all of the claims have already been searched, and because none of the alleged mutually exclusive characteristics were actually considered in the search anyway.

Because the restriction requirement is moot, Applicants respectfully request that the Examiner withdraw the restriction requirement. In the case that the restriction requirement is withdrawn, Applicants withdraw the request for a corrected Office Action and request that the Examiner continue examination of the application on the merits by entering this paper as a response to the Office Action. Therefore, if the Examiner withdraws the restriction requirement in lieu of issuing a corrected Office Action, Applicants respectfully request the Examiner enter the foregoing amendments and consider the Applicants' following remarks in response to the Office Action.

REMARKS

Claims 1-35 are pending in the application. Further examination and reconsideration are respectfully requested.

Applicants would like to thank the Examiner for the indication of allowable subject matter in dependent claims 5, 9, 15, and 20. Applicants have chosen not to amend these claims into independent form because the base claims are believed to be allowable.

Applicants would like to thank the Examiner for the courtesies and thoughtful treatment afforded to Applicants' undersigned representative during the January 26, 2010 interview. The foregoing amendments and following remarks reflect the substance of the interview.

Claims 1-3, 6-8, 23-29, 31, and 32 were rejected under 35 U.S.C. § 102(e) over U.S. Patent No. 5,825,352 (Bisset). The rejections are respectfully traversed. Reconsideration and withdrawal of the rejections are respectfully requested.

THE OFFICE ACTION'S INTERPRETATION OF "FITTING AN ELLIPSE TO AT LEAST ONE OF THE PIXEL GROUPS" IS UNREASONABLE IN LIGHT OF THE PLAIN MEANING OF "FITTING AN ELLIPSE TO" AND, IN PARTICULAR, DISREGARDS THE REQUIREMENT TO INTERPRET CLAIMS IN LIGHT OF THE SPECIFICATION

During the interview, the Examiner's interpretation of the feature of "fitting an ellipse to at least one of the pixel groups" (claim 1) was discussed. Applicants' representative disagreed with the Office Action's assertion that Bisset's "finger profile" (shown, e.g., in FIG. 7B of Bisset), which is simply a series of capacitance values measured when a finger contacts a touchpad, discloses the feature of "fitting an ellipse to ...". Specifically, paraphrasing the Office Action's interpretation, merely *obtaining* measured data is the same as *fitting an ellipse to* the data, so long as the measured data happens to be measured from an object that "is in general ellipse-like". (Office Action, page 7.) Applicants representative asserted that, under the plain meaning of the language of the claims, without more, one skilled in the art would not interpret "fitting an ellipse to at least one of the pixel groups" in such a manner. Furthermore, the Office Action's interpretation is particularly unreasonable when the claim language is viewed in light of the specification, as it must be viewed. In this regard, Applicants submit that the Office Action fails to consider the disclosure of the specification when interpreting at least the feature of "fitting an ellipse to at least one of the pixel groups." In light of the foregoing, Applicants respectfully traverse the rejections.

Nonetheless, claim 1 has been amended to recite *mathematically* fitting an ellipse to at least one of the pixel groups. During the interview, the Examiner indicated that the amendment would overcome the rejections. Claim 10 has been similarly amended. Accordingly, withdrawal of the rejections of claims 1 and 10 is respectfully requested.

THE OFFICE ACTION FAILS TO MEET THE REQUIREMENT TO EXPLAIN WHY "MEANS FOR" FEATURES ARE NOT BEING TREATED UNDER 35 U.S.C. § 112, SIXTH PARAGRAPH

Claim 24 has not been amended. The rejection of claim 24 is respectfully traversed. Claim 24 includes, among other features, means for fitting an ellipse to at least one of the pixel groups. In entering the rejection of claim 24, the Office Action does not indicate that this feature, or any other feature of the claim that begin with "means for," is being treated under 35 U.S.C. § 112, sixth paragraph. MPEP § 2181(I) requires examiners to state the reasons why a claim limitation that uses the phrase "means for" is not being treated under § 112, sixth paragraph:

> "If a claim limitation does include the phrase "means for" or "step for," that is, the first prong of the 3-prong analysis is met, but the examiner determines that either the second prong or the third prong of the 3-prong analysis is not met, then in these situations, the examiner must include a statement in the Office action explaining the reasons why a claim limitation which uses the phrase "means for" or "step for" is not being treated under 35 U.S.C. 112, sixth paragraph." (MPEP § 2181(I) (emphasis added).)

Therefore, the rejection fails to meet the requirement of MPEP § 2181.

Even more clearly than with the rejections of claims 1 and 10, the Office Action's rejection of claim 24 fails to interpret the claims in light of the specification. In asserting that Bisset discloses a means for fitting an ellipse to at least one of the pixel groups, the Office Action simply cuts-and-pastes the language used in the rejection of claim 1. Thus, the Office Action apparently does not interpret the language of the "means for" features of claim 24 as required by law. (*See, e.g.,* MPEP § 2181 ("a "means-or-step-plus-function" limitation should be interpreted in a manner different than patent examining practice had previously dictated"); MPEP § 2106(II)(C) ("Where means plus function language is used to define the characteristics of a machine or manufacture invention, such language must be interpreted to read on only the structures or materials disclosed in the specification and "equivalents thereof" that correspond to the recited function.")(emphasis added)(citations omitted); *Id.* ("Thus, at the outset, USPTO personnel must attempt to correlate claimed means to elements set forth in the written description that perform the recited step or function. The written description includes the original specification and the drawings and USPTO personnel are to give the claimed means plus function limitations their broadest reasonable interpretation consistent with all corresponding structures or materials described in the specification and their equivalents including the manner in which the claimed functions are performed.")(emphasis added)(citations omitted).)

Therefore, Applicants have chosen not to amend claim 24. Applicants respectfully request that, if the rejection is maintained, the Examiner clarify whether the language of claim 24 is being treated under § 112, sixth paragraph, and if so, the Examiner clarify how he interprets the language "means for fitting an ellipse to at least one of the pixel groups" to read only on the structures/materials disclosed in the specification and equivalents thereof including the manner in which the claims functions are performed. However, in light of the foregoing, Applicants believe claim 24 is allowable.

The remaining claims depend from the independent claims discussed above, and are believed to be allowable for at least the foregoing reasons. Therefore, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to withdraw the outstanding rejections of the claims and to pass this application to issue. If it is determined that a telephone conference would expedite the prosecution of this application, the Examiner is invited to telephone the undersigned at the number given below.

In the event the U.S. Patent and Trademark office determines that an extension and/or other relief is required, applicant petitions for any required relief including extensions of time and authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to Deposit Account No. 03-1952 referencing Docket No. 106842508604. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Dated: February 24, 2010

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PCT

WORLD INTELLECTUAL PRO
International

INTERNATIONAL APPLICATION PUBLISHED UNDE

WO 9607981A1

(51) International Patent Classification [6] :
G06K 11/16

A1

(11) International Publication Number: WO 96/07981

(43) International Publication Date: 14 March 1996 (14.03.96)

(21) International Application Number: PCT/US95/11180

(22) International Filing Date: 1 September 1995 (01.09.95)

(30) Priority Data:
08/300,387 2 September 1994 (02.09.94) US

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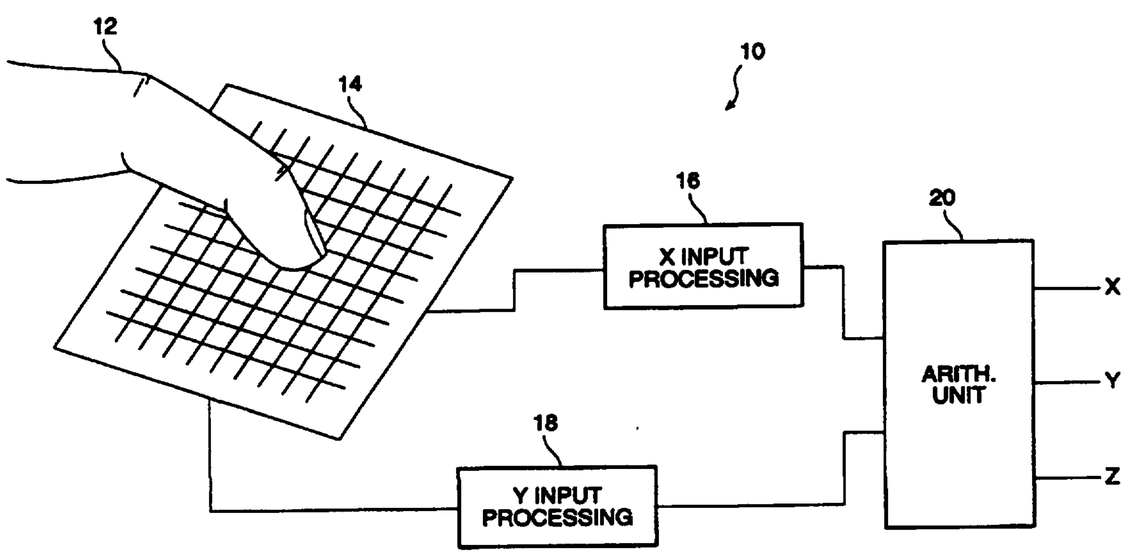
(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: OBJECT POSITION DETECTOR



(57) Abstract

A proximity sensor system includes a sensor matrix array having a characteristic capacitance on horizontal and vertical conductors connected to sensor pads. The capacitance changes as a function of the proximity of an object or objects to the sensor matrix. The change in capacitance of each node in both the X and Y directions of the matrix due to the approach of an object is converted to a set of voltages in the X and Y directions. These voltages are processed by digital circuitry to develop electrical signals representative of the centroid of the profile of the object, i.e., its position in the X and Y dimensions. Noise reduction and background level setting techniques inherently available in the architecture are employed.

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SPECIFICATION

Title Of The Invention

Object Position Detector

Background Of The Invention

1. Field Of The Invention

The present invention relates to object position sensing transducers and systems. More particularly, the present invention relates to object position recognition useful in applications such as cursor movement for computing devices and other applications.

2. The Prior Art

Numerous devices are available or have been proposed for use as object position detectors for use in computer systems and other applications. The most familiar of such devices is the computer "mouse". While extremely popular as a position indicating device, a mouse has mechanical parts and requires a surface upon which to roll its position ball. Furthermore, a mouse usually needs to be moved over long distances for reasonable resolution. Finally, a mouse requires the user to lift a hand from the keyboard to make the cursor movement, thereby upsetting the prime purpose, which is usually typing on the computer.

Trackball devices are similar to mouse devices. A major difference, however is that, unlike a mouse device, a trackball device does not require a surface across which it must be rolled. Trackball devices are still expensive, have moving parts, and require a relatively heavy touch as do the mouse devices. They are also large in size and doe not fit well in a volume-sensitive application like a laptop computer.

There are several available touch-sense technologies which may be employed for use as a position indicator. Resistive-membrane position sensors are known and used in several applications. However, they generally suffer from poor resolution, the sensor surface is exposed to the user and is thus subject to wear. In addition, resistive-membrane touch sensors are relatively expensive. A one-surface approach requires a user to be grounded to the sensor for reliable operation. This cannot be guaranteed in portable computers. An example of a one-surface approach is the UnMouse product by MicroTouch, of Wilmington, MA A two-surface approach has poorer resolution and potentially will wear out very quickly in time.

Resistive tablets are taught by United States Patent No. 4,680,430 to Yoshikawa, United States Patent No. 3,497,617 to Ellis and many others. The drawback of all such approaches is the high power consumption and the high cost of the resistive membrane employed.

Surface Acoustic Wave (SAW) devices have potential use as position indicators. However, this sensor technology is expensive and is not sensitive to light touch. In addition, SAW devices are sensitive to residue buildup on the touch surfaces and generally have poor resolution.

Strain gauge or pressure plate approaches are an interesting position sensing technology, but suffer from several drawbacks. This approach may employ piezo-electric transducers. One drawback is that the piezo phenomena is an AC phenomena and may be sensitive to the user's rate of movement. In addition, strain gauge or pressure plate approaches are somewhat expensive because special sensors are required.

Optical approaches are also possible but are somewhat limited for several reasons. All would require light generation which will require external components and increase cost and power drain. For example, a "finger-breaking" infra-red matrix position detector consumes high power and suffers from relatively poor resolution.

There have been numerous attempts to provide a device for sensing the position of a thumb or other finger for use as a pointing device to replace a mouse or trackball. Desirable attributes of such a device are low power, low profile, high resolution, low cost, fast response, and ability to operate reliably when the finger carries electrical noise, or when the touch surface is contaminated with dirt or moisture.

Because of the drawbacks of resistive devices, many attempts have been made to provide pointing capability based on capacitively sensing the position of the finger. United States Patent No. 3,921,166 to Volpe teaches a capacitive matrix in which the finger changes the transcapacitance between row and column electrodes. United States Patent No. 4,103,252 to Bobick employs four oscillating signals to interpolate x and y positions between four capacitive electrodes. United States Patent No. 4,455,452 to Schuyler teaches a capacitive tablet wherein the finger attenuates the capacitive coupling between electrodes.

United States Patent No. 4,550,221 to Mabusth teaches a capacitive tablet wherein the effective capacitance to "virtual ground" is measured by an oscillating signal. Each row or column is polled sequentially, and a rudimentary form of interpolation is applied to resolve the position between two rows or columns. An attempt is made to address the problem of electrical interference by averaging over many cycles of the oscillating waveform. The problem of contamination is addressed by sensing when no finger was present, and applying a periodic calibration during such no-finger-present periods. United States Patent No. 4,639,720 to Rympalski teaches a tablet for sensing the position of a stylus. The stylus alters the transcapacitance coupling between row and column electrodes, which are scanned sequentially. United States Patent No. 4,736,191 to Matzke teaches a radial electrode arrangement under the space bar of a keyboard, to be activated by touching with a thumb. This patent teaches the use of total touch capacitance, as an indication of the touch pressure, to control the velocity of cursor motion. Pulsed sequential polling is employed to address the effects of electrical interference.

United States Patent Nos. 4,686,332 and 5,149,919, to Greanias, teaches a stylus and finger detection system meant to be mounted on a CRT. As a finger detection system, it's X/Y sensor matrix is used to locate the two matrix wires carrying the maximum signal. With a coding scheme these two wires uniquely determine the location of the finger position to the resolution of the wire stepping. For stylus detection, Greanias first coarsely locates it, then develops a virtual dipole by driving all lines on one side of the object in one direction and all lines on the opposite side in the opposite direction. This is done three times with different dipole phases and signal polarities. Assuming a predetermined matrix response to the object, the three measurements present a set of simultaneous equations that can be solved for position.

United States Patent No. 4,733,222 to Evans is the first to teach a capacitance touch measurement system that interpolates to a high degree. Evans teaches a three terminal measurement system that uses a drive, sense and electrode signal set (3 signals) in its matrix, and bases the measurement on the attenuation effect of a finger on the electrode node signal (uses a capacitive divider phenomena). Evans sequentially scans through each drive set to measure the capacitance. From the three largest responses an interpolation routine is applied to determine finger position. Evans also teaches a zeroing technique that allows "no-finger" levels to be cancelled out as part of the measurement.

United States Patent No. 5,016,008 to Gruaz describes a touch sensitive pad that also uses interpolation. Gruaz uses a drive and sense signal set (2 signals) in the touch matrix and like Evans relies on the attenuation effect of a finger to modulate the drive signal. The touch matrix is sequentially scanned to read the response of each matrix line. An interpolation program then selects the two largest adjacent signals in both dimensions to determine the finger location, and ratiometrically determines the effective position from those 4 numbers.

Gerpheide, PCT application US90/04584, publication No. W091/03039, United States Patent No. 5,305,017 applies to a touch pad system a variation of the virtual dipole approach of Greanias. Gerpheide teaches the application of an oscillating potential of a given frequency and phase to all electrodes on one side of the virtual dipole,and an oscillating potential of the same frequency and opposite phase to those on the other side. Electronic circuits develop a "balance signal" which is zero when no finger is present, and which has one polarity if a finger is on one side of the center of the virtual dipole, and the opposite polarity if the finger is on the opposite side. To acquire the position of the finger initially, the virtual dipole is scanned sequentially across the tablet. Once the finger is located, it is "tracked" by moving the virtual dipole toward the finger once the finger has moved more than one row or column.

Because the virtual dipole method operates by generating a balance signal that is zero when the capacitance does not vary with distance, it only senses the perimeter of the finger contact area, rather than the entire contact area. Because the method relies on synchronous detection of the exciting signal, it must average for long periods to reject electrical interference, and hence it is slow. The averaging time required by this method, together with the necessity to search sequentially for a new finger contact once a previous contact is lost, makes this method, like those before it, fall short of the requirements for a fast pointing device that is not affected by electrical interference.

It should also be noted that all previous touch pad inventions that used interpolation placed rigorous design requirements on their sensing pad. Greanias and Evans use a complicated and expensive drive, sense and electrode line scheme to develop their signal. Gruaz and Gerpheide use a two signal drive and sense set. In the present invention the driving and sensing is done on the same line. This allows the row and column sections to be symmetric and equivalent. This in turn allows independent calibration of all signal paths, which makes board layout simpler and less constraining, and allows for more unique sensor topologies.

The shortcomings of the inventions and techniques described in the prior art can also be traced to the use of only one set of driving and sensing electronics, which was multiplexed sequentially over the electrodes in the tablet. This arrangement was cost effective in the days of discrete components, and avoided offset and scale differences among circuits.

The sequential scanning approach of previous systems also made them more susceptible to noise. Noise levels could change between successive measurements, thus changing the measured signal and the assumptions used in interpolation routines.

Finally, all previous approaches assumed a particular signal response for finger position versus matrix position. Because the transfer curve is very sensitive to many parameters and is not a smooth linear curve as Greanias and Gerpheide assume, such approaches are limited in the amount of interpolation they can perform.

In prior co-pending application serial No. 08/115,743, filed August 31, 1993, now United States Patent No. ___________, a two-dimensional capacitive sensing system equipped with a separate set of drive/sense electronics for each row and for each column of a capacitive tablet is disclosed. All row electrodes are sensed simultaneously, and all column electrodes are sensed simultaneously. The sensed signals are processed by analog circuitry.

It is thus an object of the present invention to provide a two-dimensional capacitive sensing system equipped with a separate set of drive/sense electronics for each row and for each column of a capacitive tablet, wherein all row electrodes are sensed simultaneously, and all column electrodes are sensed simultaneously.

It is a further object of the present invention to provide an electronic system that is sensitive to the entire area of contact of a finger or other conductive object with a capacitive tablet, and to provide as output the coordinates of some measure of the center of this contact area while remaining insensitive to the characteristic profile of the object being detected.

It is a further object of the present invention to provide an electronic system that provides as output some measure of area of contact of a finger or other conductive object with a capacitive tablet.

Yet another object of the present invention is to provide a two-dimensional capacitive sensing system equipped with a separate set of drive/sense electronics for each row and for each column of a capacitive tablet, wherein all row electrodes are sensed simultaneously, and all column electrodes are sensed simultaneously and wherein the information defining the location of a finger or other conductive object is processed in digital form.

It is a further object of the present invention to provide a two-dimensional capacitive sensing system wherein all row electrodes are sensed simultaneously, and all column electrodes are sensed simultaneously and wherein digital electronic processing is employed efficiently to define the location of a finger or other conductive object.

Brief Description Of The Invention

With the advent of very high levels of integration, it has become possible to integrate many channels of driving/sensing electronics into one integrated circuit, along with the control logic for operating them, and the interface electronics to allow the pointing device to communicate directly with a host microprocessor. The present invention uses adaptive analog techniques to overcome offset and scale differences between channels, and can thus sense either transcapacitance or self-capacitance of all tablet rows or columns in parallel. This parallel-sensing capability, made possible by providing one set of electronics per row or column, allows the sensing cycle to be extremely short, thus allowing fast response while still maintaining immunity to very high levels of electrical interference.

The present invention comprises a position-sensing technology particularly useful for applications where finger position information is needed, such as in computer "mouse" or trackball environments. However the position-sensing technology of the present invention has much more general application than a computer mouse, because its sensor can detect and report if one or more points are being touched. In addition, the detector can sense the pressure of the touch.

According to a preferred embodiment of the present invention, referred to herein as a "finger pointer" embodiment, a position sensing system includes a position sensing transducer comprising a touch-sensitive surface disposed on a substrate, such as a printed circuit board, including a matrix of conductive lines. A first set of conductive lines runs in a first direction and is insulated from a second set of conductive lines running in a second direction generally perpendicular to the first direction. An insulating layer is disposed over the first and second sets of conductive lines. The insulating layer is thin enough to promote significant capacitive coupling between a finger placed on its surface and the first and second sets of conductive lines.

Sensing electronics respond to the proximity of a finger, conductive object, or an object of high dielectric constant (i.e., greater than about 5) to translate the capacitance changes of the conductors caused by object proximity into digital information which is processed to derive position and touch pressure information. Its output is a simple X, Y and pressure value of the one object on its surface. In all descriptions herein, fingers are to be considered interchangable with conductive objects and objects of high dielectric constant.

Different prior art pad scan techniques have different advantages in different environments. Parallel drive/sense techniques according to the present invention allow input samples to be taken simultaneously, thus all channels are affected by the same phase of an interfering electrical signal, greatly simplifying the signal processing and noise filtering.

There are two drive/sense methods employed in the touch sensing technology of the present invention. According to a first and presently preferred embodiment of the invention, the voltages on all of the X lines of the sensor matrix are simultaneously moved, while the voltages of the Y lines are held at a constant voltage, with the complete set of sampled points simultaneously giving a profile of the finger in the X dimension. Next, the voltages on all of the Y lines of the sensor matrix are simultaneously moved, while the voltages of the X lines are held at a constant voltage to obtain a complete set of sampled points simultaneously giving a profile of the finger in the other dimension.

According to a second drive/sense method, the voltages on all of the X lines of the sensor matrix are simultaneously moved in a positive direction, while the voltages of the Y lines are moved in a negative direction. Next, the voltages on all of the X lines of the sensor matrix are simultaneously moved in a negative direction, while the voltages of the Y lines are moved in a positive direction. This technique doubles the effect of any transcapacitance between the two dimensions, or conversely, halves the effect of any parasitic capacitance to ground. In both methods, the capacitive information from the sensing process provides a profile of the proximity of the finger to the sensor in each dimension.

Both embodiments then take these profiles and derive a digital value representing the centroid for X and Y position and derive a second digital value for the Z pressure information. The digital information may be directly used by a host computer.

The position sensor of these embodiments can only report the position of one object on its sensor surface. If more than one object is present, the position sensor of this embodiment computes the centroid position of the combined set of objects. However, unlike prior art, because the entire pad is being profiled, enough information is available to discern simple multi-finger gestures to allow for a more powerful user interface.

According to another aspect of the present invention, several power reduction techniques which can shut down the circuit between measurements have been integrated into the system. This is possible because the parallel measurement technique according to the present invention is so much faster than prior art techniques.

According to a further aspect of the invention, a variety of noise reduction techniques are integrated into the system.

According to yet another aspect of the present invention, a capacitance measurement technique which is easier to calibrate and implement is employed.

Brief Description Of The Drawings

Figure 1 is an overall block diagram of the capacitive position sensing system of the present invention.

Figure 2a is a top view of an object position sensor transducer according to a presently preferred embodiment of the invention showing the object position sensor surface layer including a top conductive trace layer and conductive pads connected to a bottom trace layer.

Figure 2b is a bottom view of the object position sensor transducer of FIG. 2a showing the bottom conductive trace layer.

Figure 2c is a composite view of the object position sensor transducer of FIGS. 2a and 2b showing both the top and bottom conductive trace layers.

Figure 2d is a cross-sectional view of the object position sensor transducer of FIGS. 2a-2c.

Figure 3 is a block diagram of sensor decoding electronics which may be used with the sensor transducer in accordance with a preferred embodiment of the present invention.

Figure 4a is a simplified schematic diagram of a charge integrator circuit which may be used in the present invention.

Figure 4b is an illustrative schematic diagram of the charge integrator circuit of FIG. 4a.

Figure 5 is a timing diagram of the operation of charge integrator circuit of FIGS. 4a and 4b.

Figure 6 is a schematic diagram of an illustrative filter and sample/hold circuit for use in the present invention.

Figure 7 is a more detailed block diagram of a presently preferred arrangement of A/D converters for use in the present invention.

Figure 8 is a block diagram of an illustrative arithmetic unit which may be used in the present invention.

Figure 9 is a block diagram of a calibration unit which may be used with the arithmetic unit of Figure 8.

Figure 10 is a schematic diagram of a bias voltage generating circuit useful in the present invention.

Detailed Description Of A Preferred Embodiment

This application is a continuation-in-part of co-pending application serial No. 08/115,743, filed August 31, 1993, now United States Patent No. ___________, which is a continuation-in-part of co-pending application serial No. 07/895,934, filed June 8, 1992. The present invention continues the approach disclosed in the parent applications and provides more unique features not previously available. These improvements provide a more easily integrated solution, increased sensitivity, and greater noise rejection, increased data acquisition rate and decreased power consumption. Additionally, the present invention allows for continuous self calibration to subtract out the effects of environmental changes.

Those of ordinary skill in the art will realize that the following description of the present invention is illustrative only and not in any way limiting. Other embodiments of the invention will readily suggest themselves to such skilled persons.

The present invention brings together in combination a number of unique features which allow for new applications not before possible. Because the object position sensor of the present invention has very low power requirements, it is beneficial for use in battery operated or low power applications such as lap top or portable computers . It is also a very low cost solution, has no moving parts (and is therefore virtually maintenance free), and uses the existing printed circuit board traces for sensors. The sensing technology of the present invention can be integrated into a computer motherboard to even further lower its cost in computer applications. Similarly, in other applications the sensor can be part of an already existent circuit board.

Because of its small size and low profile, the sensor technology of the present invention is useful in lap top or portable applications where volume is an important consideration. The sensor technology of the present invention requires circuit board space for only a single sensor interface chip that can interface directly to a microprocessor, plus the area needed on the printed circuit board for sensing.

Referring first to FIG. 1, a simplified block diagram of the capacitive position sensing system 10 of the present invention is presented. Capacitive position sensing system 10 can accurately determine the position of a finger 12 or other conductive object proximate to or touching a sensing plane 14. The capacitance of a plurality of conductive lines running in a first direction (e.g., "X") is sensed by X input processing circuitry 16 and the capacitance of a plurality of conductive lines running in a second direction (e.g., "Y") is sensed by Y input processing circuitry 18. The sensed capacitance values are digitized in both X input processing circuitry 16 and Y input processing circuitry 18. The outputs of X input processing circuitry 16 and Y input processing circuitry 18 are presented to arithmetic unit 20, which uses the digital information to derive digital information representing the position and pressure of the finger 12 or other conductive object relative to the sensing plane 14.

The sensor material can be anything that allows creation of a conductive X/Y matrix of pads. This includes not only standard PC boards, but also includes but is not limited to flexible PC boards, conductive elastomer materials, silk-screened conductive lines, and piezo-electric Kynar plastic materials. This renders it useful as well in any portable equipment application or in human interface where the sensor needs to be molded to fit within the hand.

The sensor can be conformed to any three dimensional surface. Copper can be plated in two layers on most any surface contour producing the sensor. This will allow the sensor to be adapted to the best ergonomic form needed for any particular application. This coupled with the "light-touch" feature will make it effortless to use in many applications. The sensor can also be used in an indirect manner, i.e it can have an insulating foam material covered by a conductive layer over the touch sensing surface and be used to detect any object (not just conductive) that presses against it's surface.

Small sensor areas are practical, i.e., a presently conceived embodiment takes about 1.5"x 1.5" of area, however those of ordinary skill in the art will recognize that the area is scaleable for different applications. The matrix area is scalable by either varying the matrix trace spacing or by varying the number of traces. Large sensor areas are practical where more information is needed.

Besides simple X and Y position information, the sensor technology of the present invention also provides finger pressure information. This additional dimension of information may be used by programs to control special features such as "brush-width" modes in Paint programs, special menu accesses, etc., allowing provision of a more natural sensory input to computers. It has also been found useful for implementing "mouse click and drag" modes and for simple input gestures.

The user will not even have to touch the surface to generate the minimum reaction. This feature can greatly minimize user strain and allow for more flexible use.

The sense system of the present invention depends on a transducer device capable of providing position and pressure information regarding the object contacting the transducer. Referring now to FIGS. 2a-2d, top, bottom, composite, and cross-sectional views, respectively, are shown of a presently-preferred sensing plane 14 comprising a touch sensor array 22 for use in the present invention. Since capacitance is exploited by this embodiment of the present invention, the surface of touch sensor array 22 is designed to maximize the capacitive coupling to a finger or other conductive object.

A presently preferred touch sensor array 22 according to the present invention comprises a substrate 24 including a set of first conductive traces 26 disposed on a top surface 28 thereof and run in a first direction to comprise row positions of the array. A second set of conductive traces 30 are disposed on a bottom surface 32 thereof and run in a second direction preferably orthogonal to the first direction to form the column positions of the array. The top and bottom conductive traces 26 and 30 are alternately in contact with periodic sense pads 34 comprising enlarged areas, shown as diamonds in FIGS. 2a-2c. While sense pads 34 are shown as diamonds in FIGS. 2a-2c, any shape, such as circles, which allows them to be closely packed is equivalent for purposes of this invention. As an arbitrary convention herein, the first conductive traces 26 will be referred to as being oriented in the "X" or "row" direction and may be referred to herein sometimes as "X lines" and the second conductive traces 30 will be referred to as being oriented in the "Y" or "column" direction and may be referred to herein sometimes as "Y lines".

The number and spacing of these sense pads 34 depends upon the resolution desired. For example, in an actual embodiment constructed according to the principles of the present invention, a 0.10 inch center-to-center diamond-shaped pattern of conductive pads disposed along a matrix of 15 rows and 15 columns of conductors is employed. Every other sense pad 34 in each direction in the pad pattern is connected to conductive traces on the top and bottom surfaces 28 and 32, respectively of substrate 24.

Substrate 24 may be a printed circuit board, a flexible circuit board or any of a number of available circuit interconnect technology structures. Its thickness is unimportant as long as contact may be made therethrough from the bottom conductive traces 30 to their sense pads 34 on the top surface 28. The printed circuit board comprising substrate 24 can be constructed using standard industry techniques. Board thickness is not important. Connections from the conductive pads 34 to the bottom traces 30 may be made employing standard plated-through hole techniques well known in the printed circuit board art.

In an alternate embodiment of the present invention, the substrate material 24 may have a thickness on the order of 0.005 to 0.010 inches. Then the diamonds on the upper surface 28 and the plated through holes that connect to the lower surface traces 30, can be omitted, further reducing the cost of the system.

An insulating layer 36 is disposed over the sense pads 34 on top surface 28 to insulate a human finger or other object therefrom. Insulating layer 36 is preferably a thin layer (i.e., approximately 5 mils) to keep capacitive coupling large and may comprise a material, such as mylar, chosen for its protective and ergonomic characteristics. The term "significant capacitive coupling" as used herein shall mean capacitive coupling having a magnitude greater than about 0.5 pF.

There are two different capacitive effects taking place when a finger approaches the touch sensor array 22. The first capacitive effect is trans-capacitance, or coupling between sense pads 34, and the second capacitive effect is self-capacitance, or coupling to virtual ground. Sensing circuitry is coupled to the sensor array 22 of the present invention and responds to changes in either or both of these capacitances. This is important because the relative sizes of the two capacitances change greatly depending on the user environment. The ability of the present invention to detect changes in both self capacitance and trans-capacitance results in a very versatile system having a wide range of applications.

According to the preferred embodiment of the invention, a position sensor system including touch sensor array 22 and associated position detection circuitry will detect a finger position on a matrix of printed circuit board traces via the capacitive effect of finger proximity to the sensor array 22. The position sensor system will report the X, Y position of a finger placed near the sensor array 22 to much finer resolution than the spacing between the row and column traces 26 and 30. The position sensor according to this embodiment of the invention will also report a Z value proportional to the outline of that finger and hence indicative of the pressure with which the finger contacts the surface of insulating layer 36 over the sensing array 22.

According to the presently preferred embodiment of the invention, a very sensitive, light-touch detector circuit may be provided using adaptive analog and digital VLSI techniques. The circuit of the present invention is very robust and calibrates out process and systematic errors. The detector circuit of the present invention will process the capacitive input information and provide digital information which may be presented directly to a microprocessor.

According to this embodiment of the invention, sensing circuitry is contained on a single sensor processor integrated circuit chip. The sensor processor chip can have any number of X and Y "matrix" inputs. The number of X and Y inputs does not have to be equal. The Integrated circuit has a digital bus as output. In the illustrative example disclosed in FIGS. 2a-2d herein, the sensor array has 15 traces in both the X and Y directions. The sensor processor chip thus has 15 X inputs and 15 Y inputs. An actual embodiment constructed according to the principles of the present invention employed 18 traces in the X direction and 24 traces in the Y direction. Those of ordinary skill in the art will recognize that the size of the sensing matrix which may be employed in the present invention is arbitrary and will be dictated largely by design choice.

The X and Y matrix nodes are driven and sensed in parallel, with the capacitive information from each line indicating how close a finger is to that node. The scanned information provides a profile of the finger proximity in each dimension. According to this aspect of the present invention, the profile centroid is derived in both the X and Y directions and is the position in that dimension. The profile curve of proximity is also integrated to provide the Z information.

There are two drive and sense methods employed in the touch sensing technology of the present invention. According to a first and presently preferred embodiment of the invention, the voltages on all of the X lines of the sensor matrix are simultaneously moved, while the voltages of the Y lines are held at a constant voltage. Next, the voltages on all of the Y lines of the sensor matrix are simultaneously moved, while the voltages of the X lines are held at a constant voltage. This scanning method accentuates the measurement of capacitance to virtual ground provided by the finger. Those of ordinary skill in the art will recognize that order of these two steps is somewhat arbitrary and may be reversed.

According to a second drive/sense method, the voltages on all of the X lines of the sensor matrix are simultaneously moved in a positive direction, while the voltages of the Y lines are moved in a negative direction. Next, the voltages on all of the X lines of the sensor matrix are simultaneously moved in a negative direction, while the voltages of the Y lines are moved in a positive direction. This second drive/sense method accentuates transcapacitance and de-emphasizes virtual ground capacitance. As with the first drive/sense method, those of ordinary skill in the art will recognize that order of these two steps is somewhat arbitrary and may be reversed.

Referring now to FIG. 3, a block diagram of the presently preferred sensing circuitry 40 for use according to the present invention is presented. This block diagram, and the accompanying disclosure, relates to the sensing circuitry in one dimension (X) only, and includes the X input processing circuitry 16 of FIG. 1. Those of ordinary skill in the art will appreciate that an identical circuit would be used for sensing the opposite (Y) dimension and would include the Y input processing circuitry 18 of FIG. 1. Such skilled persons will further note that the two dimensions do not need to be orthogonal to one another. For example, they can be radial or of any other nature to match the contour of the touch sensor array and other needs of the system. Those of ordinary skill in the art will recognize that the technology disclosed herein could be applied as well to a one-dimensional case where only one set of conductive traces is used.

The capacitance at each sensor matrix node is represented by equivalent capacitors 42-1 through 42-n. The capacitance of capacitors 42-1 through 42-n comprises the capacitance of the matrix conductors and has a characteristic background value when no object (e.g., a finger) is proximate to the sensing plane of the sensor matrix. As an object approaches the sensing plane the capacitance of capacitors 42-1 through 42-n increases in proportion to the size and proximity of the object.

According to the present invention, the capacitance at each sensor matrix node is measured simultaneously using charge integrator circuits 44-1 through 44-n. Charge-integrator circuits 44-1 through 44-n serve to inject charge into the capacitances 42-1 through 42-n, respectively, and to develop an output voltage proportional to the capacitance sensed on the corresponding X matrix line. Thus charge-integrator circuits 44-1 through 44-n are shown as bidirectional amplifier symbols. Each charge-integrator circuit 44-1 through 44-n is supplied with an operating bias voltage by bias-voltage generating circuit 46.

As used herein, the phrase "proportional to the capacitance" means that the voltage signal generated is a monotonic function of the sensed capacitance. In the embodiment described herein, the voltage is directly and linearly proportional to the capacitance sensed. Those of ordinary skill in the art will recognize that other monotonic functions, including but not limited to inverse proportionality, and non-linear proportionality such as logarithmic or exponential functions, could be employed in the present invention without departing from the principles disclosed herein. In addition current-sensing as well as voltage-sensing techniques could be employed.

According to a presently preferred drive/sense method used in the present invention, the capacitance measurements are performed simultaneously across all inputs in one dimension to overcome a problem which is inherent in all prior art approaches that scan individual inputs. The problem with the prior-art approach is that it is sensitive to high frequency and large amplitude noise (large dv/dt noise) that is coupled to the circuit via the touching object. Such noise may distort the finger profile because of noise appearing in a later scan cycle but not an earlier one, due to a change in the noise level.

The present invention overcomes this problem by "taking a snapshot" of all inputs simultaneously in X and then Y directions (or visa versa). Because the injected noise is proportional to the finger signal strength across all inputs, it is therefore symmetric around the finger centroid. Because it is symmetric around the finger centroid it does not affect the finger position. Additionally, the charge amplifier performs a differential measuring function to further reject common-mode noise.

Because of the nature of the charge integrator circuits 44-1 through 44-n, their outputs will be changing over time and will have the desired voltage output for only a short time. As presently preferred, filter circuits 48-1 through 48-n are implemented as sample and hold switched capacitor filters.

The desired voltage is captured by the filter circuits 48-1 through 48-n. As controlled by control circuitry, 56, the filter circuits 48-1 through 48-n will filter out any high frequency noise from the sensed signal. This is accomplished by choosing the capacitor for the filter to be much larger than the output capacitiance of charge integrator circuits 44-1 through 44-n. In addition, those of ordinary skill in the art will recognize that the switched capacitor filter circuits 48-1 through 48-n will capture the desired voltages and store them.

According to the present invention, the capacitance information obtained in voltage form from the capacitance measurements is digitized and processed in digital format. Accordingly, the voltages stored by filter circuits 48-1 through 48-n are stored in sample/hold circuits 50-1 through 50-n so that the remainder of the circuitry processes input data taken at the same time. Sample/hold circuits 50-1 through 50-n may be configured as conventional sample/hold circuits as is well known in the art.

The sampled analog voltages at the outputs of sample/hold circuits 50-1 through 50-n are digitized by analog-to-digital (A/D) converters 52. As presently preferred, A/D converters 52 resolve the input voltage to a 10-bit wide digital signal (a resolution of one part in 1,024), although those of ordinary skill in the art will realize that other resolutions may be employed. A/D converters 52 may be conventional successive approximation type converters as is known in the art.

Given the charge integrator circuitry employed in the present invention, the background level (no object present) of the charge integrator outputs will be about 1 volt. The ΔV resulting from the presence of a finger or other object will typically be about 0.4 volt. The voltage range of the A/D converters 52 should therefore be in the range of between about 1-2 volts.

An important consideration is the minimum and maximum voltage reference points for the A/D converters (V_{min} and V_{max}). It has been found that noise will cause position jitter if these reference voltages are fixed points. A solution to this problem which is employed in the present invention is to dynamically generate the V_{min} and V_{max} reference voltages from reference capacitances 42-Vmin and 42-Vmax, sensed by charge integrator circuits 44-Vmin and 44-Vmax and processed by filter circuits 48-Vmin and 48-Vmax and stored in sample/hold circuits 50-Vmin and 50-Vmax. In this manner, any common mode noise present when thc signals are sampled from the sensor array will also be present in the V_{min} and V_{max} reference voltage values and will tend to cancel. Those of ordinary skill in the art will realize that reference capacitances 44-Vmin and 44-Vmax may either be discrete capacitors or extra traces in the sensor array.

According to the present invention, the V_{min} reference voltage is generated from a capacitor having a value equal to the lowest capacitance expected to be encountered in the sensor array with no object present (about 12pF assuming a 2 inch square sensor array). The V_{max} reference voltage is generated from a capacitor having a value equal to the largest capacitance expected to be encountered in the sensor array with an object present (about 16pF assuming a 2 inch square sensor array).

The outputs of A/D converters 52 provide inputs to arithmetic unit 20. As will be more fully disclosed with reference to FIG. 8, the function of arithmetic unit 20 is to compute the weighted average of the signals on the individual sense lines in both the X and Y directions in the touch sensor array 22. Thus, arithmetic unit 20 is shared by the X input processing circuitry 16 and the Y input processing circuitry 18 as shown in FIG. 1.

Control circuitry 56 of FIG. 3 orchestrates the operation of the remainder of the circuitry. Because the system is discretely sampled and pipelined in its operation, control circuitry 56 is present to manage the signal flow. The functions performed by control circuitry 56 may be conventionally developed via what is commonly known in the art as a state machine or microcontroller.

The structure and operation of the individual blocks of FIG. 3 will now be disclosed. Referring now to FIGS. 4a, 4b, and 5, a typical charge integrator circuit will be described. Charge integrator circuit 44 is shown as a simplified schematic diagram in FIG. 4a and as an illustrative schematic diagram in FIG. 4b. The timing of the operation of charge integrator circuit 44 is shown in FIG. 5. These timing signals are provided by the controller block 56.

Charge integrator circuit 44 is based on the fundamental physical phenomena of using a current to charge a capacitor. If the capacitor is charged for a constant time by a constant current, then a voltage will be produced on the capacitor which is inversely proportional to the capacitance. The capacitance to be charged is the sensor matrix line capacitance 42 in parallel with an internal capacitor. This internal capacitor will contain the voltage of interest.

Referring now to FIG. 4a, a simplified schematic diagram of an illustrative charge integrator circuit 44 is shown. A charge integrator circuit input node 60 is connected to one of the X (or Y) lines of the sensor matrix. A first shorting switch 62 is connected between the charge integrator circuit input node 60 and V_{DD}, the positive supply rail. A second shorting switch 64 is connected between the charge integrator circuit input node 60 and ground, the negative supply rail. A positive constant current source 66 is connected to V_{DD}, the positive supply rail and to the charge integrator circuit input node 60 and through a first current source switch 68. A negative constant current source 70 is connected to ground and to the charge integrator circuit input node 60 and through a second current source switch 72. It is obvious that other high and low voltage rails could be used in place of V_{DD} and ground.

A first internal capacitor 74 is connected between V_{DD} and output node 76 of charge integrator circuit 44. A positive voltage storage switch 78 is connected between output node 76 and input node 60. A second internal capacitor 80 has one of its plates connected to ground through a switch 82 and to output node 76 of charge integrator circuit 44 through a switch 84, and the other one of its plates connected to input node 60 through a negative voltage storage switch 86 and to V_{DD} through a switch 88. The capacitance of first and second internal capacitances 74 and 80 should be a small fraction (i.e., about 10%) of the capacitance of the individual sensor matrix lines. In a typical embodiment, the sensor matrix line capacitance will be about 10pF and the capacitance of capacitors 74 and 80 should be about 1pF.

According to the presently preferred embodiment of the invention, the approach used is a differential measurement for added noise immunity, the benefit of which is that any low frequency common mode noise gets subtracted out. For the following discussion, it is to be assumed that all switches are open unless they are noted as closed. First, the sensor matrix line is momentarily shorted to V_{DD} through switch 62, switch 78 is closed connecting capacitor 74 in parallel with the capacitance of the sensor line. Then the parallel capacitor combination is discharged with a constant current from current source 70 through switch 72 for a fixed time period. At the end of the fixed time period, switch 78 is opened, thus storing the voltage on the sensor matrix line on capacitor 74.

The sensor line is then momentarily shorted to ground through switch 64, and switches 82 and 86 are closed to place capacitor 80 in parallel with the capacitance of the sensor line. Switch 68 is closed and the parallel capacitor combination is charged with a constant current from current source 66 for a fixed time period equal to the fixed time period of the first cycle. At the end of the fixed time period, switch 86 is opened, thus storing the voltage on the sensor matrix line on capacitor 80.

The first and second measured voltages are then averaged. This is accomplished by opening switch 82 and closing switches 88 and 84, which places capacitor 80 in parallel with capacitor 74. Because capacitors 74 and 80 have the same capacitance, the resulting voltage across them is equal to the average of the voltages across each individually. This final result is the value that is then passed on to the appropriate one of filter circuits 48-1 through 48-n.

The low frequency noise, notably 50/60 Hz and their harmonics, behaves as a DC current component that adds in one measurement and subtracts in the other. When the two results are added together that noise component averages to zero. The amount of noise rejection is a function of how quickly in succession the two opposing charge-up and charge-down cycles are performed as will be disclosed herein. One of the reasons for the choice of this charge integrator circuit is that it allows measurements to be taken quickly.

Referring now to FIG. 4b, a more complete schematic diagram of an illustrative embodiment of charge integrator circuit 44 of the simplified diagram of FIG. 4a is shown. Input node 60 is shown connected to V_{DD} and ground through pass gates 90 and 92, which replace switches 62 and 64 of FIG. 4a. Pass gate 90 is controlled by a signal **ResetUp** presented to its control input and pass gate 92 is controlled by a signal **ResetDn** presented to its control input. Those of ordinary skill in the art will recognize that pass gates 90 and 92, as well as all of the other pass gates which are represented by the same symbol in FIG. 4b may be conventional CMOS pass gates as are known in the art. The convention used herein is that the pass gate will be off when its control input is held low and will be on and present a low impedance connection when its control input is held high.

P-Channel MOS transistors 94 and 96 are configured as a current mirror. P-Channel MOS transistor 94 serves as the current source 66 and pass gate 98 serves as switch 68 of FIG. 4a. The control input of pass gate 98 is controlled by a signal **StepUp**.

N-Channel MOS transistors 100 and 102 are also configured as a current mirror. N-Channel MOS transistor 100 serves as the current source 70 and pass gate 104 serves as switch 72 of FIG. 4a. The control input of pass gate 104 is controlled by a signal **StepDn**. P-Channel MOS transistor 106 and N-Channel MOS transistor 108 are placed in series with P-Channel MOS current mirror transistor 96 and N-Channel MOS current mirror transistor 102. The control gate of P-Channel MOS transistor 106 is driven by an enable signal **EN**, which turns on P-Channel MOS transistor 106 to energize the current mirrors. This device is used as a power conservation device so that the charge integrator circuit 44 may be turned off to conserve power when it is not in use.

N-Channel MOS transistor 108 has its gate driven by a reference voltage **Vbias**, which sets the current through current mirror transistors 96 and 108. The voltage **Vbias** is set by a servo feedback circuit as will be disclosed in more detail with reference to FIG. 10. Those of ordinary skill in the art will appreciate that this embodiment allows calibration to occur in real time (via long time constant feedback) thereby zeroing out any long term effects due to sensor environmental changes. In a current embodiment of the invention, **Vbias** is common for all charge integrator circuits 44-1 through 44-n and 44-Vmax and 44-Vmin.

Note that proper sizing of MOS transistors 102 and 108 may provide temperature compensation. This is accomplished by taking advantage of the fact that the threshold of N-Channel MOS transistor 108 reduces with temperature while the mobility of both N-Channel MOS transistors 102 and 108 reduce with temperature. The threshold reduction has the effect of increasing the current while the mobility reduction has the effect of decreasing the current. By proper device sizing these effects can cancel each other out over a significant part of the operating range.

Capacitor 74 has one plate connected to V_{DD} and the other plate connected to the output node 76 and to the input node 60 through pass gate 110, shown as switch 78 in FIG. 4a. The control input of pass gate 110 is driven by the control signal **SUp**. One plate of capacitor 80 is connected to input node 60 through pass gate 112 (switch 86 in FIG. 4a) and to VDD through pass gate 114 (switch 82 in FIG. 4a). The control input of pass gate 112 is driven by the control signal **SDn** and the control input of pass gate 114 is driven by the control signal **ChUp**. The other plate of capacitor 80 is connected to ground through N-Channel MOS transistor 116 (switch 82 in FIG. 4a) and to output node 76 through pass gate 118 (switch 84 in FIG. 4a). The control input of pass gate 118 is driven by control signal **Share**.

Referring now to FIGS. 4a, 4b and the timing diagram of FIG. 5, the operation of charge integrator circuit 44 during one scan cycle may be observed. First the **EN** (enable) control signal goes active by going to 0v. This turns on the current mirrors and energizes the charge and discharge current sources, MOS transistors 94 and 100. The **ResetUp** control signal is active high at this time, which shorts the input node 60 (and the sensor line to which it is connected) to V_{DD}. The **SUp** control signal is also active high at this time which connects capacitor 74 and the output node 76 to input node 60. This arrangement guarantees that the following discharge portion of the operating cycle always starts from a known equilibrium state.

The discharge process starts after **ResetUp** control signal goes inactive. The **StepDn** control signal goes active, connecting MOS transistor 100, the discharge current source, to the input node 60 and its associated sensor line. **StepDn** is active for a set amount of time, and the negative constant current source discharges the combined capacitance of the sensor line and capacitor 74thus lowering its voltage during that time. **StepDn** is then turned off. A short time later the **SUp** control signal goes inactive, storing the measured voltage on capacitor 74. That ends the discharge cycle.

Next, the **ResetDn** control signal becomes active and shorts the sensor line to ground. Simultaneously the **SDn** and **ChDn** control signals become active and connect capacitor 80 between ground and the sensor line. Capacitor 80 is discharged to ground, guaranteeing that the following charge up cycle always starts from a known state.

The charge up cycle starts after **ResetDn** control signal becomes inactive and the **StepUp** control signal becomes active. At this point the current charging source, MOS transistor 94, is connected to the sensor line and supplies a constant surrent to charge the sensor line by increasing the voltage thereon. The **StepUp** control signal is active for a set amount of time (preferably equal to the time for the previously mentioned cycle) allowing the capacitance to charge, and then it is turned off. The **SDn** control signal then goes inactive, leaving the measured voltage across capacitor 80.

The averaging cycle now starts. First the voltage on capacitor 80 is level shifted. This is done by the **ChDn** control signal going inactive, letting one plate of the capacitor 80 float. Then the **ChUp** control signal goes active, connecting the second plate of the capacitor to V_{DD}. Then the **Share** control signal becomes active which connects the first plate of capacitor 80 to output node 76, thus placing capacitors 74 and 80 in parallel. This has the effect of averaging the voltages across the two capacitors, thus subtracting out common-mode noise as previously described. This average voltage is also then available on output node 76.

Those of ordinary skill in the art will recognize that the common-mode noise-cancelling feature inherent in the averaging of the voltages obtained in the discharge and charge cycles is most effective when the two cycles are performed very close together in time. According to the present invention, the **ChDn** and **ChUp** signals should be asserted with respect to each other within a time period much less than a quarter of the period of the noise to be cancelled in order to take advantage of this feature of the present invention.

According to the present invention, two different drive/sense methods have been disclosed. Those of ordinary skill in the art will readily observe that the charge integrator circuit 44 disclosed with reference to FIGS. 4a, 4b, and 5 is adaptable to operate according to either scanning method disclosed herein.

As is clear from an understanding of the operation of charge integrator circuit 44, its output voltage is only available for a short period of time and is subject to environmental noise. In order to minimize the effects of noise, a switched capacitor filter circuit 48 is used. Referring now to FIG. 6, a schematic diagram of an illustrative switched capacitor filter circuit 48 which may be used in the present invention is shown. Those of ordinary skill in the art will recognize this switched capacitor filter circuit, which comprises an input node 120, a pass gate 122 having a control input driven by a **Sample** control signal, a capacitor 124 connected between the output of the pass gate 126 and a fixed voltage such as ground, and an output node comprising the common connection between the capacitor 124 and the output of the pass gate 126. In a typical embodiment, capacitor 116 will have a capacitance of about 10 pF.

As will be appreciated by persons of ordinary skill in the art, the switched capacitor filter 48 is in part a sample/hold circuit and has a filter time constant which is K times the period of sample, where K is the ratio of capacitor 124 to the sum of capacitors 74 and 80 of the charge integrator circuit 44 of FIGS. 4a and 4b to which it is connected. The switched capacitor filter circuit 48 further reduces noise injection in the system. In the preferred embodiment, K = 10/2 = 5. Those of ordinary skill in the art will recognize that other types of filter circuits, such as RC filters, may be employed in the present invention.

Referring now to FIG. 7, a more detailed block diagram of a presently preferred arrangement of A/D converters 52 of FIG. 3 is presented. There are fewer A/D converters than there are lines in the touch sensor array, and the inputs to the A/D converters are multiplexed to share each of the individual A/D converters among several lines in the touch sensor array. The arrangement in FIG. 7 is more efficient in the use of integrated circuit layout area than providing individual A/D converters for each input line.

In the embodiment illustrated in FIG. 7, twenty-four conductive line traces are assumed for the sensor array 10 of FIGS. 2a-2d. As shown in FIG. 7, the outputs of sample/hold circuits 50-1 through 50-24 are fed to the analog data inputs of analog multiplexer 130. Analog multiplexer 130 has six outputs, each of which drives the input of an individual A/D converter 52-1 through 52-6. The internal arrangement of analog multiplexer 130 is such that four different ones of the inputs are multiplexed to each of the outputs. Analog multiplexer 130 has been conceptually drawn as six internal multiplexer blocks 132-1 through 132-6.

In the example shown in FIG. 7, inputs taken from sample/hold circuits 50-1 through 50-4 are multiplexed to the output of internal multiplexer block 132-1 which drives A/D converter 52-1. Similarly, inputs taken from sample/hold circuits 50-5 through 50-8 are multiplexed to the output of internal multiplexer block 132-2 which drives A/D converter 52-2; inputs taken from sample/hold circuits 50-9 through 50-12 are multiplexed to the output of internal multiplexer block 132-3 which drives A/D converter 52-3; inputs taken from sample/hold circuits 50-13 through 50-16 are multiplexed to the output of internal multiplexer block 132-4 which drives A/D converter 52-4; inputs taken from sample/hold circuits 50-17 through 50-20 are multiplexed to the output of internal multiplexer block 132-51 which drives A/D converter 52-5; and inputs taken from sample/hold circuits 50-21 through 50-24 are multiplexed to the output of internal multiplexer block 132-6 which drives A/D converter 52-6.

Analog multiplexer 130 has a set of control inputs schematically represented by bus 134. In the illustrative embodiment shown in FIG. 7, each of internal multiplexers 132-1 through 132-6 are four-input multiplexers and thus control bus 134 may comprise a two-bit bus for a one-of-four selection. Those of ordinary skill in the art will recognize that the arrangement of FIG. 7 is merely one of a number of specific solutions to the task of A/D conversion from twenty-four channels, and that other satisfactory equivalent arrangements are possible.

In a straightforward decoding scheme, multiplexers 132-1 through 132-6 will pass, in sequence, the analog voltages present on their first through fourth inputs on to the inputs of A/D converters 52-1 through 52-6 respectively. After the analog values have settled in the inputs of A/D converters 52-1 through 52-6, a **CONVERT** command is asserted on common A/D control line 136 to begin the A/D conversion process.

When the A/D conversion process is complete, the digital value representing the input voltage is stored in registers 138-1 through 138-6. As presently preferred, registers 138-1 through 138-6 may each comprise a two-word register, so that one word may be read out of the registers to arithmetic unit 54 while a second word is being written into the registers in order to maximize the speed of the system. The design of such registers is conventional in the art.

Referring now to FIG. 8, a more detailed block diagram of the arithmetic unit 20 is presented. Those of ordinary skill in the art will appreciate that arithmetic unit 20 processes information from both the X and Y dimensions, i.e., from X input processing circuit 16 and Y input processing circuit 18 of FIG. 1.

Before disclosing the structural configuration of arithmetic unit 20, it is helpful to understand the preferred method by which the centroid position of an object proximate to the sensor array 22 is determined according to the present invention.

According to a presently preferred embodiment of the invention, the object position in either direction may be determined by evaluating the weighted average of the capacitances measured on the individual sense line of the sensor array 10. In the following discussion, the X direction is used, but those of ordinary skill in the art will recognize that the discussion applies to the determination of the weighted average in the Y direction as well. As is well known, the weighted average may be determined as follows:

$$\text{X position} = \frac{\sum_{i=0}^{n} i \times \Delta C_i}{\sum_{i=0}^{n} \Delta C_i} \qquad \text{[Eq. 1]}$$

where $\Delta C_i = C_i - C0_i$. C_i is the capacitance presently being measured on the ith trace and $C0_i$ is the value measured on that same trace at some past time when no object was present. In terms of these past and present capacitance measurements, the position can be expressed as:

$$\text{Xposition} = \frac{\sum_{i=0}^{n} i \times (C_i - C0_i)}{\sum_{i=0}^{n} (C_i - C0_i)} \qquad \text{[Eq. 2]}$$

Using the distributive property of multiplication over addition, this expression is seen to be equivalent to:

$$\text{Xposition} = \frac{-\sum_{i=0}^{n}(i \times C0i) + \sum_{i=0}^{n}(i \times Ci)}{-\sum_{i=0}^{n}(C0i) + \sum_{i=0}^{n}(Ci)} \qquad \text{[Eq. 3]}$$

where the negative terms in both the numerator and denominator are offsets and represent the background value of the capacitances with no object present. If the term O_N is used to represent the numerator offset and the term O_D is used to represent the denominator offset, Eq. 3 may be re-written as:

$$\text{Xposition} = \frac{-O_N + \sum_{i=0}^{n}(i \times Ci)}{-O_D + \sum_{i=0}^{n}(Ci)} \qquad \text{[Eq. 4]}$$

Referring now to FIG. 8, it may be seen that arithmetic unit 20 includes X numerator and denominator accumulators 150 and 152 and Y numerator and denominator accumulators 154 and 156. The source of operand data for X numerator and denominator accumulators 150 and 152 and Y numerator and denominator accumulators 154 and 156 are the registers 138-1 through 138-6 in each (X and Y) direction of the sensor array 22 of FIG. 1. The X and Y denominator accumulators 152 and 156 sum up the digital results from the A/D conversions. The X and Y numerator accumulators 150 and 154 compute the weighted sum of the input data rather than the straight sum. Accumulators 150, 152, 154, and 156 may be configured as hardware elements or as software running on a microprocessor as will be readily understood by those of ordinary skill in the art.

As may be seen from an examination of FIG. 8, numerator accumulators 150 and 154 compute the expression of Eq. 4:

$$\sum_{i=0}^{n} i \times C_i$$

and denominator accumulators 152 and 156 compute the expression of Eq. 4:

$$\sum_{i=0}^{n} C_i$$

The contents of X and Y numerator and denominator offset registers 158, 160, 162, and 164 are subtracted from the results stored in the accumulators 150, 152, 154, and 156 in adders 166, 168, 170, and 172. Adder 166 subtracts the offset O_{NX} stored in X numerator offset register 158. Adder 168 subtracts the offset O_{DX} stored in X denominator offset register 160. Adder 170 subtracts the offset O_{NY} stored in X numerator offset register 162. Adder 172 subtracts the offset O_{DY} stored in Y denominator offset register 164. The numerator denominator pairs are divided by division blocks 174 and 176 to produce the X and Y position data, and the X and Y denominator pair is used by block 178 to produce Z axis (pressure) data. The function performed by block 178 will be disclosed later herein. The offsets O_{DX}, O_{NX}, O_{DY}, and O_{NY} are sampled from the accumulator contents when directed by calibration unit 180.

Persons of ordinary skill in the art will readily appreciate that the architecture of the system of the present invention may be distributed in a number of ways, several of which involve the availability of a microprocessor, whether it be in a host computer to which the system of the present invention is connected or somewhere between the integrated circuit described herein and a host computer. Embodiments of the present invention are contemplated wherein the accumulated numerator and denominator values representing the summation terms are delivered to such a microprocessor along with the O_N and O_D offset values for processing, or where all processing is accomplished by a programmed microprocessor as is known in the art.

Initially, the numerator and denominator accumulators 150, 152, 154, and 156 are set to zero during system startup. If the multiplexed A/D converters as shown in FIG. 7 are employed, the digitized voltage data in the first word of register 138-1 (representing the voltage at the output of sample/hold circuit 50-1) is added to the sum in the accumulator and the result stored in the accumulator. In succession, the digitized voltage values stored in the first word of registers 138-2 through 138-6 (representing the voltage at the outputs of sample/hold circuits 50-5, 50-9, 50-17, and 50-21, respectively) are added to the sums in the accumulators and the results stored in the accumulators. As previously mentioned, A/D converters 52-1 through 52-6 may at this time be converting the voltages present at the outputs of sample/hold circuits 50-2, 50-6, 50-10, 50-14, 50-18, and 50-22 and storing the digitized values in the second words of registers 138-1 through 138-6 respectively.

Next, in succession, the digitized voltage values stored in the second words of registers 138-1 through 138-6 (representing the voltage at the outputs of-sample/hold circuits 50-2, 50-6, 50-10, 50-14, 50-18, and 50-22, respectively) are added to the sum in the accumulator and the result stored in the accumulator.

Next, in succession, the digitized voltage values stored in the first words of registers 138-1 through 138-6 (representing the voltage at the outputs of sample/hold circuits 50-3, 50-7, 50-11, 50-15, 50-19, and 50-23, respectively) are added to the sum in the accumulator and the result stored in the accumulator, followed by digitized voltage values stored in the second words of registers 138-1 through 138-6 (representing the voltage at the outputs of sample/hold circuits 50-4, 50-8, 50-12, 50-16, 50-20, and 50-24, respectively).

At this point in time, the accumulators hold the sums of all of the individual digitized voltage values. The digital values stored in the O_N and O_D offset registers 158 and 164 are now respectively subtracted from the values stored in the numerator and denominator accumulators. The division operation in dividers 174 and 176 then completes the weighted average computation.

The division operation may also be performed by an external microprocessor which can fetch the values stored in the accumulators or perform the accumulations itself. As the O_N and O_D offset values are presently derived by an external microprocessor, the additional processing overhead presented to such external microprocessor by this division operation is minimal. Alternately, a dedicated microprocessor may be included on chip to handle these processing tasks without departing from the invention disclosed herein.

The above disclosed processing takes place within about 1 millisecond and may be repeatedly performed. Current mouse standards update position information 40 times per second, and thus the apparatus of the present invention may easily be operated at this repetition rate.

Because of the nature of the method employed in the present invention, an opportunity exists to provide additional noise immunity without requiring additional hardware in the system of the present invention. While it is apparent that after the above-disclosed sequence has been performed, the accumulators may be cleared and the process repeated, the values may also be allowed to remain in the accumulators. If this is done, an averaging function may be implemented to further filter out noise. According to this aspect of the invention, a number of samples are taken and run through the accumulators without clearing them at the end of the processing sequence. As presently preferred, twenty-five samples are processed before a single division result is taken for use by the system, thus greatly reducing the effects of transient system noise spikes. Those of ordinary skill in the art will recognize that the number of samples taken prior to clearing the accumulators is a matter of design choice dictated by factors such as data acquisition rates, data processing rates etc.

The system of the present invention is adaptable to changing conditions, such as component aging, changing capacitance due to humidity, and contamination of the touch surface, etc. In addition, the present invention effectively minimizes ambient noise. According to the present invention, these effects are taken into consideration in three ways. First, the offset values O_N and O_D are dynamically updated to accommodate changing conditions. Second, a servo-feedback circuit is provided to determine the bias voltage used to set the bias of the charge-integrator circuits 44-1 through 44-n. Third, as previously disclosed herein, the reference voltage points for V_{max} and V_{min} of the A/D converters are also dynamically altered to increase the signal to noise margin.

Referring now to FIG. 9, a block diagram of a calibration unit 150 which may be used with the arithmetic unit of FIG. 8 is presented. The calibration unit 150 executes an algorithm to establish the numerator and denominator offset values by attempting to determine when no finger or other conductive object is proximate to the touch sensor array 22.

As previously disclosed, the O_N and O_D offset values represent the baseline values of the array capacitances with no object present. These values are also updated according to the present invention since baseline levels which are too low or too high have the effect of shifting the apparent position of the object depending on the sign of the error. These values are established by selection of the values read when no object is present at the sensor array 22. Since there is no external way to "know" when no object is present at sensor array 22, an algorithm according to another aspect of the present invention is used to establish and dynamically update these offset values. When the calibration unit sees a Z value which appears typical of the Z values when no finger is present, it instructs the offset registers (158, 160, 162, and 164 of FIG. 8) to reload from the current values of the accumulators. According to a presently preferred embodiment of the invention, the decision to update the offset values is based on the behavior of the sensor array 22 in only one of the X or Y directions, but when the decision is made all four offsets (O_{NX}, O_{DX}, O_{NY}, and O_{DY}) are updated. In other embodiments of the invention, the decision to update may be individually made for each direction according to the criteria set forth herein.

The calibration algorithm works by monitoring changes in a selected one of the denominator accumulator values. According to the present invention, it has been observed that the sensitivity to changes in capacitance of one of the sets of conductive lines in the touch sensor array 22 is greater than the sensitivity to changes in capacitance of the other one of the sets of conductive lines in the touch sensor array 22. Experience suggests that the set of conductive lines having the greater sensitivity to capacitance changes is the one which is physically located above the conductive lines in the other direction and therefore closest to the touch surface of the sensor array

22. The upper set of conductive lines tends to partially shield the lower set of conductive lines from capacitive changes occurring above the surface of the sensor array 22.

The finger pressure is obtained by summing the capacitances measured on the sense lines. This value is already present in the denominator accumulator after subtracting the offset O_D. A finger is present if the pressure exceeds a suitable threshold value. This threshold may be chosen experimentally and is a function of surface material and circuit timing. The threshold may be adjusted to suit the tastes of the individual user.

The pressure reported by the device is a simple function $f(X_D\ Y_D)$ of the denominators for the X and Y directions as implemented in block 178 of FIG. 8. Possible functions include choosing one preferred denominator value, or summing the denominators. In a presently preferred embodiment, the smaller of the two denominators is chosen. This choice has the desirable effect of causing the pressure to go below the threshold if the finger moves slightly off the edge of the pad, where the X sensors are producing valid data, but the Y sensors are not, or vise versa. This acts as an electronic bezel which can take the place of a mechanical bezel at the periphery of the sensor area.

In the example of FIG. 8, the Y denominator is chosen for monitoring because it is the most sensitive. The chosen denominator is referred to as Z for the purposes of the calibration algorithm. The current saved offset value for this denominator is referred to as O_Z.

The goal of the calibration algorithm is to track gradual variations in the resting Z level while making sure not to calibrate to the finger, nor to calibrate to instantaneous spikes arising from noise. As will be apparent to those of ordinary skill in the art from the following disclosure, the calibration algorithm could be implemented in digital or analog hardware, or in software. In a current embodiment actually tested by the inventors, it is implemented in software.

As Z values arrive in the calibration unit, they are passed through filter 182. History buffer 184, which operates in conjunction with filter 182, keeps a "running average" of recent Z values. When a new Z value arrives, the current running average F_Z is updated according to the formula:

$$\text{new } F_Z = \alpha(\text{old } F_Z) + (1-\alpha)Z$$

where α is a constant factor between 0 and 1 and typically close to 1 and Z is the current Z value.

In the preferred embodiment, alpha is approximately 0.95. The intention is for FZ to change slowly enough to follow gradual variations, without being greatly affected by short perturbations in Z.

The filter 182 receives a signal **ENABLE** from control unit 186. The running average F_Z is updated based on new Z values only when **ENABLE** is asserted. If **ENABLE** is deasserted, F_Z remains constant and is unaffected by current Z.

The history buffer 184 records the several most recent values of FZ. In the present embodiment, the history buffer records the two previous FZ values. The history buffer might be implemented as a shift register, circular queue, or analog delay line. When the history buffer receives a **REWIND** signal from control unit 186, it restores the current running average F_Z to the oldest saved value. It is as if the filter 182 were "retroactively" disabled for an amount of time corresponding to the depth of the history buffer. Thc purpose of the history buffer is to permit such retroactive disabling.

The current running average F_Z is compared against the current Z value and the current offset O_Z by absolute difference units 188 and 190, and comparator 192. Absolute difference unit 188 subtracts the values Z and F_Z and outputs the absolute value of their difference. Absolute difference unit 190 subtracts the values O_Z and F_Z and outputs the absolute value of their difference. Comparator 192 asserts the UPDATE signal if the output of absolute difference unit 188 is less than the output of absolute difference unit 190, i.e., if F_Z is closer to Z than it is to O_Z. The UPDATE signal will tend to be asserted when the mean value of Z shifts to a new resting level. It will tend not to be asserted when Z makes a brief excursion away from its normal resting level. The filter constant a determines the length of an excursion which will be considered "brief" for this purpose.

Subtractor unit 194 is a simple subtractor that computes the signed difference between Z and O_Z. This subtractor is actually redundant with subtractor 172 in figure 8, and so may be merged with it in the actual implementation. The output C_Z of this subtractor is the calibrated Z value, an estimate of the finger pressure. This pressure value is compared against a positive and negative Z threshold by comparators 196 and 198. These thresholds are shown as Z_{TH} and $-Z_{TH}$, although they are not actually required to be equal in magnitude.

If pressure signal C_Z is greater than Z_{TH}, the signal **FINGER** is asserted indicating the possible presence of a finger. The Z_{TH} threshold used by the calibration unit is similar to that used by the rest of the system to detect the presence of the finger, or it may have a different value. In the present embodiment, the calibration Z_{TH} is set somewhat lower than the main Z_{TH} to ensure that the calibration unit makes a conservative choice about the presence of a finger.

If pressure signal C_Z is less than - Z_{TH}, the signal **FORCE** is asserted. Since O_Z is meant to be equal to the resting value of Z with no finger present, and a finger can only increase the sensor capacitance and thus the value of Z, a largely negative C_Z implies that the device must have incorrectly calibrated itself to a finger, which has just been removed. Calibration logic 200 uses this fact to force a recalibration now that the finger is no longer present.

Control logic 186 is responsible for preventing running average F_Z from being influenced by Z values that occur when a finger is present. Output **ENABLE** is generally off when the **FINGER** signal is true, and on when the **FINGER** signal is false. However, when **FINGER** transitions from false to true, the control logic also pulses the **REWIND** signal. When **FINGER** transitions from true to false, the control logic waits a short amount of time (comparable to the depth of the history buffer) before asserting **ENABLE**. Thus, the running average is prevented from following Z whenever a finger is present, as well as for a short time before and after the finger is present.

Calibration logic 200 produces signal **RECAL** from the outputs of the three comparators 192, 196, and 198. When **RECAL** is asserted, the offset registers O_N and O_D will be reloaded from the current accumulator values. **RECAL** is produced from the following logic equation:

RECAL = FORCE or (UPDATE and not FINGER).

In addition, calibration logic 200 arranges to assert **RECAL** once when the system is first initialized, possibly after a brief period to wait for the charge integrators and other circuits to stabilize.

From the descriptions of control logic 186 and calibration logic 200, it will be apparent to those of ordinary skill in the art that these blocks can be readily configured using conventional logic as a matter of simple and routine logic design.

It should be obvious to any person of ordinary skill in the art that the calibration algorithm described is not specific to the particular system of charge integrators and accumulators of the current invention. Rather, it could be employed in any touch sensor which produces proximity or pressure data in which it is desired to maintain a calibration point reflecting the state of the sensor when no finger or spurious noise is present.

Referring now to FIG. 10, a bias voltage generating circuit 46 useful in the present invention is shown in schematic diagram form. According to a presently preferred embodiment of the invention, all of the bias transistors 108 (FIG. 4b) of charge integrator circuits 44-1 through 44-n have their gates connected to a single source of bias voltage, although persons of ordinary skill in the art recognize that other arrangements are possible. There are a number of ways in which to generate the bias voltage required by charge integrator circuits 44-1 through 4-n.

As may be seen from an examination of FIG. 10, the bias voltage generating circuit 46 is an overdamped servo system. A reference source which approximates the current source function of a typical one of the charge integrator circuits 44-1 through 44-n includes a capacitor 204 having one of its plates grounded. The other one of its plates is connected to the V_{DD} power supply through a first pass gate 206 and to a current source transistor 208 through a second passgate 210. A filter circuit 212, identical to the filter circuits 48-1 through 48-n and controlled by the same signal as filter circuits 48-1 through 48-n is connected to sample the voltage on capacitor 204 in the same manner that the filter-and-sample/hold circuits 48-1 through 48-n sample the voltages on the sensor conductor capacitances in the sensor array 22.

The output of filter circuit 212 is fed to the non-inverting input of a weak transconductance amplifier 214, having a bias current in the range of from about 0.1-0.2μA. The inverting input of the transconductance amplifier 214 is connected to a fixed voltage of about 1 volt generated, for example, by diode 216 and resistor 218. The output of transconductance amplifier 214 is shunted by capacitor 220 and also by capacitor 222 through passgate 224. Capacitor 222 is chosen to be much larger than capacitor 220. In a typical embodiment of the present invention, capacitor 220 may be about 0.2pF and capacitor 222 may be about 10pF.

Capacitor 222 is connected to the gate of N-Channel MOS transistor 226, which has its drain connected to the drain and gate of P-Channel MOS transistor 228 and its source connected to the drain and gate of N-Channel MOS transistor 230. The source of P-Channel MOS transistor 228 is connected to V_{DD} and the source of N-Channel MOS transistor 230 is connected to ground. The common drain connection of transistors 226 and 230 is the bias voltage output node.

An optional passgate 232 may be connected between a fixed voltage source (e.g., about 2 volts) and capacitor 222 through a passgate 234. Passgate 234 may be used to initialize the bias generating circuit 200 on startup by charging capacitor 222 to the fixed voltage.

During each sample period, the filter circuit 210 takes a new sample. If the new sample differs from the previous sample, the output voltage of transconductance amplifier 211 will change and start to charge or discharge capacitor 218 to a new voltage. Passgate 222 is switched on for a short time (i.e., about 1µsec) and the voltages on capacitors 218 and 220 try to average themselves. Due to the large size difference between capacitors 218 and 220, capacitor 218 cannot supply enough charge to equalize the voltage during the period when passgate 222 is open. This arrangement prevents large changes in bias voltage from cycle to cycle.

Capacitor 202 should look as much as possible like one of the sensor array channels and has a value equal to the background capacitance of a typical sensor line, (i.e., with no object proximate or present capacitance component). Capacitor 202 may be formed in several ways. Capacitor 202 may comprise an extra sensor line in a part of the sensor array, configured to approximate one of the active sensor lines but shielded from finger capacitance by a ground plane, etc. Alternately, capacitor 202 may be a capacitor formed in the integrated circuit or connected thereto and having a value selected to match that of a typical sensor line. In this respect, the signal source comprising capacitor 202 and filter circuit 210 is somewhat like the circuitry for generating the V_{max} and V_{min} reference voltages, in that it mimics a typical sensor line.

As another alternative, one of the actual sensor lines may be employed to set the bias voltage. The measured voltage on the two end-point sensor lines may be compared and the one having the lowest value may be selected on the theory that, if a finger or other object is proximate to the sensor array, it will not be present at sensor lines located at the opposite edges of the array.

The increased sensitivity of the touch sensor system of the present invention allows for a lighter input finger touch which makes it easy for human use. Increased sensitivity also makes it easier to use other input objects, like pen styli, etc. Additionally this sensitivity allows for a trade-off against a thicker protective layer, or different materials, which both allow for lower manufacturing costs.

Greater noise rejection allows for greater flexibility in use and reduced sensitivity to spurious noise problems. Two techniques are employed which allow derivation of the most noise-rejection benefit.

Due to the drive and sense techniques employed in the present invention, the data acquisition rate has been increased by about a factor of 30 over the prior art. This offers several obvious side effects. First, for the same level of signal processing, the circuitry can be turned off most of the time and reduce power consumption by roughly a factor of 30 in the analog section of the design. Second, since more data is available, more signal processing, such as filtering, and gesture recognition, can be performed.

The sensor electronic circuit employed in the present invention is very robust and calibrates out process and systematic errors. It will process the capacitive information from the sensor and provide digital information to an external device, for example, a microprocessor.

Because of the unique physical features of the present invention, there are several ergonomically interesting applications that were not previously possible. Presently a Mouse or Trackball is not physically convenient to use on portable computers. The present invention provides a very convenient and easy-to-use cursor position solution that replaces those devices.

In mouse-type applications, the sensor of the present invention may be placed in a convenient location, e.g., below the "space bar" key in a portable computer. When placed in this location, the thumb of the user may be used as the position pointer on the sensor to control the cursor position on the computer screen. The cursor may then be moved without the need for the user's fingers to leave the keyboard. Ergonomically, this is similar to the concept of the MacIntosh Power Book with it's trackball, however the present invention provides a significant advantage in size over the track ball. Extensions of this basic idea are possible in that two sensors could be placed below the "space bar" key for even more feature control.

The computer display with it's cursor feedback is one small example of a very general area of application where a display could be a field of lights or LED's, an LCD display, or a CRT. Examples include touch controls on laboratory equipment where present equipment uses a knob/button/touch screen combination. Because of the articulating ability of this interface, one or more of those inputs could be combined into one of the inputs described with respect to the present invention.

Consumer Electronic Equipment (stereos, graphic equalizers, mixers) applications often utilize significant front panel surface area for slide potentiometers because variable control is needed. The present invention can provide such control in one small touch pad location. As Electronic Home Systems become more common, denser and more powerful human interface is needed. The sensor technology of the present invention permits a very dense control panel. Hand Held TV/VCR/Stereo controls could be ergonomically formed and allow for more powerful features if this sensor technology is used.

The sensor of the present invention can be conformed to any surface and can be made to detect multiple touching points, making possible a more powerful joystick. The unique pressure detection ability of the sensor technology of the present invention is also key to this application. Computer games, "remote" controls (hobby electronics, planes) , and machine tool controls are a few examples of applications which would benefit from the sensor technology of the present invention.

Musical keyboards (synthesizers, electric pianos) require velocity sensitive keys which can be provided by the pressure sensing ability of this sensor. There are also pitch bending controls, and other slide switches that could be replaced with this technology. An even more unique application comprises a musical instrument that creates notes as a function of the position and pressure of the hands and fingers in a very articulate 3-d interface.

The sensor technology of the present invention can best detect any conducting material pressing against it. By adding a compressible insulating layer covered by a layer of conductive material on top of the sensor the sensor of the present invention may also indirectly detect pressure from any object being handled, regardless of its electrical conductivity.

Because of the amount of information available from this sensor it will serve very well as an input device to virtual reality machines. It is easy to envision a construction that allows position-monitoring in three dimensions and some degree of response (pressure) to actions.

While embodiments and applications of this invention have been shown and described, it would be apparent to those skilled in the art that many more modifications than mentioned above are possible without departing from the inventive concepts herein. The invention, therefore, is not to be restricted except in the spirit of the appended claims.

Claims

We claim:

1. A method for providing an electrical signal representative of the position of an object in a two dimensional plane, including the steps of:

providing a sensing plane including a matrix of conductors arranged as a plurality of rows and columns of spaced apart row conductive lines and column conductive lines, said sensing plane characterized by an inherent capacitance on the various ones of said row conductive lines and column conductive lines, said capacitance varying with the proximity of an object to said row and column conductors;

simultaneously developing a first set of digital signals proportional to the value of said capacitance for each of said row conductive lines when no object is located proximate to said sensing plane;

simultaneously developing a second set of digital signals proportional to the value of said capacitance for each column conductive lines when no object is located proximate to said sensing plane;

simultaneously developing a third set of digital signals proportional to the value of said capacitance for each of said row conductive lines when an object is located proximate to said sensing plane;

simultaneously developing a fourth set of digital signals proportional to the value of said capacitance for each column conductive lines when said object is located proximate to said sensing plane;

computing a first weighted average of the difference between said first set of digital signals and said third set of digital signals;

computing a second weighted average of the difference between said second set of digital signals and said fourth set of digital signals.

2. The method of claim 1, wherein the steps of simultaneously developing said first, second, third, and fourth sets of digital signals includes the steps of:

placing a first known voltage on said capacitances;

discharging said capacitances for a fixed time at a fixed current;

measuring and storing a first set of resultant voltages across said capacitances;

placing a second known voltage on said capacitances;

charging said capacitances for said fixed time at said fixed current;

measuring and storing a second set of resultant voltages across said capacitances; and

averaging corresponding ones of said first and second sets of resultant voltages.

3. The method of claim 1 wherein the steps of computing said first and second weighted averages comprises the steps of:

computing a sum and a weighted sum of said first set of digital signals;

computing a sum and a weighted sum of said second set of digital signals;

computing a sum and a weighted sum of said third set of digital signals;

computing a sum and a weighted sum of said fourth set of digital signals;

computing a row numerator by subtracting said weighted sum of said first set of digital signals from said weighted sum of said third set of digital signals;

computing a row denominator by subtracting said sum of said second set of digital signals from said sum of said fourth set of digital signals;

dividing said row numerator by said row denominator to derive a row position digital signal representing the position of said object in a row dimension;

computing a column numerator by subtracting said weighted sum of said second set of digital signals from said weighted sum of said second set of digital signals;

computing a column denominator by subtracting said sum of said second set of digital signals from said sum of said second set of digital signals; and

dividing said column numerator by said column denominator to derive a column position digital signal representing the position of said object in a column dimension.

4. The method of claim 3 including the further steps of:

storing said sum and said weighted sum of said first and third set of digital signals as a stored sum and a stored weighted sum of said second and fourth sets of digital signals; and

using said stored sum and said stored weighted sum in computing subsequent ones of said row numerators and denominators and said column numerators and denominators

using said stored stored sum and a stored weighted sum for providing an electrical signal representative of a subsequent position of said object in said two dimensional plane.

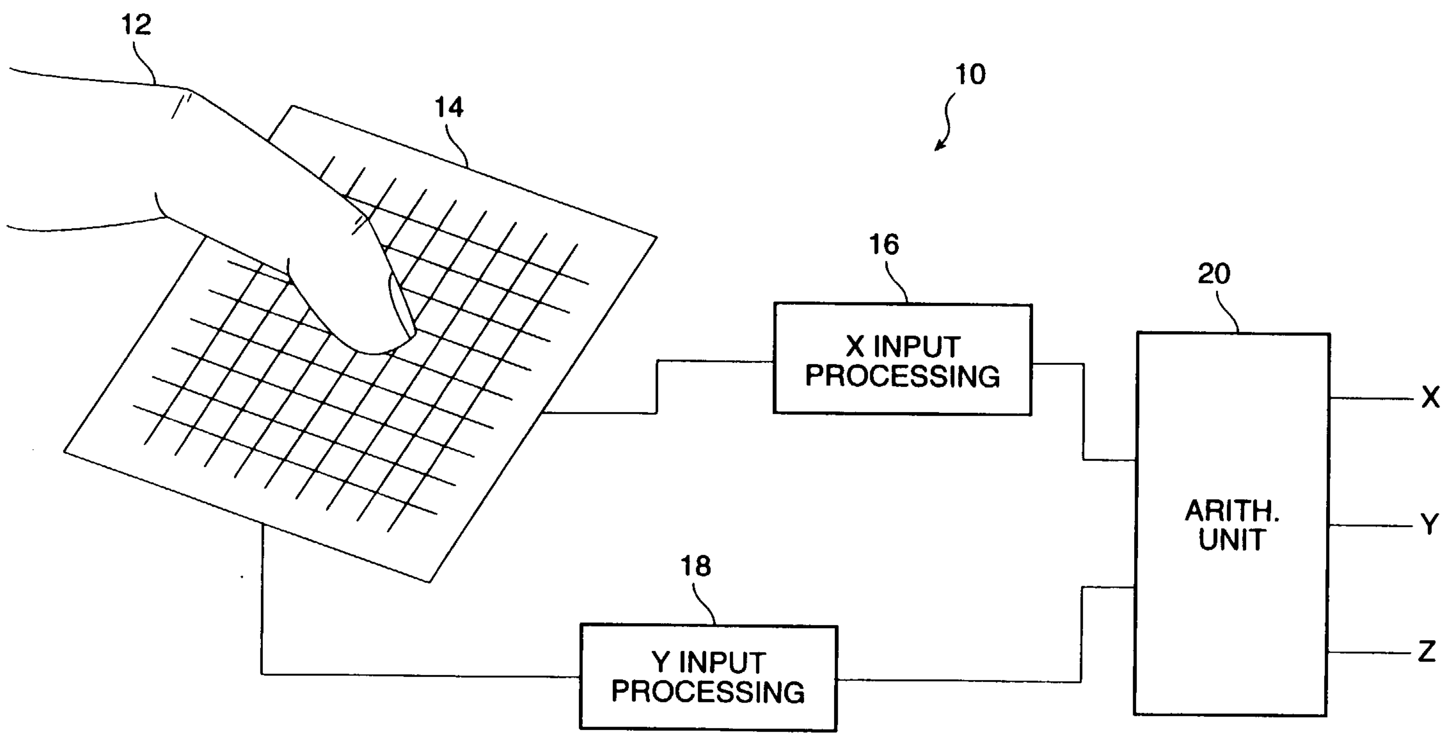
12
14
10
16
X INPUT PROCESSING
20
ARITH. UNIT
X
Y
Z
18
Y INPUT PROCESSING

FIG. 1

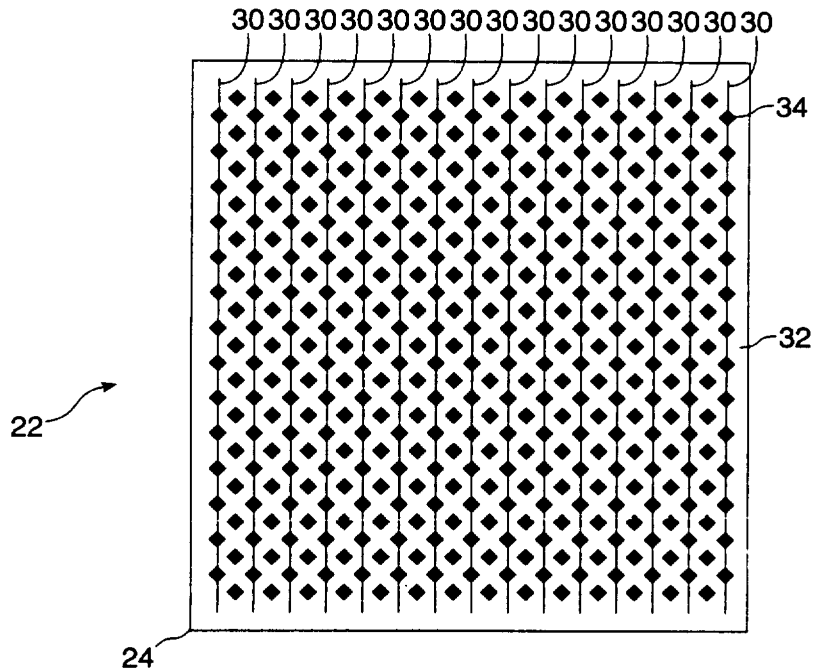
30 30 30 30 30 30 30 30 30 30 30 30 30 30 30
34
32
22
24

FIG. 2A

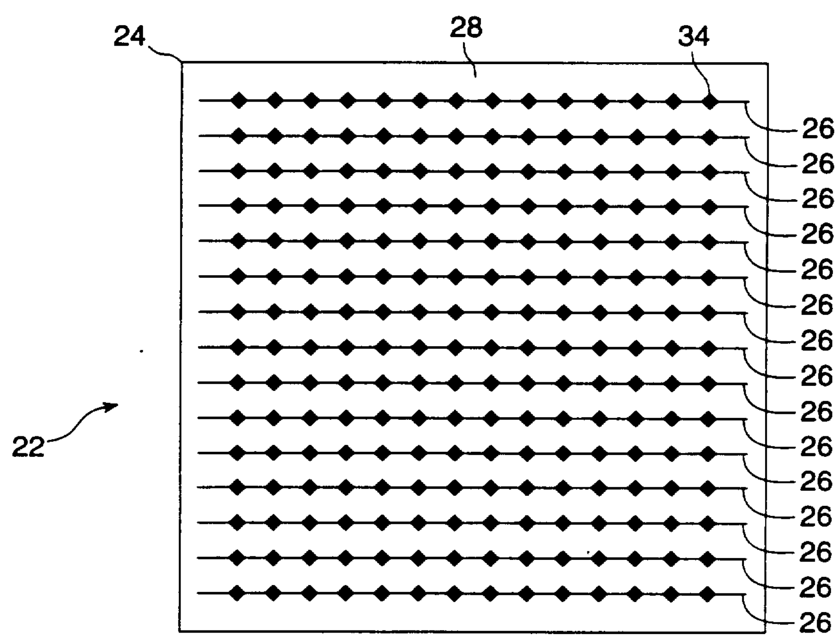
24
28
34
26
26
26
26
26
26
26
26
26
26
26
26
26
26
26
22

FIG. 2B

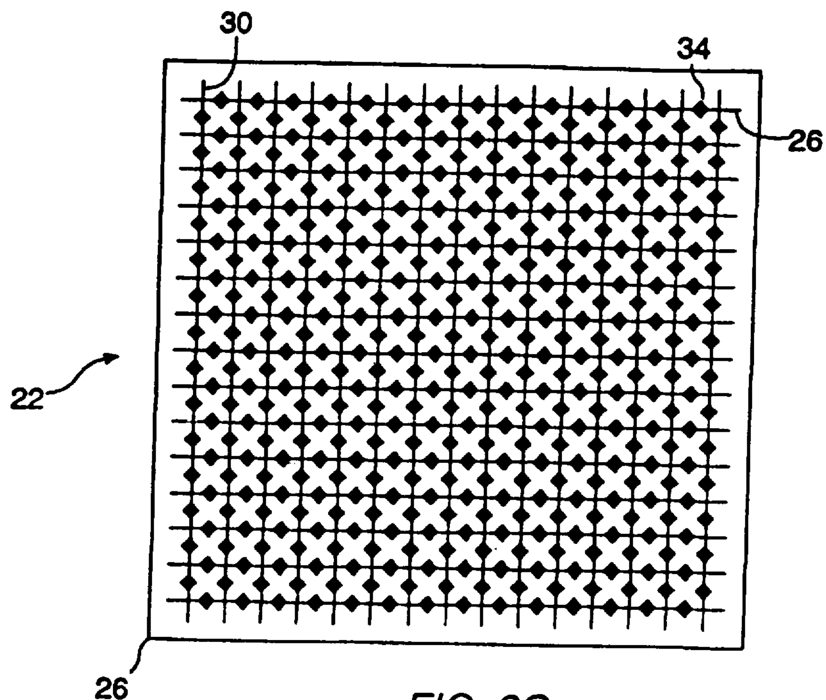

FIG. 2C

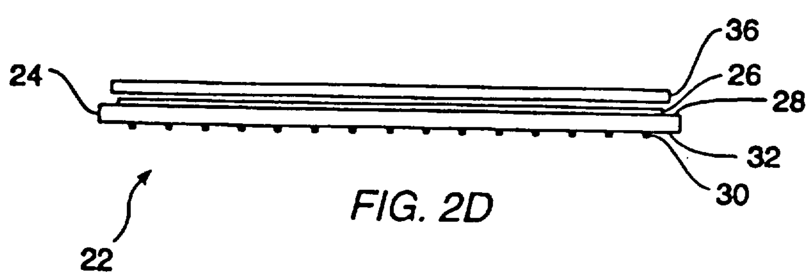

FIG. 2D

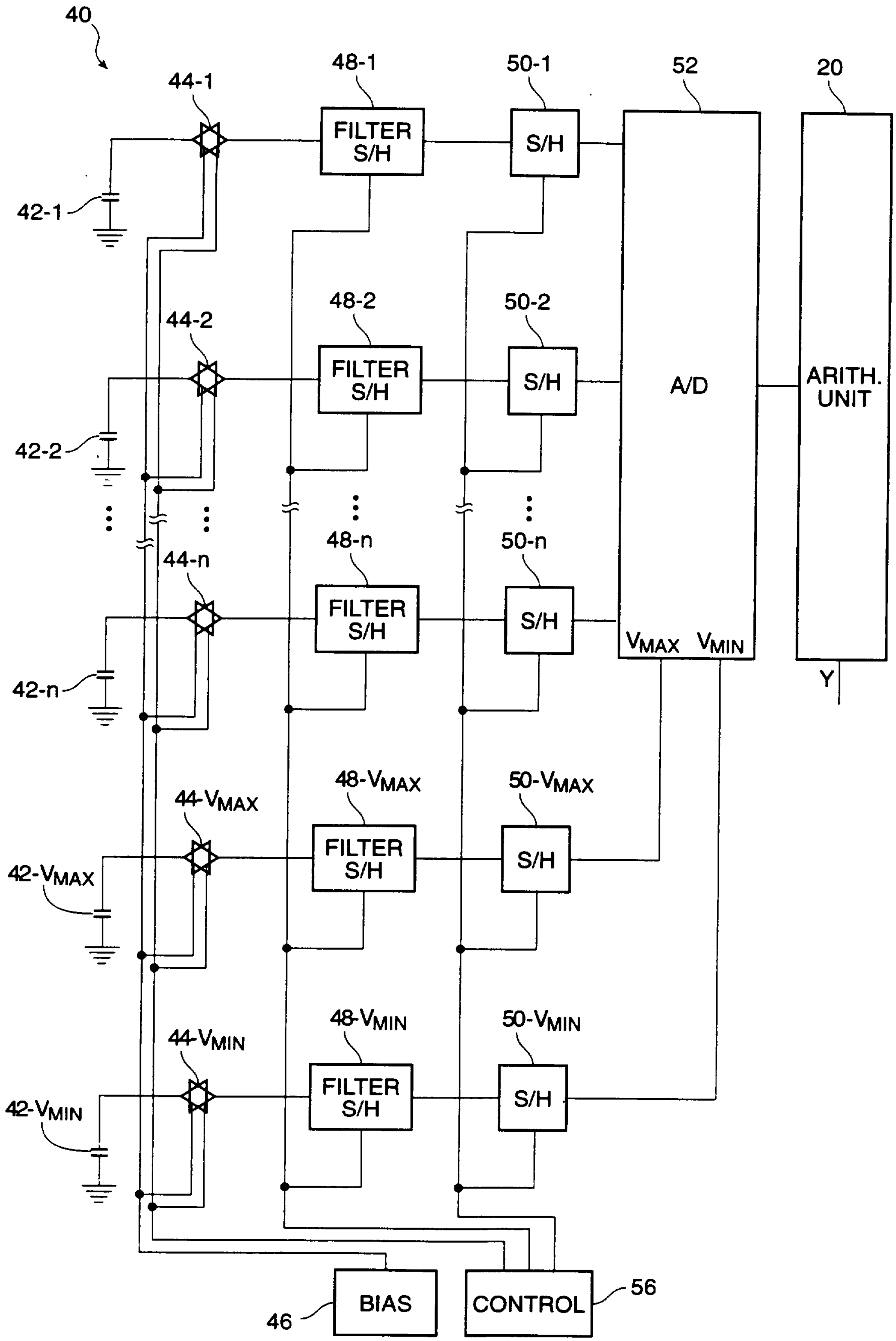
40
44-1
48-1
50-1
52
20
FILTER S/H
S/H
42-1
44-2
48-2
50-2
FILTER S/H
S/H
A/D
ARITH. UNIT
42-2
48-n
50-n
44-n
FILTER S/H
S/H
VMAX VMIN
42-n
Y
48-VMAX
50-VMAX
44-VMAX
FILTER S/H
S/H
42-VMAX
48-VMIN
50-VMIN
44-VMIN
FILTER S/H
S/H
42-VMIN
BIAS
CONTROL
56
46

FIG. 3

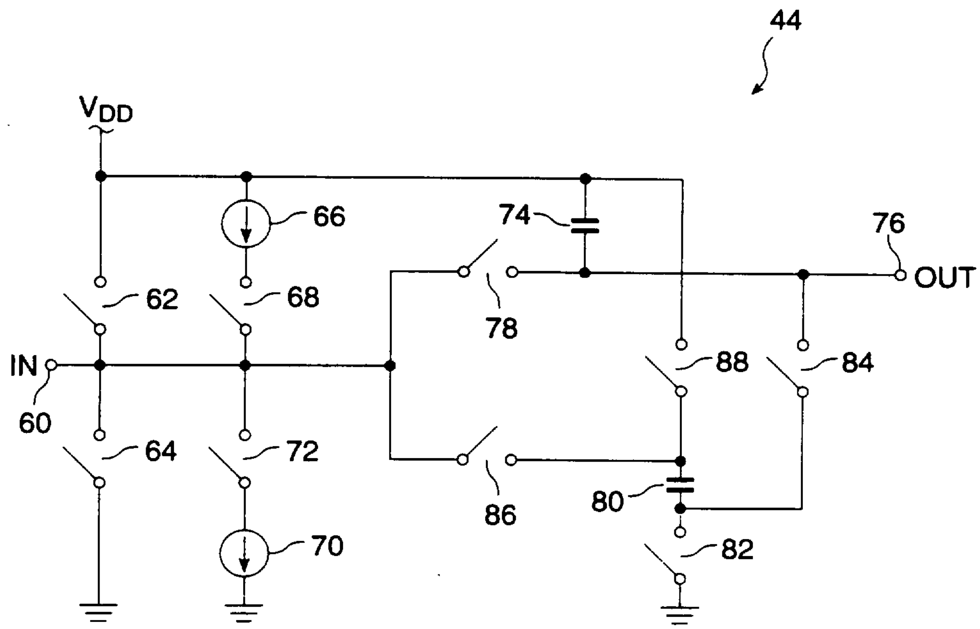
44
VDD
66
74
76
OUT
62
68
78
IN
88
84
60
64
72
80
86
70
82

FIG. 4A

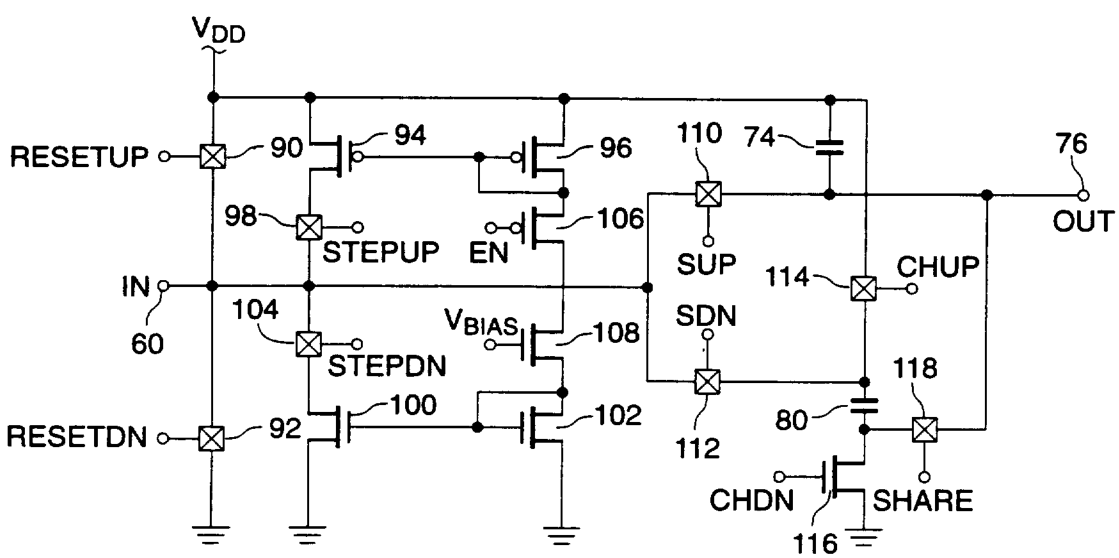
VDD
RESETUP
90
94
96
110
74
76
OUT
98
STEPUP
EN
106
SUP
114
CHUP
IN
60
104
STEPDN
VBIAS
108
SDN
118
RESETDN
92
100
102
112
80
CHDN
SHARE
116

FIG. 4B

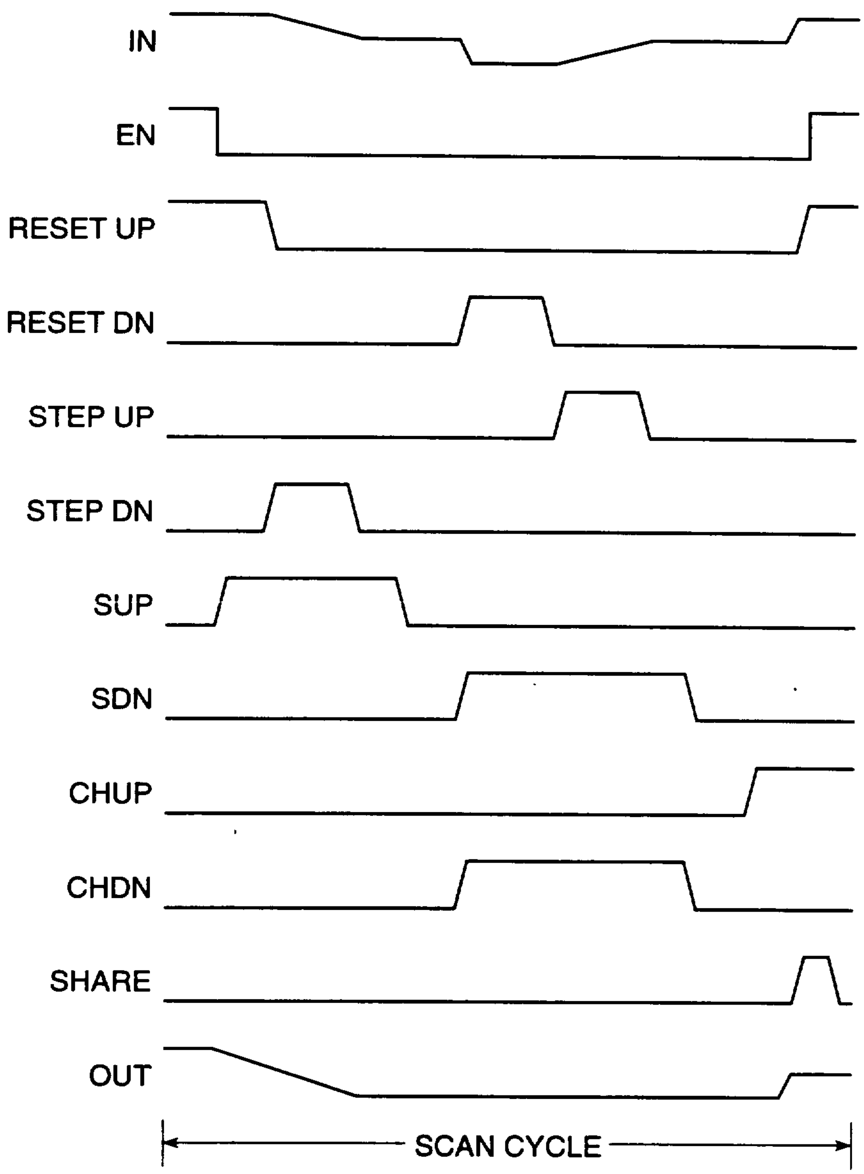
IN
EN
RESET UP
RESET DN
STEP UP
STEP DN
SUP
SDN
CHUP
CHDN
SHARE
OUT
SCAN CYCLE

FIG. 5

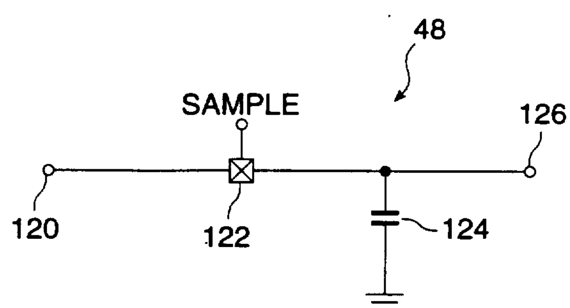
48
SAMPLE
126
120
122
124

FIG. 6

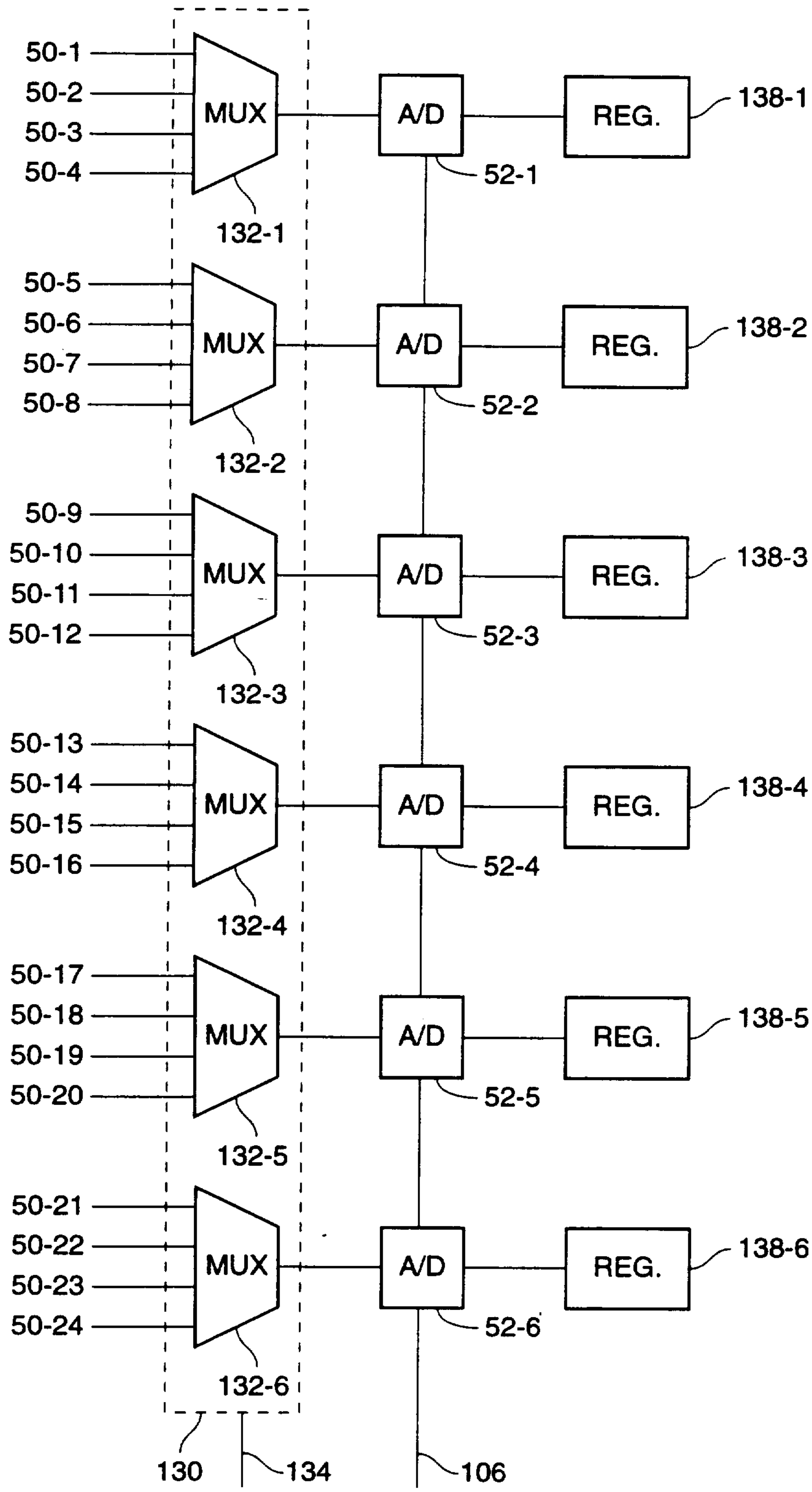
50-1
50-2
50-3
50-4
MUX
132-1
A/D
52-1
REG.
138-1
50-5
50-6
50-7
50-8
MUX
132-2
A/D
52-2
REG.
138-2
50-9
50-10
50-11
50-12
MUX
132-3
A/D
52-3
REG.
138-3
50-13
50-14
50-15
50-16
MUX
132-4
A/D
52-4
REG.
138-4
50-17
50-18
50-19
50-20
MUX
132-5
A/D
52-5
REG.
138-5
50-21
50-22
50-23
50-24
MUX
132-6
A/D
52-6
REG.
138-6
130
134
106

FIG. 7

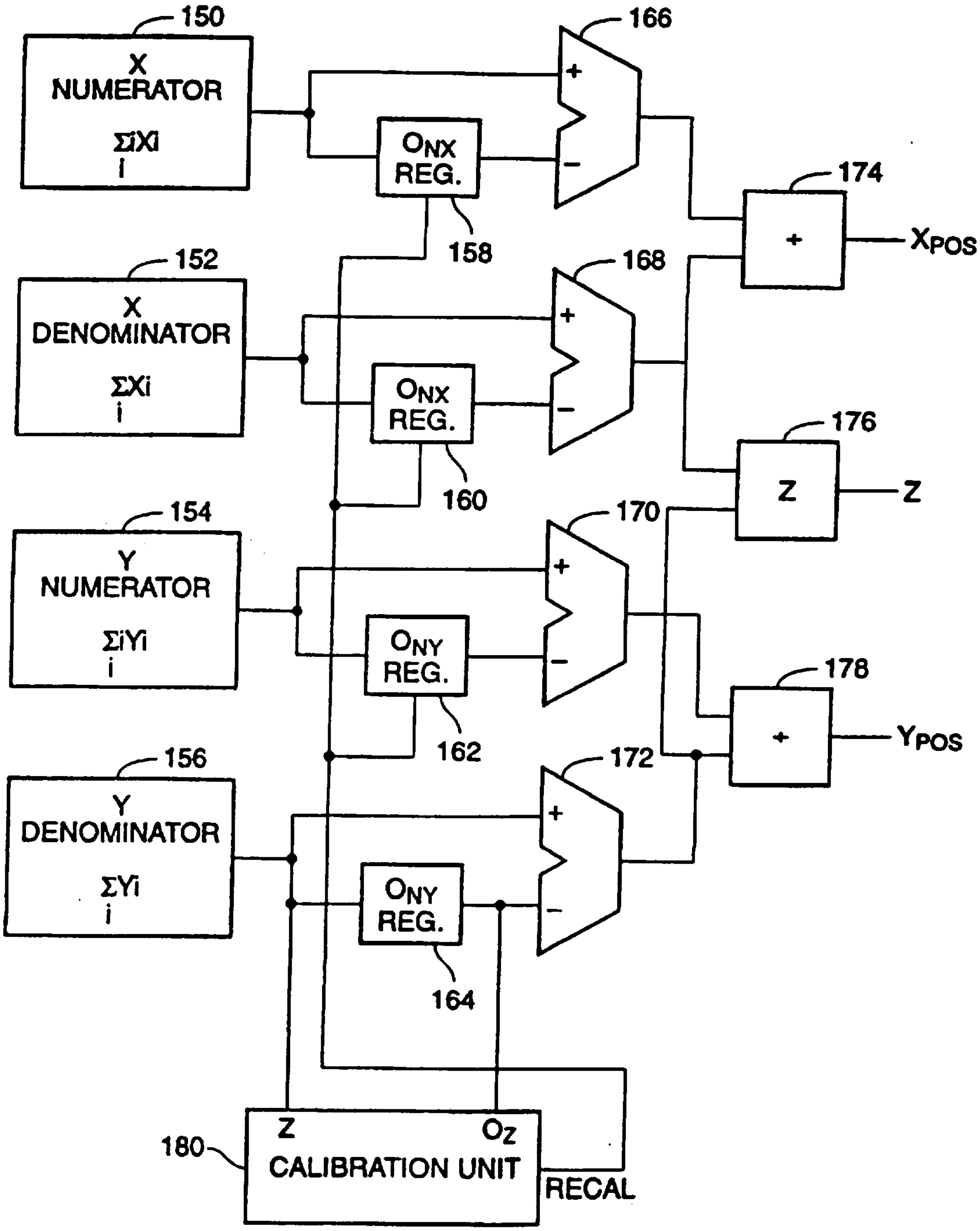
150
X NUMERATOR
ΣiXi
i
166
ONX REG.
158
174
+
XPOS
152
X DENOMINATOR
ΣXi
i
168
ONX REG.
160
176
Z
Z
154
Y NUMERATOR
ΣiYi
i
170
ONY REG.
162
178
+
YPOS
156
Y DENOMINATOR
ΣYi
i
172
ONY REG.
164
180
Z
OZ
CALIBRATION UNIT
RECAL

FIG. 8

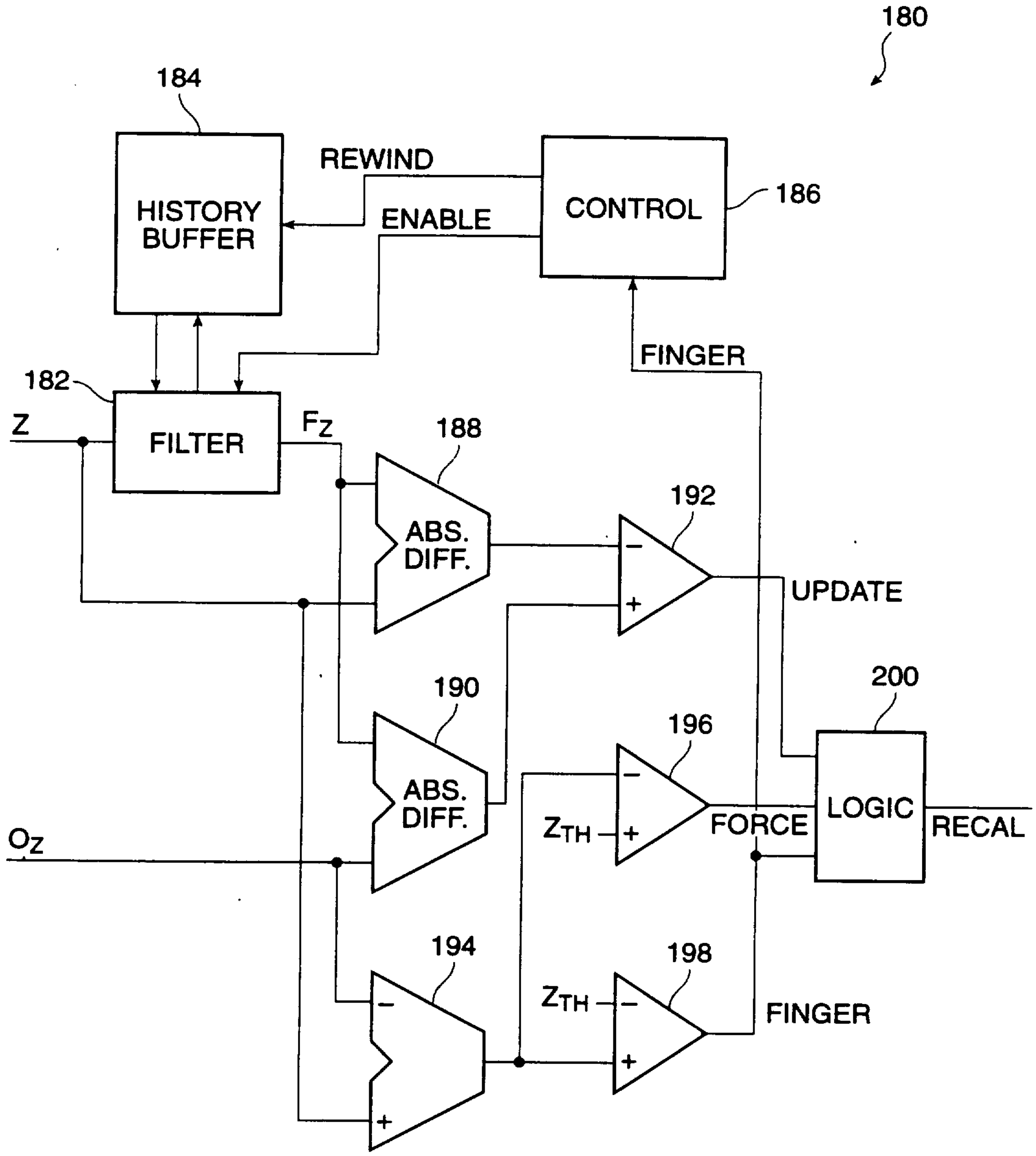
180
184
HISTORY BUFFER
REWIND
ENABLE
CONTROL
186
FINGER
182
Z
FILTER
Fz
188
ABS. DIFF.
192
UPDATE
190
ABS. DIFF.
200
196
ZTH
FORCE
LOGIC
RECAL
Oz
194
198
ZTH
FINGER

FIG. 9

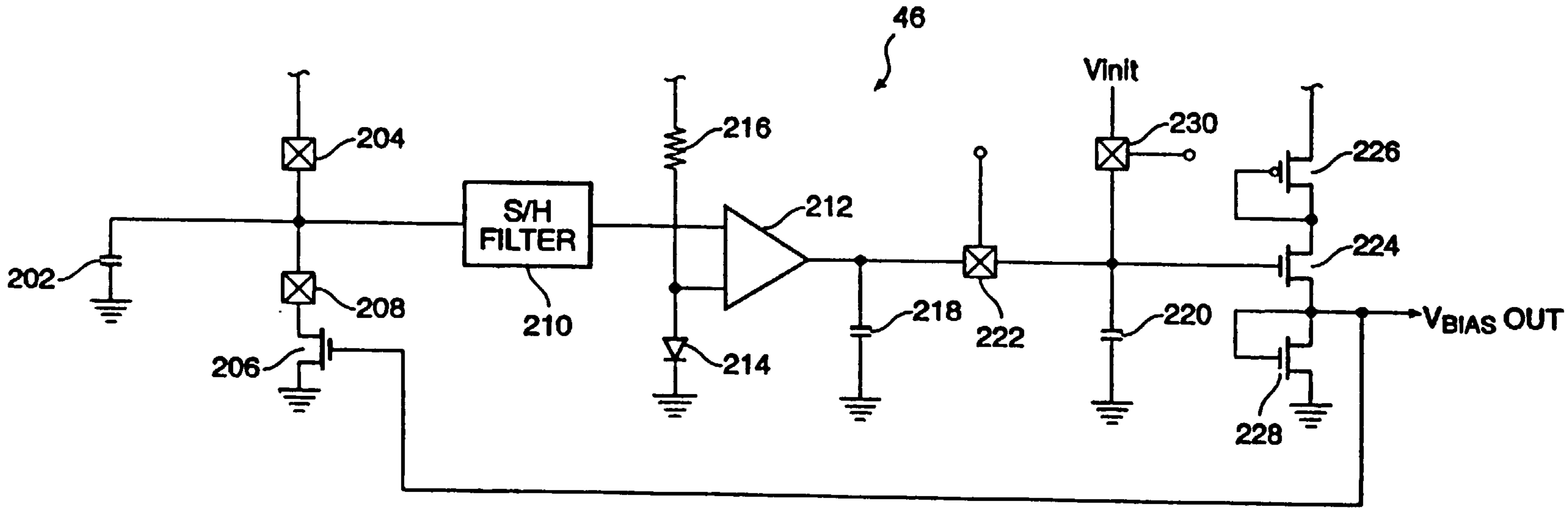
46
Vinit
204
216
230
226
212
224
S/H
FILTER
202
208
210
206
214
218
222
220
VBIAS OUT
228

FIG. 10

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 95/11180

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06K11/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,Y	US,A,5 374 787 (MILLER ROBERT J ET AL) 20 December 1994 see column 4, line 31 - column 10, line 55 see column 12, line 17 - column 13, line 14; figures 1-3	1-3
Y	EP,A,0 609 021 (AT & T CORP) 3 August 1994 see page 3, line 44 - page 4, line 20 see page 4, line 43 - page 5, line 23	1-3
A	EP,A,0 574 213 (SYNAPTICS INC) 15 December 1993 see the whole document	1,3

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
4 January 1996	15. 01. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Bailas, A

INTERNATIONAL SEARCH REPORT

Information on patent family members

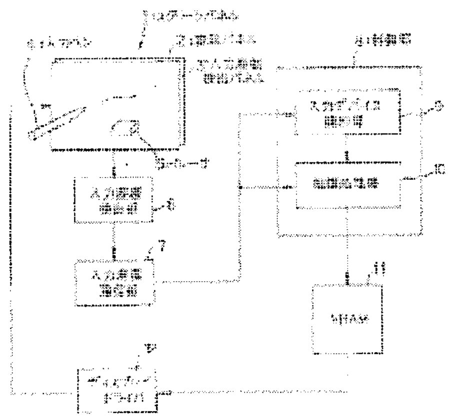
International Application No
PCT/US 95/11180

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-5374787	20-12-94	EP-A-	0574213	15-12-93
EP-A-0609021	03-08-94	US-A-	5463388	31-10-95
		JP-A-	6242875	02-09-94
EP-A-0574213	15-12-93	US-A-	5374787	20-12-94

HAND-WRITTEN INPUT DEVICE

Patent number: JP8286830 (A)
Publication date: 1996-11-01
Inventor(s): TOSHIMI KEIICHI +
Applicant(s): FUJI XEROX CO LTD +
Classification:
- international: *G06K9/62; G06F3/03; G06F3/033; G06F3/041; G06F3/048;* G06K9/62; G06F3/03; G06F3/033; G06F3/041; G06F3/048; (IPC1-7): G06K9/62; G06F3/033; G06F3/03
- european:
Application number: JP19950089456 19950414
Priority number(s): JP19950089456 19950414

Abstract of **JP 8286830 (A)**
PURPOSE: To improve a cost performance and an operability by identifying a type of an input device based on the input area or shape of a hand-written input device detected by an identification section and executing graphic drawing processing corresponding to the identification. CONSTITUTION: In the hand-written input device which executes picture drawing corresponding to an input operation by a hand-written input device (input pen 4 and an eraser 5 or the like) onto an input face (input coordinate detection panel) 3, an input device identification section 9 detects an input area or an input shape of the input device onto the input coordinate detection panel 3 and identifies the kind of the hand-written input device making an input operation based on the detected input area or input shape. A picture drawing processing section 10 selects the processing mode based on the identification information from the input device identification section 9 and processes the input coordinate data by the input pen 4 or the like fed from an input coordinate communication section 7 according to the selected processing mode to generate picture drawing data and provides an output of the data to a display use VRAM 11.



D2

(19)日本国特許庁（JP）　(12) **公開特許公報**（A）　(11)特許出願公開番号

特開平8－286830

(43)公開日　平成8年(1996)11月1日

(51)Int.Cl.⁶		識別記号	庁内整理番号	FI		技術表示箇所
G06F	3/033	360	7208－5E	G06F	3/033	360C
	3/03	380			3/03	380E
// G06K	9/62		9061－5H	G06K	9/62	G

審査請求　未請求　請求項の数1　OL　（全8頁）

(21)出願番号　特願平7－89456

(22)出願日　平成7年(1995)4月14日

(71)出願人　000005496
富士ゼロックス株式会社
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富士ゼロックス株式会社内

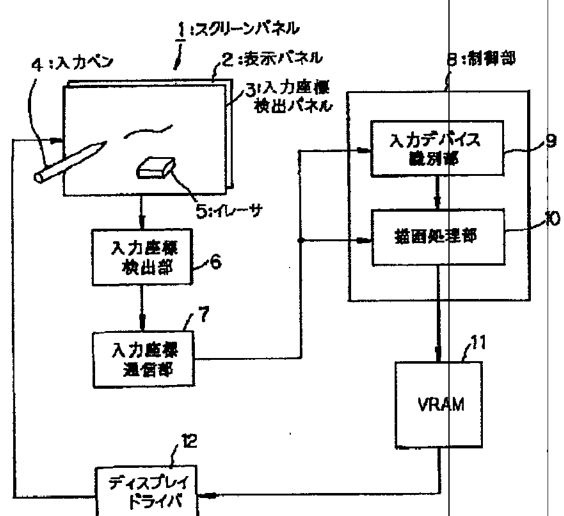
(74)代理人　弁理士　木村　高久

(54)【発明の名称】　手書き入力装置

(57)【要約】

【目的】操作者に特別な選択操作を行わすことなく手書き入力デバイスの種類の識別を可能とし、コストパフォーマンスおよび操作性を向上させる。

【構成】手書き入力デバイスの入力面積または入力形状を検出し、この検出した入力面積または入力形状に基づいて入力操作を行った手書き入力デバイスの種類を識別し、該識別した種類に対応する描画処理を実行する。



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【特許請求の範囲】

【請求項１】手書き入力デバイスの入力面への入力操作に対応した描画を実行する手書き入力装置において、
前記入力面に対する手書き入力デバイスの入力面積または入力形状を検出し、この検出した入力面積または入力形状に基づいて入力操作を行った手書き入力デバイスの種類を識別する識別手段と、
この識別手段によって識別した種類に対応する描画処理を実行する描画処理手段と、を具える手書き入力装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】この発明は、入力ペンなどの手書き入力デバイスの入力軌跡に対応する軌跡を表示画面上に描画する手書き入力装置に関し、特に手書き入力デバイスの種類を認識するための技術に関する。

【０００２】

【従来の技術】遠隔会議システムの電子黒板やパームトップコンピュータや電子手帳などに用いられている手書き入力装置においては、人が入力ペン等を介して手で書いた文字、絵、図表などが画面上に表示される。

【０００３】このような手書き入力装置は、各種表示を行う表示パネルと、この表示パネル上に積層されて入力ペンなどの手書き入力デバイスによって指示された座標位置を検出する入力座標検出パネルとを有し、手書き入力デバイスの入力軌跡に対応する軌跡が表示パネル上に表示されるようになっている。

【０００４】ところで、手書き入力デバイスによる描画には、書き込み機能の他に消去機能が備えられており、従来これら機能を区別するために以下のような手法を用いるようにしていた。

【０００５】(1)入力ペンにイレースモード（消しゴムモード）と書き込みモード（ペンモード）を選択する描画モードスイッチを設け、この描画モードスイッチによって描画モードを選択して入力操作を行う
(2)表示画面上に上記描画モードスイッチに対応するメニューボタンを設け、このメニューボタンにより描画モードを選択して入力操作を行う
(3)書き込み機能を持つ入力ペンの他に、イレーサ等の消去用入力デバイスを用意し、これら入力デバイスをシステム筐体の各所定位置に着脱自在に配設し、オペレータがこれら入力デバイスを前記各所定位置から外したことを赤外線センサなどにより検出し、外された入力デバイスに対応する描画モードの入力操作を行う。

【０００６】

【発明が解決しようとする課題】しかしながら、上記(1)(2)の手法は描画モードを切り換える度に、描画モードスイッチ或いはメニューボタンを選択操作しなくてはならず、操作が煩雑である問題があり、またその選択操作は直感的ではない。また、これら(1)(2)の手法では、選択操作後、イレース領域の指定のために、対角する２点を指定するなどの所定の操作を行わなければならず、操作が煩雑である。

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【０００７】また、上記(3)の手法では、入力ペンとイレーサを別個にしているので、選択操作が直感的である利点がある反面、イレーサ着脱部位にイレーサ以外のものが置かれた場合、誤動作につながる問題がある。

【０００８】なお、特公平６－９０２３号公報には、イレーサ内部に、イレース領域を指示するための２つの位置指示部材と、電子黒板面上でのイレーサの傾きを検出する傾きセンサと、面取りがなされたイレーサ端部のどの部分がイレーサとして使用されたかを検出するスイッチとを実装し、位置指示部材による指示領域を筆記面側で検出し、また前記傾きセンサとスイッチの検出出力を筆記面側に転送して、筆記面側でイレーサ範囲を特定することにより、長方形に準じた形状のイレーサを用いて各種のイレース領域の指定を可能にする電子黒板用イレーサが開示されている。

【０００９】しかし、この従来の電子黒板用イレーサでは、イレーサとペンを識別するための技術に関しては特に開示がない。また、この電子黒板用イレーサでは、イレーサ側に各種のセンサを内蔵するようにしているのでイレーサが重くなって使い勝手が悪くなるとともに、各種センサの情報をイレーサ側から筆記面側に転送するようにしているのでシステムコストが高くなり、また複数のイレーサを用意する場合には各イレーサの識別情報を筆記面側に転送するための構成が必要になるなどの問題がある。

【００１０】この発明はこのような実情に鑑みてなされたもので、操作者に特別な選択操作を行わすことなく手書き入力デバイスの種類の識別を可能として、コストパフォーマンスおよび操作性のよい手書き入力装置を提供することを目的とする。

【００１１】

【課題を解決するための手段】この発明では、手書き入力デバイス（４，５）の入力面（３）への入力操作に対応した描画を実行する手書き入力装置において、前記入力面（３）に対する手書き入力デバイス（４，５）の入力面積または入力形状を検出し、この検出した入力面積または入力形状に基づいて入力操作を行った手書き入力デバイス（４，５）の種類を識別する識別手段（９）と、この識別手段（９）によって識別した種類に対応する描画処理を実行する描画処理手段（１０）とを具えるようにしている。

【００１２】

【作用】かかる発明によれば、識別手段は、手書き入力デバイスの入力面積または入力形状を検出し、この検出した入力面積または入力形状に基づいて入力操作を行った手書き入力デバイスの種類を識別する。描画処理手段は、前記識別した手書き入力デバイスの種類に対応する描画処理を実行する。

【0013】手書き入力デバイスの種類が、その入力面積または入力形状に基づいて自動的に識別されるので、操作者に特別な選択操作を強いることがなく、コストパフォーマンスおよび操作性を向上させることができる。

【0014】

【実施例】以下この発明の実施例を添付図面を参照して詳細に説明する。

【0015】図1はこの発明の実施例を示すもので、スクリーンパネル1は、手書き入力画像などの各種表示を行う表示パネル2と、この表示パネル2上に積層されて入力デバイス（入力ペン4、イレーサ5など）によって指示された座標位置を検出する入力座標検出パネル3とを有している。

【0016】この場合、入力デバイスとして、図2に示すように、ペン形状の入力ペン4と、長方形状のイレーサ5とを具備させている。入力ペン4は書き込み型の描画を行うもので、イレーサ5は手書き入力された文字、図形などを消去するためのものである。

【0017】入力座標検出パネル3としては、感圧式、静電容量結合式、超音波式、電磁授受方式等の各種の方式があり、図3に感圧方式のパネルの概念的構成を示す。

【0018】図2の感圧方式パネル3では、多数本のX電極ｘ1～ｘnおよびY電極ｙ1～ｙnが交差するように積層されて配列されており、通常はX電極およびY電極間に設けられた図示しないドットスペーサによってX電極およびY電極は離間しているが、入力ペン4またはイレーサ5によってパネル3が押されることにより、該押された位置に対応する部位のX電極及びY電極が接触し、電流ループを形成する。この電流ループを検出することにより、押圧部位に対応するパネル3上の座標が検出される。図3のクロスハッチングで示された領域13は押圧部位を示し、この場合は、座標(x4,y4)、(x4,y5)、(x5,y4)、(x5,y5)のX電極及びY電極が接触している。

【0019】入力座標検出部6は、入力ペン4などによって押された入力座標検出パネル3上の座標を検出するもので、入力座標検出パネル3が感圧方式の場合、入力座標検出部6は以下のようにして押圧された座標位置を検出する。

【0020】すなわち、X電極ｘ1～ｘnをVccにプルアップした状態で、Y電極ｙ1～ｙnに、図4に示すような、時系列パルスを順次印加すると、入力ペン4による押圧によってY軸が接触したX電極のみが時系列パルスが入力されたときに“L”となる。すなわち、入力座標検出部6は、時系列パルスの印加タイミングに基づいて＊Y軸座標を特定し、かつX電極ｘ1～ｘn上のL電位を検出することによりX軸座標を特定する。

【0021】入力座標検出部6で検出された入力ペン4などの入力座標データは入力座標通信部7に出力される。入力座標通信部7は、例えばRS232Cであり、入力座標データが入力されると、この入力座標データを割り込み要求信号と共に、制御部8に出力する。

【0022】制御部8は、各種制御を実行するCPUやMPUであり、この場合は、本発明の動作に直接関係する機能を実行する構成要素として、入力デバイス識別部9および描画処理部10のみを示している。

【0023】入力デバイス識別部9は、入力座標検出パネル3に対する入力デバイスの入力面積または入力形状を検出し、この検出した入力面積または入力形状に基づいて入力操作を行った手書き入力デバイスの種類を識別し、この識別情報を描画処理部10に出力する。入力座標検出パネル3が感圧式パネルの場合は、パネル3に対して同時あるいはほぼ同時にタッチされた領域の面積または形状を検出し、この検出した面積または形状に基づいてタッチした入力デバイスの種類を識別する。図5に、各種入力デバイスによるタッチ領域の例を示す。クロスハッチングを施した領域がタッチ領域である。

【0024】描画処理部10は、入力デバイス識別部9からの識別情報に基づいて処理モードを選択し、入力座標通信部7から送られてきた座標データを前記選択した処理モードに従って処理することにより描画データ（消去データも含む）を作成し、これを表示用のVRAM11に出力する。

【0025】VRAM11には、表示パネル2に表示すべき表示データが1画面分記憶されており、ディスプレイドライバ12は、VRAM11の記憶データに従って表示パネル2を駆動することにより、VRAM11の記憶データに対応する表示を表示パネル2上で実行させる。

【0026】以下、かかる構成における入力デバイス識別部9の具体的な動作例を図6のフローチャートを参照して説明する。

【0027】ただし、この場合、入力座標検出パネル3は、概念的には、図7に示すように、多数のセンサがX－Y方向にマトリクス配置しているものとし、各センサにX－Y座標値を予め割り付けておく。

【0028】また、この場合、入力デバイスとして、次のような4種のデバイスを用いるものとする。なお、サイズ、面積の単位はセンサ1個分とする。

【0029】

(a)細ペン	サイズ（横3／縦6）	面積　18
(b)太ペン	サイズ（横7／縦16）	面積　112
(c)イレーサ（小）	サイズ（横9／縦9）	面積　81
(d)イレーサ（大）	サイズ（横21／縦21）	面積　441

入力デバイス識別部9は、上記4種の入力デバイスを識別するために、図6に示すような処理を実行する。