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(54) INTEGRATED TOUCH SCREENS

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(58) **Field of Classification Search**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,751,555 A 6/1956 Kirkpatrick
3,333,160 A 7/1967 Gorski

(Continued)

FOREIGN PATENT DOCUMENTS

AU 2005246219 12/2005
CA 1243096 A 10/1988

(Continued)

OTHER PUBLICATIONS

"Gesture Recognition," (2006). Located at <http://www.fingerworks.com/gesture_recognition.html>, last visited Jul. 25, 2006, two pages.

(Continued)

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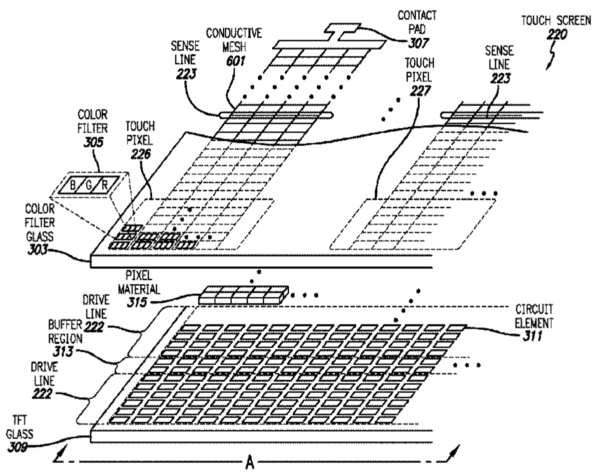
(57) **ABSTRACT**

Integrated touch screens are provided including drive lines formed of grouped-together circuit elements of a thin film transistor layer and sense lines formed between a color filter layer and a material layer that modifies or generates light. The common electrodes (Vcom) in the TFT layer can be grouped together during a touch sensing operation to form drive lines. Sense lines can be formed on an underside of a color filter glass, and a liquid crystal region can be disposed between the color filter glass and the TFT layer. Placing the sense lines on the underside of the color filter glass, i.e., within the display pixel cell, can provide a benefit of allowing the color filter glass to be thinned after the pixel cells have been assembled, for example.

23 Claims, 16 Drawing Sheets



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(56) **References Cited**

U.S. PATENT DOCUMENTS

3,541,541 A 11/1970 Englebart
3,644,835 A 2/1972 Thompson
3,662,105 A 5/1972 Hurst et al.
3,798,370 A 3/1974 Hurst
3,875,472 A 4/1975 Schermerhorn
3,974,332 A 8/1976 Abe et al.
4,194,083 A 3/1980 Abe et al.
4,233,522 A 11/1980 Grummer et al.
4,246,452 A 1/1981 Chandler
4,250,495 A 2/1981 Beckerman et al.
4,266,144 A 5/1981 Bristol
4,268,815 A 5/1981 Eventoff et al.
4,277,517 A 7/1981 Smith, Jr.
4,290,052 A 9/1981 Eichelberger et al.
4,307,383 A 12/1981 Brienza
4,313,108 A 1/1982 Yoshida
4,345,000 A 8/1982 Kawazoe et al.
4,363,027 A 12/1982 Brienza
4,394,643 A 7/1983 Williams
4,526,043 A 7/1985 Boie
4,550,221 A 10/1985 Mabusth
4,587,378 A 5/1986 Moore
4,618,989 A 10/1986 Tsukune et al.
4,623,757 A 11/1986 Marino
4,639,720 A 1/1987 Rympalski et al.
4,672,364 A 6/1987 Lucas
4,672,558 A 6/1987 Beckes et al.
4,686,332 A 8/1987 Greanias et al.
4,692,809 A 9/1987 Beining et al.
4,695,827 A 9/1987 Beining et al.
4,707,845 A 11/1987 Krein et al.
4,723,056 A 2/1988 Tamaru et al.
4,733,222 A 3/1988 Evans
4,734,685 A 3/1988 Watanabe
4,740,781 A 4/1988 Brown
4,746,770 A 5/1988 McAvinney
4,771,276 A 9/1988 Parks
4,772,885 A 9/1988 Uehara et al.
4,788,384 A 11/1988 Bruere-Dawson et al.
4,806,709 A 2/1989 Evans
4,806,846 A 2/1989 Kerber
4,853,493 A 8/1989 Schlosser et al.
4,898,555 A 2/1990 Sampson
4,910,504 A 3/1990 Eriksson
4,914,624 A 4/1990 Dunthorn et al.
4,916,308 A 4/1990 Meadows
4,954,823 A 9/1990 Binstead
4,968,877 A 11/1990 McAvinney et al.
5,003,519 A 3/1991 Noirjean
5,017,030 A 5/1991 Crews
5,062,198 A 11/1991 Sun
5,073,950 A 12/1991 Colbert et al.
5,105,186 A 4/1992 May
5,105,288 A 4/1992 Senda et al.
5,113,041 A 5/1992 Blonder et al.
5,117,071 A 5/1992 Greanias et al.
5,178,477 A 1/1993 Gambaro
5,189,403 A 2/1993 Franz et al.
5,194,862 A 3/1993 Edwards
5,224,861 A 7/1993 Glass et al.
5,239,152 A 8/1993 Caldwell et al.
5,241,308 A 8/1993 Young
5,252,951 A 10/1993 Tannenbaum et al.
5,281,966 A 1/1994 Walsh
5,293,430 A 3/1994 Shiau et al.
5,305,017 A 4/1994 Gerpheide
5,345,543 A 9/1994 Capps et al.
5,353,135 A 10/1994 Edwards
5,374,787 A 12/1994 Miller
5,376,948 A 12/1994 Roberts
5,381,160 A 1/1995 Landmeier
5,386,219 A 1/1995 Greanias et al.
5,392,058 A 2/1995 Tagawa
5,398,310 A 3/1995 Tchao et al.
5,432,671 A 7/1995 Allavena
5,442,742 A 8/1995 Greyson et al.
5,457,289 A 10/1995 Huang et al.
5,459,463 A 10/1995 Gruaz et al.
5,463,388 A 10/1995 Boie et al.
5,463,696 A 10/1995 Beernink et al.
5,483,261 A 1/1996 Yasutake
5,488,204 A 1/1996 Mead et al.
5,495,077 A 2/1996 Miller et al.
5,499,026 A 3/1996 Liao et al.
5,513,309 A 4/1996 Meier et al.
5,523,775 A 6/1996 Capps
5,530,455 A 6/1996 Gillick et al.
5,534,892 A 7/1996 Tagawa
5,543,588 A 8/1996 Bisset et al.
5,543,589 A 8/1996 Buchana et al.
5,543,590 A 8/1996 Gillespie et al.
5,543,591 A 8/1996 Gillespie et al.
5,550,659 A 8/1996 Fujieda et al.
5,552,787 A 9/1996 Schuler et al.
5,563,632 A 10/1996 Roberts
5,563,727 A 10/1996 Larson et al.
5,563,996 A 10/1996 Tchao
5,565,658 A 10/1996 Gerpheide et al.
5,572,205 A 11/1996 Caldwell et al.
5,576,070 A 11/1996 Yaniv
5,579,036 A 11/1996 Yates, IV
5,581,681 A 12/1996 Tchao et al.
5,583,946 A 12/1996 Gourdol
5,589,856 A 12/1996 Stein et al.
5,590,219 A 12/1996 Gourdol
5,592,566 A 1/1997 Pagallo et al.
5,594,806 A 1/1997 Colbert
5,594,810 A 1/1997 Gourdol
5,596,694 A 1/1997 Capps
5,612,719 A 3/1997 Beernink et al.
5,623,280 A 4/1997 Akins et al.
5,631,805 A 5/1997 Bonsall
5,633,955 A 5/1997 Bozinovic et al.
5,634,102 A 5/1997 Capps
5,636,101 A 6/1997 Bonsall et al.
5,638,093 A 6/1997 Takahashi et al.
5,642,108 A 6/1997 Gopher et al.
5,644,657 A 7/1997 Capps et al.
5,648,642 A 7/1997 Miller et al.
5,650,597 A 7/1997 Redmayne
5,666,113 A 9/1997 Logan
5,666,502 A 9/1997 Capps
5,666,552 A 9/1997 Greyson et al.
5,675,361 A 10/1997 Santilli
5,677,710 A 10/1997 Thompson-Rohrlich
5,677,744 A 10/1997 Yoneda et al.
5,686,973 A 11/1997 Lee
5,689,253 A 11/1997 Hargreaves et al.
5,710,844 A 1/1998 Capps et al.
5,729,250 A 3/1998 Bishop et al.
5,730,165 A 3/1998 Philipp
5,734,742 A 3/1998 Asaeda et al.
5,734,751 A 3/1998 Saito
5,736,976 A 4/1998 Cheung
5,741,990 A 4/1998 Davies
5,745,116 A 4/1998 Pisutha-Arnond
5,745,716 A 4/1998 Tchao et al.
5,748,269 A 5/1998 Harris et al.
5,764,218 A 6/1998 Bona et al.
5,764,818 A 6/1998 Capps et al.
5,767,457 A 6/1998 Gerpheide et al.
5,767,842 A 6/1998 Korth
5,777,596 A 7/1998 Herbert
5,790,104 A 8/1998 Shieh
5,790,106 A 8/1998 Hirano et al.
5,790,107 A 8/1998 Kasser et al.
5,802,516 A 9/1998 Shwarts et al.
5,805,144 A 9/1998 Scholder et al.
5,808,567 A 9/1998 McCloud

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,809,166 A 9/1998 Huang et al.
5,809,267 A 9/1998 Moran et al.
5,815,141 A 9/1998 Phares
5,821,690 A 10/1998 Martens et al.
5,821,930 A 10/1998 Hansen
5,823,782 A 10/1998 Marcus et al.
5,825,351 A 10/1998 Tam
5,825,352 A 10/1998 Bisset et al.
5,835,079 A 11/1998 Shieh
5,838,308 A 11/1998 Knapp et al.
5,841,078 A 11/1998 Miller et al.
5,841,415 A 11/1998 Kwon et al.
5,844,506 A 12/1998 Binstead
5,847,690 A 12/1998 Boie et al.
5,852,487 A 12/1998 Fujimori et al.
5,854,450 A 12/1998 Kent
5,854,625 A 12/1998 Frisch et al.
5,856,822 A 1/1999 Du et al.
5,861,583 A 1/1999 Schediwy et al.
5,861,875 A 1/1999 Gerpheide
5,867,151 A 2/1999 Nakai
5,869,790 A 2/1999 Shigetaka et al.
5,869,791 A 2/1999 Young
5,880,411 A 3/1999 Gillespie et al.
5,898,434 A 4/1999 Small et al.
5,914,465 A 6/1999 Allen et al.
5,917,165 A 6/1999 Platt et al.
5,920,298 A 7/1999 McKnight
5,920,309 A 7/1999 Bisset et al.
5,923,319 A 7/1999 Bishop et al.
5,929,834 A 7/1999 Inoue et al.
5,933,134 A 8/1999 Shieh
5,940,055 A 8/1999 Lee
5,940,064 A 8/1999 Kai et al.
5,942,733 A 8/1999 Allen et al.
5,943,043 A 8/1999 Furuhata et al.
5,943,044 A 8/1999 Martinelli et al.
5,945,980 A 8/1999 Moissev et al.
5,952,998 A 9/1999 Clancy et al.
5,955,198 A 9/1999 Hashimoto et al.
5,982,352 A 11/1999 Pryor
5,986,723 A 11/1999 Nakamura et al.
6,002,389 A 12/1999 Kasser
6,002,808 A 12/1999 Freeman
6,008,800 A 12/1999 Pryor
6,020,881 A 2/2000 Naughton et al.
6,020,945 A 2/2000 Sawai et al.
6,023,265 A 2/2000 Lee
6,028,581 A 2/2000 Umeya
6,029,214 A 2/2000 Dorfman et al.
6,031,524 A 2/2000 Kunert
6,037,882 A 3/2000 Levy
6,050,825 A 4/2000 Nichol et al.
6,052,339 A 4/2000 Frenkel et al.
6,057,903 A 5/2000 Colgan et al.
6,061,177 A 5/2000 Fujimoto
6,072,494 A 6/2000 Nguyen
6,081,259 A 6/2000 Teterwak
6,084,576 A 7/2000 Leu et al.
6,107,654 A 8/2000 Yamazaki
6,107,997 A 8/2000 Ure
6,124,848 A 9/2000 Ballare et al.
6,128,003 A 10/2000 Smith et al.
6,131,299 A 10/2000 Raab et al.
6,135,958 A 10/2000 Mikula-Curtis et al.
6,137,427 A 10/2000 Binstead
6,144,380 A 11/2000 Shwarts et al.
6,163,313 A 12/2000 Aroyan et al.
6,172,667 B1 1/2001 Sayag
6,177,918 B1 1/2001 Colgan et al.
6,188,391 B1 2/2001 Seely et al.
6,191,828 B1 2/2001 Kim et al.
6,198,515 B1 3/2001 Cole
6,204,897 B1 3/2001 Colgan et al.
6,208,329 B1 3/2001 Ballare
6,211,585 B1 4/2001 Sato et al.
6,222,465 B1 4/2001 Kumar et al.
6,222,528 B1 4/2001 Gerpheide et al.
6,239,389 B1 5/2001 Allen et al.
6,239,788 B1 5/2001 Nohno et al.
6,239,790 B1 5/2001 Martinelli et al.
6,243,071 B1 6/2001 Shwarts et al.
6,246,862 B1 6/2001 Grivas et al.
6,249,606 B1 6/2001 Kiraly et al.
6,259,490 B1 7/2001 Colgan et al.
6,271,835 B1 8/2001 Hoeksma
6,285,428 B1 9/2001 Kim et al.
6,288,707 B1 9/2001 Philipp
6,289,326 B1 9/2001 LaFleur
6,292,178 B1 9/2001 Bernstein et al.
6,297,811 B1 10/2001 Kent et al.
6,310,610 B1 10/2001 Beaton et al.
6,323,846 B1 11/2001 Westerman et al.
6,323,849 B1 11/2001 He et al.
6,337,678 B1 1/2002 Fish
6,342,938 B1 1/2002 Song et al.
6,347,290 B1 2/2002 Bartlett
6,377,009 B1 4/2002 Philipp
6,380,931 B1 4/2002 Gillespie et al.
6,411,287 B1 6/2002 Scharff et al.
6,414,671 B1 7/2002 Gillespie et al.
6,417,846 B1 7/2002 Lee
6,421,039 B1 7/2002 Moon et al.
6,421,234 B1 7/2002 Ricks et al.
6,425,289 B1 7/2002 Igel et al.
6,452,514 B1 9/2002 Philipp
6,457,355 B1 10/2002 Philipp
6,459,424 B1 10/2002 Resman
6,466,036 B1 10/2002 Philipp
6,483,498 B1 11/2002 Colgan et al.
6,501,528 B1 12/2002 Hamada
6,501,529 B1 12/2002 Kurihara et al.
6,504,530 B1 1/2003 Wilson et al.
6,504,713 B1 1/2003 Pandolfi et al.
6,515,669 B1 2/2003 Mohri
6,522,772 B1 2/2003 Morrison et al.
6,525,547 B2 2/2003 Hayes
6,525,749 B1 2/2003 Moran et al.
6,535,200 B2 3/2003 Philipp
6,543,684 B1 4/2003 White et al.
6,543,947 B2 4/2003 Lee
6,549,193 B1 4/2003 Huang et al.
6,570,557 B1 5/2003 Westerman et al.
6,593,916 B1 7/2003 Aroyan
6,602,790 B2 8/2003 Kian et al.
6,610,936 B2 8/2003 Gillespie et al.
6,624,833 B1 9/2003 Kumar et al.
6,624,835 B2 9/2003 Willig
6,628,268 B1 9/2003 Harada et al.
6,639,577 B2 10/2003 Eberhard
D482,368 S 11/2003 Den Toonder et al.
6,650,319 B1 11/2003 Hurst et al.
6,658,994 B1 12/2003 McMillan
6,670,894 B2 12/2003 Mehring
6,677,932 B1 1/2004 Westerman
6,677,934 B1 1/2004 Blanchard
6,680,448 B2 1/2004 Kawashima et al.
6,690,387 B2 2/2004 Zimmerman et al.
6,721,375 B1 4/2004 Hammel
6,723,929 B2 4/2004 Kent
6,724,366 B2 4/2004 Crawford
6,757,002 B1 6/2004 Oross et al.
6,762,752 B2 7/2004 Perski et al.
6,784,948 B2 8/2004 Kawashima et al.
6,785,578 B2 8/2004 Johnson et al.
6,803,906 B1 10/2004 Morrison et al.
6,825,833 B2 11/2004 Mulligan et al.
6,842,672 B1 1/2005 Straub et al.
6,846,579 B2 1/2005 Anderson et al.
6,856,259 B1 2/2005 Sharp
6,876,355 B1 4/2005 Ahn et al.
6,888,536 B2 5/2005 Westerman et al.
6,900,795 B1 5/2005 Knight, III et al.
6,906,692 B2 6/2005 Ishiyama

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,924,789	B2	8/2005	Bick
6,927,761	B2	8/2005	Badaye et al.
6,927,763	B2	8/2005	LaMonica
6,942,571	B1	9/2005	McAllister et al.
6,943,779	B2	9/2005	Satoh
6,961,049	B2	11/2005	Mulligan et al.
6,965,375	B1	11/2005	Gettemy et al.
6,970,160	B2	11/2005	Mulligan et al.
6,972,401	B2	12/2005	Akitt et al.
6,977,666	B1	12/2005	Hedrick
6,982,432	B2	1/2006	Umemoto et al.
6,985,801	B1	1/2006	Straub et al.
6,992,659	B2	1/2006	Gettemy
6,995,752	B2	2/2006	Lu
7,009,663	B2	3/2006	Abileah et al.
7,015,894	B2	3/2006	Morohoshi
7,023,427	B2	4/2006	Kraus et al.
7,030,860	B1	4/2006	Hsu et al.
7,031,228	B2	4/2006	Born et al.
7,038,659	B2	5/2006	Rajkowski
7,042,444	B2	5/2006	Cok
7,046,235	B2	5/2006	Katoh
7,088,342	B2	8/2006	Rekimoto
7,088,343	B2	8/2006	Smith
7,098,127	B2	8/2006	Ito
7,098,897	B2	8/2006	Vakil et al.
7,109,978	B2	9/2006	Gillespie et al.
7,129,935	B2	10/2006	Mackey
7,133,032	B2	11/2006	Cok
7,138,984	B1	11/2006	Miles
7,151,528	B2	12/2006	Taylor et al.
7,154,481	B2	12/2006	Cross et al.
7,177,001	B2	2/2007	Lee
7,184,064	B2	2/2007	Zimmerman et al.
7,190,416	B2	3/2007	Paukshto et al.
7,202,856	B2	4/2007	Cok
7,230,608	B2	6/2007	Cok
7,254,775	B2	8/2007	Geaghan et al.
7,268,770	B1	9/2007	Takahata et al.
7,274,353	B2	9/2007	Chiu et al.
7,280,167	B2	10/2007	Choi et al.
7,292,229	B2	11/2007	Morag et al.
7,307,231	B2	12/2007	Matsumoto et al.
RE40,153	E	3/2008	Westerman et al.
7,339,579	B2	3/2008	Richter et al.
7,355,592	B2	4/2008	Jong et al.
7,362,313	B2	4/2008	Geaghan et al.
7,372,455	B2	5/2008	Perski et al.
7,379,054	B2	5/2008	Lee
7,453,444	B2	11/2008	Geaghan
7,463,246	B2	12/2008	Mackey
7,483,016	B1	1/2009	Gettemy et al.
7,554,624	B2	6/2009	Kusuda et al.
7,633,484	B2	12/2009	Ito
7,663,607	B2	2/2010	Hotelling et al.
7,683,888	B1	3/2010	Kennedy
7,688,315	B1	3/2010	Gettemy et al.
7,705,834	B2	4/2010	Swedin
7,730,401	B2	6/2010	Gillespie et al.
7,742,041	B2	6/2010	Lee et al.
7,746,326	B2	6/2010	Sato
7,755,683	B2	7/2010	Sergio et al.
7,800,589	B2	9/2010	Hurst et al.
7,812,828	B2	10/2010	Westerman et al.
7,843,439	B2	11/2010	Perski et al.
7,920,129	B2	4/2011	Hotelling et al.
8,031,180	B2	10/2011	Miyamoto et al.
8,125,463	B2	2/2012	Hotelling et al.
8,130,209	B2	3/2012	Chang
8,243,027	B2	8/2012	Hotelling et al.
8,259,078	B2	9/2012	Hotelling et al.
8,416,209	B2	4/2013	Hotelling et al.
8,432,371	B2	4/2013	Hotelling et al.
8,479,122	B2	7/2013	Hotelling et al.
8,493,330	B2	7/2013	Krah
8,552,989	B2	10/2013	Hotelling et al.
8,605,051	B2	12/2013	Hotelling et al.
8,654,083	B2	2/2014	Hotelling et al.
8,743,300	B2	6/2014	Chang et al.
8,804,056	B2	8/2014	Chang et al.
8,872,785	B2	10/2014	Hotelling et al.
8,928,618	B2	1/2015	Hotelling et al.
8,982,087	B2	3/2015	Hotelling et al.
9,025,090	B2	5/2015	Chang et al.
9,035,907	B2	5/2015	Hotelling et al.
2001/0000961	A1	5/2001	Hikida et al.
2001/0020578	A1	9/2001	Baier
2001/0020986	A1	9/2001	Ikeda et al.
2001/0020987	A1	9/2001	Ahn et al.
2002/0015024	A1	2/2002	Westerman et al.
2002/0041356	A1	4/2002	Tanada et al.
2002/0049070	A1	4/2002	Bick
2002/0084922	A1	7/2002	Yagi
2002/0089496	A1	7/2002	Numao
2002/0101410	A1	8/2002	Sakata et al.
2002/0118848	A1	8/2002	Karpenstein
2002/0140649	A1	10/2002	Aoyama et al.
2002/0159015	A1	10/2002	Seo et al.
2002/0167489	A1	11/2002	Davis
2002/0185981	A1	12/2002	Dietz et al.
2002/0185999	A1	12/2002	Tajima et al.
2002/0186210	A1	12/2002	Itoh
2002/0190964	A1	12/2002	Van Berkel
2002/0191029	A1	12/2002	Gillespie et al.
2002/0192445	A1	12/2002	Ezzell et al.
2002/0196237	A1	12/2002	Fernando et al.
2003/0006974	A1	1/2003	Clough et al.
2003/0035479	A1	2/2003	Kan et al.
2003/0067451	A1	4/2003	Tagg et al.
2003/0069653	A1	4/2003	Johnson et al.
2003/0076301	A1	4/2003	Tsuk et al.
2003/0076303	A1	4/2003	Huppi
2003/0076306	A1	4/2003	Zadesky et al.
2003/0085882	A1	5/2003	Lu
2003/0095095	A1	5/2003	Pihlaja
2003/0095096	A1	5/2003	Robbin et al.
2003/0098858	A1	5/2003	Perski et al.
2003/0151600	A1	8/2003	Takeuchi et al.
2003/0174128	A1	9/2003	Matsufusa
2003/0179323	A1	9/2003	Abileah et al.
2003/0201984	A1	10/2003	Falvo
2003/0206162	A1	11/2003	Roberts
2003/0206202	A1	11/2003	Moriya
2003/0222857	A1	12/2003	Abileah
2003/0234768	A1	12/2003	Rekimoto et al.
2003/0234769	A1	12/2003	Cross et al.
2003/0234770	A1	12/2003	MacKey
2004/0022010	A1	2/2004	Shigetaka
2004/0056839	A1	3/2004	Yoshihara
2004/0080501	A1	4/2004	Koyama
2004/0090429	A1	5/2004	Geaghan et al.
2004/0095335	A1	5/2004	Oh et al.
2004/0109097	A1	6/2004	Mai
2004/0119701	A1	6/2004	Mulligan et al.
2004/0141096	A1	7/2004	Mai
2004/0150629	A1	8/2004	Lee
2004/0155871	A1	8/2004	Perski et al.
2004/0155991	A1	8/2004	Lowles et al.
2004/0188150	A1	9/2004	Richard et al.
2004/0189587	A1	9/2004	Jung et al.
2004/0189612	A1	9/2004	Bottari et al.
2004/0217945	A1	11/2004	Miyamoto et al.
2004/0227736	A1	11/2004	Kamrath et al.
2004/0239650	A1	12/2004	Mackey
2004/0243747	A1	12/2004	Rekimoto
2004/0263484	A1	12/2004	Mantysalo et al.
2005/0007349	A1	1/2005	Vakil et al.
2005/0012723	A1	1/2005	Pallakoff
2005/0017737	A1	1/2005	Yakabe et al.
2005/0046621	A1	3/2005	Kakikuranta
2005/0052425	A1	3/2005	Zadesky et al.
2005/0052427	A1	3/2005	Wu et al.
2005/0052582	A1	3/2005	Mai
2005/0062620	A1	3/2005	Schaefer

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0073507 A1 4/2005 Richter et al.
2005/0083307 A1 4/2005 Aufderheide et al.
2005/0099402 A1 5/2005 Nakanishi et al.
2005/0104867 A1 5/2005 Westerman et al.
2005/0110768 A1 5/2005 Marriott et al.
2005/0146511 A1 7/2005 Hill et al.
2005/0162402 A1 7/2005 Watanachote
2005/0170668 A1 8/2005 Park et al.
2005/0231487 A1 10/2005 Ming
2005/0237439 A1 10/2005 Mai
2005/0243023 A1 11/2005 Reddy et al.
2006/0007087 A1 1/2006 Choi et al.
2006/0007165 A1 1/2006 Yang et al.
2006/0012575 A1 1/2006 Knapp et al.
2006/0017710 A1 1/2006 Lee et al.
2006/0022955 A1 2/2006 Kennedy
2006/0022956 A1 2/2006 Lengeling et al.
2006/0026521 A1 2/2006 Hotelling et al.
2006/0026535 A1 2/2006 Hotelling et al.
2006/0026536 A1 2/2006 Hotelling et al.
2006/0032680 A1 2/2006 Elias et al.
2006/0033724 A1 2/2006 Chaudhri et al.
2006/0044259 A1 3/2006 Hotelling et al.
2006/0053387 A1 3/2006 Ording
2006/0066582 A1 3/2006 Lyon et al.
2006/0085757 A1 4/2006 Andre et al.
2006/0097991 A1 5/2006 Hotelling et al.
2006/0109222 A1 5/2006 Lee et al.
2006/0132462 A1 6/2006 Geaghan
2006/0145365 A1 7/2006 Halls et al.
2006/0145983 A1 7/2006 Lee et al.
2006/0146033 A1 7/2006 Chen et al.
2006/0146034 A1 7/2006 Chen et al.
2006/0197753 A1 9/2006 Hotelling
2006/0227114 A1 10/2006 Geaghan et al.
2006/0232564 A1 10/2006 Nishimura et al.
2006/0232567 A1 10/2006 Westerman et al.
2006/0238517 A1 10/2006 King et al.
2006/0238518 A1 10/2006 Westerman et al.
2006/0238519 A1 10/2006 Westerman et al.
2006/0238520 A1 10/2006 Westerman et al.
2006/0238521 A1 10/2006 Westerman et al.
2006/0238522 A1 10/2006 Westerman et al.
2006/0244736 A1 11/2006 Tseng
2006/0278444 A1 12/2006 Binstead
2006/0279679 A1 12/2006 Fujisawa et al.
2006/0284857 A1 12/2006 Oh
2006/0290863 A1 12/2006 HoeSup
2007/0013678 A1 1/2007 Nakajima et al.
2007/0018969 A1 1/2007 Chen et al.
2007/0027932 A1 2/2007 Thibeault
2007/0062739 A1 3/2007 Philipp et al.
2007/0075977 A1 4/2007 Chen et al.
2007/0085838 A1 4/2007 Ricks et al.
2007/0109274 A1 5/2007 Reynolds
2007/0152976 A1 7/2007 Townsend et al.
2007/0159561 A1 7/2007 Chien
2007/0176905 A1 8/2007 Shih et al.
2007/0182706 A1 8/2007 Cassidy et al.
2007/0216657 A1 9/2007 Konicek
2007/0229464 A1 10/2007 Hotelling et al.
2007/0236466 A1 10/2007 Hotelling
2007/0247429 A1 10/2007 Westerman
2007/0257890 A1 11/2007 Hotelling et al.
2007/0262967 A1 11/2007 Rho
2008/0048994 A1 2/2008 Lee et al.
2008/0055221 A1 3/2008 Yabuta et al.
2008/0055268 A1 3/2008 Yoo et al.
2008/0055270 A1 3/2008 Cho et al.
2008/0062139 A1 3/2008 Hotelling et al.
2008/0062140 A1 3/2008 Hotelling et al.
2008/0062147 A1 3/2008 Hotelling et al.
2008/0062148 A1 3/2008 Hotelling et al.
2008/0067528 A1 3/2008 Choi et al.
2008/0074401 A1 3/2008 Chung et al.
2008/0079697 A1 4/2008 Lee et al.
2008/0129898 A1 6/2008 Moon
2008/0131624 A1 6/2008 Egami et al.
2008/0136980 A1 6/2008 Rho et al.
2008/0150901 A1 6/2008 Lowles et al.
2008/0157867 A1 7/2008 Krah
2008/0158167 A1 7/2008 Hotelling et al.
2008/0158181 A1 7/2008 Hamblin et al.
2008/0165158 A1 7/2008 Hotelling et al.
2008/0186288 A1 8/2008 Chang
2008/0297476 A1 12/2008 Hotelling et al.
2009/0066670 A1 3/2009 Hotelling et al.
2009/0096757 A1 4/2009 Hotelling et al.
2009/0096758 A1 4/2009 Hotelling et al.
2009/0115743 A1 5/2009 Oowaki
2009/0160816 A1 6/2009 Westerman et al.
2009/0273581 A1 11/2009 Kim et al.
2009/0303193 A1 12/2009 Lim et al.
2010/0066650 A1 3/2010 Lee et al.
2010/0103121 A1 4/2010 Kim et al.
2010/0182273 A1 7/2010 Noguchi et al.
2010/0188347 A1 7/2010 Mizuhashi et al.
2010/0194699 A1 8/2010 Chang
2010/0238134 A1 9/2010 Day et al.
2010/0289770 A1 11/2010 Lee et al.
2011/0187677 A1 8/2011 Hotelling
2012/0105371 A1 5/2012 Hotelling et al.
2012/0133858 A1 5/2012 Shin et al.
2012/0162104 A1 6/2012 Chang
2012/0162584 A1 6/2012 Chang
2013/0082964 A1 4/2013 Agari et al.
2013/0106780 A1 5/2013 Hotelling et al.
2014/0078108 A1 3/2014 Hotelling
2014/0139457 A1 5/2014 Hotelling et al.
2014/0152619 A1 6/2014 Hotelling et al.
2014/0300578 A1 10/2014 Hotelling
2015/0022497 A1 1/2015 Chang et al.

FOREIGN PATENT DOCUMENTS

CA 2494353 A1 2/2004
CN 1867882 A 11/2006
CN 101241277 A 8/2008
DE 197 06 168 8/1998
DE 102 51 296 A1 5/2004
EP 0 156 593 A2 10/1985
EP 0 156 593 A3 10/1985
EP 0 250 931 A2 1/1988
EP 0 250 931 A3 1/1988
EP 0 250 931 B1 1/1988
EP 0 464 908 A2 1/1992
EP 0 464 908 A3 1/1992
EP 0 464 908 B1 1/1992
EP 0 288 692 A2 7/1993
EP 0 288 692 A3 7/1993
EP 0 288 692 B1 7/1993
EP 0 664 504 A2 7/1995
EP 0 786 745 A2 7/1997
EP 0 786 745 A3 7/1997
EP 0 786 745 B1 7/1997
EP 0 932 117 A2 7/1999
EP 0 932 117 A3 7/1999
EP 0 932 117 B1 7/1999
EP 0 973 123 A1 1/2000
EP 1 014 295 A2 1/2002
EP 1 014 295 A3 1/2002
EP 1 211 633 A1 6/2002
EP 1 211 633 B1 6/2002
EP 1 322 104 A1 6/2003
EP 1 391 807 A1 2/2004
EP 1 396 812 A2 3/2004
EP 1 396 812 A3 3/2004
EP 1 418 491 A2 5/2004
EP 1 418 491 A3 5/2004
EP 1 422 601 A1 5/2004
EP 1 455 264 A2 9/2004
EP 1 455 264 A3 9/2004
EP 2 267 584 A1 12/2010
GB 1 486 988 A 9/1977

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

GB	2 168 816	A	6/1986
GB	2 368 483	A	7/2004
JP	53-147626	A2	11/1978
JP	58-166430	A	10/1983
JP	59-214941	A	12/1984
JP	60-123927	A	7/1985
JP	60-211529	A	10/1985
JP	61-131314	A	6/1986
JP	63-279316	A	11/1988
JP	02-030024	A	1/1990
JP	03-180922	A	8/1991
JP	03-294918	A	12/1991
JP	04-127314	A	4/1992
JP	05-053726		3/1993
JP	05-080923	A	4/1993
JP	05-224818	A	9/1993
JP	06-161661	A	6/1994
JP	07-036017	A	2/1995
JP	07-044305	A	2/1995
JP	07-110741	A	4/1995
JP	07-141086	A	6/1995
JP	08-016307	A	1/1996
JP	08-147092	A	6/1996
JP	08-242458	A	9/1996
JP	08-297267	A	11/1996
JP	09-054650	A	2/1997
JP	09-091079	A	4/1997
JP	09-096792	A	4/1997
JP	09-212302	A	8/1997
JP	09-292950	A	11/1997
JP	09-325852	A	12/1997
JP	10-003349	A	1/1998
JP	11-145141	A	5/1999
JP	11-505641	A	5/1999
JP	11-249813	A	9/1999
JP	2000-105670	A	4/2000
JP	2000-112642	A	4/2000
JP	2000-163031	A	6/2000
JP	2000-172437	A	6/2000
JP	2000-172447	A	6/2000
JP	2000-221932	A	8/2000
JP	2001-283228	A	10/2001
JP	2002-501271	A	1/2002
JP	2002-116017	A	4/2002
JP	2002-259052	A	9/2002
JP	2002-287660	A	10/2002
JP	2002-342014	A	11/2002
JP	2002-342033	A	11/2002
JP	2002-366304	A	12/2002
JP	2003-029899	A	1/2003
JP	2003-099192	A	4/2003
JP	2003-516015	A	5/2003
JP	2003-173237	A	6/2003
JP	2003-185688	A	7/2003
JP	2003-196023	A	7/2003
JP	2003-249738	A	9/2003
JP	2003-255855	A	9/2003
JP	2004-038919	A	2/2004
JP	2004-102985	A	4/2004
JP	2004-186333	A	7/2004
JP	2005-346047	A	12/2005
JP	2007-533044	A	11/2007
JP	2008-032756	A	2/2008
JP	2009-244958	A	10/2009
KR	10-0226812	B1	7/1999
KR	10-2003-0028973	A	4/2003
KR	10-2004-0002310	A	1/2004
KR	10-2004-0013029	A	2/2004
KR	10-2004-0022243	A	3/2004
KR	10-2005-0019799	A	3/2005
KR	10-2006-0089645		8/2006
KR	10-0887775	B1	3/2009
KR	10-2010-0127164	A	12/2010
TW	2003-02778	A	8/2003
TW	2004-21156		10/2004
TW	2005-29441	A	9/2005
WO	WO-87/04553	A1	7/1987
WO	WO-92/13328	A1	8/1992
WO	WO-96/15464	A1	5/1996
WO	WO-96/18179	A1	6/1996
WO	WO-97/18547	A1	5/1997
WO	WO-97/23738	A1	7/1997
WO	WO-98/14863	A1	4/1998
WO	WO-99/38149	A1	7/1999
WO	WO-01/27868	A1	4/2001
WO	WO-01/39371		5/2001
WO	WO-03/079176	A2	9/2003
WO	WO-03/088176	A1	10/2003
WO	WO-2004/013833	A2	2/2004
WO	WO-2004/013833	A3	2/2004
WO	WO-2004/023376	A2	3/2004
WO	WO-2004/023376	A3	3/2004
WO	WO-2004/053576	A1	6/2004
WO	WO-2004/061808	A2	7/2004
WO	WO-2004/061808	A3	7/2004
WO	WO-2004/114265	A2	12/2004
WO	WO-2005/064451	A1	7/2005
WO	WO-2005/114369	A2	12/2005
WO	WO-2005/114369	A3	12/2005
WO	WO-2006/023569	A1	3/2006
WO	WO-2006/054585	A1	5/2006
WO	WO-2007/115032	A2	10/2007
WO	WO-2007/115032	A3	10/2007
WO	WO-2007/146779	A2	12/2007
WO	WO-2007/146779	A3	12/2007
WO	WO-2007/146780	A2	12/2007
WO	WO-2007/146780	A3	12/2007
WO	WO-2007/146783	A2	12/2007
WO	WO-2007/146783	A3	12/2007
WO	WO-2007/146785	A2	12/2007
WO	WO-2007/146785	A3	12/2007
WO	WO-2008/085457	A2	7/2008
WO	WO-2008/085457	A3	7/2008
WO	WO-2009/035471	A1	3/2009
WO	WO-2012/087639	A2	6/2012

OTHER PUBLICATIONS

3M (2002). MicroTouch Capacitive Touch Screens Datasheets, 3M Innovation, six pages.

Agrawal, R. et al. (Jul. 1986). "An Overview of Tactile Sensing," Center for Research on Integrated Manufacturing: Robot Systems Division, The University of Michigan, 47 pages.

Anonymous. (May 8, 1992). "The Sensor Frame Graphic Manipulator," *NASA Phase II Final Report*, 28 pages.

Anonymous. (Oct. 30, 2001). "Radiotelephone with Rotating Symbol Keypad and Multi-Directional Symbol Input," located at www.vitgn.com/mobile_terminal.com, 12 pages.

Anonymous. "4-Wire Resistive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-4resistive.html generated Aug. 5, 2005.

Anonymous. "5-Wire Resistive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-resistive.html generated Aug. 5, 2005.

Anonymous. "A Brief Overview of Gesture Recognition" obtained from http://www. Dai. Ed. Ac.uk/Cvonline/LOCA_COPIES/COHEN/gesture_overview.Html, generated Apr. 20, 2004.

Anonymous. "Capacitive Position Sensing" obtained from http://www.synaptics.com/technology/cps.cfin generated Aug. 5, 2005.

Anonymous. "Capacitive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-capacitive.html generated Aug. 5, 2005.

Anonymous. "Comparing Touch Technologies" obtained from http://www.touchscreens.com/intro-touchtypes.html generated Oct. 10, 2004.

Anonymous. "FingerWorks—Gesture Guide—Application Switching," obtained from http://www.fingerworks.com/gesture_guide_apps.html, generated on Aug. 27, 2004, 1-pg.

Anonymous. "FingerWorks—Gesture Guide—Editing," obtained from http://www.fingerworks.com/gesure_guide_editing.html, generated on Aug. 27, 2004, 1-pg.

(56) **References Cited**

OTHER PUBLICATIONS

Anonymous. "FingerWorks—Gesture Guide—File Operations," obtained from http://www.fingerworks.com/gesture_guide_files.html, generated on Aug. 27, 2004, 1-pg.
Anonymous. "FingerWorks—Gesture Guide—Text Manipulation," obtained from http://www.fingerworks.com/gesture_guide_text_manip.html, generated on Aug. 27, 2004, 2-pg.
Anonymous. "FingerWorks—Gesture Guide—Tips and Tricks," obtained from http://www.fingerworks.com/gesture_guide_tips.html, generated Aug. 27, 2004, 2-pgs.
Anonymous. "FingerWorks—Gesture Guide—Web," obtained from http://www.fingerworks.com/gesture_guide_web.html, generated on Aug. 27, 2004, 1-pg.
Anonymous. "FingerWorks—Guide to Hand Gestures for USB Touchpads," obtained from http://www.fingerworks.com/igesture_userguide.html, generated Aug. 27, 2004, 1-pg.
Anonymous. "FingerWorks—iGesture—Technical Details," obtained from http://www.fingerworks.com/igesture_tech.html, generated Aug. 27, 2004, 1-pg.
Anonymous. "FingerWorks—The Only Touchpads with Ergonomic Full-Hand Resting and Relaxation!" obtained from http://www.fingerworks.com/resting.html, Copyright 2001, 1-pg.
Anonymous. "FingerWorks—Tips for Typing on the Mini," obtained from http://www.fingerworks.com/mini_typing.html, generated on Aug. 27, 2004, 2-pgs.
Anonymous. "GlidePoint®" obtained from http://www.cirque.com/technology/technology_gp.html generated Aug. 5, 2005.
Anonymous. "How do touchscreen monitors know where you're touching?" obtained from http://www.electronics.howstuffworks.com/question716.html generated Aug. 5, 2005.
Anonymous. "How does a touchscreen work?" obtained from http://www.touchscreens.com/intro-anatomy.html generated Aug. 5, 2005.
Anonymous. "iGesture Pad—the MultiFinger USB TouchPad with Whole-Hand Gestures,"obtained from http://www.fingerworks.com/igesture.html, generated Aug. 27, 2004, 2-pgs.
Anonymous. "iGesture Products for Everyone (learn in minutes) Product Overview"FingerWorks.com downloaded Aug. 30, 2005.
Anonymous. "Infrared Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-infrared.html generated Aug. 5, 2005.
Anonymous. "Mouse Emulation" FingerWorks obtained from http://www.fingerworks.com/gesture_guide_mouse.html generated Aug. 30, 2005.
Anonymous. "Mouse Gestures in Opera" obtained from http://www.opera.com/products/desktop/mouse/index.dml generated Aug. 30, 2005.
Anonymous. "Mouse Gestures," Optim oz, May 21, 2004.
Anonymous. "MultiTouch Overview" FingerWorks obtained from http://www.fingerworks.com/multoverview.html generated Aug. 30, 2005.
Anonymous. "Near Field Imaging Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-nfi.html generated Aug. 5, 2005.
Anonymous. "PenTouch Capacitive Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-pentouch.html generated Aug. 5, 2005.
Anonymous. "Surface Acoustic Wave Touchscreens" obtained from http://www.touchscreens.com/intro-touchtypes-saw.html generated Aug. 5, 2005.
Anonymous. "Symbol Commander" obtained from http://www.sensiva.com/symbolcommander/, generated Aug. 30, 2005.
Anonymous. "Tips for Typing" FingerWorks http://www.fingerworks.com/mini_typing.html generated Aug. 30, 2005.
Anonymous. "Touch Technologies Overview" 2001, 3M Touch Systems, Massachusetts.
Anonymous. "Touchscreen Technology Choices," <http://www.elotouch.com/products/detech2.asp>, downloaded Aug. 5, 2005.
Anonymous. "Wacom Components—Technology" obtained from http://www.wacom-components.com/english/tech.asp generated on Oct. 10, 2004.
Anonymous. "Watershed Algorithm" http://rsb.info.nih.gov/ij/plugins/watershed.html generated Aug. 5, 2005.
Baxter, L.K. (1996). *Capacitive Sensors: Design and Applications*, vol. 1 of IEEE Press Series on Electronics Technology, John Wiley & Sons: New York, NY, (Table of Contents Only) three pages.
Bennion, S.I. et al. (Dec. 1981). "Touch Sensitive Graphics Terminal Applied to Process Control," *Computer Graphics* 15(4):342-350.
Bier et al., "Toolglass and Magic Lenses: The see-through interface" In James Kijiya, editor, Computer Graphics (SIGGRAPH '93 Proceedings), vol. 27, pp. 73-80, Aug. 1993.
Boie, R.A. (Mar. 1984). "Capacitive Impedance Readout Tactile Image Sensor," *Proceedings of 1984 IEEE International Conference on Robotics and Automation*, pp. 370-378.
Buxton, W.A.S. (Mar./Apr. 1994). "Combined Keyboard/Touch Tablet Input Device," *XEROX Disclosure Journal* 19(2):109-111.
Chinese Search Report mailed Feb. 2, 2015, for CN Application No. 201210568727.0, filed Jun. 8, 2007, two pages.
Chun, K. et al. (Jul. 1985). "A High-Performance Silicon Tactile Imager Based on a Capacitive Cell," *IEEE Transactions on Electron Devices* 32(7):1196-1201.
Cliff (Jul. 24, 2002). "Building a Pressure-Sensitive, Multi-Point TouchScreen?" Posted from the D-I-Y-Baby Department, one page.
Collberg, C. et al. (2002). "TetraTetris: A Study of Multi-User Touch-Based Interaction Using DiamondTouch," located at cs.arizona.edu, eight pages.
Dannenberg, R.B. et al. (1989). "A Gesture Based User Interface Prototyping System," *ACM*, pp. 127-132.
Davies, E.R. (Aug. 1987). "Lateral Histograms for Efficient Object Location: Speed versus Ambiguity," *Pattern Recognition Letters* 6(3):189-198.
Davies, E.R. (1990). *Machine Vision: Theory, Algorithms, Practicalities*, Academic Press, Inc..: San Diego, CA, pp. xi-xxi (Table of Contents Only.).
Davies, E.R. (1997). "Boundary Pattern Analysis," Chapter 7 *in Machine Vision: Theory, Algorithms, Practicalities*, 2nd Edition, Academic Press, Inc.: San Diego, CA, pp. 171-191.
Davies, E.R. (1997). "Ellipse Detection," Chapter 11 *in Machine Vision: Theory, Algorithms, Practicalities*, 2nd Edition, Academic Press, Inc.: San Diego, CA, pp. 271-290.
Davies, E.R. (1997). "Image Acquisition," Chapter 23 *in Machine Vision: Theory, Algorithms, Practicalities*, 2nd Edition, Academic Press, Inc.: San Diego, CA, pp. 583-601.
Diaz-Marino, R.A. et al. (2003). "Programming for Multiple Touches and Multiple Users: A Toolkit for the DiamondTouch Hardware," *Proceedings of ACM UIST'03 User Interface Software and Technology*, two pages.
Dietz, P. et al. (2001). "DiamondTouch: A Multi-User Touch Technology," *Proceedings of the 14th Annual ACM Symposium on User Interface Software and Technology*, Nov. 11-14, 2001, Orlando, FL, pp. 219-226.
Douglas et al., *The Ergonomics of Computer Pointing Devices* (1997).
Esenther, A. et al. (Nov. 2002). "DiamondTouch SDK: Support for Multi-User, Multi-Touch Applications," *Mitsubishi Electric Research Laboratories, Inc.*, five pages.
European Search Report mailed Jul. 28, 2011, for EP Application No. 11159164.0, filed Jun. 8, 2007, eight pages.
European Search Report mailed Oct. 21, 2011, for EP Application No. 11159166.5, filed Jun. 8, 2007, seven pages.
European Search Report mailed Feb. 16, 2012, for EP Application No. 11183531.0, 11 pages.
European Search Report mailed Mar. 27, 2012, for EP Application No. 10178558.2, nine pages.
European Search Report received in EP 1 621 989 (@ *Beyer Weaver & Thomas, LLP*) dated Mar. 27, 2006.
EVB ELEKTRONIK "TSOP6238 IR Receiver Modules for Infrared Remote Control Systems" dated Jan. 2004 1-pg.
Fearing, R.S. (Jun. 1990). "Tactile Sensing Mechanisms," *The International Journal of Robotics Research* 9(3):3-23.
Final Office Action mailed Jul. 6, 2010, for U.S. Appl. No. 11/760,036, filed Jun. 8, 2007, 51 pages.
Final Office Action mailed Jul. 6, 2010, for U.S. Appl. No. 11/760,080, filed Jun. 8, 2007, 66 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Final Office Action mailed Jul. 22, 2010, for U.S. Appl. No. 11/760,049, filed Jun. 8, 2007, 52 pages.
Final Office Action mailed Aug. 2, 2010, for U.S. Appl. No. 11/760,060, filed Jun. 8, 2007, 78 pages.
Final Office Action mailed Sep. 1, 2011, for U.S. Appl. No. 11/650,203, filed Jan. 3, 2007, nine pages.
Final Office Action mailed Oct. 17, 2011, for U.S. Appl. No. 11/818,395, filed Jun. 13, 2007, 16 pages.
Final Office Action mailed Dec. 16, 2011, for U.S. Appl. No. 11/760,036, filed Jun. 8, 2007, 53 pages.
Final Office Action mailed Jan. 30, 2012, for U.S. Appl. No. 11/760,049, filed Jun. 8, 2007, 64 pages.
Final Office Action mailed Feb. 27, 2012, for U.S. Appl. No. 11/760,080, filed Jun. 8, 2007, 62 pages.
Final Office Action mailed May 9, 2013, for U.S. Appl. No. 12/976,997, filed Dec. 22, 2010, 7 pages.
Final Office Action mailed Oct. 27, 2014, for U.S. Appl. No. 11/818,395, filed Jun. 13, 2007, 17 pages.
Fisher, et al., "Repetitive Motion Disorders: The Design of Optimal Rate—Rest Profiles," Human Factors, 35(2):283-304 (Jun. 1993).
Fukumoto and Yoshinobu Tonomura, "Body Coupled Fingering: Wireless Wearable Keyboard," *CHI97*, pp. 147-154 (Mar. 1997).
Fukumoto, et al., "ActiveClick: Tactile Feedback for Touch Panels," In CHI 2001 Summary, pp. 121-122, 2001.
Hardy, "Fingerworks" Mar. 7, 2002; BBC World on Line.
Hector, J. et al. (May 2002). "Low Power Driving Options for an AMLCD Mobile Display Chipset," Chapter 16.3 *in SID 02 Digest* (2002 SID International Symposium, Digest of Technical Papers), XXXIII(II):694-697.
Hillier and Gerald J. Lieberman, *Introduction to Operations Research* (1986).
Hinckley, K. et al. (1998). "Interaction and Modeling Techniques for Desktop Two-Handed Input," *Proceedings of ACM USIT'98 Symposium on User Interface Software and Technology*, pp. 49-58.
Hinckley, K. et al. (May 1999). "Touch-Sensing Input Devices," *CHI 99* pp. 223-230.
Hinckley, K. et al. (2000). "Sensing Techniques for Mobile Interaction," *CHI Letters* 2(2):91-100.
Hlady, A.M. (1969). "A Touch Sensitive X-Y Position Encoder for Computer Input," *Fall Joint Computer Conference*, pp. 545-551.
Hotelling, et al., Office action for U.S. Appl. No. 10/840,862 mailed May 14, 2008.
International Search Report dated Mar. 3, 2006 (PCT/US 05/03325; 119-0052WO).
International search report for International Application No. PCT/US2005/014364 mailed Jan. 12, 2005.
International Search Report mailed Mar. 6, 2008, for PCT Application No. PCT/2007/70733, filed Jun. 8, 2007, five pages.
International Search Report mailed Mar. 7, 2008, for PCT Application No. PCT/2007/70722, filed Jun. 8, 2007, three pages.
International Search Report mailed Jun. 24, 2008, for PCT Application No. PCT/US2007/026298, filed Dec. 21, 2007, two pages.
International Search Report mailed Jul. 18, 2008, for PCT Application No. PCT/2007/70725, filed Jun. 8, 2007, six pages.
International Search Report mailed Jul. 18, 2008, for PCT Application No. PCT/2007/70729, filed Jun. 8, 2007, five pages.
International Search Report mailed Oct. 16, 2008, for PCT Application No. PCT/US2007/088749, filed Dec. 21, 2007, four pages.
International Search Report mailed Jun. 15, 2012, for PCT/US2011/064455, filed Dec. 12, 2011, four pages.
International Search Report received in corresponding PCT application No. PCT/US2006/008349 dated Oct. 6, 2006.
Jacob et al., "Integrality and Separability of Input Devices," *ACM Transactions on Computer-Human Interaction*, 1:3-26 (Mar. 1994).
Kanda, E. et al. (2008). "55.2: Integrated Active Matrix Capacitive Sensors for Touch Panel LTPS-TFT LCDs," *SID 08 Digest*, pp. 834-837.
Kinkley, et al., "Touch-Sensing Input Devices," in CHI '99 Proceedings, pp. 223-230, 1999.
Kionx "KXP84 Series Summary Data Sheet" copyright 2005,dated Oct. 21, 2005, 4-pgs.
Kirk, D.E. (1970). "Numerical Determination of Optimal Trajectories," Chapter 6 *in Optimal Control Theory: An Introduction*, Prentice Hall, Inc.: Englewood Cliffs, NY. pp. 329-413, with Table of Contents, pp. vii-ix. (90 pages total).
Kling, M. et al. (Sep. 2003). "Interface Design: LCD Touch Interface for ETRAX 100LX," Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science, UMEA University, Umea, Sweden, 79 pages.
Ko, H. (Jul. 2000). "Open Systems Advanced Workstation Transition Report," Technical Report 1822, *U.S. Navy*, SSC San Diego, CA, 82 pages.
Krein, P. et al. (May/Jun. 1990). "The Electroquasistatics of the Capacitive Touch Panel," *IEEE Transactions on Industry Applications* 26(3):529-534.
Krueger, M. et al. (Jun. 10, 1988). "Videoplace, Responsive Environment, 1972-1990," located at http://www.youtube.com/watch?v=dmmxVA5xhuo, last visited Aug. 5, 2011, two pages.
Lee, "A Fast Multiple-Touch-Sensitive Input Device," Master's Thesis, University of Toronto (1984).
Lee, S.K. et al. (Apr. 1985). "A Multi-Touch Three Dimensional Touch-Sensitive Tablet," *Proceedings of CHI: ACM Conference on Human Factors in Computing Systems*, pp. 21-25.
Leeper, A.K. (May 21, 2002). "Integration of a clear capacitive touch screen with a 1/8-VGA FSTN-LCD to form and LCD based touchpad," Synaptics Inc., society for information display, 3 pages.
Leigh, J. et al. (2002). "Amplified Collaboration Environments," *VizGrid Symposium*, Nov. 2002, Tokyo, Japan, nine pages.
Ljungstrand, P. et al. eds. (2002). UBICOMP2002, Adjunct Proceedings, *4th International Conference on Ubiquitous Computing*, Sep. 29-Oct. 1, 2002, Goteborg, Sweden, 90 pages.
Magerkurth, C. et al. (2004). "Towards the Next Generation of Tabletop Gaming Experiences," *Graphics Interface 2004* (*GI'04*), May 17-19, 2004, Ontario, Canada, pp. 1-8.
Malik, S. et al. (2004). "Visual Touchpad: A Two-Handed Gestural Input Device," *ICMI'04 Proceedings of the 6th International Conference on Multimodal Intercases, ACM*, 8 pages.
Matsushita et al., "HoloWall: Designing a Finger, Hand, Body and Object Sensitive Wall," In Proceedings of UIST '97, Oct. 1997.
Matsushita, N. et al. (2000). "Dual Touch: A Two-Handed Interface for Pen-Based PDAs," *CHI Letters* 2(2):211-212.
McMillan, G.R. (Oct. 1998). "The Technology and Applications of Gesture-Based Control," *presented at the RTO Lecture Series on Alternative Control Technologies: Human Factor Issues*, Oct. 14-15, 1998, Ohio, USA, pp. 4-1-4-11.
Mehta, N. et al. (May 1982). "Feature Extraction as a Tool for Computer Input," *Proceedings of ICASSP '82*, May 3-5, 1982, Paris, France, pp. 818-820.
Mitchell, G. D. (Oct. 2003). "Orientation on Tabletop Displays," Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science, Simon Fraser University, 119 pages.
Noda, K. et al. (2001). "Production of Transparent Conductive Films with Inserted SiO_2 Anchor Layer, and Application to a Resistive Touch Panel," *Electronics and Communications in Japan* Part 2 84(7):39-45.
Non-Final Office Action mailed May 14, 2008, for U.S. Appl. No. 10/840,862, filed May 6, 2004, six pages.
Non-Final Office Action mailed Dec. 24, 2008, for U.S. Appl. No. 10/840,862, filed May 6, 2004, nine pages.
Non-Final Office Action mailed Jun. 2, 2009, for U.S. Appl. No. 10/840,862, filed May 6, 2004, seven pages.
Non-Final Office Action mailed Nov. 12, 2009, for U.S. Appl. No. 10/840,862, filed May 6, 2004, eight pages.
Non-Final Office Action mailed Mar. 12, 2010, for U.S. Appl. No. 11/760,080, filed Jun. 8, 2007, 31 pages.
Non-Final Office Action mailed Apr. 22, 2010, for U.S. Appl. No. 11/760,036, filed Jun. 8, 2007, 37 pages.
Non-Final Office Action mailed Apr. 23, 2010, for U.S. Appl. No. 11/760,060, filed Jun. 8, 2007, 66 pages.
Non-Final Office Action mailed May 5, 2010, for U.S. Appl. No. 11/760,049, filed Jun. 8, 2007, 65 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Non-Final Office Action mailed Jun. 21, 2010, for U.S. Appl. No. 11/650,203, filed Jan. 3, 2007, eight pages.
Non-Final Office Action mailed Jan. 25, 2011, for U.S. Appl. No. 11/818,395, filed Jun. 13, 2007, 31 pages.
Non-Final Office Action mailed Mar. 14, 2011, for U.S. Appl. No. 11/650,203, filed Jan. 3, 2007, nine pages.
Non-Final Office Action mailed May 13, 2011, for U.S. Appl. No. 12/267,540, filed Nov. 7, 2008, seven pages.
Non-Final Office Action mailed Jul. 8, 2011, for U.S. Appl. No. 12/267,532, filed Nov. 7, 2008, five pages.
Non-Final Office Action mailed Jul. 14, 2011, for U.S. Appl. No. 12/267,522, filed Nov. 7, 2008, six pages.
Non-Final Office Action mailed Aug. 4, 2011, for U.S. Appl. No. 11/760,036, filed Jun. 8, 2007, 45 pages.
Non-Final Office Action mailed Aug. 11, 2011, for U.S. Appl. No. 11/760,049, filed Jun. 8, 2007, 60 pages.
Non-Final Office Action mailed Sep. 1, 2011, for U.S. Appl. No. 11/760,060, filed Jun. 8, 2007, 76 pages.
Non-Final Office Action mailed Nov. 14, 2011, for U.S. Appl. No. 11/760,080, filed Jun. 8, 2007, 60 pages.
Non-Final Office Action mailed Feb. 17, 2012, for U.S. Appl. No. 13/251,099, filed Sep. 30, 2011, seven pages.
Non-Final Office Action mailed Jun. 20, 2012, for U.S. Appl. No. 13/345,347, filed Jan. 6, 2012, five pages.
Non-Final Office Action mailed Sep. 12, 2012, for U.S. Appl. No. 11/650,203, filed Jan. 3, 2007, nine pages.
Non-Final Office Action mailed Oct. 5, 2012, for U.S. Appl. No. 12/976,997, filed Dec. 22, 2010, 6 pages.
Non-Final Office Action mailed Mar. 29, 2013, for U.S. Appl. No. 13/717,573, filed Dec. 17, 2012, five pages.
Non-Final Office Action mailed May 30, 2013, for U.S. Appl. No. 13/251,099, filed Sep. 30, 2011, seven pages.
Non-Final Office Action mailed Jun. 27, 2013, for U.S. Appl. No. 11/760,080, filed Jun. 8, 2007, 48 pages.
Non-Final Office Action mailed Dec. 24, 2013, for Ex Parte Reexamination of U.S. Pat. No. 7,663,607, 52 pages.
Non-Final Office Action mailed Dec. 30, 2013, for U.S. Appl. No. 12/976,997, filed Dec. 22, 2010, six pages.
Non-Final Office Action mailed May 16, 2014, for Ex Parte Reexamination of U.S. Pat. No. 7,663,607, 34 pages.
Non-Final Office Action mailed Mar. 25, 2014, for U.S. Appl. No. 14/073,818, filed Nov. 6, 2013, six pages.
Non-Final Office Action mailed Apr. 18, 2014, for U.S. Appl. No. 11/818,395, filed Jun. 13, 2007, 17 pages.
Non-Final Office Action mailed Sep. 26, 2014, for U.S. Appl. No. 14/308,646, filed Jun. 18, 2013, five pages.
Non-Final Office Action mailed Jan. 30, 2015, for U.S. Appl. No. 14/047,960, filed Oct. 7, 2013, 18 pages.
Notice of Allowability (Corrected) mailed Jun. 27, 2014, for U.S. Appl. No. 12/976,997, filed Dec. 22, 2010, five pages.
Notice of Allowability (Corrected) mailed Jan. 21, 2015, for U.S. Appl. No. 14/308,646, filed Jun. 18, 2014, five pages.
Notice of Allowance mailed Apr. 27, 2012, for U.S. Appl. No. 11/760,036, filed Jun. 8, 2007, eight pages.
Notice of Allowance mailed Oct. 25, 2011, for U.S. Appl. No. 12/267,540, filed Nov. 7, 2008, seven pages.
Notice of Allowance mailed Mar. 27, 2012, for U.S. Appl. No. 11/760,060, filed Jun. 8, 2007, 17 pages.
Notice of Allowance mailed Jul. 12, 2012, for U.S. Appl. No. 13/251,099, filed Sep. 30, 2011, seven pages.
Notice of Allowance mailed Sep. 19, 2012, for U.S. Appl. No. 13/345,347, filed Jan. 6, 2012, seven pages.
Notice of Allowance mailed Oct. 29, 2012, for U.S. Appl. No. 13/345,347, filed Jan. 6, 2012, eight pages.
Notice of Allowance mailed Feb. 6, 2013, for U.S. Appl. No. 13/084,402, filed Apr. 11, 2011, 12 pages.
Notice of Allowance mailed Feb. 19, 2013, for U.S. Appl. No. 13/538,498, filed Jun. 29, 2012, 16 pages.
Notice of Allowance mailed Apr. 26, 2013, for U.S. Appl. No. 11/650,203, filed Jan. 3, 2007, 8 pages.
Notice of Allowance mailed May 28, 2013, for U.S. Appl. No. 11/760,049, filed Jun. 8, 2007, 10 pages.
Notice of Allowance mailed Jul. 19, 2013, for U.S. Appl. No. 13/717,573, filed Dec. 17, 2012, 9 pages.
Notice of Allowance mailed Oct. 10, 2013, for U.S. Appl. No. 11/760,080, filed Jun. 8, 2007, 10 pages.
Notice of Allowance mailed Mar. 3, 2014, for U.S. Appl. No. 13/251,099, filed Sep. 30, 2011, eight pages.
Notice of Allowance mailed Apr. 14, 2014, for U.S. Appl. No. 12/976,997, filed Dec. 22, 2010, 8 pages.
Notice of Allowance mailed Jul. 14, 2014, for U.S. Appl. No. 14/073,818, filed Nov. 6, 2013, seven pages.
Notice of Allowance mailed Oct. 31, 2014, for U.S. Appl. No. 14/308,595, filed Jun. 18, 2014, eight pages.
Notice of Allowance mailed Nov. 6, 2014, for U.S. Appl. No. 14/308,646, filed Jun. 18, 2014, eight pages.
Notice of Allowance mailed Dec. 23, 2014, for U.S. Appl. No. 14/456,831, filed Aug. 11, 2014, eight pages.
Notice of Allowance mailed Jan. 14, 2015, for U.S. Appl. No. 14/086,877, filed Nov. 21, 2013, eight pages.
Notice of Prior and Concurrent Proceedings under 37 C.F.R. § 1.565(a) for U.S. Ex Parte Reexamination Control No. 90/012,935, filed Jul. 30, 2013 (Reexamination of U.S. Pat. No. 7,663,607), 279 pages. (submitted in four parts).
Ogawa, H. et al. (1979). "Preprocessing for Chinese Character Recognition and Global Classification of Handwritten Chinese Characters," *Pattern Recognition* 11:1-7.
Partial European Search Report mailed Mar. 15, 2011, for EP Application No. 10178661.4, filed Jun. 8, 2007, six pages.
Partial European Search Report mailed Oct. 21, 2011, for EP Application No. 11159165.7 filed Jun. 8, 2007, seven pages.
Partial European Search Report mailed Oct. 24, 2011, for EP Application No. 11159167.3 filed Jun. 8, 2007, eight pages.
Phipps, C.A. (Spring 2003). "A Metric to Measure Whole Keyboard Index of Difficulty Based on Fitts' Law," A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Ph.D., 103 pages.
Quantum Research Group "QT510 / Qwheel™ Touch Slider IC" copyright 2004-2005, 14-pgs.
Quantum Research Group Ltd.(1997). QT9701B2 Datasheet, 30 pages.
Quantum Research Group Ltd. (1999). QProx™ QT60320 32-Key Qmatrix™ Charge-Transfer IC Datasheet, pp. 1-14.
Quantum Research Group Ltd. (2001). QT60325, QT60485, QT60645 32, 48, 64 Key QMatrix™ Keypanel Sensor Ics Datasheet, 42 pages.
Quantum Research Group Ltd. (2002). QMatrix™ QT60040 4-Key Charge-Transfer IC Datasheet, pp. 1-9.
Quantum Research Group Ltd. (Oct. 10, 2002). Quantum Research Application Note AN-KDO1: Qmatrix™ Panel Design Guidelines, four pages.
Quek, "Unencumbered Gestural Interaction," *IEEE Multimedia*, 3:36-47 (Winter 1996).
Rabuffetti, M. (2002). "Touch-screen System for Assessing Visuo-motor Exploratory Skills in Neuropsychological Disorders of Spatial Cognition," *Medical & Biological Engineering & Computing* 40:675-686.
Radwin, "Activation Force and Travel Effects on Overexertion in Repetitive Key Tapping," *Human Factors*, 39(1):130-140 (Mar. 1997).
Raisamo, R. (Dec. 7, 1999). "Multimodal Human-Computer Interaction: A Constructive and Empirical Study," Dissertation, University of Tampere, Finland, 86 pages.
Rekimoto et al., "ToolStone: Effective Use of the Physical Manipulation Vocabularies of Input Devices," In Proc. Of UIST 2000, 2000.
Rekimoto, J. (2002). "SmartSkin: An Infrastructure for Freehand Manipulation on Interactive Surfaces," *CHI 2002*, Apr. 20-25, 2002. [(Apr. 25, 2002). 4(1):113-120.].
Rekimoto, J. et al. (2003). "Pre-Sense: Interaction Techniques for Finger Sensing Input Devices," *CHI Letters* 5(2):203-212.

(56) **References Cited**

OTHER PUBLICATIONS

Request for Ex Parte Reexamination of U.S. Pat. No. 7,663,607, 106 pages.
Response to Non-Final Office Action in Ex Parte Reexamination dated Mar. 24, 2014, of U.S. Pat. No. 7,663,607, part 1, 200 pages.
Response to Non-Final Office Action in Ex Parte Reexamination dated Mar. 24, 2014, of U.S. Pat. No. 7,663,607, part 2, 192 pages.
Rong, J. et al. (2002). "AIAA 2002-4553: Hierarchical Agent Based System for General Aviation CD&R Under Free Flight," *AIAA Guidance, Navigation, and Control Conference and Exhibit*, Aug. 5-8, 2002, Monterey, CA, pp. 1-11.
Rubine et al., "Programmable Finger-Tracking Instrument Controllers," *Computer Music Journal*, vol. 14, No. 1 (Spring 1990).
Rubine, D. (Jul. 1991). "Specifying Gestures by Example," *Computer Graphics* 25(4):329-337.
Rubine, D. et al. (1988). "The VideoHarp," *Proceedings of the 14th International Computer Music Conference*, Cologne, W. Germany, Sep. 20-25, 1988, pp. 49-55.
Rubine, D. et al. (1991). "The Videoharp: An Optical Scanning MIDI Controller," *Contemporary Music Review* 6(1):31-46.
Rubine, D.H. (Dec. 1991). "The Automatic Recognition of Gestures," CMU-CS-91-202, Submitted in Partial Fulfillment of the Requirements of the Degree of Doctor of Philosophy in Computer Science at Carnegie Mellon University, 285 pages.
Rubine, D.H. (May 1992). "Combining Gestures and Direct Manipulation," CHI '92, pp. 659-660.
Russell, D.M. et al. (2004). "The Use Patterns of Large, Interactive Display Surfaces: Case Studies of Media Design and use for BlueBoard and MERBoard," *Proceedings of the 37th Hawaii International Conference on System Sciences 2004*, IEEE, pp. 1-10.
Rutledge et al., "Force-To-Motion Functions for Pointing," Human-Computer Interaction—Interact (1990).
Sears, A. (Mar. 11, 1991). "Improving Touchscreen Keyboards: Design Issues and a Comparison with Other Devices," *Human-Computer Interaction Laboratory*, pp. 1-19.
Sears, A. et al. (Jun. 1990). "A New Era for High-Precision Touchscreens," *Advances in Human-Computer Interaction*, vol. 3, Tech Report HCIL-90-01, one page only.
Segen, J. et al. (1998). "Human-Computer Interaction Using Gesture Recognition and 3D Hand Tracking," *IEEE*, pp. 188-192.
Shen, C. et al. (Jan. 2004). "DiamondSpin: An Extensible Toolkit for Around-the-Table Interaction," *CHI 2004*, Apr. 24-29, 2004, Vienna, Austria, 10 pgs.
Siegel, D.M. et al. (1987). "Performance Analysis of a Tactile Sensor," *IEEE*, pp. 1493-1499.
Singapore Examination Report mailed Jan. 11, 2010, for SG Patent Application No. 0607116-1, five pages.
Son, J.S. et al. (1996). "Comparison of Contact Sensor Localization Abilities During Manipulation," *Robotics and Autonomous System* 17 pp. 217-233.
Stansfield, S.A. (Mar. 1990). "Haptic Perception With an Articulated, Sensate Robot Hand," *SANDIA Report*: SAND90—0085—UC-406, 37 pages.
Stauffer, R.N. ed. (Jun. 1983). "Progress in Tactile Sensor Development," *Robotics Today* pp. 43-49.
Stumpe, B. (Mar. 16, 1977). "A New Principle for an X-Y Touch Screen," *CERN*, 19 pages.
Stumpe, B. (Feb. 6, 1978). "Experiments to Find a Manufacturing Process for an X-Y Touch Screen: Report on a Visit to Polymer-Physik GmbH," *CERN*, five pages.
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 (Oct. 1994).
Sugiyama, S. et al. (Mar. 1990). "Tactile Image Detection Using a 1k-element Silicon Pressure Sensor Array," *Sensors and Actuators* A21-A23(1-3):397-400.
Suzuki, K. et al. (Aug. 1990). "A 1024-Element High-Performance Silicon Tactile Imager," *IEEE Transactions on Electron Devices* 37(8):1852-1860.
Texas Instruments "TSC2003 / 12C Touch Screen Controller" Data Sheet SBAS 162, dated Oct. 2001, 20-pgs.
TW Search Report mailed Jun. 27, 2011, for TW Patent Application No. 097100481, one page.
TW Search Report mailed Feb. 11, 2014, for TW Patent Application No. 110145112, one page.
TW Search Report mailed Feb. 21, 2014, for TW Patent Application No. 100145112, with English translation, two pages.
U.S. Appl. No. 60/072,509 filed Jan. 26, 1998, by Westerman et al.
U.S. Appl. No. 60/333,770 filed Nov. 29, 2001, by Perski et al.
U.S. Appl. No. 60/406,662, on Aug. 29, 2002, filed by Morag et al.
U.S. Appl. No. 60/501,484, filed Sep. 5, 2003, by Perski et al.
Van Kleek, M. (Feb. 2003). "Intelligent Environments for Informal Public Spaces: The Ki/o Kiosk Platform," Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Engineering, MIT, 108 pages.
Van Oversteegen, B.G.F.A.W. (Apr. 10, 1998). "Touch Screen Based Measuring Equipment: Design and Implementation," Master's Thesis, Submitted to Technische Universiteit, Eindhoven, The Nederlands, 103 pages.
Vazquez, A.A. (Sep. 1990). "Touch Screen Use on Flight Simulator Instructor/Operator Stations," Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Information Systems, 78 pages.
Vernier, F. et al. (2002). "Multi-User, Multi-Finger Drag & Drop of Multiple Documents,"located at http://www.edgelab.ca/CSCW/Workshop2002/fred_vernier, three pages.
Wacom Company Limited. (Nov. 12, 2003). Wacom intuos® 2 User's Manual for Windows®, English V4.1, 165 pages.
Wallergard, M. (2003). "Designing Virtual Environments for Brain Injury Rehabilitation," Thesis, Lund University, Sweden, 98 pages.
Wellner, "The Digital Desk Calculators: Tangible Manipulation on a Desk Top Display" In ACM UIST '91 Proceedings, pp. 27-34, Nov. 1991.
Westerman, W. (Spring 1999). "Hand Tracking, Finger Identification, and Chordic Manipulation on a Multi-Touch Surface," A Dissertation Submitted to the Faculty of the University of Delaware in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Electrical Engineering, 364 pages.
Westerman, W. et al. (2001). "Multi-Touch: A New Tactile 2-D Gesture Interface for Human-Computer Interaction," *Proceedings of the Human Factors and Ergonomics Societ 45th Annual Meeting*, pp. 632-636.
Williams, "Applications for a Switched-Capacitor Instrumentation Building Block" Linear Technology Application Note 3, Jul. 1985, pp. 1-16.
Wu, M. et al. (2003). "Multi-Finger and Whole Hand Gestural Interaction Techniques for Multi-User Tabletop Displays," *ACM* pp. 193-202.
Yamada, et al., "A Switched-Capacitor Interface for Capacitive Pressure Sensors" IEEE Transactions on Instrumentation and Measurement, vol. 41, No. 1, Feb. 1992, pp. 81-86.
Yee, K-P. (2004). "Two-Handed Interaction on a Tablet Display,"CHI'04, pp. 1493-1496.
Yeh, et al., "Switched Capacitor Interface Circuit for Capacitive Transducers" 1985 IEEE.
Zhai, et al., "Dual Stream Input for Pointing and Scrolling," *Proceedings of CHI '97 Extended Abstracts* (1997).
Zimmerman, et al., "Applying Electric Field Sensing to Human-Computer Interfaces," In CHI '85 Proceedings, pp. 280-287, 1995.
Non-Final Office Action mailed May 7, 2015, for U.S. Appl. No. 14/174,760, filed Feb. 6, 2014, 27 pages.
Non-Final Office Action mailed May 12, 2015, for U.S. Appl. No. 14/670,306, filed Mar. 26, 2015, five pages.

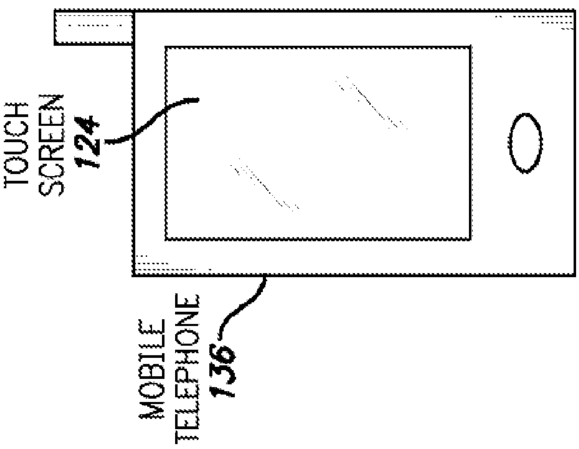


FIG. 1A

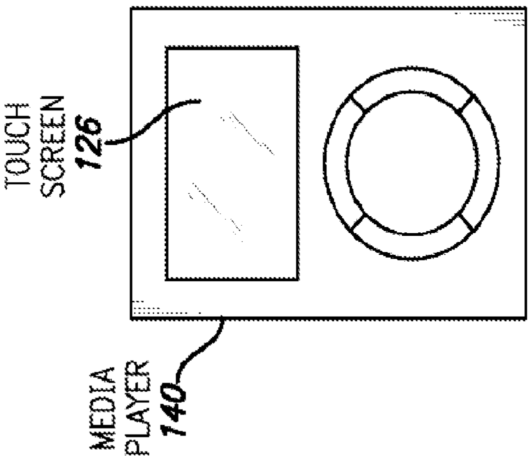


FIG. 1B

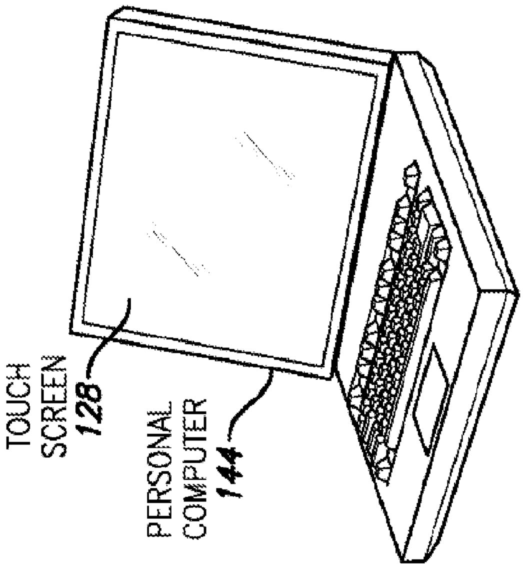
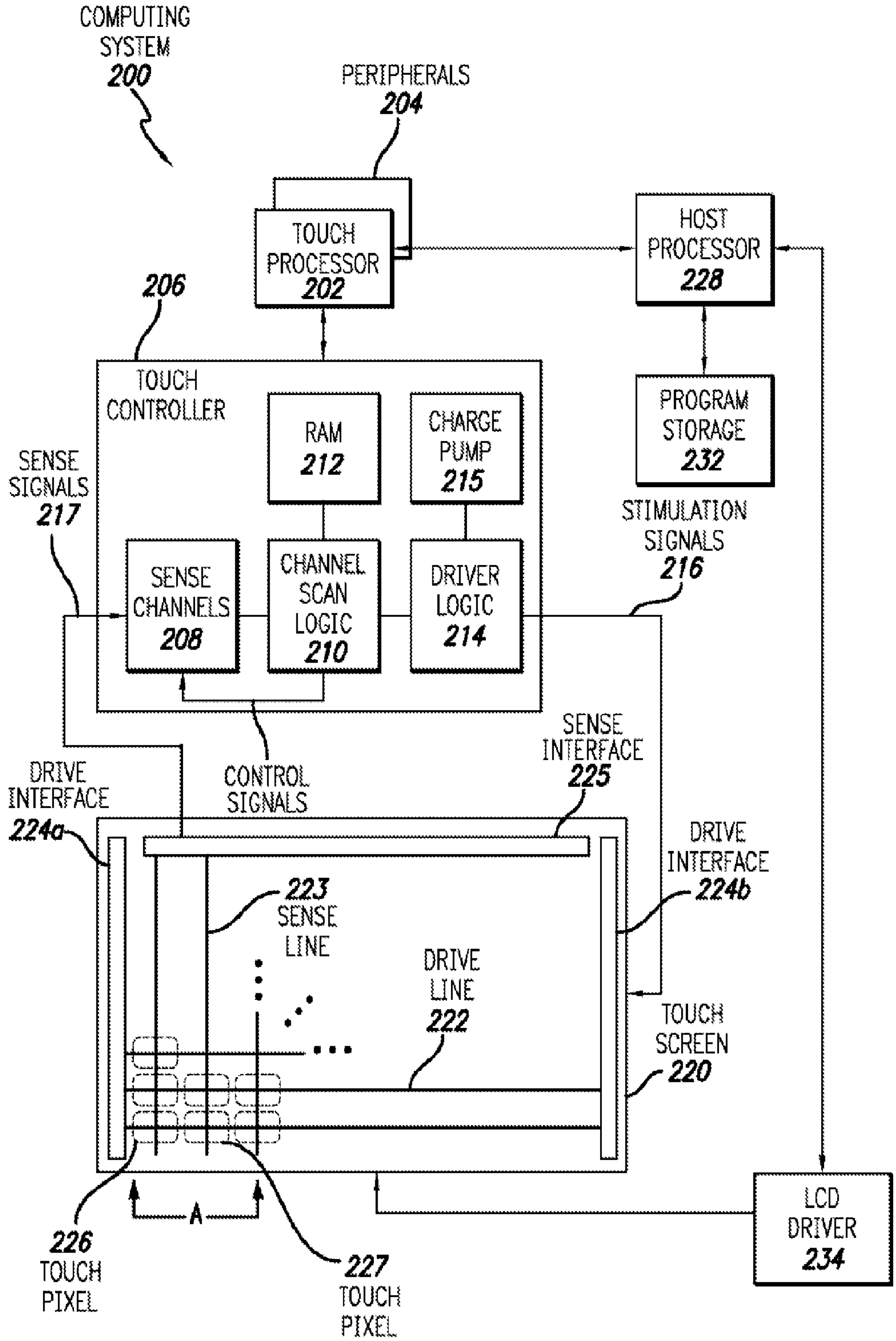


FIG. 1C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PERIPHERALS 204
TOUCH PROCESSOR 202
HOST PROCESSOR 228
206
TOUCH CONTROLLER
RAM 212
CHARGE PUMP 215
PROGRAM STORAGE 232
SENSE SIGNALS 217
STIMULATION SIGNALS 216
SENSE CHANNELS 208
CHANNEL SCAN LOGIC 210
DRIVER LOGIC 214
SENSE INTERFACE 225
CONTROL SIGNALS
DRIVE INTERFACE 224a
DRIVE INTERFACE 224b
223 SENSE LINE
DRIVE LINE 222
TOUCH SCREEN 220
A
226 TOUCH PIXEL
227 TOUCH PIXEL
LCD DRIVER 234

FIG. 2

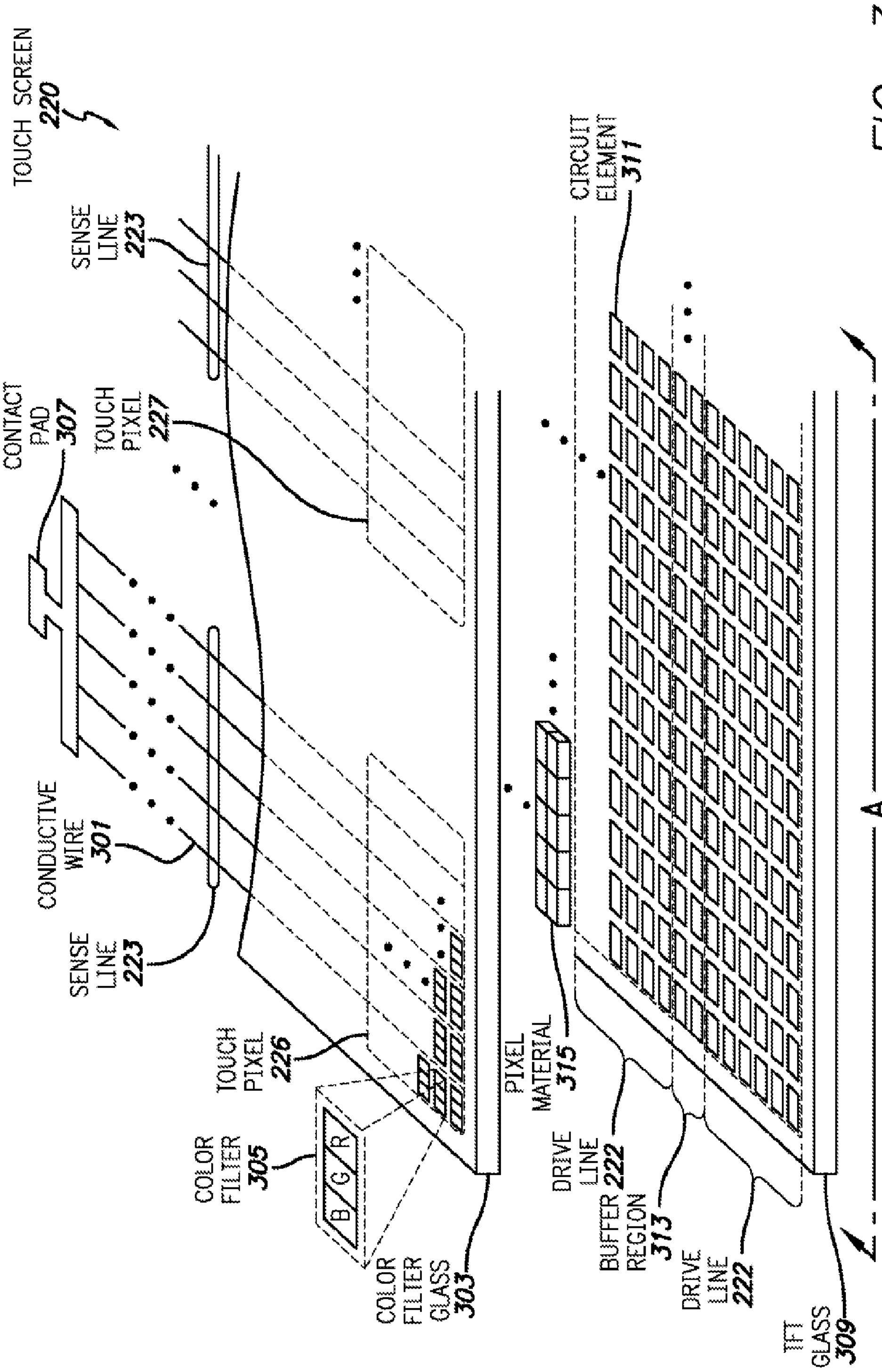
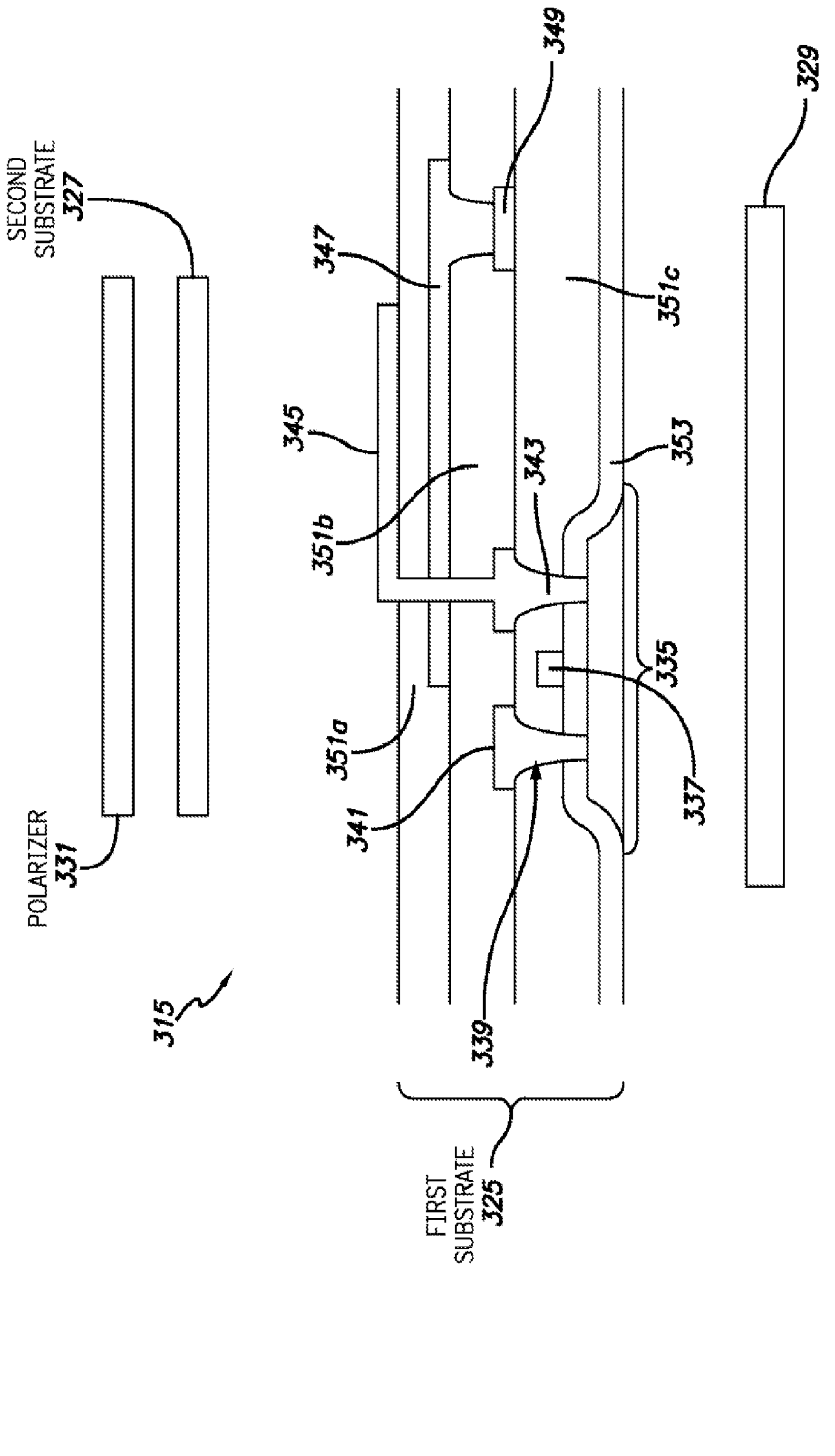

TOUCH SCREEN 220
CONTACT PAD 307
SENSE LINE 223
TOUCH PIXEL 227
CONDUCTIVE WIRE 301
SENSE LINE 223
TOUCH PIXEL 226
COLOR FILTER 305
B G R
COLOR FILTER GLASS 303
PIXEL MATERIAL 315
CIRCUIT ELEMENT 311
DRIVE LINE 222
BUFFER REGION 313
DRIVE LINE 222
TFT GLASS 309
A

FIG. 3


SECOND SUBSTRATE 327
POLARIZER 331
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FIRST SUBSTRATE 325
329
349
347
345
351a
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351c
343
353
335
337
341
339

FIG. 3A

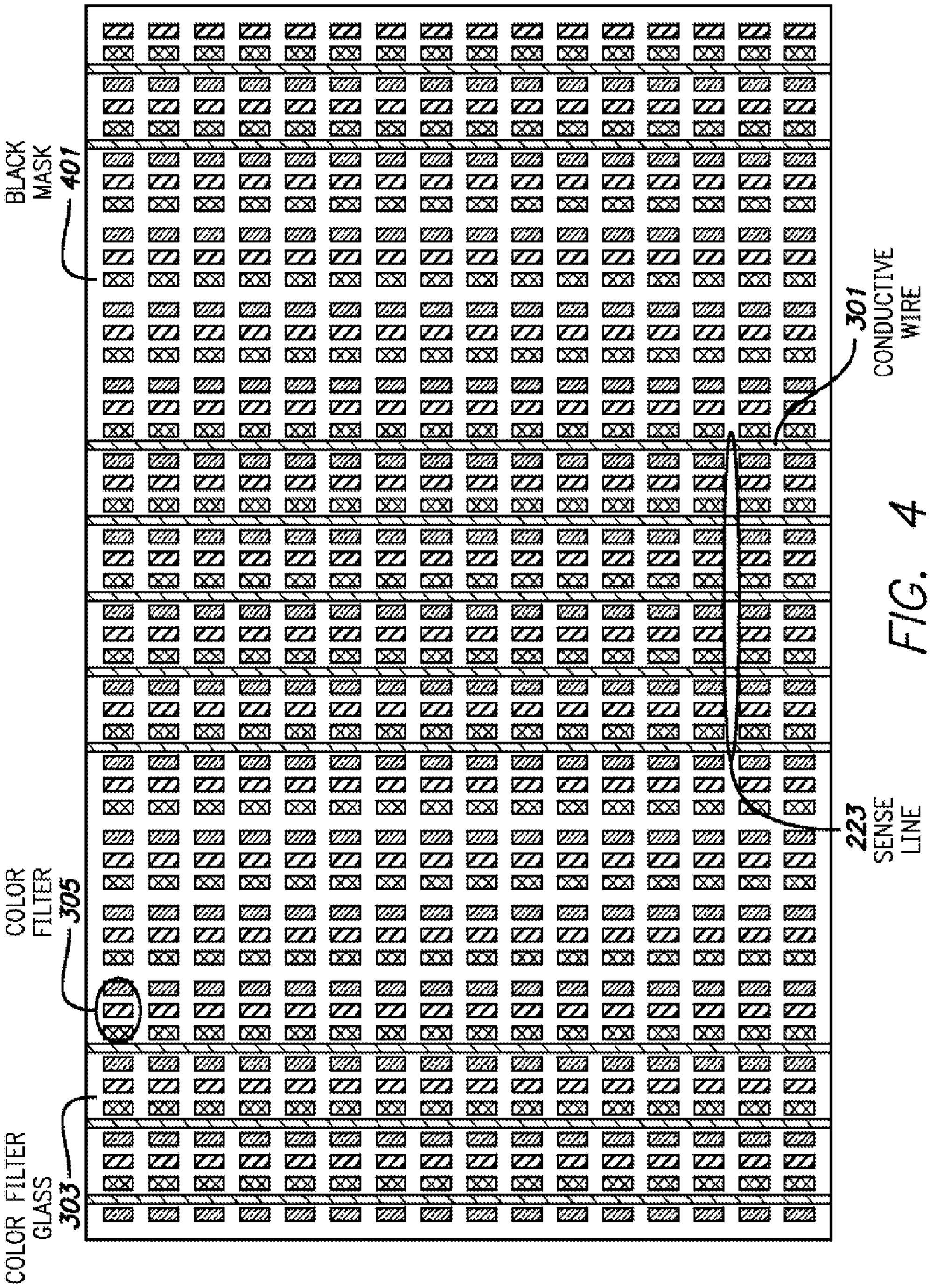
BLACK MASK 401
COLOR FILTER 305
COLOR FILTER GLASS 303
301 CONDUCTIVE WIRE
223 SENSE LINE

FIG. 4

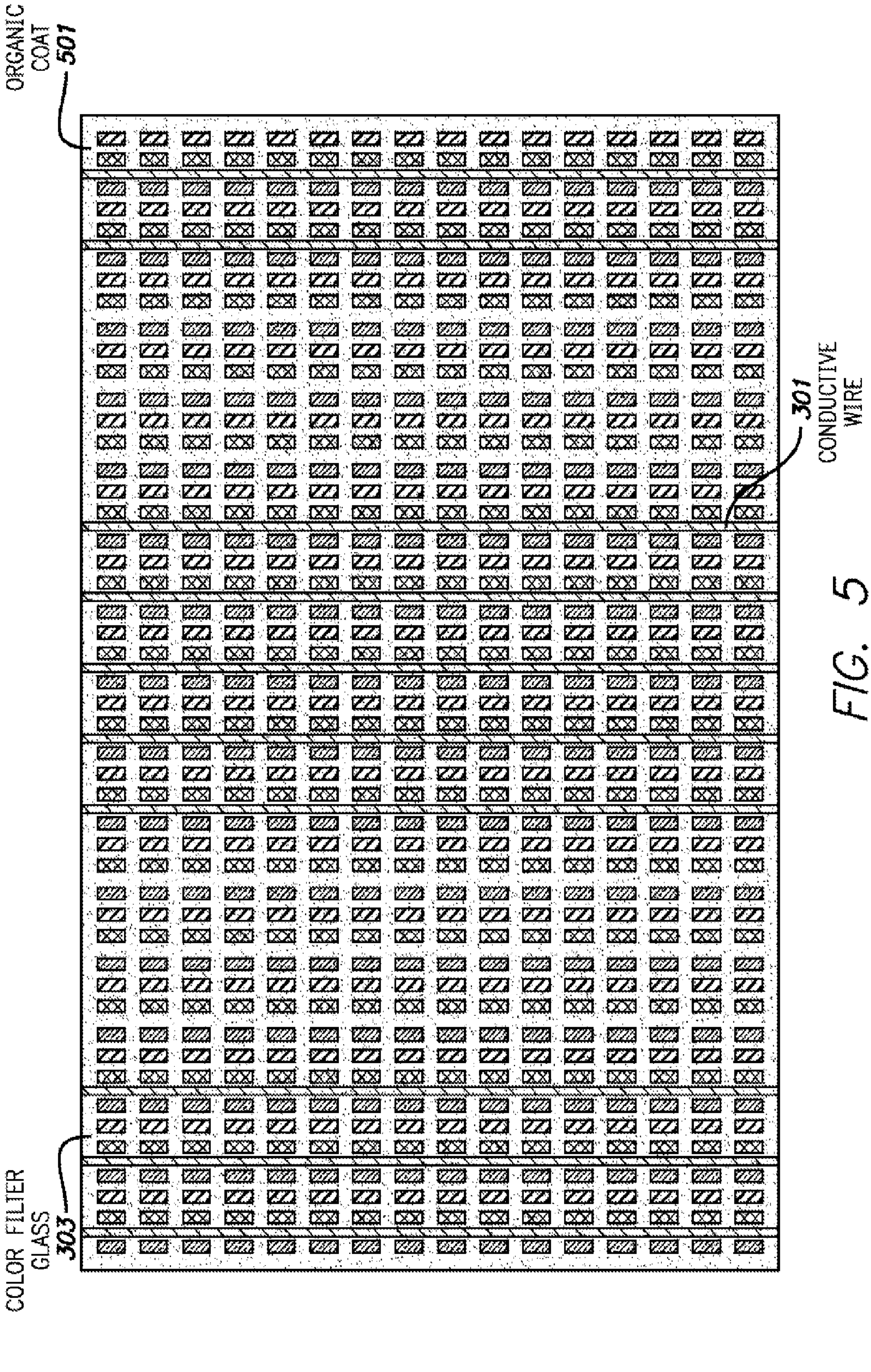
ORGANIC COAT
501
301
CONDUCTIVE WIRE
COLOR FILTER GLASS
303

FIG. 5

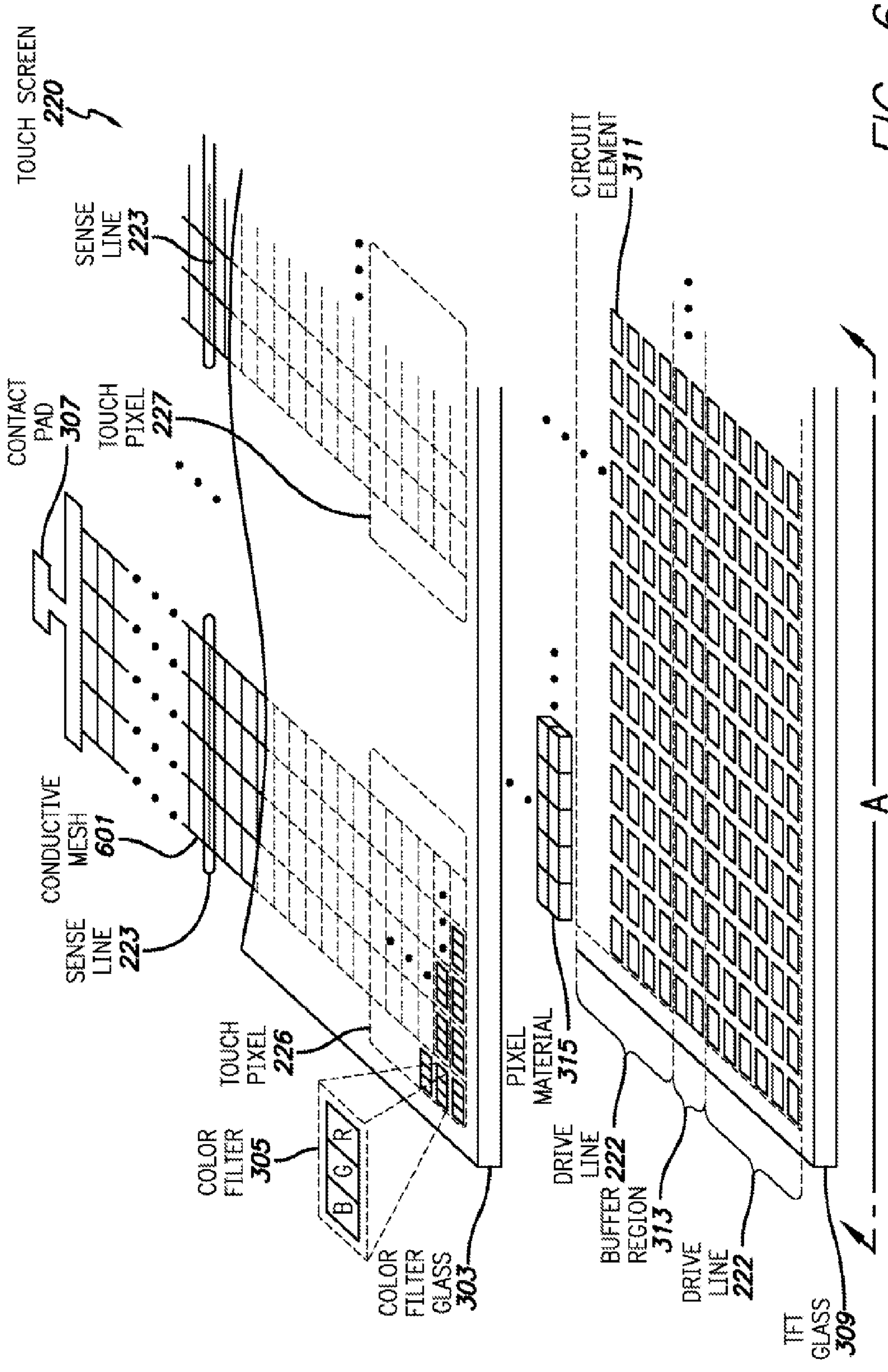
TOUCH SCREEN 220
CONTACT PAD 307
SENSE LINE 223
TOUCH PIXEL 227
CONDUCTIVE MESH 601
SENSE LINE 223
TOUCH PIXEL 226
COLOR FILTER 305
B G R
COLOR FILTER GLASS 303
PIXEL MATERIAL 315
CIRCUIT ELEMENT 311
DRIVE LINE 222
BUFFER REGION 313
DRIVE LINE 222
TFT GLASS 309
A

FIG. 6

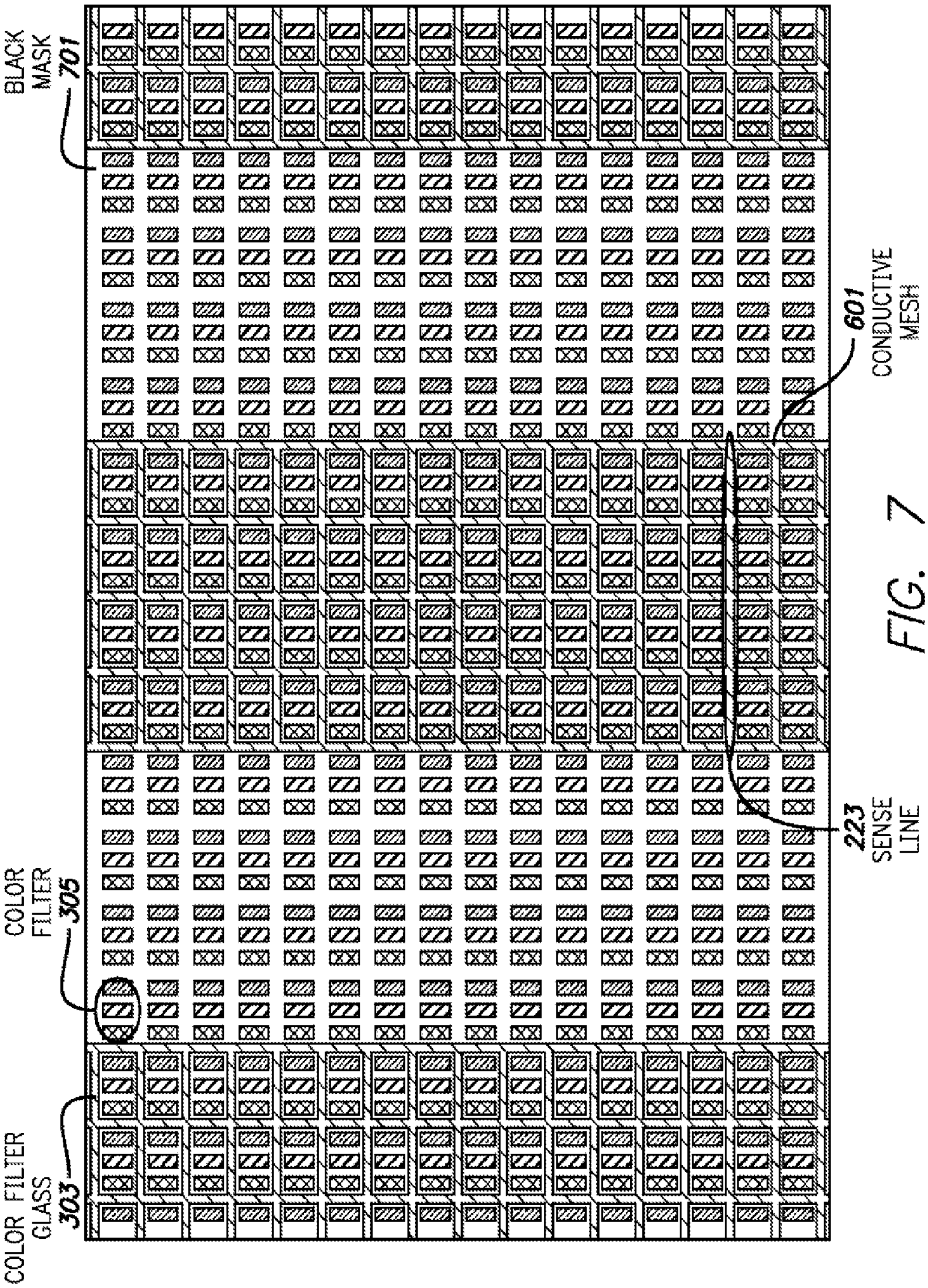
BLACK MASK
701
601
CONDUCTIVE MESH
COLOR FILTER
305
223
SENSE LINE
COLOR FILTER GLASS
303

FIG. 7

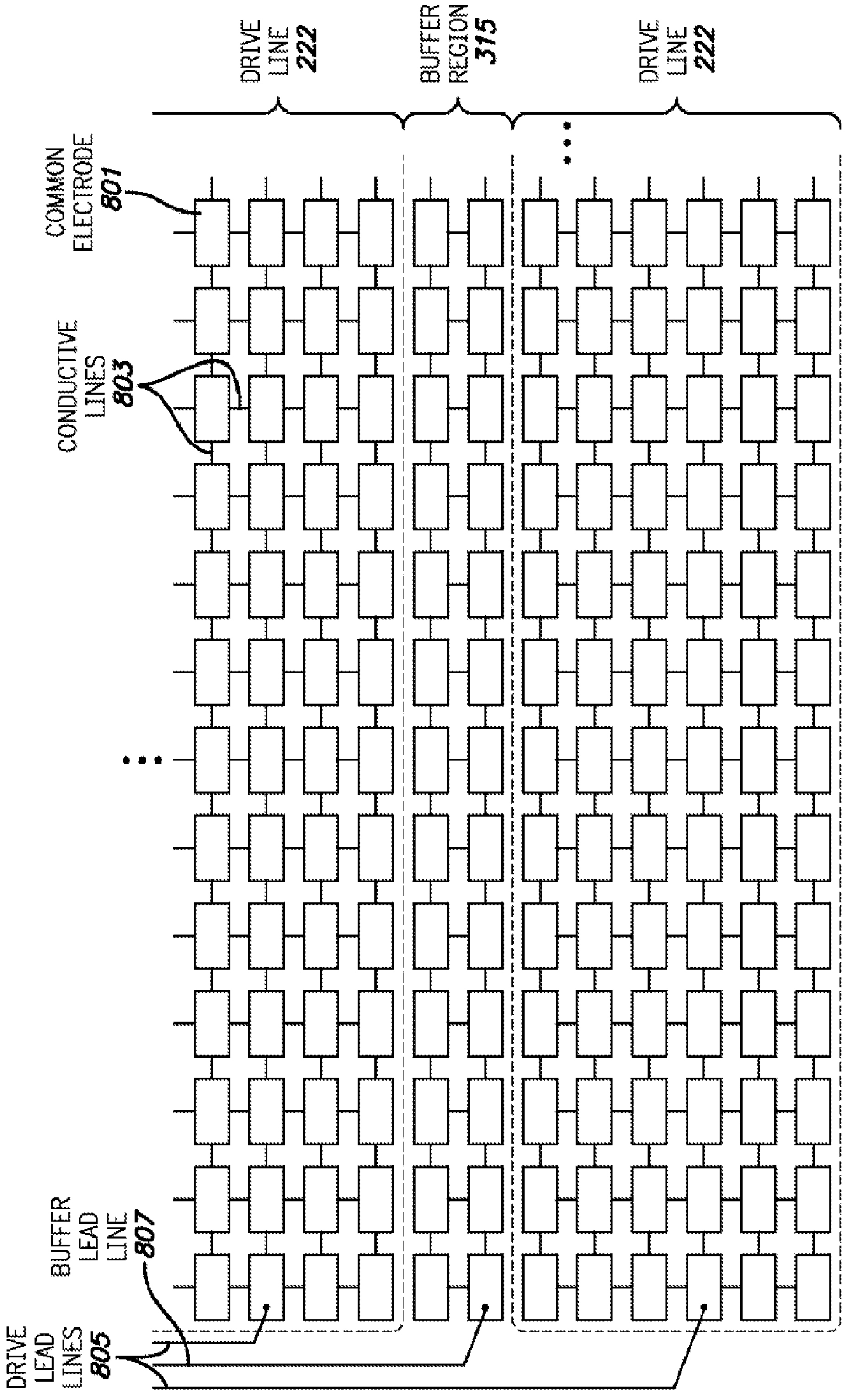
DRIVE LINE 222
BUFFER REGION 315
DRIVE LINE 222
COMMON ELECTRODE 801
CONDUCTIVE LINES 803
BUFFER LEAD LINE 807
DRIVE LEAD LINES 805

FIG. 8

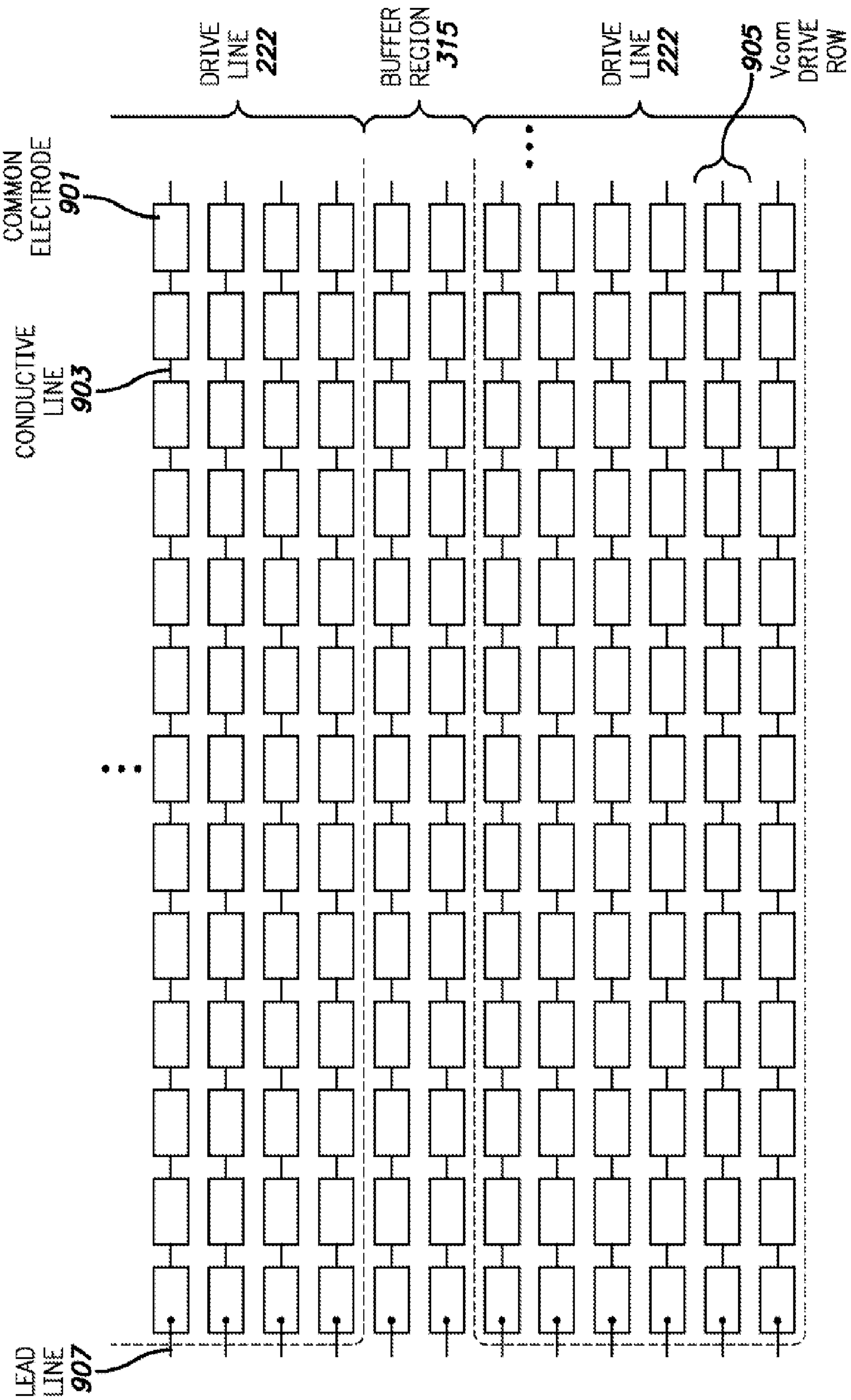
DRIVE LINE 222
BUFFER REGION 315
DRIVE LINE 222
905 Vcom DRIVE ROW
COMMON ELECTRODE 901
CONDUCTIVE LINE 903
LEAD LINE 907

FIG. 9

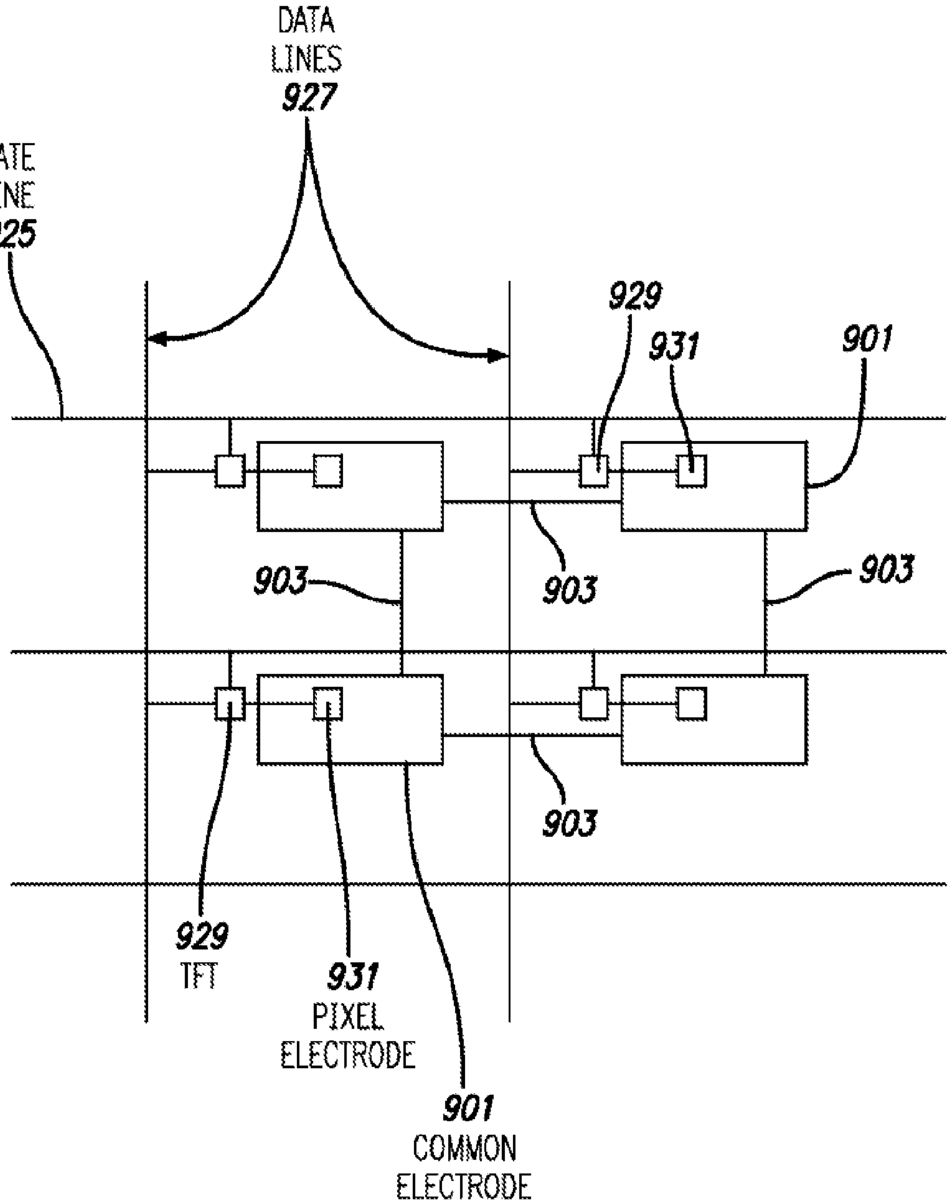
DATA
LINES
927
GATE
LINE
925
929
931
901
903
903
903
903
929
TFT
931
PIXEL
ELECTRODE
901
COMMON
ELECTRODE

FIG. 9A

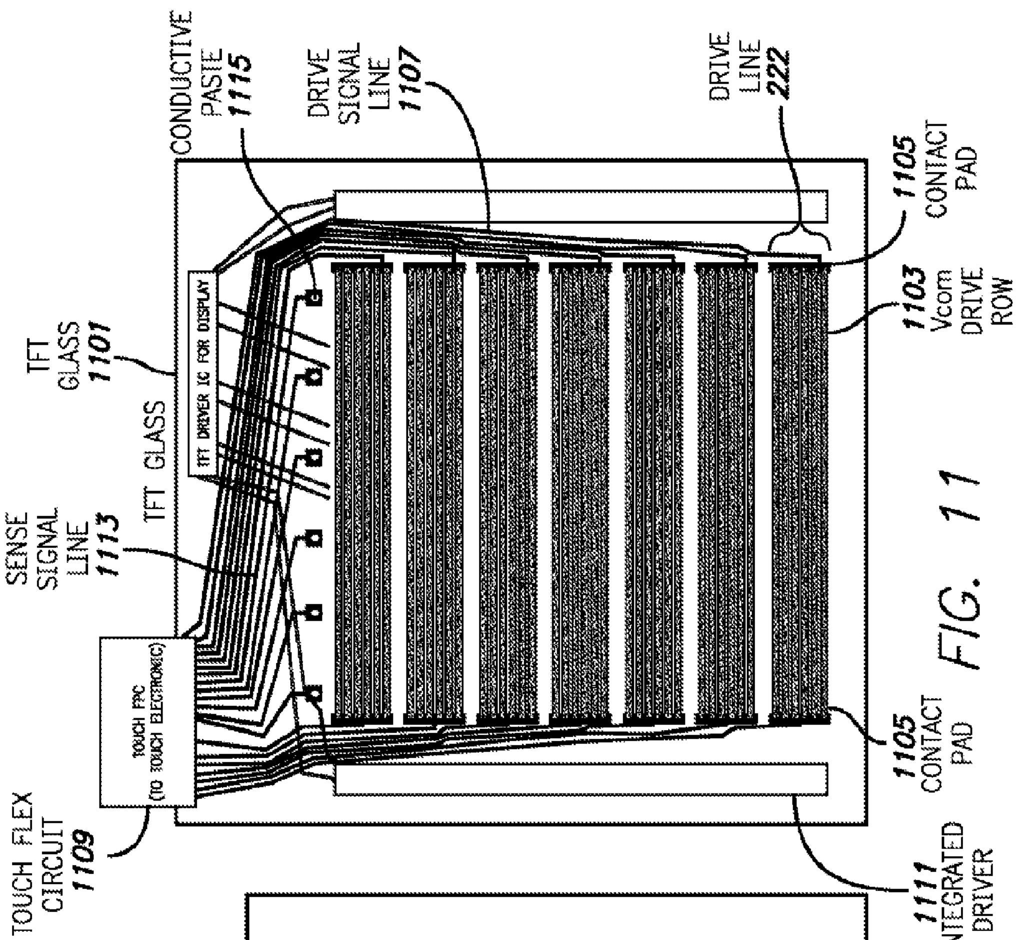
TFT GLASS 1101
TFT GLASS
CONDUCTIVE PASTE 1115
DRIVE SIGNAL LINE 1107
DRIVE LINE 222
SENSE SIGNAL LINE 1113
TFT DRIVER IC FOR DISPLAY
TOUCH FPC (TO TOUCH ELECTRONIC)
TOUCH FLEX CIRCUIT 1109
1105 CONTACT PAD
1103 Vcom DRIVE ROW
1105 CONTACT PAD
1111 INTEGRATED DRIVER

FIG. 11

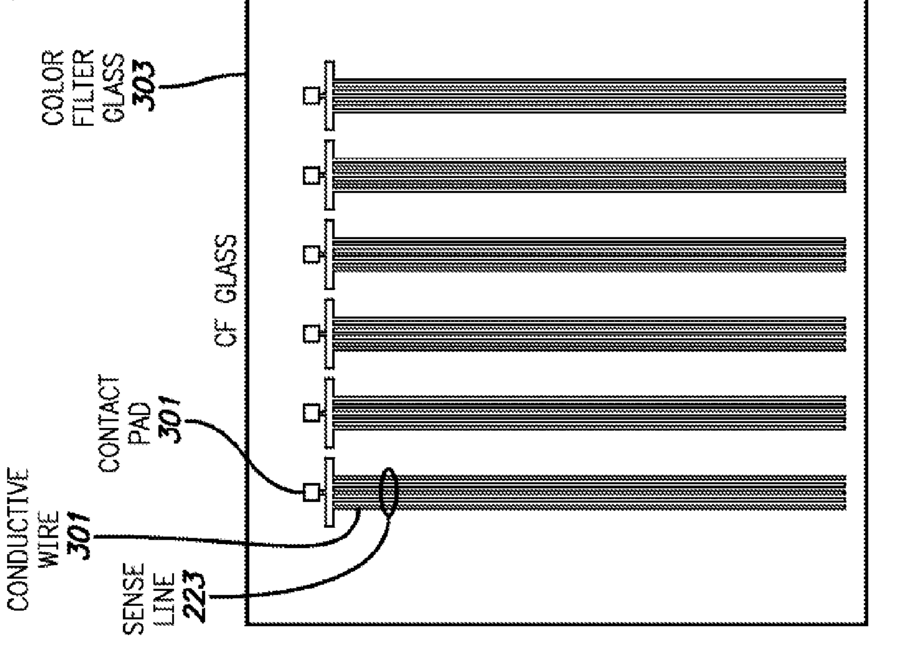
COLOR FILTER GLASS 303
CF GLASS
CONTACT PAD 301
CONDUCTIVE WIRE 301
SENSE LINE 223

FIG. 10

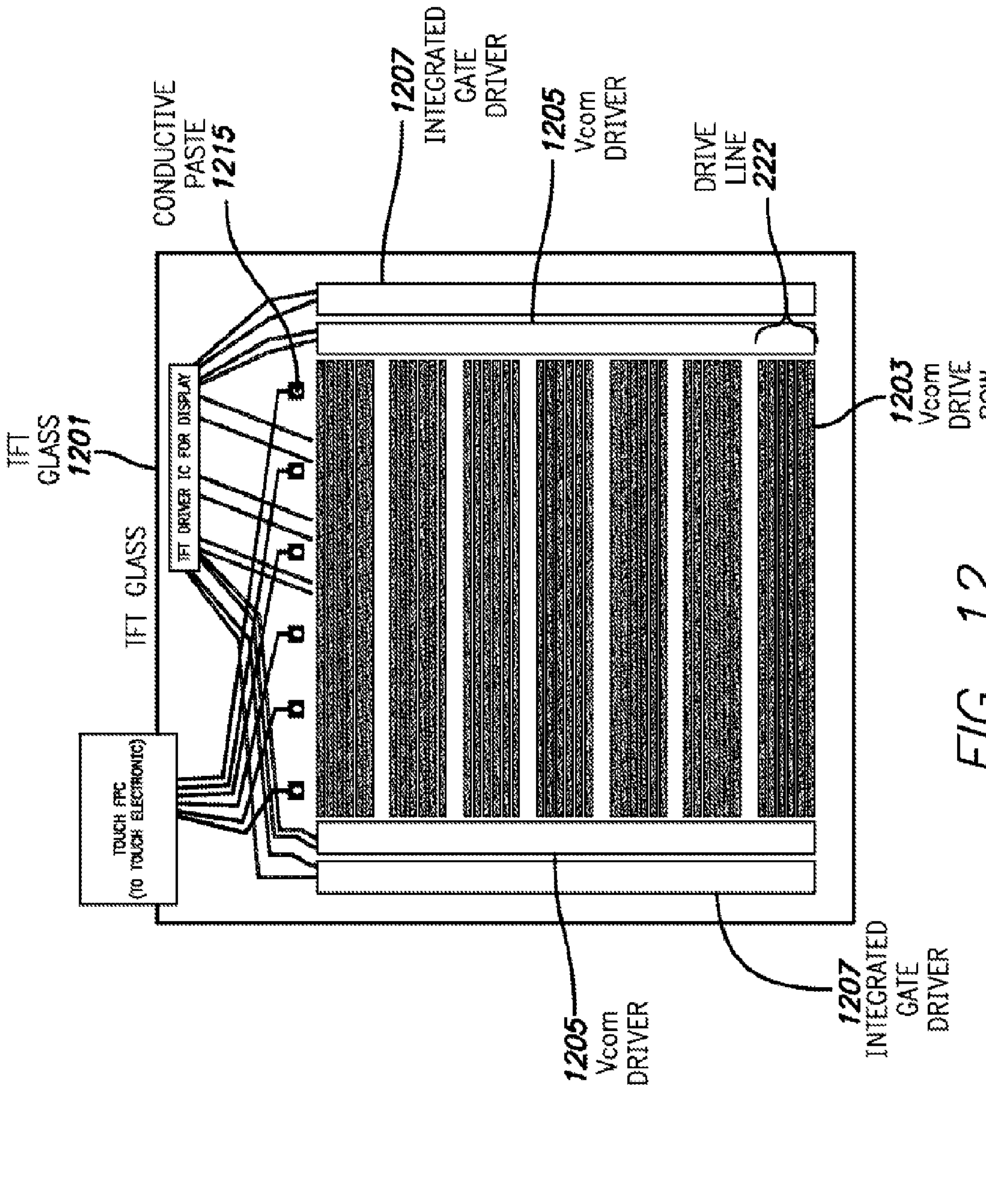
TFT GLASS 1201
TFT GLASS
CONDUCTIVE PASTE 1215
1207 INTEGRATED GATE DRIVER
1205 Vcom DRIVER
DRIVE LINE 222
1203 Vcom DRIVE ROW
TFT DRIVER IC FOR DISPLAY
TOUCH FPC (TO TOUCH ELECTRONIC)
1205 Vcom DRIVER
1207 INTEGRATED GATE DRIVER

FIG. 12

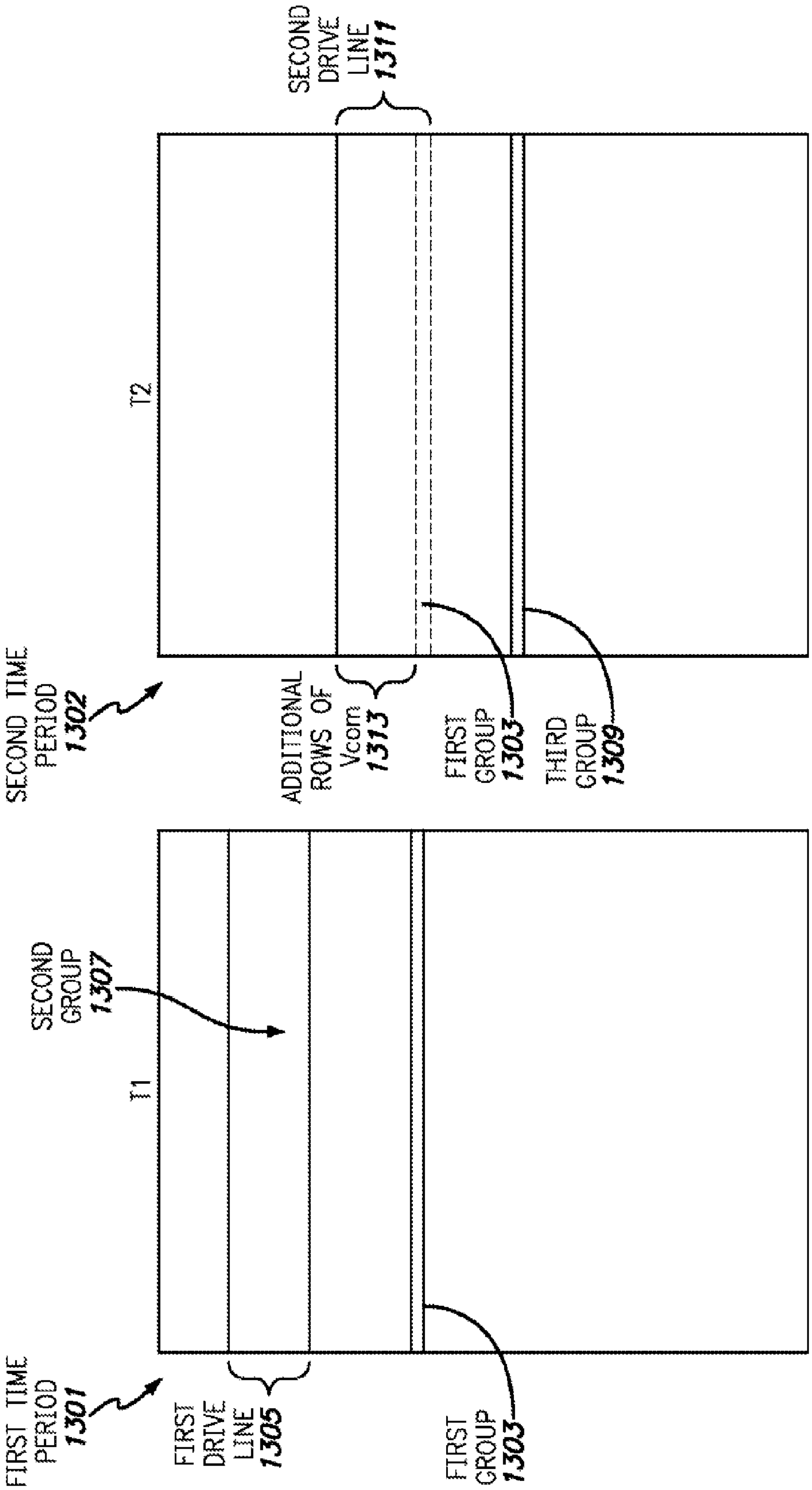
FIRST TIME PERIOD 1301
FIRST DRIVE LINE 1305
FIRST GROUP 1303
SECOND GROUP 1307
T1
SECOND TIME PERIOD 1302
ADDITIONAL ROWS OF Vcom 1313
FIRST GROUP 1303
THIRD GROUP 1309
T2
SECOND DRIVE LINE 1311

FIG. 13

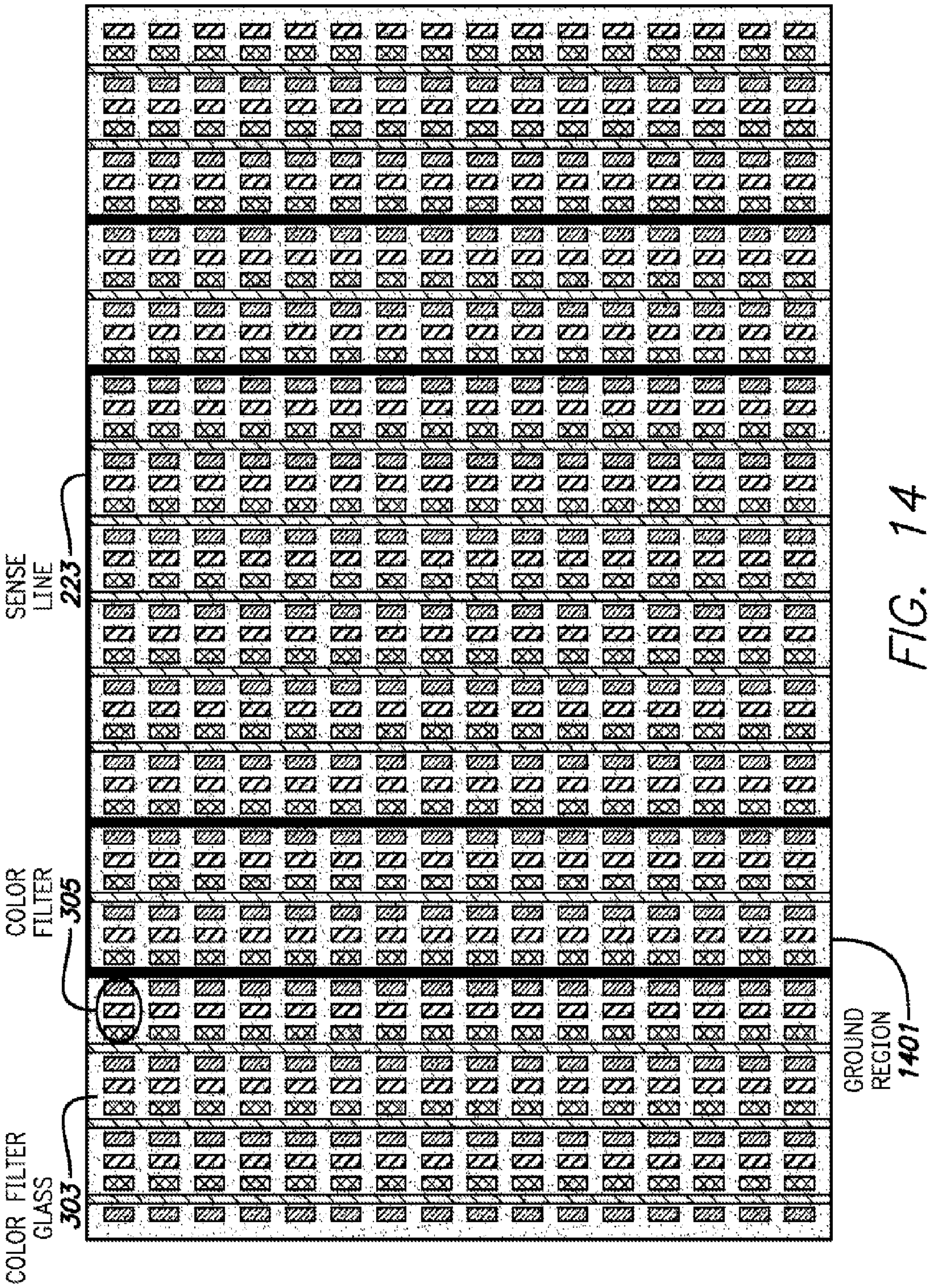
SENSE LINE 223
COLOR FILTER 305
COLOR FILTER GLASS 303
GROUND REGION 1401

FIG. 14

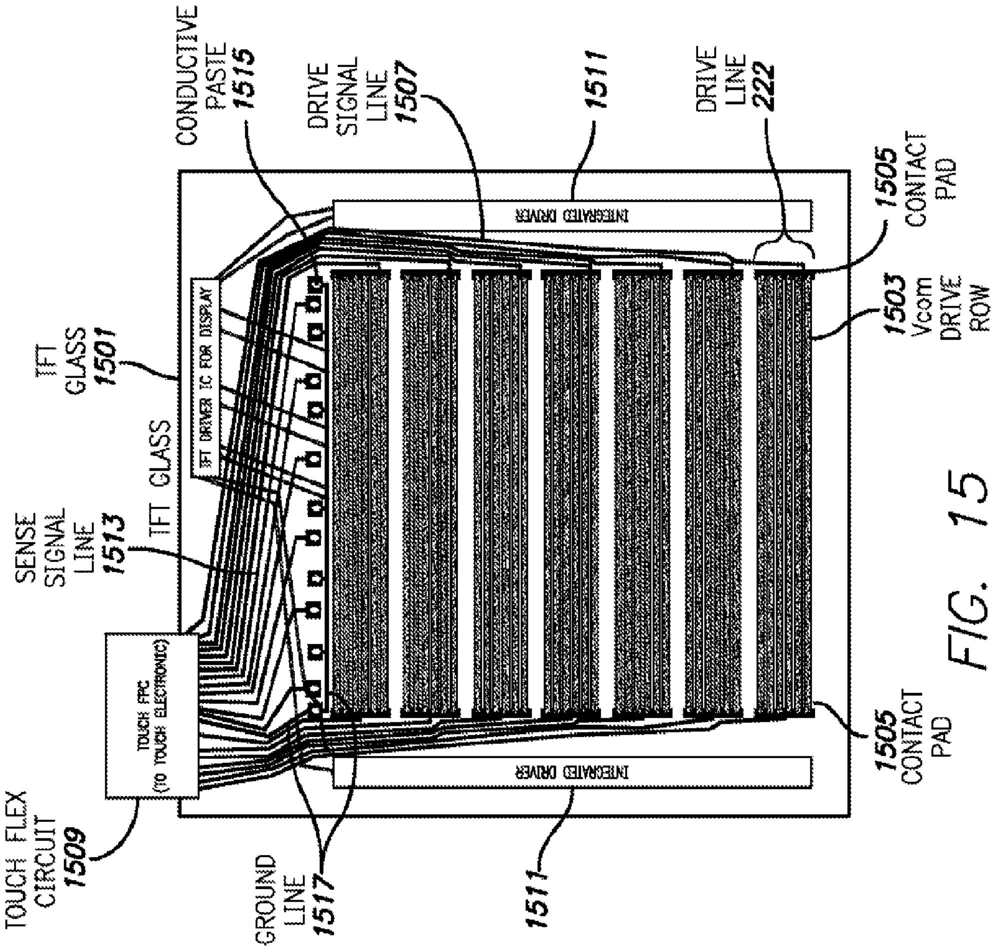
CONDUCTIVE PASTE 1515
DRIVE SIGNAL LINE 1507
1511
DRIVE LINE 222
1505 CONTACT PAD
1503 Vcom DRIVE ROW
TFT GLASS 1501
TFT GLASS
SENSE SIGNAL LINE 1513
TOUCH FLEX CIRCUIT 1509
GROUND LINE 1517
1511
TOUCH FPC (TO TOUCH ELECTRONIC)
TFT DRIVER IC FOR DISPLAY
INTEGRATED DRIVER
INTEGRATED DRIVER
1505 CONTACT PAD

FIG. 15

INTEGRATED TOUCH SCREENS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 14/456,831, filed Aug. 11, 2014, which is a divisional of application Ser. No. 12/976,997, filed Dec. 22, 2010 (now U.S. Pat. No. 8,804,056, issued Aug. 12, 2014), the contents of which are incorporated by reference herein in their entirety for all purposes.

FIELD OF THE DISCLOSURE

This relates generally to integrated touch screens, and more particularly, to integrated touch screens including drive lines formed of grouped-together circuit elements of a thin film transistor layer and sense lines formed between a color filter layer and a material layer that modifies or generates light.

BACKGROUND OF THE DISCLOSURE

Many types of input devices are presently available for performing operations in a computing system, such as buttons or keys, mice, trackballs, joysticks, touch sensor panels, touch screens and the like. Touch screens, in particular, are becoming increasingly popular because of their ease and versatility of operation as well as their declining price. Touch screens can include a touch sensor panel, which can be a clear panel with a touch-sensitive surface, and a display device such as a liquid crystal display (LCD) that can be positioned partially or fully behind the panel so that the touch-sensitive surface can cover at least a portion of the viewable area of the display device. Touch screens can allow a user to perform various functions by touching the touch sensor panel using a finger, stylus or other object at a location often dictated by a user interface (UI) being displayed by the display device. In general, touch screens can recognize a touch and the position of the touch on the touch sensor panel, and the computing system can then interpret the touch in accordance with the display appearing at the time of the touch, and thereafter can perform one or more actions based on the touch. In the case of some touch sensing systems, a physical touch on the display is not needed to detect a touch. For example, in some capacitive-type touch sensing systems, fringing electrical fields used to detect touch can extend beyond the surface of the display, and objects approaching near the surface may be detected near the surface without actually touching the surface.

Capacitive touch sensor panels can be formed from a matrix of drive and sense lines of a substantially transparent conductive material, such as Indium Tin Oxide (ITO), often arranged in rows and columns in horizontal and vertical directions on a substantially transparent substrate. It is due in part to their substantial transparency that capacitive touch sensor panels can be overlaid on a display to form a touch screen, as described above. Some touch screens can be formed by integrating touch sensing circuitry into a display pixel stackup (i.e., the stacked material layers forming the display pixels).

SUMMARY

The following description includes examples of integrated touch screens including drive lines formed of grouped-together circuit elements of a thin film transistor layer and sense lines formed between a color filter layer and a material layer that modifies or generates light. In some examples, the touch screen can be an in-plane switching (IPS) liquid crystal display (LCD), fringe field switching (FFS), advanced fringe field switching (AFFS), etc. The common electrodes (Vcom) in the TFT layer can be grouped together during a touch sensing operation to form drive lines. Sense lines can be formed on an underside of a color filter glass, and a liquid crystal region can be disposed between the color filter glass and the TFT layer. Placing the sense lines on the underside of the color filter glass, i.e., within the display pixel cell, can provide a benefit of allowing the color filter glass to be thinned after the pixel cells have been assembled, for example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1A-1C** illustrate an example mobile telephone, an example media player, and an example personal computer that each include an example touch screen according to embodiments of the disclosure.

FIG. **2** is a block diagram of an example computing system that illustrates one implementation of an example touch screen according to embodiments of the disclosure.

FIG. **3** illustrates example configurations of sense lines, drive lines, and other example structures of a touch screen according to embodiments of the disclosure.

FIG. **3**A illustrates an example display pixel stackup according to embodiments of the disclosure.

FIG. **4** illustrates a more detailed view of an example color filter glass including sense lines disposed on an underside of the color filter glass according to embodiments of the disclosure.

FIG. **5** illustrates an example color filter glass that includes an organic coat formed over conductive wires according to embodiments of the disclosure.

FIG. **6** illustrates other example configurations of sense lines, drive lines, and other example structures of a touch screen according to embodiments of the disclosure.

FIG. **7** illustrates a more detailed view of another example color filter glass including sense lines disposed on an underside of the color filter glass according to embodiments of the disclosure.

FIG. **8** illustrates an example configuration of drive lines including circuit elements of a TFT layer of a touch screen according to embodiments of the disclosure.

FIG. **9** illustrates another example configuration of drive lines including circuit elements of a TFT layer of a touch screen according to embodiments of the disclosure.

FIG. **9**A illustrates an example circuit of a TFT substrate according to embodiments of the disclosure.

FIG. **10** includes an example configuration of a color filter glass including contact pads connected to sense lines according to embodiments of the disclosure.

FIG. **11** illustrates an example configuration of a TFT glass according to embodiments of the disclosure.

FIG. **12** illustrates another example configuration of a TFT glass according to embodiments of the disclosure.

FIG. **13** illustrates an example method of driving circuit elements of a touch screen in a display operation and in a touch sensing operation according to embodiments of the disclosure.

FIG. **14** illustrates another example configuration of a color filger glass according to embodiments of the disclosure.

FIG. **15** illustrates another example configuration of a TFT glass according to embodiments of the disclosure.

DETAILED DESCRIPTION

In the following description of example embodiments, reference is made to the accompanying drawings which form a part hereof, and in which it is shown by way of illustration specific embodiments in which embodiments of the disclosure can be practiced. It is to be understood that other embodiments can be used and structural changes can be made without departing from the scope of the embodiments of this disclosure.

The following description includes examples of integrated touch screens including drive lines formed of grouped-together circuit elements of a thin film transistor layer and sense lines formed between a color filter layer and a material layer that modifies or generates light. In some examples, the touch screen can be an in-plane switching (IPS) liquid crystal display (LCD), fringe field switching (FFS), advanced fringe field switching (AFFS), etc. The common electrodes (Vcom) in the TFT layer can be grouped together during a touch sensing operation to form drive lines. Sense lines can be formed on an underside of a color filter glass, and a liquid crystal region can be disposed between the color filter glass and the TFT layer. Placing the sense lines on the underside of the color filter glass, i.e., within the display pixel cell, can provide a benefit of allowing the color filter glass to be thinned after the pixel cells have been assembled, for example.

During a display operation, in which an image is displayed on the touch screen, the Vcom can serve as part of the display circuitry, for example, by carrying a common voltage to create, in conjunction with a pixel voltage on a pixel electrode, an electric field across the liquid crystal. During a touch sensing operation, the a stimulation signal can be applied to a group of Vcom that form a drive line. A sense signal based on the stimulation signal can be received by the sense lines on the underside of the color filter glass and processed by a touch processor to determine an amount and location of touch on the touch screen.

FIGS. **1A-1C** show example systems in which a touch screen according to embodiments of the disclosure may be implemented. FIG. **1A** illustrates an example mobile telephone **136** that includes a touch screen **124**. FIG. **1B** illustrates an example digital media player **140** that includes a touch screen **126**. FIG. **1C** illustrates an example personal computer **144** that includes a touch screen **128**. Touch screens **124**, **126**, and **128** can be based on mutual capacitance. A mutual capacitance based touch system can include, for example, drive regions and sense regions, such as drive lines and sense lines. For example, drive lines can be formed in rows while sense lines can be formed in columns (e.g., orthogonal). Touch pixels can be formed at the intersections of the rows and columns. During operation, the rows can be stimulated with an AC waveform and a mutual capacitance can be formed between the row and the column of the touch pixel. As an object approaches the touch pixel, some of the charge being coupled between the row and column of the touch pixel can instead be coupled onto the object. This reduction in charge coupling across the touch pixel can result in a net decrease in the mutual capacitance between the row and the column and a reduction in the AC waveform being coupled across the touch pixel. This reduction in the charge-coupled AC waveform can be detected and measured by the touch sensing system to determine the positions of multiple objects when they touch the touch screen. In some embodiments, a touch screen can be multi-touch, single touch, projection scan, full-imaging multi-touch, capacitive touch, etc.

FIG. **2** is a block diagram of an example computing system **200** that illustrates one implementation of an example touch screen **220** according to embodiments of the disclosure. Computing system **200** could be included in, for example, mobile telephone **136**, digital media player **140**, personal computer **144**, or any mobile or non-mobile computing device that includes a touch screen. Computing system **200** can include a touch sensing system including one or more touch processors **202**, peripherals **204**, a touch controller **206**, and touch sensing circuitry (described in more detail below). Peripherals **204** can include, but are not limited to, random access memory (RAM) or other types of memory or storage, watchdog timers and the like. Touch controller **206** can include, but is not limited to, one or more sense channels **208**, channel scan logic **210** and driver logic **214**. Channel scan logic **210** can access RAM **212**, autonomously read data from the sense channels and provide control for the sense channels. In addition, channel scan logic **210** can control driver logic **214** to generate stimulation signals **216** at various frequencies and phases that can be selectively applied to drive lines of the touch sensing circuitry of touch screen **220**, as described in more detail below. In some embodiments, touch controller **206**, touch processor **202** and peripherals **204** can be integrated into a single application specific integrated circuit (ASIC).

Computing system **200** can also include a host processor **228** for receiving outputs from touch processor **202** and performing actions based on the outputs. For example, host processor **228** can be connected to program storage **232** and a display controller, such as an LCD driver **234**. The LCD driver **234** can provide voltages on select (gate) lines to each pixel transistor and can provide data signals along data lines to these same transistors to control the pixel display image as described in more detail below. Host processor **228** can use LCD driver **234** to generate an image on touch screen **220**, such as an image of a user interface (UI), and can use touch processor **202** and touch controller **206** to detect a touch on or near touch screen **220**, such a touch input to the displayed UI. The touch input can be used by computer programs stored in program storage **232** to perform actions that can include, but are not limited to, moving an object such as a cursor or pointer, scrolling or panning, adjusting control settings, opening a file or document, viewing a menu, making a selection, executing instructions, operating a peripheral device connected to the host device, answering a telephone call, placing a telephone call, terminating a telephone call, changing the volume or audio settings, storing information related to telephone communications such as addresses, frequently dialed numbers, received calls, missed calls, logging onto a computer or a computer network, permitting authorized individuals access to restricted areas of the computer or computer network, loading a user profile associated with a user's preferred arrangement of the computer desktop, permitting access to web content, launching a particular program, encrypting or decoding a message, and/or the like. Host processor **228** can also perform additional functions that may not be related to touch processing.

Touch screen **220** can include touch sensing circuitry that can include a capacitive sensing medium having a plurality of drive lines **222** and a plurality of sense lines **223**. It should be noted that the term "lines" is a sometimes used herein to mean simply conductive pathways, as one skilled in the art will readily understand, and is not limited to elements that are strictly linear, but includes pathways that change direction, and includes pathways of different size, shape, materials, etc, and multiple electrically conductive circuit elements that can be electrically connected to form a single electrically conductive pathway. Drive lines **222** can be driven by stimulation signals **216** from driver logic **214** through drive interfaces **224***a* and **224***b*, and resulting sense signals **217** generated in sense lines **223** can be transmitted through a sense interface **225** to sense channels **208** (also referred to as an event detection and demodulation circuit) in touch controller **206**. The stimulation signal may be an alternating current (AC) waveform. In this way, drive lines and sense lines can be part of the touch sensing circuitry that can interact to form capacitive sensing nodes, which can be thought of as touch picture elements (touch pixels), such as touch pixels **226** and **227**. This way of understanding can be particularly useful when touch screen **220** is viewed as capturing an "image" of touch. In other words, after touch controller **206** has determined an amount of touch detected at each touch pixel in the touch screen, the pattern of touch pixels in the touch screen at which a touch occurred can be thought of as an "image" of touch (e.g. a pattern of fingers touching the touch screen).

Structures and operations of various example embodiments of integrated touch screens will now be described with reference to FIGS. **3-15**.

FIG. **3** illustrates example embodiments of sense lines, drive lines, and other example structures of touch screen. FIG. **3** shows a more detailed view of a lower left hand portion of touch screen **220** along line "A" shown in FIG. **2**. In the example embodiment shown in FIG. **3**, each sense line **223** includes multiple conductive wires **301**, e.g., five conductive wires in this example embodiment. Conductive wires **301** are disposed on the underside of a color filter glass **303**, between the color filter glass and the TFT glass. The color filter glass **303** can include a plurality of color filters **305**. In this example embodiment, color filters **305** each include three colors, blue (B), green (G), and red (R), such as in an RGB display. Each conductive wire **301** is positioned between two columns of color filters **305**. In this example, the space between the columns of the color filters can be widened to accommodate the conductive wire. In the example shown, five conductive wires **301** of each sense line **223** can be connected to a contact pad **307** that conductively connects the conductive wires of the sense line and allows each group of five conductive wires to operate as a single sense line. Contact pads **307** can be electrically connected to, for example, sense channels **208** of touch controller **206** shown in FIG. **2**, so that sense signals **217** received by each sense line **223** can be processed by the touch controller.

FIG. **3** also shows a TFT glass **309**, on which can be formed circuit elements **311**. Circuit elements **311** can be, for example, multi-function circuit elements that operate as part of the display circuitry of the touch screen and also as part of the touch sensing circuitry of the touch screen. In some embodiments, circuit elements **311** can be single-function circuit elements that operate only as part of the touch sensing system. In addition to circuit elements **311**, other circuit elements (not shown) can be formed on TFT glass **309**, such as transistors, capacitors, conductive vias, data lines, gate lines, etc. Circuit elements **311** and the other circuit elements formed on TFT glass **309** can operate together to perform various display functionality required for the type of display technology used by touch screen **220**, as one skilled in the art would understand. The circuit elements can include, for example, elements that can exist in conventional LCD displays. It is noted that circuit elements are not limited to whole circuit components, such a whole capacitor, a whole transistor, etc., but can include portions of circuitry, such as only one of the two plates of a parallel plate capacitor.

Some of the circuit elements **311** can be electrically connected together such that the circuit elements **311** and their interconnections together form drive lines **222**. Various example methods of connecting together circuit elements **311** to form drive lines **222** will be discussed in more detail in reference to FIGS. **8-9**. Some of the circuit elements **311** that lie between drive lines **222** can serve as a buffer region **313**. One purpose of the buffer region **313** can be to separate drive lines **222** from one another to reduce or to prevent cross talk and stray capacitance effects. Circuit elements **311** in buffer region **313** can, for example, be unconnected from drive lines **222**. In various embodiments, some or all of the circuit elements **311** in buffer region **313** can be, for example, electrically connected to each other, electrically unconnected from each other, maintained at a fixed voltage during a touch sensing operation, maintained at a floating potential during a touch sensing operation, etc. The example configurations of sense lines **223** and drive lines **222** shown in FIG. **3** can be laid out as shown in FIG. **2** as an overlapping orthogonal grid to form touch pixels **226** and **227**, for example. Although not illustrated in FIG. **3**, it is understood that first and second polarizers can be provided, the first polarizer can be adjacent the TFT glass and the second polarizer can be adjacent the color filter glass such that the TFT glass and the color filter glass are disposed between the first and second polarizers.

FIG. **3** also shows a pixel material **315** disposed between TFT glass **309** and color filtered glass **303**. Pixel material **315** is shown in FIG. **3** as separate volumn regions or cells above the circuit elements **311**. For example, when the pixel material is a liquid crystal, these volumn regions or cells are meant to illustrate regions of the liquid crystal controlled by the electric field produced by the pixel electrode and common electrode of the volume region or cell under consideration. Pixel material **315** can be a material that, when operated on by the display circuitry of touch screen **220**, can generate or control an amount, color, etc., of light produced by each display pixel. For example, in an LCD touch screen, pixel material **315** can be formed of liquid crystal, with each display pixel controlling a volumn region or cell of the liquid crystal. In this case, for example, various methods exist for operating liquid crystal in a display operation to control the amount of light emanating from each display pixel, e.g., applying an electric field in a particular direction depending on the type of LCD technology employed by the touch screen. In an in-plane switching (IPS), fringe field swithing (FFS), and advanced fringe field switching (AFFS) LCD displays, for example, electrical fields between pixel electrodes and common electrodes (Vcom) disposed on the same side of the liquid crystal can operate on the liquid crystal material to control the amount of light from a backlight that passes through the display pixel. In an OLED (organic light emitting diode) display, for example, pixel material **315** can be, for example, an organic material in each pixel that generates light when a voltage is applied across the material. One skilled in the art would understand that various pixel materials can be used, depending on the type of display technology of the touch screen.

FIG. 3A illustrates an enlarged view of a display pixel (as for example, a particular R, B, or G sub-pixel). As may be seen in FIG. 3A, there can be provided a first substrate **325** (such as the TFT glass **309** of FIG. **3**), a second substrate **327** (such as the color filter glass **303** of FIG. **3**), a first polarizer **329** and a second polarizer **331**. The first polarizer **329** can be disposed adjacent the first substrate **325**, and the second polarizer **331** can be disposed adjacent the second substrate **327**. One display pixel of the first substrate **325** is shown greatly enlarged for purposes of illustration. A TFT **335** can have a gate **337**, a source **339** connected to a data line **341**, and a drain **343** connected to pixel electrode **345**. Common electrode **347** can be disposed adjacent the pixel electrode **345** and can be connected to a common electrode conductive line **349**. Layers of diectric material **351*a***, **351*b*** and **351*c*** can be disposed as shown in FIG. 3A to separate electrodes from one another. FIG. 3A also illustrates gate insulation layer **353**. An electrical fringe field between the pixel electrode **345** and the common electrode **347** can control the pixel material disposed between the first and second substrates during the display operation in order to provide a display image.

FIG. **4** illustrates a more detailed view of color filter glass **303**. FIG. **4** includes color filters **305**, conductive wires **301**, which form sense lines **203**. Conductive wires **301** can be, for example, metal lines such as aluminum, etc. In this regard conductive wires **301** can be positioned behind a black mask **401** so that the conductive wires are not visible to a user. Therefore conductive wires **301** need not be transparent conductors. However, in some example embodiments, conductive wires **301** can be transparent metal. Although in the example embodiment shown in FIG. **4** the spacing between the columns of color filters **305** can be widened to accommodate conductive wires **301**, in some embodiments the spacing can be different, including equal spacing between the color filters.

FIG. **5** illustrates an example embodiment that includes an organic coat **501** that has been formed over conductive wires **301**. In other words, conductive wires **301** can be formed on the underside of color filter glass **303**, and then organic coat **501** can be formed on conductive wires **301**, such that the conductive wires are disposed between color filter glass **303** and organic coat **501**. Organic coat **501** can be formed of a material that can protect the conductive wires from exposure to chemicals, from physical abrasion, etc.

FIG. **6** illustrates another example embodiment showing another example configuration of sense lines **223**. As in the example shown in FIG. **3**, the example shown in FIG. **6** is a perspective view along line "A" shown in FIG. **2**. In the example embodiment shown in FIG. **6**, each of the sense lines **223** can include a conductive mesh **601**. Conductive mesh **601** can be formed of, for example, metal wires, metal strips, etc., that are formed on the underside of color filter glass **303**. Conductive mesh **601** can be, for example, a conductive orthogonal grid, the conductive lines of which are disposed between individual color filters **305**.

Sense line **223**, formed of conductive mesh **601**, can be conductively connected to contact pad **307** such that a sense signal received by the sense line can be transmitted to touch controller **206** for processing. Similar to the previous embodiment, the portion of touch screen **220** shown in example embodiment in FIG. **6** includes drive lines **222** and buffer regions **313**, each of which can be formed of circuit elements **311** that have been grouped together either operationally or physically to perform their respective functions. In a touch sensing operation, stimulation signals applied to drive lines **222** can allow touches to be sensed by sense lines **223** in the areas of various touch pixels, such as touch pixels **226** and **227**. The example embodiment shown in FIG. **6** also includes pixel material **315**, similar to the example embodiment shown in FIG. **3**.

FIG. **7** illustrates a more detailed view of color filter glass **303** shown in the example embodiment FIG. **6**. FIG. **7** includes color filters **305** and conductive mesh **601**, which form sense lines **203**. Conductive mesh **601** can be, for example, formed of non-transparent metal lines such as aluminum, etc. In this regard conductive mesh **601** can be positioned behind a black mask **701** so that the conductive mesh is not visible to a user. Therefore, in this embodiment, the conductive mesh **601** need not be made of transparent conductors. However, in some example embodiments, conductive mesh **601** can be transparent metal.

FIG. **8** illustrates a more detailed view of an example configuration of drive lines **222** and buffer regions **313** according to various embodiments. In this example embodiment, circuit elements **311** can include common electrodes **801**. Common electrodes **801** can be operated as multi-function circuit elements that can operate as part of the display circuitry in a display operation and can operate as part of the touch sensing circuitry in a touch sensing operation of the touch screen. Common electrodes **801** can be electrically connected together with conductive lines **803**, to form the required regions such as regions that operate as drive lines **222** and regions that operate as buffer regions **313**. In this example embodiment, common electrodes functional region can be physically connected with fixed conductive lines. In other words, the common electrodes in each region can be permanently connected through the physical design of the touch screen. In other words, common electrodes **801** can be grouped together to form drive lines. Grouping multi-function circuit elements of display pixels can include operating the multi-function circuit elements of the display pixels together to perform a common function of the group. Grouping into functional regions may be accomplished through one or a combination of approaches, for example, the structural configuration of the system (e.g., physical breaks and bypasses, voltage line configurations), the operational configuration of the system (e.g., switching circuit elements on/off, changing voltage levels and/or signals on voltage lines), etc.

Stimulation signals can be applied to drive lines **222** through drive lead lines **805**. For example, drive lead lines can be electrically connected to driver logic **214**, which can provide the stimulation signals during the touch sensing operation. Buffer region **313** can be connected to a buffer lead line **807**, which can be connected to a buffer operator (not shown).

In the example shown in FIG. **8**, each common electrode (Vcom) **801** can serve as a multi-function circuit element that can operate as display circuitry of the display system of touch screen **220** and can also operate as touch sensing circuitry of the touch sensing system. In this example, each common electrode **801** can operate as a common electrode of the display circuitry of the touch screen, and can also operate together when grouped with other common electrodes as touch sensing circuitry of the touch screen. For example, a group of common electrodes **801** can operate together as a part of a drive line of the touch sensing circuitry during the touch sensing operation. Other circuit elements of touch screen **220** can form part of the touch sensing circuitry by, for example, electrically connecting together common electrodes **801** of a region, switching electrical connections, etc. Each display pixel can include a common electrode **801**, which can be a circuit element of the display system circuitry in the pixel stackup (i.e., the stacked material layers forming the display pixels) of the display pixels of some types of conventional LCD displays, e.g., fringe field switching (FFS) displays, that can operate as part of the display system to display an image.

In general, each of the touch sensing circuit elements may be either a multi-function circuit element that can form part of the touch sensing circuitry and can perform one or more other functions, such as forming part of the display circuitry, or may be a single-function circuit element that can operate as touch sensing circuitry only. Similarly, each of the display circuit elements may be either a multi-function circuit element that can operate as display circuitry and perform one or more other functions, such as operating as touch sensing circuitry, or may be a single-function circuit element that can operate as display circuitry only. Therefore, in some embodiments, some of the circuit elements in the display pixel stackups can be multi-function circuit elements and other circuit elements may be single-function circuit elements. In other embodiments, all of the circuit elements of the display pixel stackups may be single-function circuit elements.

In the embodiment shown in FIG. **9**, the circuit elements used to form drive lines, Vcom **901** in this example, can be physically connected together on the TFT glass through conductive lines **903** to form individual rows of connected together Vcom **901**. The individual rows of Vcom, i.e., Vcom drive rows **905**, can be connected together with other Vcom drive rows in the periphery using contact pads **907**. In this example, each drive line **222** can be formed through fixed electrical connections.

FIG. **9**A illustrates a more detailed view of the of the TFT glass substrate previously illustrated in FIGS. **3**, **6**, **8** and **9**. It is understood that the pixel electrodes, gate lines, data lines, TFT elements, and common electrode conductive lines connecting together the common electrodes are also present in FIGS. **3**, **6**, **8** and **9**, but have been omitted for simplicity of illustration. Thus, as seen in FIG. **9**A, gate lines **925** extend in a row (horizontal) direction and data lines **927** extend in a column (vertical) direction. The gate lines can be connected to gates of transistors **929** (for example, thin film transistors, TFTs) and control (e.g., turn on) these transistors to permit data from the data lines **927** to be applied to pixel electrodes **931** during a display operation. During the display operation, common electrodes **901** can be held at a preset voltage. FIG. **9**A also shows conductive lines **903** interconnecting common electrodes **901** along the row and column directions. An electrical field can be formed by the difference in voltage between pixel electrode **931** and its corresponding common electrode **901** and this electric field can control the pixel material disposed above the first substrate (disposed between the first and second substrates). A pixel can be formed at each crossing of gate line **925** and data line **927** and comprises the pixel electrode **931** and its corresponding common electrode **901**.

FIGS. **10** and **11** illustrate an example color filter glass design and an example TFT design, respectively, according to various embodiments. FIG. **10** includes an example configuration of multiple sense lines **223**, each including multiple conductive wires such as conductive wires **301**, connected to multiple contact pads, such as contact pad **311**. For the sake of clarity, individual color filters are not shown in FIG. **10** In this example embodiment, conductive wires **301** and contact pads **307** can be formed on color filter glass **303** by, for example, physical vapor deposition (PVD).

FIG. **11** illustrates an example TFT glass according to various example embodiments. TFT glass **1101** can include various touch sensing circuitry and display circuitry. Touch sensing circuitry can include, for example, drive lines **222**. In this example embodiment, each drive line **222** can include multiple Vcom drive rows **1103**. In this example embodiment, each Vcom drive row **1103** in a drive line **222** can be connected to a single conductive contact pad **1105** on the left side of the TFT glass, and connected to a single contact pad **1105** on the right side of TFT glass. Contact pads **1105** can be connected through drive signal lines **1107** to touch controller **206** (FIG. **2**) through a touch flex circuit **1109**. In this way, for example, multiple Vcom drive rows **1103** can be driven together as a single drive line **222** during a touch sensing operation. TFT glass **1101** can also include integrated drivers **1111** that can drive the display circuitry, for example, using various display circuit elements such as gate lines, data lines, etc. Touch flex circuit **1109** can also be connected to sense signal lines **1113**, which can be connected to contact pads **307** on the color filter glass through conductive paste **1115**.

FIG. **12** illustrates another example TFT glass design. FIG. **12** shows a TFT glass **1201** in which individual rows of Vcom are electrically connected together to form Vcom drive rows **1203**. In other words, similar to the previous embodiment, each Vcom circuit element in Vcom drive row **1203** is permanently connected to the other Vcom in the drive row. However, in the example embodiment shown in FIG. **12**, each individual Vcom drive row **1203** can be connected to a Vcom driver **1205** in the periphery of TFT glass **1201**. Vcom driver **1205** can operate the Vcom drive rows **1203** in each drive line **222** to generate the same stimulation signals on each individual Vcom drive row **1203** of each drive line **222** during a touch sensing operation. In other words, a first stimulation signal can be applied to a first group of individual rows of Vcom, and a second stimulation signal can be applied to a second group of individual rows of Vcom. In this way, for example, a group of multiple Vcom drive rows **1203** can be operated together as a single drive line **222** even though the individual Vcom drive rows themselves are not connected to each other through fixed electrical connections.

Likewise, during a display operation of the touch screen, integrated gate drivers **1207** can operate the individual Vcom drive rows **1203** as part of the display circuitry to display an image on the touch screen. Therefore, in this example embodiment, the individual Vcom drive rows **1203** can be grouped together or operated individually as needed depending on the operation of the touch screen.

FIG. **13** illustrates an example method of driving the circuit elements of the touch screen in the display operation and in the touch sensing operation. This example method can apply to an operation of a touch screen including the design of TFT glass **1201** of FIG. **12**, for example. In this example embodiment, the display operation in which an image is displayed and the touch sensing operation in which touch is sensed can occur concurrently by operating different portions of the touch screen differently, that is, one group of circuit elements can be operated as display circuitry to display an image while, at the same time, another group of the circuit elements can be operated as touch sensing circuitry to sense a touch.

In a first time period **1301**, integrated gate driver **1207**, along with other display circuitry, can update a first group **1303** of circuit elements, e.g., an individual row of display pixels, to display a line of an image on the touch screen. For example, integrated gate driver **1207** can apply a common voltage to the Vcom in the first row of display pixels. Concurrently, in first time period **1301**, Vcom driver **1205** can apply a stimulation signal to a first drive line **1305** that includes a second group **1307** of the circuit elements. Applying the stimulation signal can include, for example, applying the same stimulation signal to each of the individual Vcom drive rows **1203** in the first drive line **222**. Because the image scanning row currently being scanned by integrated gate driver **1207** is not located in first drive line **1305**, the Vcom drive rows **1203** being used for updating the displayed image do not overlap with the Vcom drive rows **1203** used for touch sensing as a drive line.

A second time period **1302** shows a third group **1309** of circuit elements can be operated as display circuitry, e.g., integrated gate driver **1207** can apply a common voltage to the Vcom in a third row of display pixels. The common voltage applied to the Vcom in the third row can be, for example, of an opposite polarity to the common voltage applied to the Vcom in the first row of display pixels. Concurrently, in second time period **1302**, Vcom driver **1205** can apply a stimulation signal to a second drive line **1311** that includes first group **1303** and additional rows of Vcom **1313**. In this way, for example, display operation and touch sensing operation can occur concurrently in an integrated touch screen.

In the example driving method shown in FIG. **13**, display updating can be done on a row by row basis for individual

Vcom drive rows **1203**. In some embodiments, integrated gate driver **1207** can change the Vcom polarity on a row by row basis as well. For example, for each row of display pixel integrated gate driver **1207** can operate to change the polarity of Vcom, switch the gates of the row of display pixels to an "on" state, write data into each display pixel, and switch the gates to an "off" state. When different rows of Vcom are operated to perform touch sensing concurrently with display updating, as in this example embodiment, it is noted that in the touch sensing groups of circuit elements no data is being written into the display pixels in the rows of pixels in the drive line because the gate lines of these rows of display pixels are in the "off" state.

FIG. **14** illustrates another example embodiment of sense lines **223**. FIG. **14** illustrates a color filter glass **303** that includes sense lines **223** formed of a transparent conductor, such as indium tin oxide (ITO), on the underside of color filter glass **303**. The ITO can be deposited on the underside of color filter glass **303** to cover a contiguous area including covering color filters **305**. FIG. **14** also illustrates ground regions **1401** between sense lines **223**. Ground regions **1401** can be formed of transparent conductor, such as ITO formed on the underside of color filter glass **303** and electrically separated from the sense lines on either side of each sense line. Ground regions **1401** can be connected to, for example, a ground or virtual ground in the periphery of the panel. Positioning ground regions between sense regions can help reduce interference in some embodiments.

FIG. **15** illustrates an example TFT glass design, TFT glass **1501**. In this example, TFT glass **1501** can include various touch sensing circuitry and display circuitry. Touch sensing circuitry can include, for example, drive lines **222**. In this example embodiment, each drive line **222** can include multiple Vcom drive rows **1503**. In this example embodiment, each Vcom drive row **1503** in a drive line **222** can be connected to a single conductive contact pad **1505** on the left side of the TFT glass, and connected to a single contact pad **1105** on the right side of TFT glass. Contact pads **1505** can be connected through drive signal lines **1507** to touch controller **206** through a touch flex circuit **1509**. In this way, for example, multiple Vcom drive rows **1503** can be driven together as a single drive line **222** during a touch sensing operation. TFT glass **1501** can also include integrated drivers **1511** that can drive the display circuitry, for example, using various display circuit elements such as gate lines, data lines, etc. Touch flex circuit **1509** can also be connected to sense signal lines **1513**, which can be connected to contact pads **307** on the color filter glass through conductive paste **1515**.

In FIGS. **3**, **6**, **8** and **9**, each row of display pixels is illustrated as having a separate common electrode for each display pixel. These common electrodes (for example, circuit elements **311** of FIGS. **3** and **6**, common electrode **801** of FIG. **8**, and common electrode **901** of FIG. **9**) may however, not be physically distinct and separate structures corresponding to each pixel electrode. In some embodiments the common electrodes that are electrically connected together across a particular row, as for example, Vcom drive row **905** of FIG. **9**, may be formed by a single, continuous layer of conductive material, e.g., ITO. Further, a single continuous layer of conductive material (ITO) may be used for an entire drive line **222** such as in FIG. **8** where the illustrated common electrodes within each drive line **222** are electrically connected together along both rows (first direction) and columns (second direction, perpendicular to the first direction).

In addition, although example embodiments herein may describe the display circuitry as operating during a display operation, and describe the touch sensing circuitry as operating during a touch sensing operation, it should be understood that a display operation and a touch sensing operation may be operated at the same time, e.g., partially or completely overlap, or the display operation and touch phase may operate at different times. Also, although example embodiments herein describe certain circuit elements as being multi-function and other circuit elements as being single-function, it should be understood that the circuit elements are not limited to the particular functionality in other embodiments. In other words, a circuit element that is described in one example embodiment herein as a single-function circuit element may be configured as a multi-function circuit element in other embodiments, and vice versa.

Although embodiments of this disclosure have been fully described with reference to the accompanying drawings, it is to be noted that various changes and modifications including, but not limited to, combining features of different embodiments, omitting a feature or features, etc., as will be apparent to those skilled in the art in light of the present description and figures.

For example, one or more of the functions of computing system **200** described above can be performed by firmware stored in memory (e.g. one of the peripherals **204** in FIG. **2**) and executed by touch processor **202**, or stored in program storage **232** and executed by host processor **228**. The firmware can also be stored and/or transported within any computer-readable medium for use by or in connection with an instruction execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch the instructions from the instruction execution system, apparatus, or device and execute the instructions. In the context of this document, a "computer-readable medium" can be any medium that can contain or store the program for use by or in connection with the instruction execution system, apparatus, or device. The computer readable medium can include, but is not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus or device, a portable computer diskette (magnetic), a random access memory (RAM) (magnetic), a read-only memory (ROM) (magnetic), an erasable programmable read-only memory (EPROM) (magnetic), a portable optical disc such a CD, CD-R, CD-RW, DVD, DVD-R, or DVD-RW, or flash memory such as compact flash cards, secured digital cards, USB memory devices, memory sticks, and the like.

The firmware can also be propagated within any transport medium for use by or in connection with an instruction execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch the instructions from the instruction execution system, apparatus, or device and execute the instructions. In the context of this document, a "transport medium" can be any medium that can communicate, propagate or transport the program for use by or in connection with the instruction execution system, apparatus, or device. The transport readable medium can include, but is not limited to, an electronic, magnetic, optical, electromagnetic or infrared wired or wireless propagation medium.

Example embodiments may be described herein with reference to a Cartesian coordinate system in which the x-direction and the y-direction can be equated to the horizontal direction and the vertical direction, respectively. However, one skilled in the art will understand that reference to a particular coordinate system is simply for the purpose of clarity, and does not limit the direction of the elements to a particular direction or a particular coordinate system. Furthermore, although specific materials and types of materials may be included in the descriptions of example embodiments, one skilled in the art will understand that other materials that achieve the same function can be used. For example, it should be understood that a "metal layer" as described in the examples below can be a layer of any electrically conductive material.

In some embodiments, the drive lines and/or sense lines can be formed of other elements including, for example other elements already existing in typical LCD displays (e.g., other electrodes, conductive and/or semiconductive layers, metal lines that would also function as circuit elements in a typical LCD display, for example, carry signals, store voltages, etc.), other elements formed in an LCD stackup that are not typical LCD stackup elements (e.g., other metal lines, plates, whose function would be substantially for the touch sensing system of the touch screen), and elements formed outside of the LCD stackup (e.g., such as external substantially transparent conductive plates, wires, and other elements). For example, part of the touch sensing system can include elements similar to known touch panel overlays.

Although various embodiments are described with respect to display pixels, one skilled in the art would understand that the term display pixels can be used interchangeably with the term display sub-pixels in embodiments in which display pixels are divided into sub-pixels. For example, some embodiments directed to RGB displays can include display pixels divided into red, green, and blue sub-pixels. In other words, in some embodiments, each sub-pixel can be a red (R), green (G), or blue (B) sub-pixel, with the combination of all three R, G and B sub-pixels forming one color display pixel. One skilled in the art would understand that other types of touch screen could be used. For example, in some embodiments, a sub-pixel may be based on other colors of light or other wavelengths of electromagnetic radiation (e.g., infrared) or may be based on a monochromatic configuration, in which each structure shown in the figures as a sub-pixel can be a pixel of a single color.

What is claimed is:

1. A capacitive touch screen comprising:
- a TFT layer;
- a plurality of display pixels positioned on the TFT layer; each display pixel comprising a pixel electrode;
- one or more common electrodes positioned on the TFT layer; each pixel electrode operatively coupled to one of the one or more common electrodes to provide a display function in a display mode of operation;
- a color filter substrate;
- the thin film transistor (TFT) layer including a plurality of drive lines, wherein the drive lines are configured to transmit stimulation signals, the stimulation signals used to stimulate the capacitive touch screen for the purpose of detecting touch input events, each drive line configured from the one or more common electrodes in a touch sensing mode of operation;
- a pixel material disposed between the TFT layer and the color filter substrate; and
- a plurality of sense lines disposed on a side of the color filter substrate facing the pixel material, wherein the sense lines are configured to receive signals based on the stimulation signals transmitted by the drive lines and wherein the drive lines and the sense lines form a plurality of capacitive sensing nodes.

2. The touch screen of claim **1**, wherein each of the plurality of drive lines includes display pixels disposed along a first and second, different directions.

3. The touch screen of claim **2**, wherein during a touch sensing operation first stimulation signals are applied to a first drive line and second stimulation signals are applied to a second drive line.

4. The touch screen of claim **2**, wherein the one or more common electrodes are connected to display circuitry during a display mode of operation of the touch screen.

5. The touch screen of claim **1**, wherein electric fields are applied to the pixel material during the display mode of operation, the electric fields being based on voltages applied to the one or more common electrodes.

6. The touch screen of claim **1**, wherein during a touch sensing operation first stimulation signals are applied to a first drive line and second stimulation signals are applied to a second drive line.

7. The touch screen of claim **1**, wherein each sense line includes a plurality of conductive lines disposed on the color filter layer.

8. The touch screen of claim **7**, wherein each of the plurality of sense lines includes a conductive mesh disposed on the color filter substrate.

9. The touch screen of claim **1**, wherein the color filter substrate includes a black mask, and the plurality of sense lines are non-transparent conductors disposed behind the black mask so as not to be visible to a user of the touch screen.

10. A capacitive touch screen including a plurality of display pixels, the touch screen comprising:
- a color filter layer disposed on a first substrate;
- a plurality of drive lines, disposed on a second substrate, the plurality of drive lines carrying, during a touch sensing mode of operation, stimulation signals that are used to stimulate the touch screen for the purpose of detecting touch and proximity events, each of the plurality of drive lines configured from one or more common electrodes;
- a pixel material disposed between the plurality of drive lines and the color filter layer;
- display circuitry that controls the pixel material, during a display mode of operation, such that a controlled amount of light from each display pixel passes through the color filter layer to form an image;
- a plurality of sense lines that receive sense signals based on the stimulation signals, the sense lines being disposed on a side of the first substrate facing the pixel material; and
- touch sensing circuitry connected to receive the sense signals from the plurality of sense lines.

11. The touch screen of claim **10**, wherein:
- the sense lines are disposed on the color filter layer; and
- each of the plurality of drive lines includes groups of the plurality display pixels.

12. The touch screen of claim **11**, wherein the color filter layer includes a plurality of individual color filters, and the sense lines include conductive material disposed between individual color filters.

13. The touch screen of claim **11**, wherein the sense lines include non-transparent conductive material.

14. The touch screen of claim **11**, wherein the sense lines include transparent conductive material.

15. The touch screen of claim **11**, further comprising an organic coating disposed on the sense lines.

16. The touch screen of claim **10**, wherein the pixel material includes a light modifying material.

17. The touch screen of claim **10**, wherein the pixel material includes a light generating material.

18. A touch screen including a plurality of display pixels, the touch screen comprising:
- a first substrate including a plurality display pixels having one or more common electrodes, each display pixel

including a pixel electrode and a switching element for connecting a data line to the pixel electrode to display an image on the touch screen during a display mode of operation;

a plurality of drive lines disposed on the first substrate, each of the plurality of drive lines formed from the one or more common electrodes;

the one or more common electrode receiving a common voltage during the display mode of operation and a stimulation voltage during the touch sensing mode of operation;

a second substrate including a color filter layer;

a pixel material disposed between the first and second substrates; and

a plurality of sense lines disposed between the color filter layer and the pixel material.

19. The touch screen of claim **18**, wherein the pixel electrodes of the plurality of display pixels and the one or more common electrodes are configured in an in-plane-switching arrangement.

20. The touch screen of claim **19**, wherein the display pixels are arranged along a first direction and along a second direction, perpendicular to the first direction, and wherein a plurality of drive lines is formed by the plurality of groups of display pixels; and

the sense lines are disposed along the second direction, crossing the drive lines;

wherein each intersection of one of the drive lines with one of the sense lines forms a capacitive sensing node.

21. The touch screen of claim **18**, wherein the pixel material includes a light modifying material.

22. The touch screen of claim **18**, wherein the pixel material includes a light generating material.

23. The touch screen of claim **18**, wherein the pixel electrodes of the plurality of display pixels and the one or more common electrodes are configured in a fringe-field-switching arrangement.

* * * * *

patsnap

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摘要(译)

提供集成触摸屏，包括由薄膜晶体管层的分组在一起的电路元件形成的驱动线和在滤色器层和修改或产生光的材料层之间形成的感测线。TFT层中的公共电极（Vcom）可以在触摸感测操作期间被分组在一起以形成驱动线。感光线可以形成在滤色镜玻璃的下侧，并且液晶区域可以设置在滤色镜玻璃和TFT层之间。将感测线放置在滤色器玻璃的下侧上，即在显示像素单元内，可以提供例如在组装像素单元之后允许滤色器玻璃变薄的益处。