US007077313B2

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Chung et al.

(10) **Patent No.: US 7,077,313 B2**
(45) **Date of Patent: Jul. 18, 2006**

(54) **ELECTRONIC VOTING METHOD FOR OPTICALLY SCANNED BALLOT**

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(73) Assignee: **Avante International Technology, Inc.**, Princeton Junction, NJ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 89 days.

(21) Appl. No.: **10/410,824**

(22) Filed: **Apr. 10, 2003**

(65) **Prior Publication Data**

US 2003/0173404 A1 Sep. 18, 2003

Related U.S. Application Data

(63) Continuation-in-part of application No. 10/260,167, filed on Sep. 30, 2002.

(60) Provisional application No. 60/326,265, filed on Oct. 1, 2001, provisional application No. 60/341,633, filed on Dec. 19, 2001, provisional application No. 60/377,824, filed on May 7, 2002, provisional application No. 60/382,033, filed on May 20, 2002, provisional application No. 60/385,118, filed on May 30, 2002, provisional application No. 60/389,635, filed on Jun. 17, 2002, provisional application No. 60/403,151, filed on Aug. 12, 2002.

(51) **Int. Cl.**
G06K 17/00 (2006.01)

(52) **U.S. Cl.** ..... **235/386**; 235/51; 235/54 F

(58) **Field of Classification Search** ..... 235/51, 235/50 R, 50 A, 50 B, 54 F, 386, 454; 705/12
See application file for complete search history.

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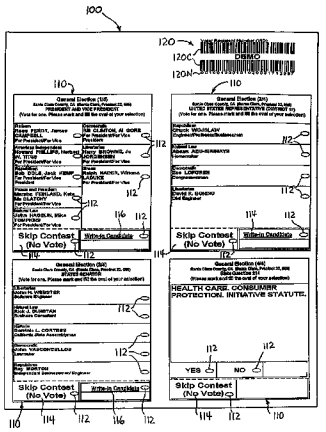
Primary Examiner—Karl D. Frech
(74) *Attorney, Agent, or Firm*—Dann, Dorfman, Herrell & Skillman, P.C.

(57) **ABSTRACT**

A method for reading ballots comprises reading/imaging each ballot transported on a transport path including reading/imaging orientation indicia and a jurisdiction identifier thereof and voting selections marked thereon; determining from the orientation indicia the orientation of each ballot; processing the jurisdiction identifier for each ballot for selecting a template; and recording the voting selections marked on each ballot in accordance with the selected template and the determined orientation of the ballot.

67 Claims, 11 Drawing Sheets



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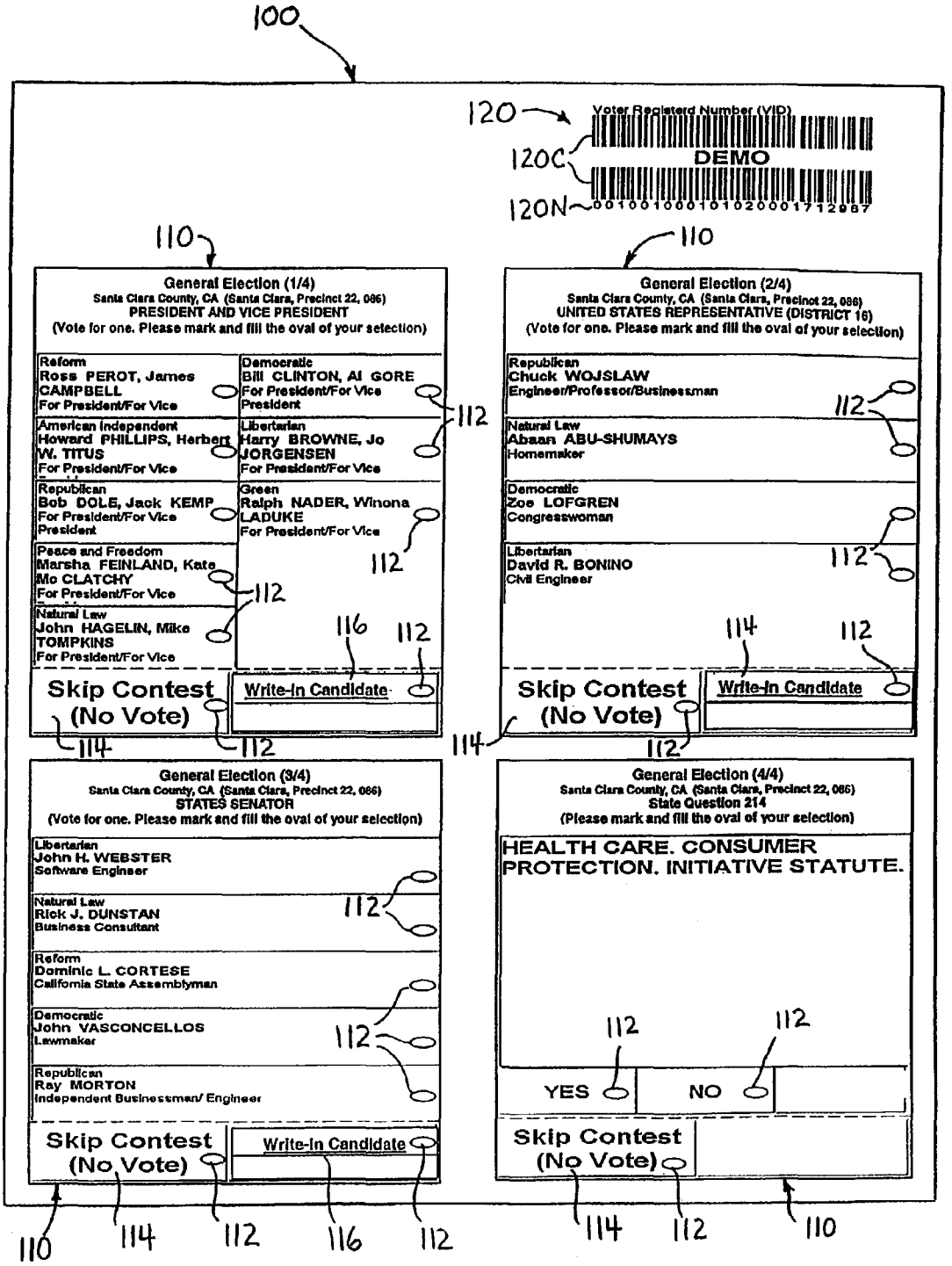
100
120
Voter Registerd Number (VID)
120C
DEMO
120N
00100100010102000171298?
110
General Election (1/4)
Santa Clara County, CA (Santa Clara, Precinct 22, 086)
PRESIDENT AND VICE PRESIDENT
(Vote for one. Please mark and fill the oval of your selection)
Reform
Ross PEROT, James CAMPBELL
For President/For Vice President
Democratic
Bill CLINTON, Al GORE
For President/For Vice President
American Independent
Howard PHILLIPS, Herbert W. TITUS
For President/For Vice President
Libertarian
Harry BROWNE, Jo JORGENSEN
For President/For Vice President
Republican
Bob DOLE, Jack KEMP
For President/For Vice President
Green
Ralph NADER, Winona LADUKE
For President/For Vice President
Peace and Freedom
Marsha FEINLAND, Kate Mc CLATCHY
For President/For Vice President
Natural Law
John HAGELIN, Mike TOMPKINS
For President/For Vice President
Skip Contest (No Vote)
Write-In Candidate
112
114
116
110
General Election (2/4)
Santa Clara County, CA (Santa Clara, Precinct 22, 086)
UNITED STATES REPRESENTATIVE (DISTRICT 16)
(Vote for one. Please mark and fill the oval of your selection)
Republican
Chuck WOJSLAW
Engineer/Professor/Businessman
Natural Law
Abaan ABU-SHUMAYS
Homemaker
Democratic
Zoe LOFGREN
Congresswoman
Libertarian
David R. BONINO
Civil Engineer
Skip Contest (No Vote)
Write-In Candidate
General Election (3/4)
Santa Clara County, CA (Santa Clara, Precinct 22, 086)
STATES SENATOR
(Vote for one. Please mark and fill the oval of your selection)
Libertarian
John H. WEBSTER
Software Engineer
Natural Law
Rick J. DUNSTAN
Business Consultant
Reform
Dominic L. CORTESE
California State Assemblyman
Democratic
John VASCONCELLOS
Lawmaker
Republican
Ray MORTON
Independent Businessman/ Engineer
Skip Contest (No Vote)
Write-In Candidate
General Election (4/4)
Santa Clara County, CA (Santa Clara, Precinct 22, 086)
State Question 214
(Please mark and fill the oval of your selection)
HEALTH CARE. CONSUMER PROTECTION. INITIATIVE STATUTE.
YES
NO
Skip Contest (No Vote)

FIGURE 1

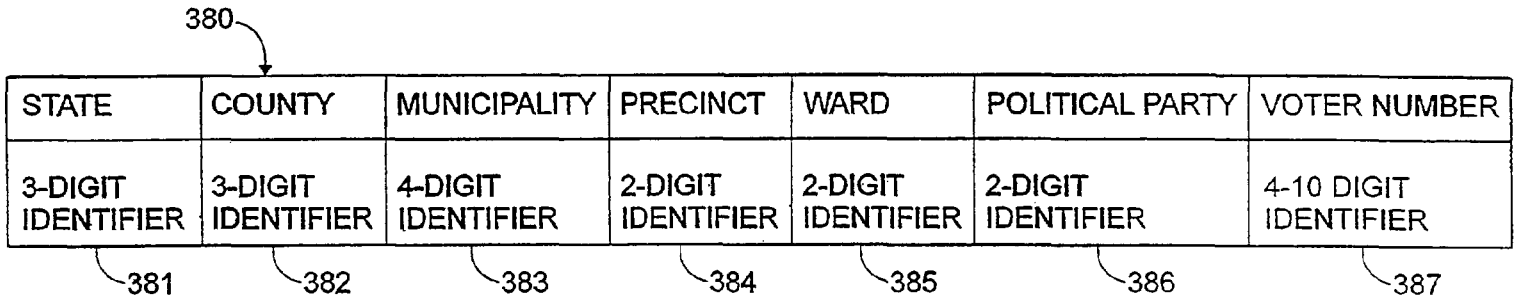

FIGURE 2

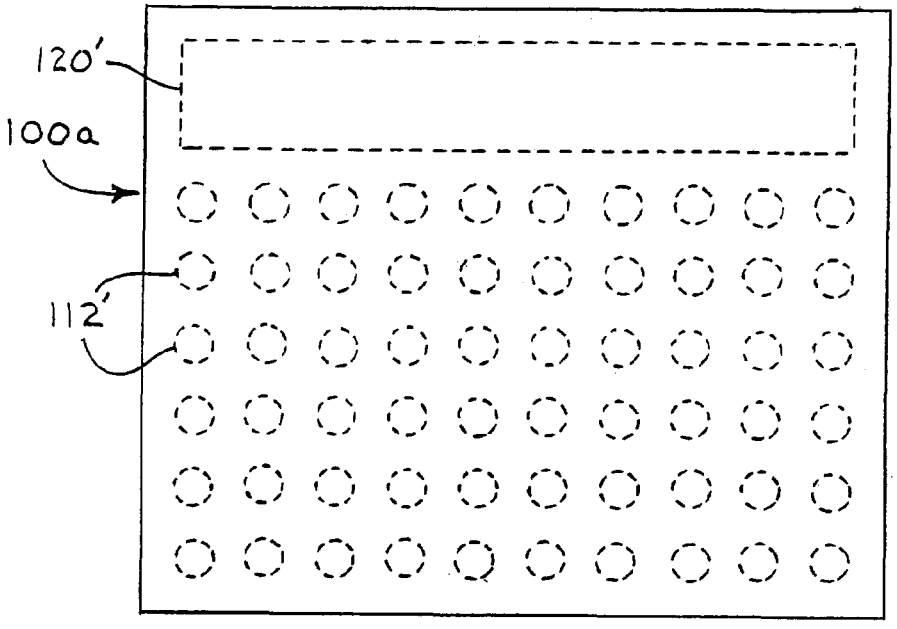

FIGURE 3A

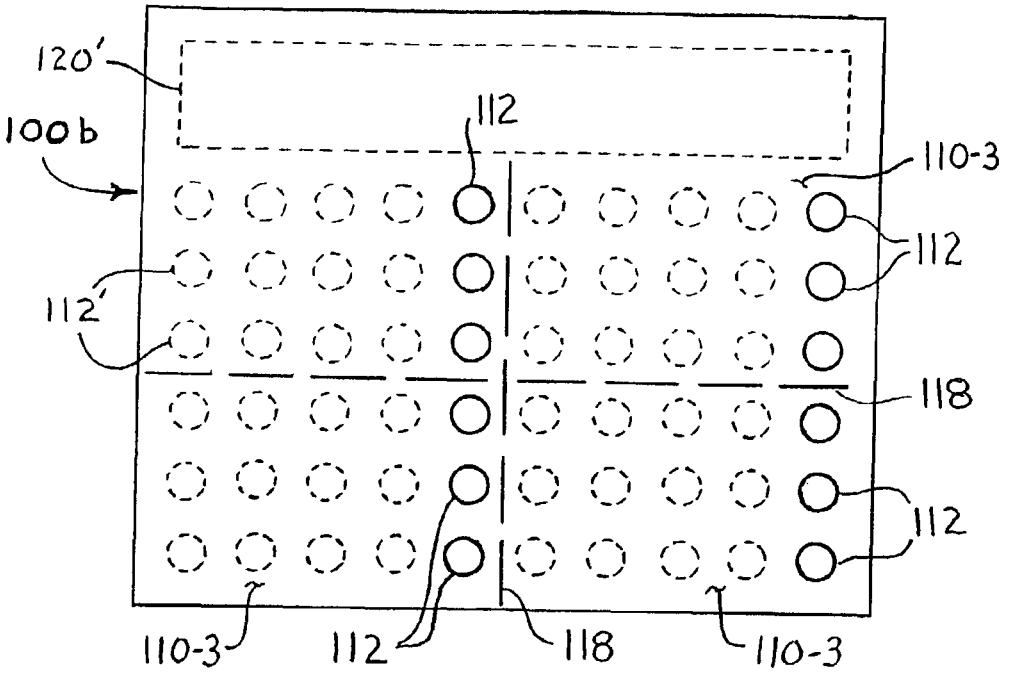

FIGURE 3B

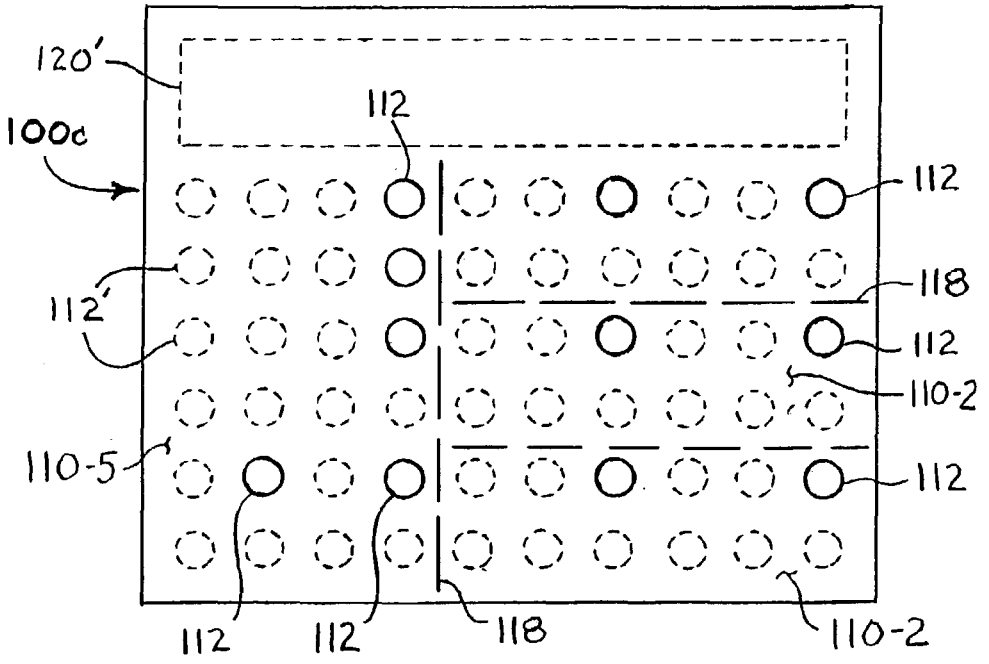

FIGURE 3C

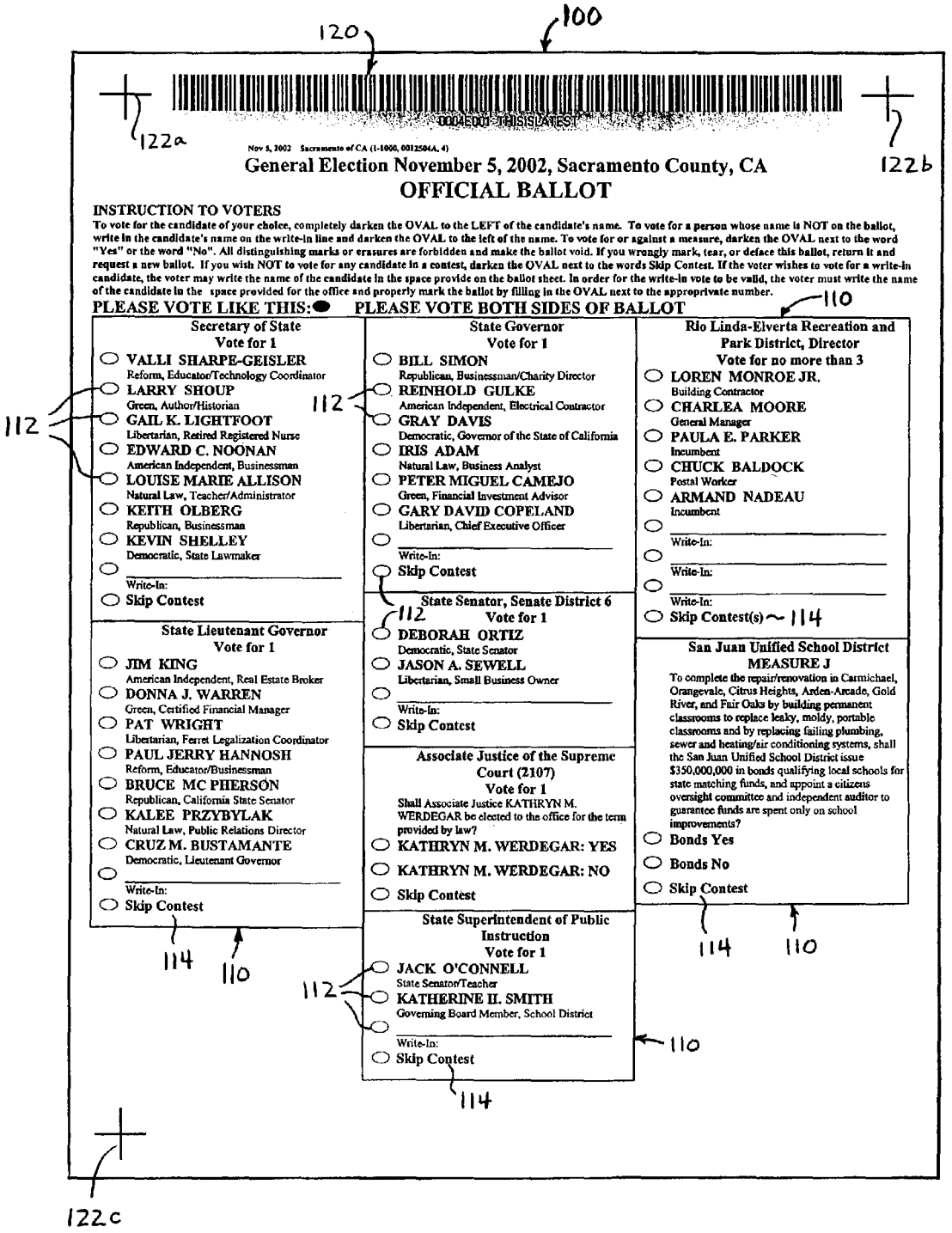
120
100
122a
122b
122c
Nov 5, 2002 Sacramento CA (1-1000, 0012504A, 4)
General Election November 5, 2002, Sacramento County, CA
OFFICIAL BALLOT
INSTRUCTION TO VOTERS
To vote for the candidate of your choice, completely darken the OVAL to the LEFT of the candidate's name. To vote for a person whose name is NOT on the ballot, write in the candidate's name on the write-in line and darken the OVAL to the left of the name. To vote for or against a measure, darken the OVAL next to the word "Yes" or the word "No". All distinguishing marks or erasures are forbidden and make the ballot void. If you wrongly mark, tear, or deface this ballot, return it and request a new ballot. If you wish NOT to vote for any candidate in a contest, darken the OVAL next to the words Skip Contest. If the voter wishes to vote for a write-in candidate, the voter may write the name of the candidate in the space provide on the ballot sheet. In order for the write-in vote to be valid, the voter must write the name of the candidate in the space provided for the office and properly mark the ballot by filling in the OVAL next to the appropriate number.
PLEASE VOTE LIKE THIS: ● PLEASE VOTE BOTH SIDES OF BALLOT
110
Secretary of State
Vote for 1
VALLI SHARPE-GEISLER
Reform, Educator/Technology Coordinator
LARRY SHOUP
Green, Author/Historian
GAIL K. LIGHTFOOT
Libertarian, Retired Registered Nurse
EDWARD C. NOONAN
American Independent, Businessman
LOUISE MARIE ALLISON
Natural Law, Teacher/Administrator
KEITH OLBERG
Republican, Businessman
KEVIN SHELLEY
Democratic, State Lawmaker
Write-In:
Skip Contest
112
State Lieutenant Governor
Vote for 1
JIM KING
American Independent, Real Estate Broker
DONNA J. WARREN
Green, Certified Financial Manager
PAT WRIGHT
Libertarian, Ferret Legalization Coordinator
PAUL JERRY HANNOSH
Reform, Educator/Businessman
BRUCE MC PHERSON
Republican, California State Senator
KALEE PRZYBYLAK
Natural Law, Public Relations Director
CRUZ M. BUSTAMANTE
Democratic, Lieutenant Governor
Write-In:
Skip Contest
114
110
State Governor
Vote for 1
BILL SIMON
Republican, Businessman/Charity Director
REINHOLD GULKE
American Independent, Electrical Contractor
GRAY DAVIS
Democratic, Governor of the State of California
IRIS ADAM
Natural Law, Business Analyst
PETER MIGUEL CAMEJO
Green, Financial Investment Advisor
GARY DAVID COPELAND
Libertarian, Chief Executive Officer
Write-In:
Skip Contest
112
State Senator, Senate District 6
Vote for 1
DEBORAH ORTIZ
Democratic, State Senator
JASON A. SEWELL
Libertarian, Small Business Owner
Write-In:
Skip Contest
Associate Justice of the Supreme Court (2107)
Vote for 1
Shall Associate Justice KATHRYN M. WERDEGAR be elected to the office for the term provided by law?
KATHRYN M. WERDEGAR: YES
KATHRYN M. WERDEGAR: NO
Skip Contest
State Superintendent of Public Instruction
Vote for 1
JACK O'CONNELL
State Senator/Teacher
KATHERINE H. SMITH
Governing Board Member, School District
Write-In:
Skip Contest
112
110
114
Rio Linda-Elverta Recreation and Park District, Director
Vote for no more than 3
LOREN MONROE JR.
Building Contractor
CHARLEA MOORE
General Manager
PAULA E. PARKER
Incumbent
CHUCK BALDOCK
Postal Worker
ARMAND NADEAU
Incumbent
Write-In:
Write-In:
Write-In:
Skip Contest(s)
114
San Juan Unified School District
MEASURE J
To complete the repair/renovation in Carmichael, Orangevale, Citrus Heights, Arden-Arcade, Gold River, and Fair Oaks by building permanent classrooms to replace leaky, moldy, portable classrooms and by replacing failing plumbing, sewer and heating/air conditioning systems, shall the San Juan Unified School District issue $350,000,000 in bonds qualifying local schools for state matching funds, and appoint a citizens oversight committee and independent auditor to guarantee funds are spent only on school improvements?
Bonds Yes
Bonds No
Skip Contest
114
110

FIGURE 3D

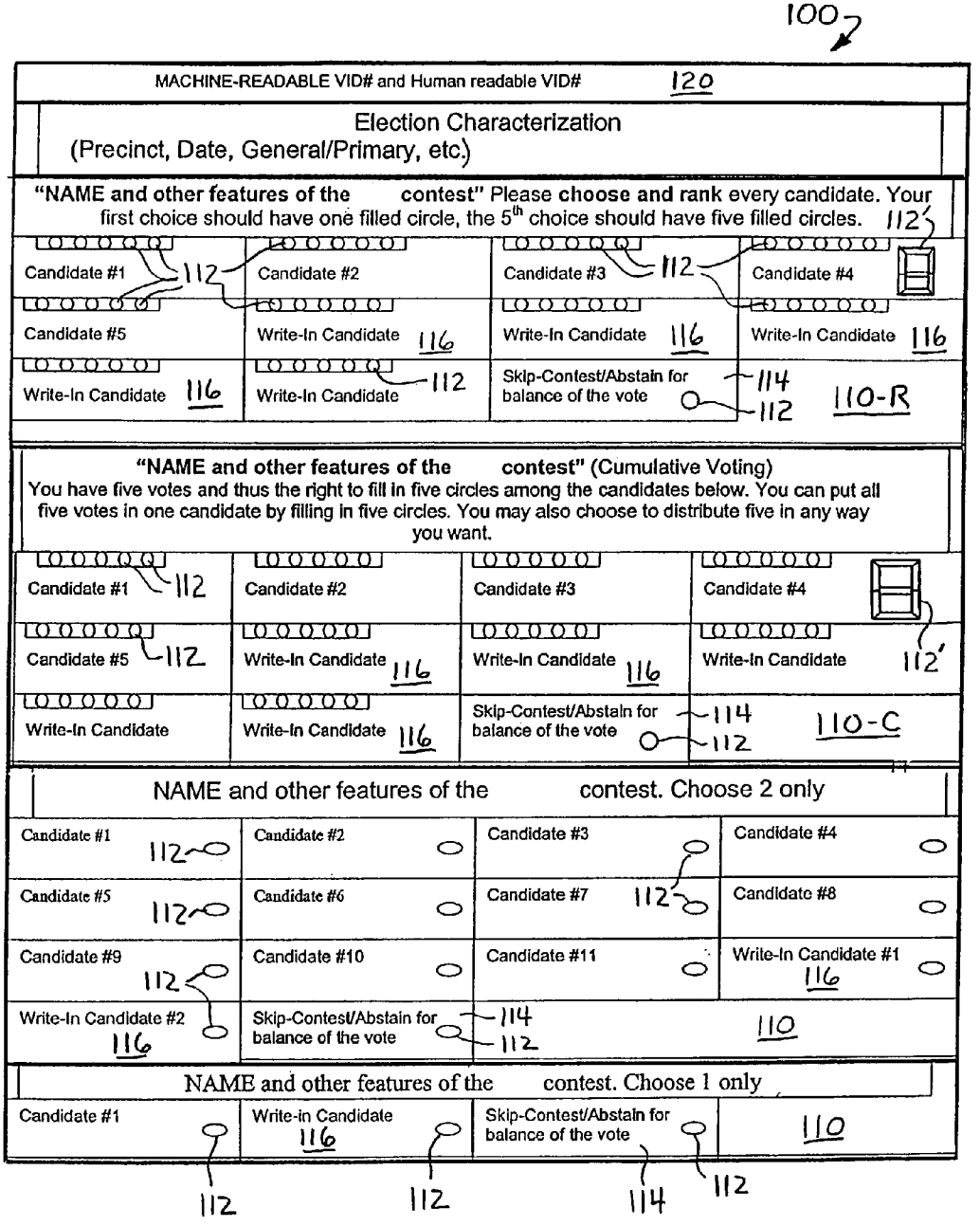
100
MACHINE-READABLE VID# and Human readable VID# 120
Election Characterization
(Precinct, Date, General/Primary, etc.)
"NAME and other features of the contest" Please choose and rank every candidate. Your first choice should have one filled circle, the 5th choice should have five filled circles. 112
Candidate #1
Candidate #2
Candidate #3
Candidate #4
Candidate #5
Write-In Candidate 116
Write-In Candidate 116
Write-In Candidate 116
Write-In Candidate 116
Write-In Candidate
Skip-Contest/Abstain for balance of the vote 114 112
110-R
"NAME and other features of the contest" (Cumulative Voting)
You have five votes and thus the right to fill in five circles among the candidates below. You can put all five votes in one candidate by filling in five circles. You may also choose to distribute five in any way you want.
Candidate #1
Candidate #2
Candidate #3
Candidate #4
Candidate #5
Write-In Candidate 116
Write-In Candidate 116
Write-In Candidate 112'
Write-In Candidate
Write-In Candidate 116
Skip-Contest/Abstain for balance of the vote 114 112
110-C
NAME and other features of the contest. Choose 2 only
Candidate #1
Candidate #2
Candidate #3
Candidate #4
Candidate #5
Candidate #6
Candidate #7
Candidate #8
Candidate #9
Candidate #10
Candidate #11
Write-In Candidate #1 116
Write-In Candidate #2 116
Skip-Contest/Abstain for balance of the vote 114 112
110
NAME and other features of the contest. Choose 1 only
Candidate #1
Write-in Candidate 116
Skip-Contest/Abstain for balance of the vote
110
112
112
114
112

FIGURE 4

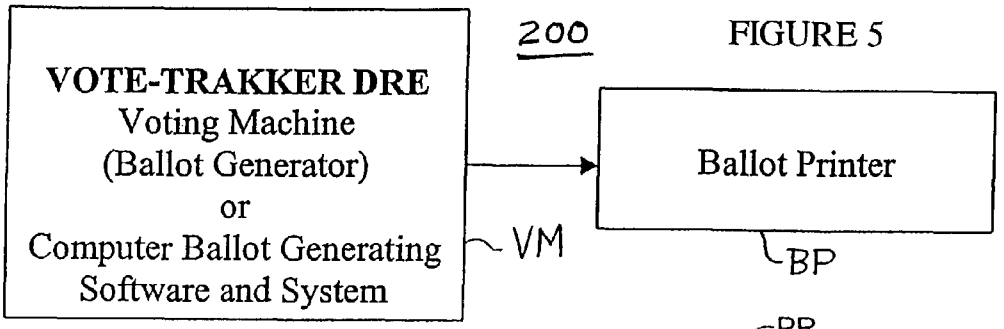

FIGURE 5

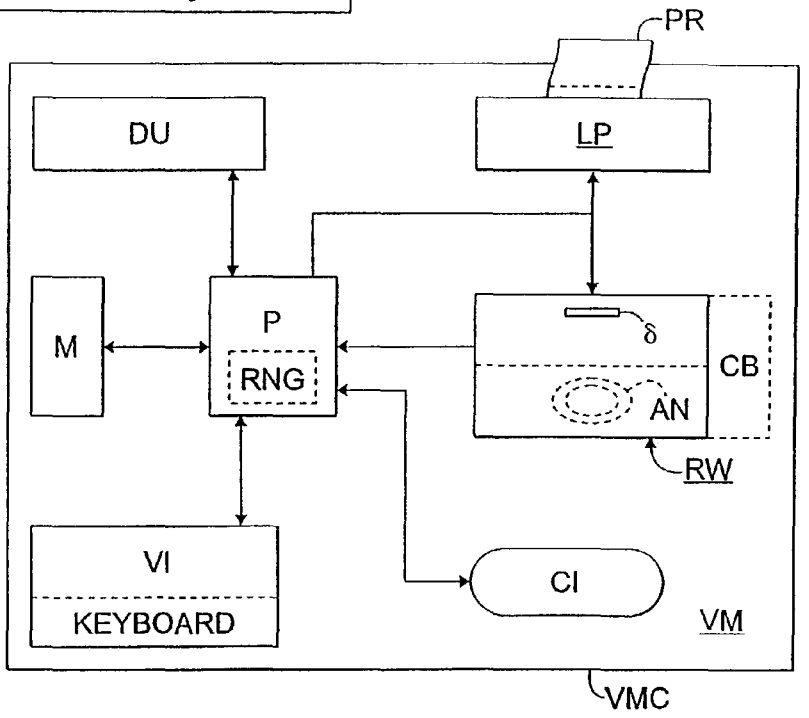

FIGURE 6

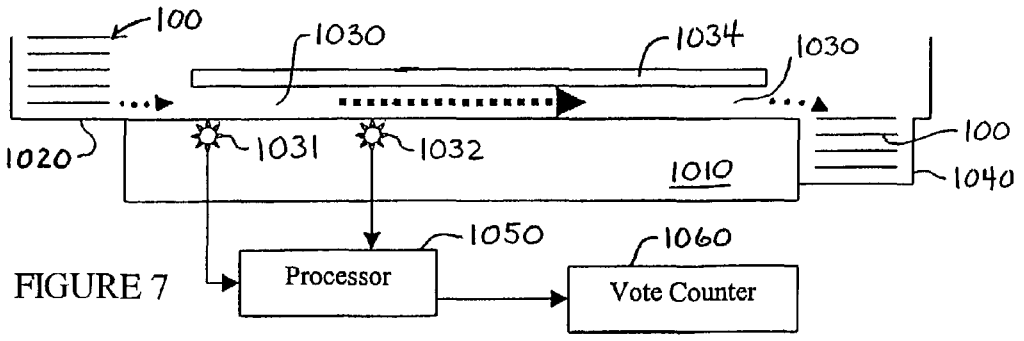

FIGURE 7

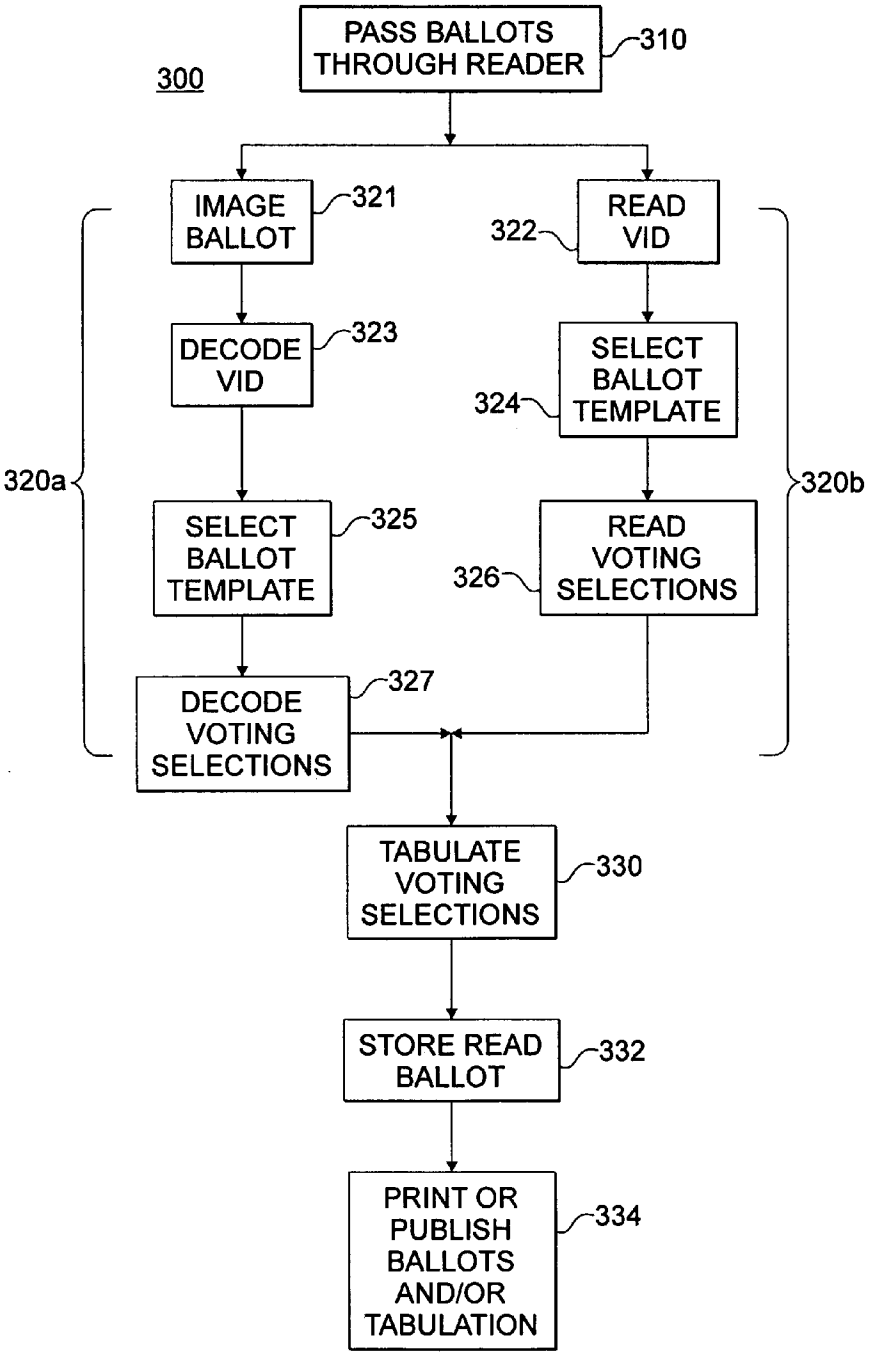
300
PASS BALLOTS THROUGH READER
310
IMAGE BALLOT
321
READ VID
322
DECODE VID
323
SELECT BALLOT TEMPLATE
324
320a
320b
SELECT BALLOT TEMPLATE
325
READ VOTING SELECTIONS
326
DECODE VOTING SELECTIONS
327
TABULATE VOTING SELECTIONS
330
STORE READ BALLOT
332
PRINT OR PUBLISH BALLOTS AND/OR TABULATION
334

Fig. 8

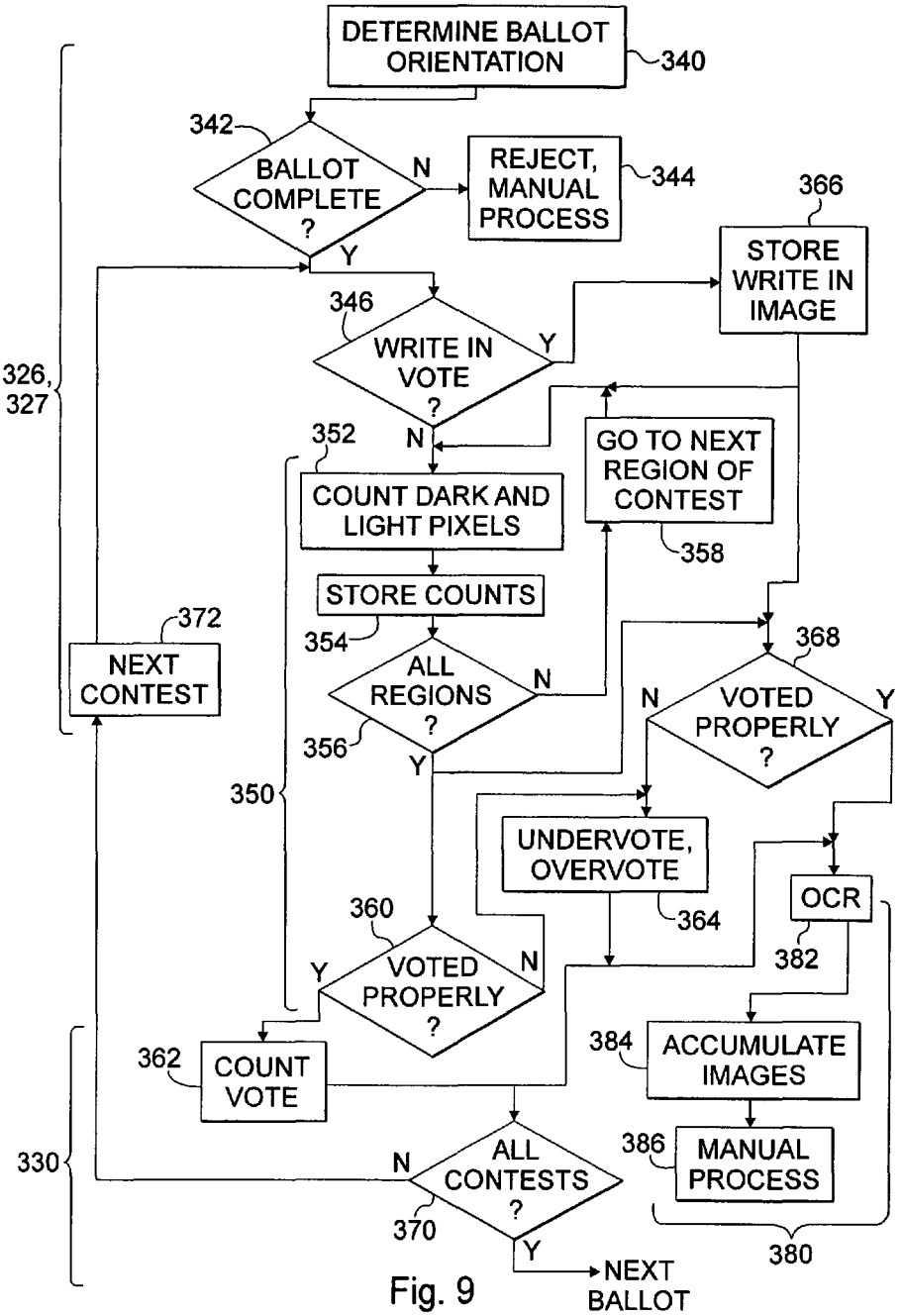
DETERMINE BALLOT ORIENTATION
340
342
BALLOT COMPLETE ?
N
REJECT, MANUAL PROCESS
344
366
STORE WRITE IN IMAGE
Y
346
WRITE IN VOTE ?
Y
326, 327
N
352
GO TO NEXT REGION OF CONTEST
358
COUNT DARK AND LIGHT PIXELS
STORE COUNTS
372
354
NEXT CONTEST
ALL REGIONS ?
N
356
368
N
VOTED PROPERLY ?
Y
Y
350
UNDERVOTE, OVERVOTE
364
OCR
382
360
Y
VOTED PROPERLY ?
N
362
COUNT VOTE
384
ACCUMULATE IMAGES
386
MANUAL PROCESS
330
N
ALL CONTESTS ?
370
Y
380
NEXT BALLOT

Fig. 9

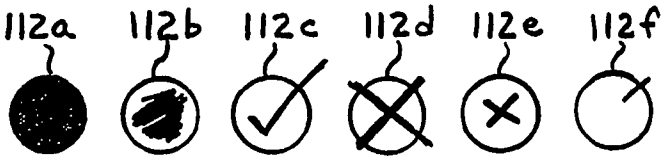

FIGURE 10A

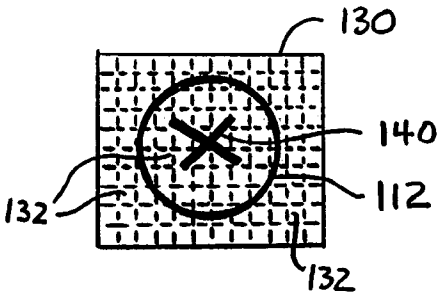

FIGURE 10B

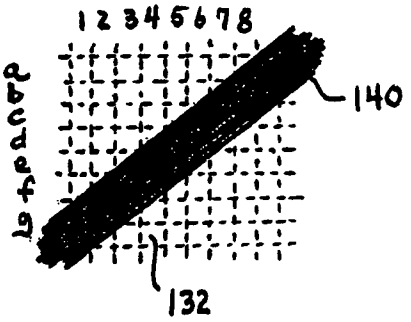

FIGURE 10C

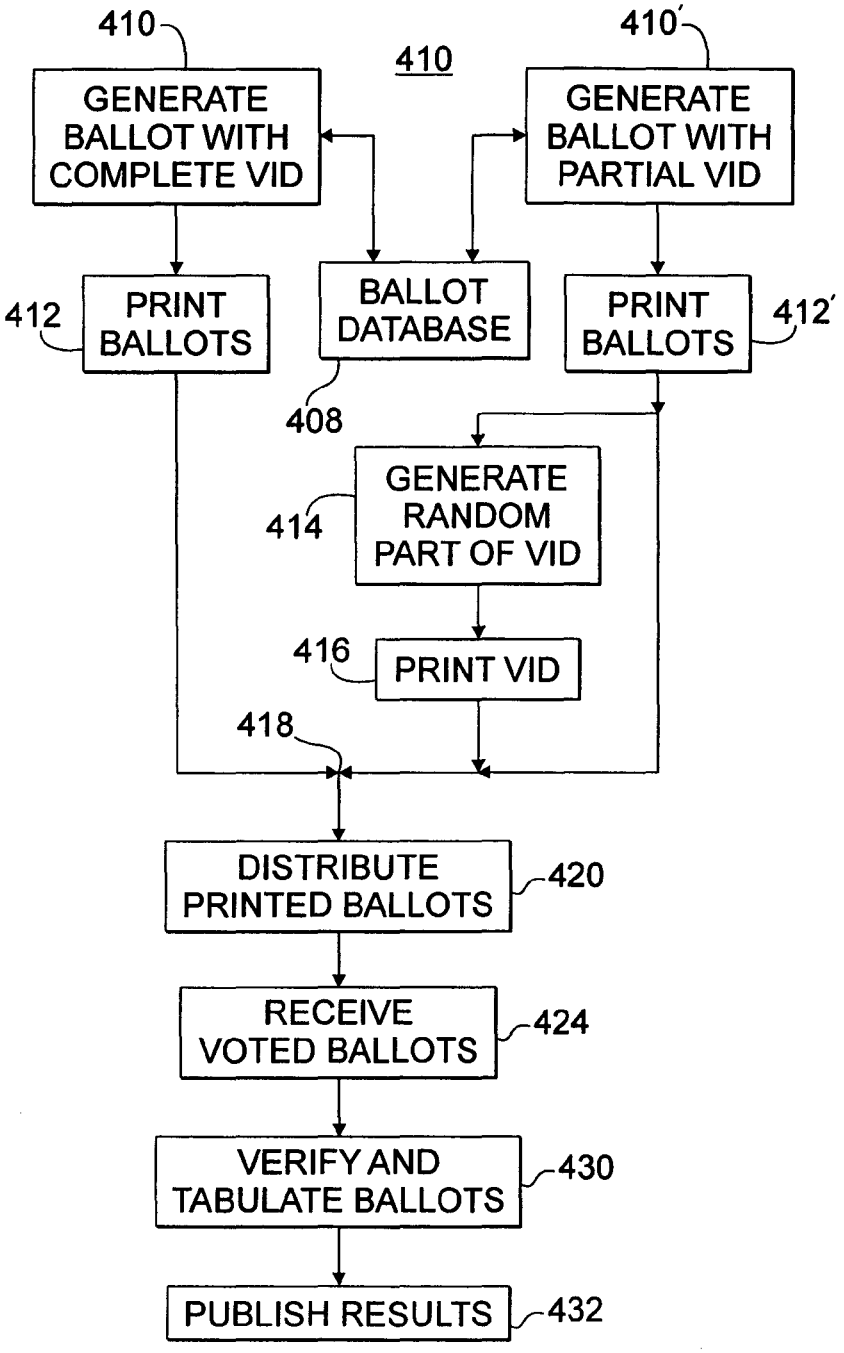
410
410
410'
GENERATE BALLOT WITH COMPLETE VID
GENERATE BALLOT WITH PARTIAL VID
412
PRINT BALLOTS
BALLOT DATABASE
PRINT BALLOTS
412'
408
GENERATE RANDOM PART OF VID
414
PRINT VID
416
418
DISTRIBUTE PRINTED BALLOTS
420
RECEIVE VOTED BALLOTS
424
VERIFY AND TABULATE BALLOTS
430
PUBLISH RESULTS
432

Fig. 11

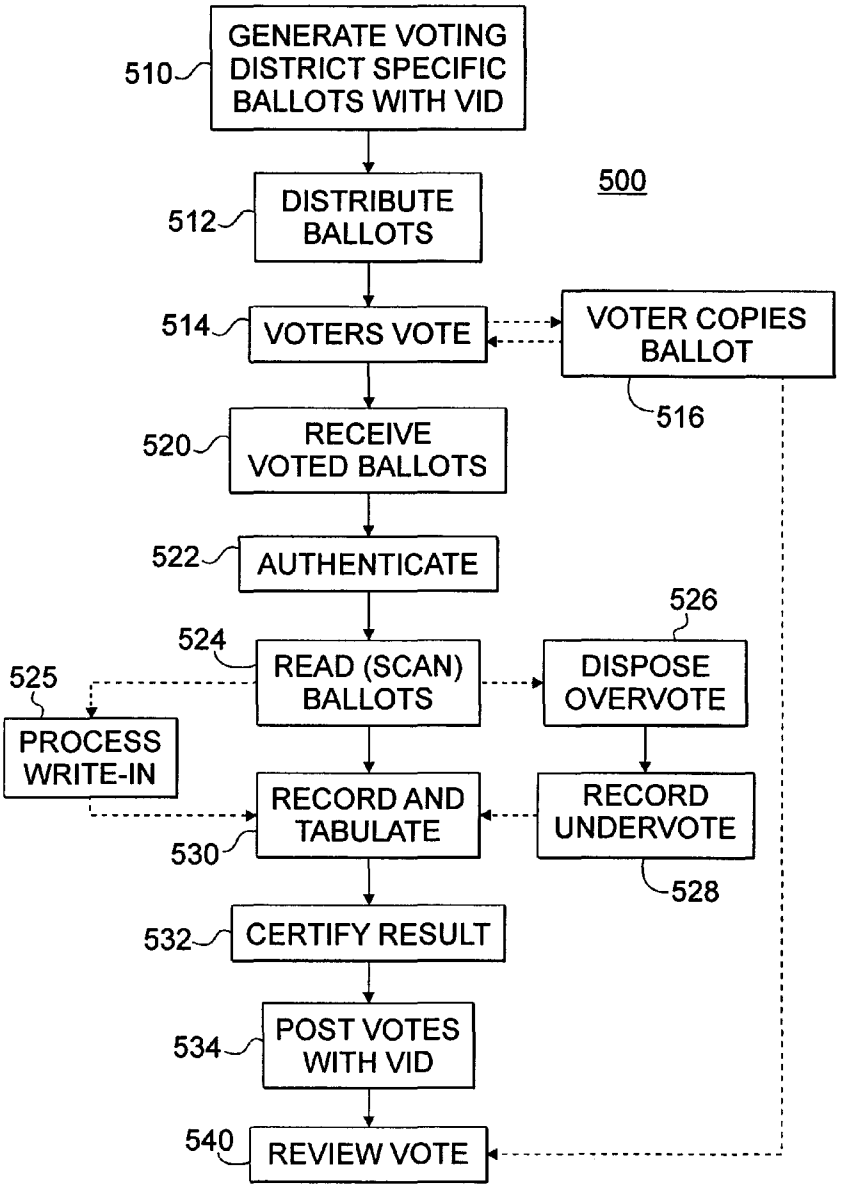
GENERATE VOTING DISTRICT SPECIFIC BALLOTS WITH VID
510
500
DISTRIBUTE BALLOTS
512
VOTERS VOTE
514
VOTER COPIES BALLOT
516
RECEIVE VOTED BALLOTS
520
AUTHENTICATE
522
526
READ (SCAN) BALLOTS
524
DISPOSE OVERVOTE
525
PROCESS WRITE-IN
RECORD AND TABULATE
530
RECORD UNDERVOTE
528
CERTIFY RESULT
532
POST VOTES WITH VID
534
REVIEW VOTE
540

Fig. 12

ELECTRONIC VOTING METHOD FOR OPTICALLY SCANNED BALLOT

This Application is a continuation-in-part of U.S. patent application Ser. No. 10/260,167 filed Sep. 30, 2002 which claims the benefit of:

U.S. Provisional Application Ser. No. 60/326,265 filed Oct. 1, 2001, of

U.S. Provisional Application Ser. No. 60/341,633 filed Dec. 19, 2001,

U.S. Provisional Application Ser. No. 60/377,824 filed May 7, 2002,

U.S. Provisional Application Ser. No. 60/382,033 filed May 20, 2002,

U.S. Provisional Application Ser. No. 60/385,118 filed May 30, 2002,

U.S. Provisional Application Ser. No. 60/389,635 filed Jun. 17, 2002, and

U.S. Provisional Application Ser. No. 60/403,151 filed Aug. 12, 2002.

The present invention relates to a voting method and, in particular, to a voting method employing an optically read ballot.

Under current election law and regulations in certain jurisdictions, a paper record of certain voter's voting selections made on a paper ballot, e.g., a conventional "mark-sense" ballot, must be made and preserved. Most commonly, a paper voting record or ballot must be utilized for absentee voting and/or for provisional voting. Absentee voting is where a voter who will be absent from the jurisdiction or otherwise unable to be present at a designated polling location during the time for voting is issued a paper ballot in advance of the election and votes by completing and submitting the paper absentee ballot by hand, mail, messenger, or other permitted means. Provisional voting is where a voter who is unable to establish his eligibility to vote at a polling place during an election is issued a paper ballot and is permitted to vote thereby "provisionally," i.e. by sealed paper provisional ballot that is only opened and counted if the eligibility of the provisional voter to vote is established by election officials after the time for voting ends.

Irrespective of whether a jurisdiction utilizes paper ballots or more modern electronic voting machines, absentee and provisional ballots must be handled separately and counted manually by election officials, i.e. apart from the votes recorded by voters voting normally (e.g., by voting machine) in the election, and may delay the completion of tabulating the voting results and/or the certification thereof Certain jurisdictions even require a paper absentee and/or provisional ballot even where the absentee and/or provisional voting is done on an electronic (DRE) voting machine. In addition, because the paper ballots approved for being counted are placed into groups so that they are anonymous for counting, there is no way for a voter to know whether his vote was counted and/or was counted correctly.

The prevalent paper ballot is an optically read or optically scanned paper ballot on which a voter marks his voting selections by darkening or otherwise marking one or more regions typically indicated by an outline in the shape of a circle, oval, rectangle, square or other desired closed shape. The marking areas of such conventional "mark-sense" ballots are typically arranged in discrete columns that correspond to the positions of the sensors in a conventional ballot reading machine. A different paper ballot, i.e. a customized ballot, is typically required to be prepared for each election and jurisdiction, e.g., voting district or precinct. In addition, a corresponding customized template must be provided for each different paper ballot, thereby necessitating the manual sorting of the paper ballots by voting district or precinct and the separate reading/scanning thereof for each voting district or precinct.

Accordingly, it would be desirable to have a method for processing paper ballots, such as optically scanned or optically read ballots, in a more versatile and/or efficient manner and preferably one suitable for use with a modern electronic (e.g., DRE) voting machine

To this end, a method for reading a ballot comprising:

reading each ballot transported on a transport path including reading fiducial marks and a jurisdiction identifier thereof and voting selections marked thereon;

determining from the fiducial marks the orientation of each ballot;

processing the jurisdiction identifier for each ballot for selecting a template; and

recording the voting selections marked on each ballot in accordance with the selected template and the determined orientation of the ballot.

BRIEF DESCRIPTION OF THE DRAWING

The detailed description of the preferred embodiments of the present invention will be more easily and better understood when read in conjunction with the FIGURES of the Drawing which include:

FIG. **1** is a schematic diagram illustrating an example ballot intended to be read by an optical reader;

FIG. **2** is a schematic diagram illustrating an example format for a voter identifier (VID);

FIGS. **3**A, **3**B, **3**C and **3**D are schematic diagrams illustrating a generalized example ballot intended to be read by an optical reader;

FIG. **4** is a schematic diagram illustrating an example ballot including ranked and/or cumulative voting that is intended to be read by an optical reader;

FIG. **5** is a schematic block diagram of an example ballot generating apparatus;

FIG. **6** is a schematic block diagram of an example voting apparatus;

FIG. **7** is a schematic diagram illustrating an example ballot reader for reading optically read ballots of the sorts illustrated in FIGS. **1**, **3**A–**3**D and **4**;

FIG. **8** is a schematic flow diagram of an example ballot reading process compatible with the apparatus of FIG. **7**;

FIG. **9** is a schematic flow diagram illustrating details of a portion of the ballot reading process of FIG. **8**;

FIGS. **10**A, **10**B, and **10**C are schematic diagrams of mark spaces of a ballot marked in a variety of ways and of details thereof;

FIG. **11** is a schematic flow diagram of an example process for generating the ballots of FIGS. **1**, **3**A–**3**D and **4**; and

FIG. **12** is a schematic flow diagram of an example voting process utilizing the ballot of FIGS. **1**, **3**A–**3**D and **4**.

In the Drawing, where an element or feature is shown in more than one drawing figure, the same alphanumeric designation may be used to designate such element or feature in each figure, and where a closely related or modified element is shown in a figure, the same alphanumerical designation primed may be used to designate the modified element or feature. Similarly, similar elements or features may be designated by like alphanumeric designations in different figures of the Drawing and with similar nomenclature in the specification, but in the Drawing are followed by a character unique to the embodiment described. It is noted that, according to common practice, the various features of the drawing are not to scale, and the dimensions of the various features are arbitrarily expanded or reduced for clarity.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

The arrangement of the present application operates in conjunction with an electronic voting machine, also referred to as electronic voting apparatus and/or as a direct recording electronic (DRE) voting apparatus. Suitable voting apparatus, and methods employed therewith, are described in U.S. patent application Ser. No. 09/737,306 entitled "Electronic Voting Apparatus, System and Method" filed Dec. 15, 2000 and in U.S. patent application Ser. No. 10/255,348 entitled "Electronic Voting Apparatus, System and Method" filed Sep. 26, 2002, which applications are hereby incorporated herein by reference in their entireties.

FIG. **1** is a diagram illustrating an example ballot **100** intended to be read by an optical reader. Ballot **100** includes four regions **110** each containing information pertaining to a particular election contest or question and a number of marking regions or mark spaces **112** therein in which a voter makes a mark to select one or more voting selections for the particular election contest or question. Mark spaces **112** may be any convenient closed shape and provide a defined area in a defined location in which a voter marks his voting selections by darkening or otherwise marking therein. Mark spaces **112** are typically indicated by an outline in the shape of a circle, oval, rectangle, square or other desired closed shape. After the ballot **100** is marked by the voter, it is voted (e.g., deposited in a ballot box or otherwise submitted) and is read and tabulated, typically by a reading machine or reader that optically reads or senses the defined mark spaces to determine whether each mark space **112** is marked or unmarked, thereby indicating a voting selection. The reading machine is programed to define a "template" corresponding to the locations on the ballot where each of the contests/questions **110** and the respective mark spaces **112** therefor are located.

In the example illustrated, a first region **110** designated "General Election (1/4)" contains the names and party affiliations of candidates for "President and Vice President" and a mark space **112** for each set of candidates, as well as mark spaces **112** for a "Skip Contest" or "No Vote" (abstain) selection **114** and for a write-in candidate selection **116**. A second region **110** designated "General Election (2/4)" contains the names and party affiliations of candidates for "United States Representative (District 16)" and a mark space **112** for each candidate, as well as mark spaces **112** for a "Skip Contest" or "No Vote" (abstain) selection **114** and for a write-in candidate selection **116**. A third region **110** designated "General Election (3/4)" contains the names and party affiliations of candidates for "State Senator" and a mark space **112** for each candidate, as well as mark spaces **112** for a "Skip Contest" or "No Vote" (abstain) selection **114** and for a write-in candidate selection **116**. A fourth region **110** designated "General Election (4/4)" contains a question put before the voters designated as "State Question **214**" and a mark space **112** for a "Yes" or "No" selection, as well as a mark space for a "Skip Contest" or "No Vote" (abstain) selection **114**.

In addition, each ballot includes a voter registration number **120**, also known as a voter identifier number or voter identification number, commonly abbreviated as "VID." Identifier or VID **120** is preferably located at a predefined location on ballot **100**, e.g., near the upper right hand corner as illustrated. VID **120** may be provided in any convenient machine readable format, including but not limited to a bar code, two-dimensional bar code, a prescribed font, optical character recognition (OCR) characters, alphanumeric characters, non-alphanumeric characters, symbols, and the like. Typically, however, a human-readable number **120**N and an equivalent simple machine-readable bar code **120**C are satisfactory.

FIG. **2** is a schematic diagram illustrating an example format **380** for a voter identifier (VID) **120**. VID **120** is a sequence of numbers or other alphanumeric characters or symbols that uniquely identify a voter and provide voting information relating to the voter that may be utilized by a voting machine or by a ballot reading machine or by election officials. VID format **380** includes, for example, six different informational fields **381**–**386**. Field **381** includes a number of characters, typically 3, that uniquely identify the voter's state of residence and field **382** includes a number of characters, typically 3, that uniquely identify the voter's county of residence. Fields **381**–**386** may be used for automatic reading and tabulation of different ballots without manual or other sorting prior to their being read and tabulated, as well as for absentee and provisional voting. While a three-digit numerical field is typical, providing up to 999 different entries, two-digit fields may be utilized where a lesser number (i.e. 99 or less) of possible entries are needed, as in the United States where there are only 50 states. Any field may be of greater or lesser number of characters as is convenient.

Field **383** includes a number of characters, typically 4, that uniquely identify the voter's municipality of residence. Field **384** includes a number of characters, typically 2, that uniquely identify the voter's voting precinct or district within the county or municipality, and field **385** includes a number of characters, typically 2, that uniquely identify the voter's voting ward, if any, within the voting precinct or district. Field **386** includes a number of characters, typically 2, that uniquely identify the voter's political party affiliation if any has been declared and may be utilized for presenting the ballot of the declared political party for voting in a party primary election or for straight party voting, where permitted.

Field **387** includes a number of characters, typically 4–10, that uniquely identifies the particular ballot in the applicable

county, voting precinct, district and/or ward, as the case may be. The random generated number, field **387**, is a randomly-generated unique identifier that is printed on a ballot prior to the election, and may or may not be traceable to the identity of a particular voter, as desired for security and privacy. The same unique identifiers as are printed on paper ballots, e.g., for absentee and/or provisional voting, may be stored in a voting machine or in a vote tabulating machine for verifying the authenticity and uniqueness of ballot when it is tabulated.

In the United States, voting is typically conducted on a state by state basis, and most states delegate to its counties the conduct of elections. In local voting, i.e. voting wherein a particular voting machine is dedicated for voting by voters of a particular county, municipality, precinct, district or ward, fields **382**–**385** may be utilized by the voting machine or vote tabulating machine to verify that the voter is using the proper ballot form before the voting session is initiated and/or before the voting selections marked on the ballot are tabulated, e.g., in provisional voting. Typically in local voting, the voting machine is situated in a location in a particular precinct, district or ward and voters from that particular voting precinct, district or ward come to that location to vote, and provisional and/or absentee voters may vote using such voting machines even though their voting selections are then reproduced on a printed ballot, e.g., as printed by a printer associated with the voting machine.

Data from fields **381**–**386** is utilized to select the voting screens and/or voting contests to be presented on a voting machine and/or on one or more printed ballot sheets that together comprise a proper complete election ballot for that voter in a given election. Each voting machine may generate on a voter-by-voter basis a complete election ballot by selectively combining, for example, a "general ballot" including one or more voting contests **110** that are to be presented to all voters, a "residence-specific ballot" including one or more voting contests **110** to be presented to voters according to their residence, and/or a "party-specific ballot" including one or more voting contests **110** to be presented to voters in a party primary election according to their party affiliation. Thus, a voting machine and/or ballot printer is not constrained or limited to local voting, but may be utilized for county-wide or state-wide or nation-wide voting, for regional voting, and/or for remote voting.

Where voters are issued a chip card or smart card containing his VID number **120** and an electronic voting machine is utilized for printing paper ballots, the voting machine is responsive to voting jurisdiction information **381**–**386** read from each voter's chip card for providing a ballot to the voter and may retain the chip card for the writing of the voter's voting selections therein and then collects the chip card in a collection container or may allow an election official to have the chip card. Optionally, the voting machine and/or vote tabulating machine may reject the chip card and/or the paper ballot **100** if the voter registration information **381**–**386** and/or the unique identifier **387** read therefrom do not match corresponding information stored in the voting machine and/or vote tabulating machine, and may return or collect the chip card. In either case, the chip card once inserted into the voting machine may be retained in a way that the voter may not retrieve the chip card, e.g., for securing the card against use to vote more than once. For provisional voting, the chip card may be likewise retained until the voting selections of a provisional voter are stored therein, and then may be returned to the provisional voter and/or a voting official, e.g., with a proper authorization. Unique identifiers **387** once used for an election may be "retired" and not used in one or more subsequent elections as a means to reduce the likelihood of fraudulent in a future election, e.g., either as a VID number **120** and/or by a counterfeit smart card.

FIGS. **3**A, **3**B, **3**C and **3**D are schematic diagrams illustrating a generalized example ballot **100** intended to be read by an optical reader. Generalized ballot format **100***a* of FIG. **3**A has a plurality of locations **112'** at which mark spaces **112** may be provided and has a region **120'** in which a VID number **120** may be represented. Ballot format **100***a* is generalized in that it illustrates all possible mark space locations **112'** and a relatively large region in which a VID number **120** representation may be provided. An actual ballot format will typically be on a standardized paper, such as an 80-column machine readable card or an 8½×11 inch or an A4 size paper, and have many more possible mark space locations **112'**.

In any particular ballot **100**, less than all of possible mark space locations **112'** will be utilized as mark spaces **112** and less than the entire region **120'** will typically be utilized for providing the VID number **120** representation. Generalized ballot format **100***a* represents a ballot pattern from which particular ballots **100** and areas for particular contests **110**, each utilizing specific selected ones of mark space locations **112'**, according to a template, may be provided.

FIG. **3**B illustrates an example ballot **100***b* which is provided from a ballot format **100***a* on which contest regions **110** are defined by dashed lines **118** in the region having the possible mark spaces **112'** and in which ones of possible mark spaces **112'** to be utilized for marking voting selections are mark spaces **112** defined by solid line circles. The dashed lines **118** defining contest regions **110** and the mark spaces **112** that may be selected together define a template for ballot **100***b*, i.e. define the pattern by which voting selections will be marked for each of plural voting contests as well as the pattern by which voting selections will be read by a vote tabulating machine or reader for each of the voting contests in tabulating the vote. The template of ballot **100***b* defines four contest areas **110** of the same size, with each having three active mark spaces **112**. Each three mark space contest **110-3** might be utilized, e.g., for a contest among three candidates, or for a contest among three candidates where mark spaces are provided for a "No Vote" selection and a write-in selection, or for a public question or other "Yes-No" response matter where a mark space is provided for a "No Vote" or "Abstain" selection.

FIG. **3**C illustrates an example ballot **100**A which is provided from a ballot format **100**A on which contest regions **110** are defined by dashed lines **118** in the region having the possible mark spaces **112'** and in which ones of possible mark spaces **112'** to be utilized for marking voting selections are mark spaces **112** defined by solid line circles. The dashed lines **118** defining contest regions **110** and the mark spaces **112** that may be selected together define a template for ballot **100**A, i.e. define the pattern by which

voting selections will be marked and tabulated. The template of ballot **100**A defines four contest areas **110** of two different sizes, one having five active mark spaces **112**, and three having two mark spaces **112**. The five mark space contest **110-5** might be utilized, e.g., for a contest among five candidates or for a contest among three candidates where mark spaces are provided for a "No Vote" or "Abstain" selection and for a write-in selection. Each two-mark space contest **110-2** may be utilized, e.g., for a public question or other "Yes-No" response matter.

FIG. **3**D illustrates a generalized example ballot **100** intended to be read by an optical reader, wherein ballot **100** includes a number of orientation indicia or fiducial marks **122** that are located in predetermined asymmetric positions that when read by a ballot reader may be utilized to define the orientation of ballot **100**. Although only one indicia or fiducial mark **122** is necessary to define ballot orientation, and will satisfactorily define the orientation of ballot **100** for reading by an automatic ballot reader, plural (at least two or more) indicia or fiducial marks **122** are preferred so that the orientation of ballot **100** may be determined even when ballot **100** is not properly and precisely aligned for reading by a ballot reader and so that the scale of the ballot may be determined.

In particular, orientation indicia or fiducial mark **122***a* near the upper corner of ballot **100** and orientation indicia or fiducial marks **122***b* and **122***c* near the lower edge, e.g., near the right-hand and left-hand corners of ballot **100** define the orientation of ballot **100** and, because the predetermined positional locations of indicia or fiducial marks **122***a*, **122***b* and **122***c* are precisely known, i.e. they are spaced apart a predetermined distance, orientation indicia or fiducial marks **122** also define the scale and/or size of ballot **100**. Further, each mark space **112** is in a predetermined position relative to indicia or fiducial marks **122**, and so the relative locations of all mark spaces **112**, as well as any other location on ballot **100**, can be determined from fiducial marks **122**, whether or not a mark space **112** has been marked. Where ballots are imaged, the positions of each indicia or fiducial mark **122** and of each mark space **112** is defined in the same coordinate system as are the pixels of the ballot image, e.g., in X-Y coordinates, thereby to facilitate the "reading" of the ballot via its ballot image, e.g. to determine which mark spaces **112** are marked to indicate a voting selection.

Comparing the predetermined relative positions and/or spacings of indicia or fiducial marks **122** with the imaged positions thereof permits the scale/size of the ballot image and the position of each mark space **112** to be determined. This is helpful for normalizing the ballot image provided by the ballot reader as well as for locating the proper positions of ballot identifier **120** and of marking areas **112** as defined by the appropriate ballot template. Scaling and/or normalizing the size of the ballot image can be utilized to compensate for small changes in the size of ballots, e.g., due to stress, moisture content and the like, thereby to avoid any inaccuracy that might otherwise result therefrom.

Suitable indicia or fiducial marks include, for example, cross-hair lines, cross-hair lines in a circle, targets, bulls-eye shapes, bullets, "+" marks, "X" marks, boxes, any of the foregoing with one or more black, darkened or contrasting adjacent sections, and/or any combination thereof. Symmetrical indicia or fiducial marks that uniquely define their own center are preferred. Indicia or fiducial marks **122** and/or the pattern thereof may be standardized for all ballots and/or may be different for different ballots and defined by the ballot template therefor. Indicia or fiducial marks **122** may located be any location(s) suitable for defining the orientation, and preferably also defining the scale/size, of ballot **100**. To this end, an odd-number of indicia or fiducial marks **122** disposed in an asymmetric pattern are preferred. Where a two-sided or plural sheet ballot is utilized, each sheet and/or side includes marking indicia or fiducial marks **122**.

In addition, where a ballot is too long to be provided on one ballot sheet, plural sheets may be provided with a page number identifier on each sheet that is read and utilized to select the proper ballot sheet template or to determine the portion of a selected ballot template applicable to each ballot sheet. Preferably, page number identifiers are human-readable and machine-readable, such as a numeral in a font easily read by a computer reader. Further, so-called "summary" ballots may be utilized wherein the candidates and questions are provided in a booklet, and each candidate and/or response is identified in the booklet by a number; in this case, the mark spaces **112** of the summary ballot are each associated with one of the numbers set forth in the booklet. In addition, a candidate name and/or response selection (e.g., a "yes" or "no") may be printed on the summary ballot with the number.

FIG. **4** is a schematic diagram illustrating an example ballot **100** including ranked and/or cumulative voting that is intended to be read by an optical reader. Ballot **100** includes a plurality of contest areas **110** (each having a region wherein "NAME and other features of the contest" information identifying the particular contest is placed and wherein mark spaces for selecting a candidate are placed) and also includes a VID area **120**, as described above. Any one or more contest areas **110** may be utilized for straight voting, for ranked voting and/or for cumulative voting, as may be the case for a particular election and/or contest.

A first contest area **110**-R is arranged for conducting ranked voting wherein the voter may rank the candidates in his order of preference. In this example, five candidates may be ranked. Filling one mark space **112** indicates first choice ranking, filling two mark spaces **112** indicates second choice ranking, and so forth. The opposite sense, where marking a greater number of mark spaces for a candidate indicates a greater preference, could also be utilized. Thus, five mark spaces **112** are associated with each candidate's name and with each write-in candidate position **116**. Optionally and/or alternatively, plural mark spaces may be associated with rank numbers (e.g., a "1" mark space for first choice, a "2" mark space for second choice, a "3" mark space for third choice, and so forth) for each candidate in a contest.

Ranked voting may be utilized for conducting an "instant run-off" where no candidate or an insufficient number of candidates receives sufficient first-choice votes to be elected (e.g., fails to receive a majority of the votes cast) under the election rules in effect. If no candidates win or fewer than the required number win, a run-off election is required. Conventionally the run-off election occurs later in time and incurs the expense of conducting a second election. In an

instant run off, so called because the voting needed for the run off are cast in the initial election and so are immediately ("instantly") available. In an instant run-off election, candidate(s) receiving the least first choice votes are eliminated and the voters' second choice rankings of candidates other than those eliminated are then counted to determine the winner(s). One mark space **112** is provided to skip the entire contest and/or to abstain **114** for the balance of that contest, i.e. to intentionally under vote. The voting apparatus and ballots described herein permit an instant run-off election to be conducted automatically and electronically if no winner emerges from the initial voting.

A second contest area **110**-C of ballot **100** is arranged for conducting cumulative voting wherein the voter may distribute a given number of votes among the candidates in his order of preference, typically where more than one candidate is to be elected in a given contest. Cumulative voting allows the voter to distribute his vote among any one or more of the candidates rather than being limited to voting for or not voting for each candidate equally, as in straight voting. In this example, five votes may be cast (five mark spaces **112** may be marked) in the contest and the five votes may be cast for any one or more candidates. Filling more mark spaces **112** for a candidate indicates a greater number of votes, and thus a greater preference, for that candidate. Thus, five mark spaces **112** are associated with each candidate's name and with each write-in candidate **116**. One mark space **112** is provided to skip the entire contest and/or to abstain **114** for the balance of that contest, i.e. to intentionally under vote.

Alternatively to providing plural mark spaces **112** for each candidate for conducting ranked and/or cumulative voting, mark space **112** may be arranged as a seven-segment mark space **112'** wherein selected ones of the seven segment spaces thereof may be marked to define a numeral. For example, marking the two vertical segments at the left or at the right indicates the number "1", marking the top, middle and bottom horizontal segments and the upper right and lower left vertical segments indicates the number "**2**", marking all seven segments indicated the number "**8**", and so forth, in like manner to illuminating selected segments of a seven-segment display to display numbers.

The two remaining contest areas **110** of ballot **100** are examples of straight voting for two different example contests, one in which two candidates of eleven are to be elected and the other in which one candidate is to be elected. Ballot **100** may include, and preferably does include plural positional indicia **122** as described above in relation to FIG. **3**D.

FIG. **5** is a schematic block diagram of an example ballot generating apparatus **200**. Apparatus **200** includes a processor for generating ballots **100** from information provided thereto either by election officials entering contest information, candidate information and the like, i.e. for generating ballot form and/or formats for particular jurisdictions and/or sub-divisions thereof The processor may be the processor included in an electronic voting machine that includes ballot generating capability, such as the VOTE-TRAKKER™ direct recording electronic voting machine available from Avante International Technology, Inc. located in Princeton Junction, N.J. described in patent applications Ser. Nos. 09/737,306 and 10/255,348, or may be a computer running suitable ballot generating software.

Ballot printer BP may be a conventional ballot printer that prints ballots provided it is capable of printing the VID number **120** in machine-and/or human readable form and of printing the unique random portion of the VID **120**, or may be a printer associated with voting machine VM. The actual format of ballots **100** will be in conformance to the applicable federal, state, county, and/or local legal requirements for election ballots, as is the case for conventional optically-scanned ballots. Thus, standardized paper sizes, e.g., 8½×11 inches or 8½×14 inches or A4 metric paper, may be utilized, and single-page ballot requirements, minimum font size standards, candidate ballot space standards, and the like, will be met, in a customized and/or conventional ballot format. For example, ballots **100** may be conventional ballots such as a Scantron ballot, which has an array of 48×80 elliptical mark spaces on fixed grid pattern on an 8½×11 inch paper ballot, onto which is added VID number **120** in machine-and/or human-readable form as described herein.

FIG. **6** is a schematic block diagram of an example voting apparatus VM as shown and described in patent applications Ser. Nos. 09/737,306 and 10/255,348 incorporated herein. Voting machine VM includes a processor P for processing information relative to a voter and/or voting and for providing a voting session identifier, a non-volatile memory M for storing and providing such information, a display unit DU for displaying information to the voter, and a voter interface VI whereby the voter can enter information into voting machine VM for processor P and/or memory M. It is noted that the components of voting machine VM are similar to the components of a personal computer and so a conventional personal computer, with or without modification, may be utilized in voting machine VM, although it is likely that conventional computer components, particularly processor P and memory M, may be utilized in conjunction with displays DU and input devices VI adapted to or customized for the voting machine application, for example, for ruggedness, resistance to tampering and/or abuse. In addition, processor P includes a function for providing unique voting session identifiers for each voting session, for example, a random-number or random-character generator RAG or a look-up table or other suitable generator. Voter interface VI may be a touch screen and so would provide display DU and a keyboard.

Memory M may also be of any suitable non-volatile memory type. Suitable memory devices include floppy disks, computer hard disk drives, writeable optical disks, memory cards, memory modules and flash memory modules (such as those utilized in electronic cameras), magnetic and optical tapes and disks, as well as semiconductor memories such as non-volatile random-access memory (RAM), programmable read-only memory (PROM), electronically erasable programmable read-only memory (EEPROM) and the like. Memory M or a separate memory contains the operating system, data base and application software that operates processor P as voting machine VM.

Alternatively, various programming information, a voting session identifier generator or list, voting information, candidate and office information and the like may be provided in firmware, such as in an EPROM, which provides additional resistance to tampering and/or hacking attack. Such firmware may be utilized, for example, for controlling the

reading and writing of information to optional smart cards SC, the storing of voting record information in memory M, particularly, a specific memory device such as a memory chip card, an optical disk or tape, or other electronic, magnetic or optical media. Preferably, memory M of voting machine VM includes two independent non-volatile memory devices so that voting record information and a voting session identifier are stored on two separate, independent memory devices for redundancy and preservation of at least one copy of the accumulated voting records in the event one of the memory devices fails or otherwise becomes inoperative. Desirably, the two non-volatile memories are of different types, such as a semiconductor memory and a hard disk, or a memory card and an optical disk, or any other convenient combination.

Voter interface VI may be a standard or custom keyboard, as may facilitate write-in voting, or may be dedicated vote buttons or switches similar to conventional mechanical voting machines, for example, or may be a touch-screen interface associated with display unit DU, and is typically connected to processor P via cabling. Special keys can be provided for voting functions such as "Elect" or "Select" or "Vote," or for "Erase" or "Change," or for "Write-in." Alternative voter interfaces VI may include voice recognition apparatus, Braille keyboards or pen systems with writing recognition interfaces, each preferably with confirmation of the data entered displayed on display unit DU or even aurally via headphones. For a "standard" computer keyboard, for example, it is preferred that the "function keys," i.e. those keys that can be used for a purpose other than voting, such as to access and/or control the operating system and other programs, e.g., the F1–F12 keys, be disabled or rendered inoperative, either by software control or physical means.

In addition, a voter interface VI for allowing visually impaired voters to vote without assistance may employ a modified standard keyboard of which only certain keys are responded to in combination with an aural device. E.g., only the four keys (buttons) at the corners of a numeric keypad or the four areas (buttons) in the four corners of a touch screen may be enabled to indicate possible selections such as vote, skip, next, previous, and the like, with audible voice instructions and confirmation of buttons pressed provided via a headphone. A typical function assignment to the corner keys can include: upper right key="repeat" (to hear voice message again), lower right key="Enter" (to make a selection within the allotted time), lower left key="Cast Vote" (and proceed to the next contest), and upper right key="Increase Speed" (to increase the rate at which contests and/or voice indications are presented). Any or all of these functional keys may be exaggerated in size or otherwise made easily distinguished by tactile feel. Such keyboard/button programming is commonly provided by software.

Display unit DU may be of any suitable type, such as a conventional cathode ray tube or computer display, an LCD display, a touch-screen display or other suitable device, for displaying alphanumeric and/or graphical information, or a set of illuminated buttons, as desired, and is typically connected to processor P via cabling. Display unit DU may also include Braille devices, aural information via headphones, or other devices specially suited for people with handicaps.

Operatively associated with or coupled to processor P and memory M are a printer LP for providing a tangible record of the voting session, e.g., a printed paper receipt and an optional smart card reader/writer RW for writing and/or reading information from/to a smart card. Preferably, local printer LP and optional reader/writer RW are built into the physical container VMC of voting machine VM along with processor P, memory or memories M, display DU and voter interface VI, and that physical container VMC is rugged and sealable for security and to prevent unauthorized access to the components therein, thereby being resistant to tampering. Other voting booth components, such as a privacy curtain, the opening and closing mechanism therefor, or a floor stand, need not be part of voting machine container VMC, but may be permanently or demountably attached thereto as is convenient.

Optional smart card reader/writer RW is operatively associated with or coupled to processor P and memory M for writing information including at least a unique voting session identifier and a voting record into the memory of a smart card SC and optionally for reading information, such as voter registration and/or identifying information, from a smart card. Each voting session identifier is a randomly-generated unique identifying or serial number or character sequence (e.g., a pseudo-random number) of at least eight characters or digits, and preferably of 12 or more characters or digits. Such voting session identifiers are generated for each voting session of each election, either centrally and then loaded into memories M of voting machines VM or by processor P as each voter participates in a voting session. It may be desirable for the voting session identifiers to include additional characters identifying voting district and/or the polling place and/or the voting machine VM on which the vote associated with the identifying number was cast, and/or the date and time of the voting session, but not the voter, so as to preserve voter anonymity while providing traceability of voting records. If any information particular to an individual voter is stored in the memory of smart card SC, as may be the case where information confirming voter registration or an identifying PIN number, security code or other personal data is utilized, such information is written over or erased or otherwise rendered permanently unrecoverable either before or at the time that voting record and voting session identifier information is stored in the memory of smart card SC by reader/writer RW of voting machine VM.

For optical ballot voting, voting machine VM generates a ballot format **100** for a particular jurisdiction, for example, according to a pre-programmed ballot information and/or in response to the voting jurisdiction information corresponding to the voter's VID number (fields **381**–**386**) as entered via voter interface VI and/or a smart card and reader RW, as the case may be. The ballot format is generated by processor P as described above and in incorporated patent applications Ser. Nos. 09/737,306 and 10/255,348, with a format layout for contests **110** consistent with local election requirements rather than as a series of voting screens. Ballot **100** so generated is printed by printer LP and is provided to the voter, e.g., by hand for provisional voting and/or by mail for

absentee voting. Ballots **100** may be printed in advance of an election and/or may be printed during an election on a demand, i.e. as needed, basis.

If reader/writer RW is a contact-type reader for use with contact-type smart cards, then the smart card SC is inserted into slot S thereof to be read and/or written to. If reader/writer RW is a wireless or contact-less-type reader for use with wireless or contact-less-type smart cards, then the smart card SC is placed proximate to antenna AN of reader/writer RW to be read from and/or written to. If reader/writer RW is of a type for use with both contact-type and wireless or contact-less-type smart cards, then the smart card SC is inserted into slot S if it is a contact-type smart card and is placed proximate to antenna AN if it is a wireless-type smart card, or is either inserted into slot S or is placed proximate antenna AN if it is a so-called "combos-card" that combines both external contacts and an internal antenna so that it can be read from or written to either via contacts or a wireless communication.

Further, while optional smart card encoder RW need only be able to write information to a smart card, it may also read information stored in a smart card SC and provide same to processor P. Reader/writer RW may also be a decoder to decode information read from a smart card SC in encrypted or encoded form, and/or may also be a coder that encrypts or encodes information being written to the smart card SC. Such encryption and/or encoding may use public key encryption or any other suitable encryption and/or coding arrangement. Optionally, and preferably, reader/writer RW may include a "take-in" or capture mechanism that grabs smart card SC when it is inserted into slot S and, after the voting record and voting session identifier information is stored in the memory of smart card SC, deposits smart card SC into a secure collection box CB operatively associated with reader/writer RW and located in voting machine cabinet VMC. If this option is utilized, and it may be utilized with either contact-type or wireless smart cards SC, a separate collection box CB and action by each voter to deposit his or her smart card SC therein is not needed.

Local printer LP may provide a tangible independent record of each individual voter's voting selections associated with the voter's unique identifying number and/or may be utilized to print ballots **100**. Printer LP if utilized for printing voting receipts is of a type that retains no record of the data printed (e.g., is not a daisy wheel or other printer employing a ribbon or other sheet-type ink source from which information printed may be extracted or reconstructed) such as a thermal printer, a dot matrix printer, an ink-jet printer, a bubble jet printer, a laser printer and the like, which are conventional. A specialty or security-type of paper, or other medium making authentication of a printed receipt and/or a printed ballot **100** easier and counterfeiting of altering of same more difficult, can be utilized, thereby reducing the likelihood of counterfeiting or fraud. Desirably, printer LP also prints information identifying the election district, the date and time of voting and similar information that may help to authenticate printed receipt PR and/or optical ballot **100**.

The preferred VOTE-TRAKKER™ voting system and apparatus as illustrated by FIG. **4** is provided in incorporated patent applications Ser. Nos. 09/737,306 and 10/255,348. Desirably, the VOTE-TRAKKER™ voting system and apparatus provides redundancy for voting record and voting session identifier data in that each vote is recorded by at least one additional independent and verifiable means: to wit, by electronic recording in the memory of a smart card separate from the voting machine and the printed record. This apparatus, and the method it performs, can provide 100% transparency of each and every vote and can maintain 100% privacy and confidentiality of each and every voter and vote, although other embodiments may not do so.

FIG. **7** is a schematic block diagram illustrating an example ballot reader apparatus **1000** for reading machine-readable ballots **100**. Ballot reader apparatus **1000** includes reading device **1010** that has an input container **1020** into which ballots **100** to be read are placed for being fed through transport path **1030** to an output container **1040** into which ballots **100** that have been read as they pass through transport path **1030** are deposited, i.e. are collected. Therebetween, ballot transport path **1030** defines a path through which ballots **100** are transported for being read as they are transported between input container **1020** and output container **1040**. Transport path **1030** includes two readers **1031** and **1032** of reader device **1010** which read the information and/or markings on ballots **100** as they pass thereby. Preferably, ballots **100** are optically-read ballots **100** of the sorts illustrated in FIGS. **1** and **3**A–**3**D and readers **1031** and **1032** are optical readers. Member **1034** may be a guide for transport path **1030** that also provides a light shield for optical readers **1031**, **1032**.

It is noted that conventional optical readers have only one optical reader and must be preprogrammed with a template corresponding to the particular ballots to be passed therethrough and read, and so the ballots must be sorted by jurisdiction and the like so that only ballots of the same form, i.e. of the form that corresponds to the preprogrammed template, are passed through to be read at any one time. Ballots of different format must be passed through as separate batches after the corresponding template therefor has been programmed into the optical reader. Even if a conventional optical reader were to have two optical readers, both optical readers thereof would be programmed for reading the ballots against the same preprogrammed template, i.e. would be for making redundant readings for verifying the correctness of either reading against one predetermined preprogrammed template.

On the other hand, reader **1010** includes two readers **1031** and **1032** and a processor **1050** that cooperate for reading ballots **100** of different forms without the need to pre-sort the ballots into groups of like form. Specifically, optical reader **1031** reads ballots **100** for reading the VID number **120** thereon and communicates the VID number **120** to processor **1050**. Reader **1031** need not read any other part of ballots **100**. Processor **1050** is responsive to the VID number **120** read from each ballot **100** by reader **1031** to identify and select the ballot template corresponding thereto. Optical reader **1032** reads ballots **100** for reading the mark spaces **112** thereon that have been marked for comparison in accordance with the ballot template selected by processor **1050**.

The VID number **120** read from each ballot **100** by reader **1031** should include at least the jurisdictional information

fields thereof, e.g., fields **381**–**386**, utilized to identify and select the ballot template. Optical reader **1031** should also read the unique random number field, e.g., field **387**, so that the unique random number portion of VID **120** is associated with the stored voting selection information and is available for later verification of the ballot and/or of the correct reading thereof, as well as for tracking of his vote by the voter, e.g., via an Internet or other posting, as described herein. Where VID **120** is on ballot **100** in two different forms, e.g., in machine-readable form and in human-readable form, reader **1000** may have the ability to read both forms of VID **120**, e.g., a bar-code reader and an OCR reader, usually in processor **1050**.

Reader **1032** need not read portions of ballot **100** other than those containing valid mark spaces **112** according to the template corresponding to that ballot. The unnecessary portions of ballot **100** not containing valid mark spaces **112** may either not be read or may be read and then discarded while retaining the readings of mark spaces **112**. Only images of the VID and mark space zones need be obtained and stored for tabulating and/or verifying voting by vote counter **1060**. Images of the VID and mark space zones may be stored in any suitable electronic format including but not limited to .BMP, .TIFF, .PDF or any other suitable format. In this way, the amount of storage capacity needed to store the information read from each ballot is substantially reduced because the standardized information, e.g., names of contests, names of candidates, and the like, are not stored.

As a result, ballots **100** placed into input container **1020** do not have to be pre-sorted to be of the same format, but may be of different formats because readers **1031**, **1032** in cooperation with processor **1050** determine the proper template to be utilized for reading each ballot **100** according to its format. Specifically, because the information in fields **381**–**386** of each VID number **120** printed on each ballot **100** define the particular voting jurisdiction (e.g., state, county, municipality, precinct, ward and/or political party), they also define the form of ballot **100** for such jurisdiction. From the VID number **120** read by optical reader **1031**, processor **1050** determines the jurisdiction and the ballot form therefor and supplies the template therefor for use in conjunction with the pattern of mark spaces **112** marked on ballot **100** for determining the voting selections made thereon.

Simply put and by way of example, reader **1031** reads the VID number **120** from a first ballot **100** of form A and signals same to processor **1050** which then provides the mark space template for ballots **100** of form A for reading the marked voting selections from first ballot **100** read by optical reader **1032**. The marked voting selections read by reader **1032** are then tabulated as votes by vote counter **1060**. Next, reader **1031** reads the VID number **120** from a second ballot **100** of form B and signals same to processor **1050** which then provides the mark space template for ballots **100** of form B for reading the marked voting selections from second ballot **100** read by optical reader **1032**, which read marked voting selections are then tabulated as votes by vote counter **1060**. Next, reader **1031** reads the VID number **120** from a third ballot **100** of form C and signals same to processor **1050** which then provides the mark space template for ballots **100** of form C for reading the marked voting selections from third ballot **100** read by optical reader **1032**, which read marked voting selections are then tabulated as votes by vote counter **1060**. If the next ballot is of form B, for example, reader **1031** reads the VID number **120** from that ballot **100** of form B and signals same to processor **1050** which then provides the mark space template for ballots **100** of form B for reading the marked voting selections from that ballot **100** read by optical reader **1032**, which read marked voting selections are then tabulated as votes by vote counter **1060**, and so forth. The process repeats for each ballot read by reader **1000** wherein the template for each ballot is selected by processor **1050** responsive to the VID number **120** read from that ballot, i.e., specifically responsive to the jurisdictional information defined in fields **121**–**127** of VID number **120**.

Accordingly, an optical reader for reading paper ballots having a jurisdiction identifier thereon and having voting selections marked thereon, comprises a transport path for transporting paper ballots between an input and an output thereof; a first optical reader for reading the jurisdiction identifier of each paper ballot transported on said transport path, and a second optical reader for reading the voting selections marked on each paper ballot transported on said transport path. A processor receives the jurisdiction identifier read by the first optical reader for each paper ballot for selecting a template for reading in accordance with the selected template the voting selections marked on each paper ballot, whereby the voting selections marked on each paper ballot are read in accordance with a template corresponding to the jurisdiction identifier for that paper ballot.

In addition and optionally, processor **1050** may include optical character recognition (OCR) software to provide alphanumeric outputs of the information in the VID field read by reader **1031** and/or of write-in information in the write-in portions of the voting fields read by reader **1032** according to the template selected by processor **1050**. It is preferred that reader **1000** move ballots through transport path **1030** at the rate of at least about 10–12 inches per second (about 25–30 cm/sec.) so that ballots on either 8½×11 inch paper and/or on A4 paper may be read at a rate of at least about one ballot per second. It is also preferred that readers **1031** and **1032** have a resolution of at least about 100 dpi or greater, and it is desirable in some cases that reader **1000** provide dual-side document scanning.

Reader **1000** may be utilized at a polling place or other voting location for "checking" ballots marked by voters prior to their being voted, i.e. officially deposited into a collection container. In this case, vote counter **1060** is eliminated and no record of the actual voting selections marked is retained; processor **1050** processes only the VID number **120** and the mark space **112** regions to select the corresponding ballot template and to verify that the proper number of mark spaces have been marked for each contest and/or question.

Reader **1000** in checking a ballot preferably signals or otherwise provides a notice or indication if a ballot is under voted (i.e. less than the required number of spaces have been marked for each contest/question) or is over voted (i.e. more than the required number of spaces have been marked for each contest/question, which may invalidate a vote in a contest/question or may invalidate an entire ballot) or is otherwise incorrectly marked. Ballot checking may be uti-

lized with straight voting, ranked voting, and/or cumulative voting similarly, e.g., indicating if improper ranking has been marked and/or if the wrong number of cumulative votes have been marked. While such checking function advances the goal that ballots reflect voter intent, it can reduce but not eliminate under voting and over voting; however, it will at least give the voter an opportunity to correct such condition or at least indicate an intentional "no vote" if a "No Vote" or "Abstain" mark space **112** is marked.

Ballot checking may avoid or at least mitigate the condition where the intent of the voter cannot be determined because under and over voting can be reduced and/or eliminated. However, where applicable law allows, under and over voting in cumulative voting contests may be adjusted and/or rectified when the ballot is counted by applying proportioning and/or normalizing rules to the votes actually cast by marking mark spaces, e.g., by adding or subtracting a proportionate weighted vote. Ballot checking may be preformed by a reader **1000** or by an other ballot reader such as a ballot imager based on commercial office imaging equipment.

Reader **1000** utilized for ballot checking may also have a printer associated therewith for providing a tangible voting record, e.g., a printed receipt, to each voter, as described in patent applications Ser. Nos. 09/737,306 and 10/255,348. Desirably, such printed receipt includes the complete VID **120** including the unique random portion **381** so that the voter may track and verify his vote where the voting results are available via an Internet and/or other posting including the VID. Preferably, the VID read from the read ballot is printed on the receipt. If the receipt includes a record of the voter's voting selections, the receipt also provides an immediate confirmation that the ballot can be read and of the voting selections marked, whereby the voter may seek correction of any error and/or omission prior to voting his ballot.

While the reader arrangement described in the immediately preceding paragraphs is preferred, optical ballots **100** including a VID number as described herein may be sorted and read by conventional readers in the conventional manner, assuming, of course, that the election officials are willing and able to sort the paper ballots into groups of like form and to program the conventional readers for each particular ballot form before running ballots of that form therethrough for counting. Ballot readers as described herein may utilize all or part of conventional ballot readers and/or may utilize parts of conventional office equipment such as copiers, scanners, facsimile (fax) machines, and other commercial imaging and/or scanning devices, and the like, e.g., for imaging and/or optically reading the information contained on an optically-readable paper ballot.

Examples of conventional ballot readers include the PAGESCAN II reader available from Peripheral Dynamics, Inc. located in Plymouth Meeting, Pa., and the SCANMARK ES2800 reader available from Scantron located in Tustin, Calif. It is noted that such conventional ballot readers employ sensors positioned on a fixed grid pattern (e.g., in columns) corresponding to the fixed grid pattern of the mark-sense spaces of the ballot sheets with which they are utilized, and such readers do not image a ballot and so they cannot identify or determine pixel density and/or location as may be done for a true ballot image as described herein. Examples of commercial imaging scanners include types DR5020 and DR5080 available from Canon Electronics, Inc. located in Japan, and type IS330DC available from Ricoh Company located in Japan. Examples of commercial printers suitable for ballot printing include the ImageRUNNER 600 and 105 available from Canon Electronics, Inc., and similar equipment available from Hewlett Packard of Palo Alto, Calif. and Fujitsu of Japan.

In addition, a "trial" ballot reader is preferably provided at each polling place so that a voter has the opportunity to have his voted ballot scanned privately and to have the voting selections read therefrom be displayed to him privately so that the correctness thereof may be confirmed before the ballot is cast. Preferably, the trial ballot scanner should employ the same reading apparatus and method as the ballot scanners that will read the ballot in counting and tabulating the vote. In any event, the trail ballot reader should be "read only" and have no memory or ability to store or transmit the voting selections from any ballot, whether by template and/or image, thereby to assure privacy. I.e. it is for vote checking only.

FIG. **8** is a schematic flow diagram of an example ballot reading process **300** compatible with the apparatus of FIG. **7**. Process **300** commences with passing **310** the voted ballots through a ballot reader, e.g., along a transport path of an optical scan reader, wherein the ballots do not need to be, but may be, sorted according to jurisdictions and/or ballot formats. The ballots are individually and serially read/imaged and the voting information thereon is read/decoded via either of alternative processes **320***a* or **320***b*. Path **320***a* comprises imaging **321** each ballot and then decoding the voting selection information thereon in two decoding steps **323**, **327**. Path **320***b* comprises reading the ballots in two steps **322**, **326**, wherein the voting selection information is read in second reading step **326**. In either path, the ballot template (e.g., a set of computer instructions and/or statements and/or data defining a pattern of ballot mark spaces for a ballot) for reading/decoding the voting information is selected responsive to the voting identifier and/or ballot identifier read/decoded in the first reading/decoding step **322**, **323**.

Ballot imaging process **320***a* comprises imaging **321** the ballot to acquire an image of the voting information thereon and then decoding **323** a ballot identifier (e.g., VID) from the ballot image. While the entire ballot identifier (e.g., VID) may be decoded, only that portion thereof that contains jurisdiction information (e.g., ones of fields **381**–**386**) need be decoded; decoding the unique random identifier portion (e.g., field **387**) is optional). The decoded identifier correlates to a particular ballot format represented by a ballot template, and the ballot template corresponding to the decoded identifier is selected **325** from a database or other collection and/or set of ballot templates for decoding **327** the voting selection information from the ballot image previously imaged **321**. Thus, each ballot of a mixed set of ballots is read (decoded) according to a template corresponding to the particular ballot format to obtain the voting selection information thereon.

Ballot imaging process **320***b* comprises reading **322** the ballot to read a ballot identifier (e.g., VID) thereon, typically in a predefined location, area or region of the ballot. While the entire ballot identifier (e.g., VID) may be read, only that portion thereof that contains jurisdiction information (e.g., ones of fields **381**–**386**) need be read; reading the unique random identifier portion (e.g., field **387**) is optional). The read identifier correlates to a particular ballot format represented by a ballot template, and the ballot template corresponding to the read identifier is selected **324** from a database or other collection and/or set of ballot templates for reading **326** the voting selection information from the ballot. While the entire ballot may be read **326**, only that portion containing voting selection information according to the selected template **324** need be read. Thus, each ballot of a mixed set of ballots is read according to a template corresponding to the particular ballot format to obtain the voting selection information thereon.

It is noted that the foregoing reading/imaging **321**, **322**, **323**, **326**, **327** of the VID and voting selections, and the template selecting **324**, **325**, and/or the tabulating **330** and storing **332**, may be performed in "real-time" as each ballot is read, i.e., the voting selections are read/decoded, stored **332** and tabulated **330** substantially contemporaneously with the ballot passing through reader **1010**. Alternatively, the VID and voting selections read/imaged **321**, **322**, **326** may be stored in "real-time" as each ballot passes through reader **1010**, and the template selecting **324**, **325**, the decoding/reading **322**, **323**, **326**,**327** of the stored VID and voting selections, and the tabulating **330** and storing **332** thereof may be performed after some or all of the ballots have passed through reader **1010**, i.e. delayed in time.

It is further noted that in reading ballot **100**, it is preferred that the ballot image be read/decoded **326**, **327** to determine whether or not all of the mark spaces **112** as defined **324**, **325** by the appropriate ballot template, and the indicia **122**, if any, are present in the ballot image, thereby to enable detection of an anomalous and/or erroneous ballot **100**, and/or to detect that a ballot **100** is, e.g., folded, torn, altered or otherwise incomplete or incorrect. Where an indicia **122** is employed to define the orientation of each ballot and a VID is employed to define the ballot form, the ballots may be in any order and orientation, the ballots need not be sorted by jurisdiction and/or voting district or the like and need not be placed in a given orientation prior to being read/imaged and/or decoded **321**, **322**, **323**, **326**, **327**.

The voting selection information read/decoded **326**, **327** is tabulated **330** for counting the vote and determining an election outcome/result. The read/decoded **326**, **327** voting selection information may be stored **332**, e.g., for later verification, auditing, confirmation and/or comparison with the paper ballots and the like, and may be printed and/or otherwise published **334**, in whole or in part, in connection therewith. The steps of tabulating **330**, storing **332** and/or printing/publishing **334** may be either or without the voter identifier (e.g., VID) and/or other ballot identifier.

In addition, it is sometimes, if not usually, preferred that the printing and/or publishing **334** of voting results be positively blocked prior to a predetermined time, e.g., prior to the end of the time for voting. This, for example, allows absentee ballots received prior to the election to be authenticated, read and/or tabulated prior to the end of the election period while the results thereof are not available until after the time for voting is completed. Advantageously, this may allow election personnel to more efficiently process both absentee ballots and the regular voted ballots.

An advantage may obtain, however, where the tabulated **330** and/or stored **332** voter selection information is associated with the identifier where the identifier is not related and/or relatable to the identity of a particular voter, i.e. the voter remains anonymous. In such case, particular ballots can be inspected against the electronic records without compromising voter anonymity and privacy, including publishing voting results on a ballot-by ballot basis, e.g., via the Internet, as described in incorporated patent applications Ser. Nos. 09/737,306 and 10/255,348. Such ability to verify that a ballot has been received and has been counted could be desirable for absentee and/or provisional voters, as well as for general voting.

FIG. **9** is a schematic flow diagram illustrating details of a portion of the ballot reading process **300** of FIG. **8**. In particular, an example of details relating to the steps of decoding **327** voting selections, reading **326** voting selections and/or tabulating **330** voting selections using the selected **324**, **325** ballot template are illustrated. In a preferred embodiment, ballots are imaged, read and/or decoded **320***a*, **320***b* irrespective of the orientation of each ballot as it is passed through the ballot reader and/or irrespective of the jurisdiction, voting district, precinct and the like to which it pertains.

First, the orientation of each ballot is determined **340** from the location(s) of one or more indicia disposed in an asymmetrical pattern on the ballot, and then the ballot image and/or the selected **324**, **325** template therefor is electronically oriented to be in the same orientation. Before, after, and/or contemporaneously therewith, the ballot is tested or checked **342** to verify that it is a complete ballot, i.e. that it includes all of the indicia **122** and marking space **112** outlines that the ballot should include as defined by the selected **324**, **325** template, and so is not torn, folded, altered and the like. If the ballot is not complete **342**, path "N" is taken and the ballot is rejected, e.g., is physically separated from the other ballots for manual verification and processing.

If the ballot is complete **342**, the path "Y" is taken and the ballot is tested **346** to determine whether there is any write-in voting selection thereon. If testing **346** finds any one or more write-in voting selections, the path "Y" is taken and, preferably, the portion(s) of the ballot image containing a write-in voting selection(s) are stored **366**, preferably along with the ballot VID for later verification, if necessary or desired. Typically, write-in voting selections are processed separately from voting selections from among the nominated candidates or other regular voting selections. Ballot processing then proceeds to the detail steps of decoding **350** the regular voting selections, i.e. those made by mark space(s) **112**.

If testing **346** finds no write-in voting selection is present, then path "N" is taken directly to the detail decoding **350** of regular voting selections. Decoding **350** includes a number of steps that determine whether each mark space **112** has been marked to indicate that a voting selection has been

made or has not been so marked. For example, the pixels of the ballot image, e.g., in a TIFF or BMP or other bitmapped or pixelated format, for each mark space **112** are tested to determine whether it is a "light" (e.g., not marked) pixel or a "dark" (e.g., marked) pixel. The number of "light" and "dark" pixels for each mark space **112** are counted **352** and the counts of "light" and "dark" pixel are stored **354**. Preferably, the ballot VID is associated with the stored counts of "light" and "dark" pixels thereof, e.g., for auditing and/or recount. If a sufficient portion of the tested pixels in a given mark space are "dark" pixels, then that mark space **112** is considered to be marked, e.g., as described below.

Testing **356** determines whether all of the mark spaces **112** of a contest have been counted **352** and the counts thereof stored **354**. If not, path "N" is taken to go to **358** the next region of the contest repeat the pixel counting **352** and storing **354** until all of mark spaces **112** have been processed. When all mark spaces **112** of a contest have been processed, the path "Y" is taken from testing **356** to determine **360** whether the contest has been voted properly, i.e. whether the proper number of mark spaces have been marked. If the proper number of mark spaces **112** have been marked, the path "Y" is taken and the voting selection for that contest is counted **362**. If either too many (over vote) or too few (under vote) mark spaces **112** have been marked, the path "N" is taken and the under vote or over vote is stored for later processing. If an under vote, the voting selections made can be counted **362**, if the applicable law allows.

In addition, if there is a write-in voting selection, the fact thereof is tested **368** with the affirmative result of the all regions counted test **356** at path "Y" to determine **368** whether the contest is voted properly considering the presence of a write-in voting selection. If not, then path "N" is taken and an over vote or under vote is recorded **364**. If the voting selection is determined **368** to be proper, then path "Y" is taken and the write-in voting selection is processed **380**.

Following the counting of a voting selection **362**, an under vote or over vote **364** or a "Y" determination **368**, testing **370** determines whether all contests for that ballot have been counted and processed. If not, path "N" is taken to the next contest **372** which is then processed **350** and so forth as described. If yes, path "Y" is taken and the next ballot is then processed in like manner to that just described until all of the ballots have been processed and the voting selections thereon have been counted and tabulated **330**.

Separate processing **380** of write-in voting selections may proceed as follows, typically after all the regular voting selections have been tabulated. Optionally, the write-in voting selections may be converted to alphanumeric characters by optical character recognition (OCR) **382**. The stored **366** images of the write-in voting selections are accumulated **384**, with their corresponding OCR result, if any, and are displayed for manual processing **386**, including validation, by election officials. The display may be on a computer display or the like or may be a printed form, as may be desired and/or required by applicable law.

Preferably, write-in voting selection images are "clipped" from the ballot images and have the ballot VID associated therewith, and plural clipped images are displayed on one screen or printed on one page. Manually processed **386** valid write-in voting selections are counted and tabulated **330** with the total vote. In processing write-in voting selections, either the clipped image is displayed, or if the ballot VID is associated therewith, the entire ballot image may be displayed or the original ballot may be retrieved for use in manual processing **386**. Where the ballots are read, not imaged, based upon comparison to a ballot template, only the result of reading the ballot is stored, and so the original ballot is preferably separated and kept for manual processing **386** of write-in voting selections.

A typical ballot image in a pixel or bitmap format may have a file size in the range of 3–500 kilobytes, depending upon the format and the degree of file compression utilized, but could be as large as 1–10 megabytes without file compression. A computer hard drive of the sort typically found in a current commercially available personal computer, e.g., of 60–100 gigabytes capacity, can easily store full-ballot images (of nominal or average 500 kilobyte size) for a population of 100,000 voters. One or more servers may be utilized for storing ballot images for a population of one million or more voters.

Typically, full ballot images are stored initially on the hard drive of a computer and are later transferred to permanent storage media, e.g., a "write-once, read-many" (WORM) medium such as a CR-R disk, for long-term storage. Reduced images, whether by compression and/or by "clipping" the portions of the ballot image that include mark spaces, write-in voting spaces, identifiers and the like, and other information pertinent to voting selection other than the standard information and candidates names printed on the ballot, may be utilized to reduce the quantity of information that needs be processed on counting and tabulating the vote and/or that needs to be stored. Such techniques can be utilized reduce the size of each ballot image file to as low as 10 kilobytes or less.

FIGS. **10**A, **10**B, and **10**C are schematic diagrams of mark spaces **112** of a ballot **100** marked in a variety of ways and of enlarged diagrams illustrating details thereof, and are helpful to understanding a preferred aspect for counting voting selections of the method described herein.

FIG. **10**A illustrates some of the various ways that a voter may mark a mark space **112** in making a voting selection. For example, mark space **112***a* has been fully marked by the voter so that it is essentially 100% filled in and there is no question that the voter intended to mark that region **112***a* and it should be counted as a vote. Mark space **112***b* is partially marked and may be about 50% filled in, and it is likely the voter intended to mark that region **112***b* and it should be counted as a vote. Similarly, mark spaces **112***c*, **112***d* and **112***e* are marked with a check, a large X and a small x, respectively, and it is likely that the mark was intended and should be counted as a vote. However, mark space **112***f* contains a small mark that may be an intended or unintended mark therein, and so may or may not be counted as a vote.

Each ballot image captured by ballot reader in reading ballots **100** must be read to determine which ones of mark spaces **112** thereon have been marked sufficiently to count as being marked to indicate a voting selection and which ones have not. The ballot reader produces a ballot image, whether of the entire ballot or only of portions thereof selected in accordance with the applicable ballot template, that is pref-

erably in a pixelated or bitmapped format, e.g., a TIFF or a BMP image, or other bitmapped format. Ballot images in such format may be produced directly by a commercially available office copier or scanner or may be converted to such format, if necessary, or may be provided by a specialized ballot scanning apparatus.

FIG. **10**B illustrates a reading region **130** of a ballot which contains a marked mark space **112**. Based on the applicable ballot template, e.g., the template selected **324**, **325** from among the possible ballot templates using the VID number read/decoded **322**, **323** from the ballot, a number of reading regions **130** each including one mark space **112** are selected from the ballot image. Each reading region **130** is preferably slightly larger than and includes one mark space **112**. Each region includes a large number of pixels **132** as illustrated by the dotted grid lines, e.g., representing an over scan of mark space **112**. Mark space **112** includes mark **140**, e.g., a mark made by a voter to indicate a voting selection.

For clarity, only a few rows and columns of pixels are illustrated, it being understood that a large number, e.g., 800–1000 pixels is typical. In one embodiment, reading region **130** includes about 900 pixels. Because each reading region **130**, whether or not marked by a voter, includes the printed outline of mark space **112**, a predetermined number of the pixels representing the mark space **112** outline will be "dark" pixels. In one embodiment, the outline of mark space **112** includes about **100** dark pixels, with a tolerance of about ±40 pixels due to ballot to ballot variations, e.g., printing variations, outline-to-pixel pattern registration differences, reading/imaging differences, scanner lighting variations, sensor noise, and the like.

One preferred arrangement for determining whether a mark space **112** has been marked to indicate a voting selection is as follows. The maximum number of pixels **132** that a mark **140** could darken (i.e. the number of "markable pixels") is determined by subtracting the number of pixels of the outline of mark space **112** from the total number of pixels **132** in reading region **130**. For the example embodiment, the number of markable pixels is 900−100=800 pixels.

A predetermined threshold of dark markable pixels (e.g., the "voted threshold") is established for determining that a mark space **112** has been marked (voted). For example, voted thresholds of between about 20% and about 50% of the maximum number of markable pixels **132** have been found satisfactory, and are preferred, although higher or lower voted thresholds are satisfactory and may be utilized. If a higher percentage voted threshold were to be utilized, the effect is that the voter is being required to more fully darken the mark space **112** in order for a voting selection to be considered as such. If a lower percentage voted threshold is established, then mark space **112** outlines having a positive tolerance and/or reading "noise" could determine that a voting selection has been made when none was intended. In some tests, thresholds of about 10% and less were found to produce readings of a voting selection where none was intended.

To determine whether a voting selection has been made in a given mark space **112**, the number of pixels of the mark space outline is subtracted from the number of marked pixels, and the difference is compared with the predetermined voted threshold. This provides additional safety margin against erroneous reading because the number of dark pixels of the mark space outline is subtracted both in calculating the voted threshold and in determining the number of pixels that have been read as marked by the voter.

In the example embodiment, a voted threshold of 20% is equal to 160 marked pixels (20% of 800 markable pixels), and a threshold of 50% is equal to 400 marked pixels, in a reading region **130**. It is noted that using the lower voted threshold of 20% requires that at least 160 marked pixels be present which is about four times the expected tolerance of 40 pixels of the outline of mark space **112** and so an unmarked mark space **112** will be unlikely to be erroneously determined to be a voting selection.

An advantage obtains where the counts of the numbers of "light" and "dark" pixels are stored for each mark space **112** of each ballot, as is preferred, but is not necessary, as described above. After the ballots are read/imaged, their "light" and "dark" pixels counted and stored, and voting selections counted and tabulated with a given predetermined voted threshold, the predetermined voted threshold may be changed and the voting selections recounted and re-tabulated using the stored "light" and "dark" pixels counts, without having to again scan the ballots. This is performed quickly and electronically, without the need for scanning or otherwise processing the original paper ballots, and ballot images may be inspected in case of a question.

Thus the effect of changing the value of the predetermined voted threshold on the tabulated election result may be determined, and may be compared with the election result (e.g., the vote margin of the winning candidate) for determining whether that effect is significant with respect to the outcome of the election. Where the ballot VID is associated with the stored pixel counts, as is optional but is preferred, the ballots for which the reading of the voting selection is changed by the changing of the predetermined voted threshold may be identified, and may be obtained for visual inspection by voting officials. Typically, the differences in reading voting selections provided by the foregoing ballot reading and counting arrangement have been found to be relatively small, and so would not be significant in terms of an election result in all but the closest of elections.

Because the counts of dark and light pixels are stored in the pixel-based preferred arrangement, it is quite easy to vary the predetermined threshold for what is and is not a voted (marked) mark space and to determine the variance if either a higher or lower threshold had been utilized (i.e. a higher or lower percentage of filled area of the mark spaces **112**). For example, a typical predetermined threshold level might be set at 20%, 25%, 30%, 35% or 40%. Once the votes are read and counted using the predetermined threshold, it is quite easy to perform one or more recounts with the threshold set at a higher or lower threshold level utilizing the stored counts of light and dark pixels without having to re-scan (re-image) and reprocess the ballots.

For example, where the ballots are initially read and decoded utilizing a predetermined threshold of 30%, the results can be tested and compared simply by setting the predetermined threshold to 20% and recounting using the stored counts of light and dark pixels and then to set the predetermined threshold to 40% and again recounting using the same stored counts of light and dark pixels. The differ-

ences in vote tallies generated using different predetermined thresholds of light and dark pixels will determine the sensitivity of the vote count to the relative level of marking filling of the vote selection mark spaces.

Further, where the preferred arrangement is employed wherein the ballot identifier (VID) is associated with the ballot image and the stored counts of light and dark pixels, the voting results obtained for each ballot for each predetermined threshold level may be compared and the ballots for which the voting result changes when the predetermined threshold is varied may be identified by their respective ballot identifiers (VIDs) and may then be retrieved for manual inspection, e.g., by an election official and/or a court or other authority conducting an examination of the voting result.

Thus, the described arrangement facilitates the identification of those ballots for which voter intent may be in issue and also provides means whereby the ballots in question may be identified and evaluated automatically and without subjective human intervention. If this arrangement had been utilized in the November 2000 presidential election in the United States, for example, then the recounting of votes in certain counties of the state of Florida would have been much quicker and accurate, and may have been freed from the taint and embarrassment of partisan human interpretation.

FIG. **10**C illustrates an enlarged view of a portion of reading region **130** which contains a portion of a mark **140** in mark space **112** (or of an outline of a mark space **112**). Therein, dashed lines indicate rows a, b, c, . . . and columns **1**, **2**, **3**, . . . of pixels **132** on which a portion of a mark **140** (or a mark space **112** outline) is superimposed, and pixels **132** are designated as "x-y" where "x" is the letter of the row thereof and "y" is the number of the column thereof, e.g., the pixel at row a, column **1**, is designated as pixel "a-**1**." It is seen that while a mark **140** completely fills some pixels **132**, it does not either completely fill or completely not fill all pixels **132**. Thus a criteria is needed to determine whether any given pixel is "dark" or is "light," i.e. is not dark.

One convenient criteria is that the pixel is considered "light" if the intensity (brightness) of a pixel is greater than 50% of full brightness and is considered "dark" if its intensity (brightness) is less than 50% of full brightness, although any other suitable level could be utilized. Thus, illustrated pixels b-**1**, c-**1**, c-**4**, and f-**7**, among others, are "light" and illustrated pixels f-**3**, d-**6**, c-**7** and b-**8**, among others, are "dark." Other illustrated pixels, such as pixels f-**2**, e-**3**, g-**3** and e-**6**, among others, are more than 50% covered by mark **140** and so would be considered "dark" pixels, while illustrated pixels f-**1**, b-**6**, f-**5** and d-**8**, among others, are less than 50% covered by mark **140** and so would be considered "light" pixels.

Pixel intensity (brightness) is tested for each pixel and each pixel is determined to be either "light" or "dark" and the total numbers of "light" and "dark" pixels, respectively, are counted for each reading region **130**, as described above. Because the processing of each reading region **130** as described above makes provision for variations in reading characteristics, the accuracy of counting of voting selections is not particularly sensitive to the predetermined intensity threshold that is utilized for determining "light" and "dark" pixels. It is noted that the preferred threshold of 50% is symmetrical and tends to avoid a statistical bias towards determining whether any given pixel is a "light" pixel or a "dark" pixel.

FIG. **11** is a schematic flow diagram of an example process **400** for generating the ballots of FIGS. **1**, **3**A–**3**D and **4**. In process **400**, a ballot is generated **410**, **410'** including the contests and/or questions to be presented to the voters generated from information entered by election officials prior to an election. Typically, election officials generate a database **408** of ballot forms (styles) for the various jurisdictions, districts, polling locations and the like, and in the case of a primary, for each political party, each being associated with a particular jurisdictional portion of the voter identifier (VID). In printing ballots, the appropriate form/style is selected from the database **408** thereof in accordance with the jurisdictional portion of a particular VID, e.g., ballot generation as described herein and/or in incorporated patent applications Ser. Nos. 09/737,306 and 10/255,348.

Ballots may be generated **410** with a complete voter identifier (VID), i.e. an identifier including the jurisdictional information (e.g., fields **381**–**386**) and a unique random identifier (e.g., field **387**), and printed **412** as a set of unique ballots, either in advance of an election and/or "on-demand" in an election. Ballots may be generated **410'** with a partial voter identifier (VID), i.e. an identifier including the jurisdictional information (e.g., fields **381**–**386**), and printed **412'** as a set of identical ballots either in advance of an election (e.g., conventional printing) and/or "on-demand" in an election. Such ballots may be utilized directly, i.e. without the unique identifier portion of the VID, or a unique random identifier (e.g., field **387**) portion of a voter identifier may be generated **414** and may be printed **416** on the ballots to provide a set of unique ballots and/or may be printed on labels to be affixed to the printed ballots at a later time. A list of the voter identifiers utilized on ballots may be retained, e.g., in a database on a computer, for later use in verifying and/or authenticating voted ballots received **424**, and may be without compromising voter anonymity and privacy where no record is kept that could relate a particular ballot to a particular voter. Further, printed ballots including the VID may be placed into envelopes, e.g., absentee ballots placed into mailing envelopes, by automated equipment to reduce the possibility of human action that may compromise privacy and/or anonymity.

In either case, the printed ballots with a complete VID and/or with a partial jurisdictional VID are distributed **420** for being utilized by voters in voting in an election in accordance with the applicable election procedure, e.g., by marking their voting selections in the mark spaces provided. It is noted that the ballots may be distributed **420** in advance of an election, e.g., as absentee ballots or as ballots for early voting, may be distributed **420** during an election as the usual ballot for all voters, e.g., at polling locations on an election day or days, and/or may be distributed **420** to particular voters, e.g., to voters voting provisionally.

Absentee ballot envelopes may be printed in like manner to that employed for printing ballots, i.e. either as a batch printing process **412** and/or on demand **412'**–**416**. An envelope voter identifier (EVID) may be printed on each enve-

lope or later applied, e.g., by label, that includes fields identifying the jurisdiction and ballot type, with or without a unique randomly-generated identifier, in similar manner to the VID utilized on the ballot. The EVID may be utilized to identify the envelope/ballot upon distribution **420**, e.g., sending/mailing out to the voter, and upon return **424**, and facilitates automated placement of ballots into envelopes as described.

Marked (voted) ballots are received **424**, e.g., by election officials, the ballots having been submitted by mail, in-person or other delivery method, e.g., in the case of absentee ballots or ballots for early voting, by deposit in ballot containers or delivery to an election official at a polling location or other designated location, e.g., as the usual ballots voted and/or as provisional ballots. Ballots voted as absentee, early and/or provisional voting ballots are typically sealed in a plain opaque envelope after the voter marks his voting selections thereon and the plain envelope is then sealed inside an opaque outer envelope on which is marked the voter's name and address, the election, jurisdiction, date, and/or other particulars, and a voter signature, and/or the identification and signature of a witness. Each ballot is verified **430**, i.e. the information on the outer envelope is utilized by election officials to determine whether the ballot sealed therein should be opened and counted. Such determination may include, e.g., whether the voter is eligible to vote, whether the voter signature on the envelope matches the voter signature in the voter registration records, and/or whether the ballot is a valid ballot for the particular election (possibly including whether the ballot is a duplicate of another vote in the name of the voter).

Upon return **424** of an absentee ballot and before opening it to obtain the ballot therein for counting, the envelope EVID on the outer envelope is read and is utilized for authenticating/verifying **430** the absentee ballot and for indicating that the voter to whom is was provided has voted and/or for disqualifying the absentee ballot if the voter has voted in person during the election, thereby to reduce the likelihood for a voter voting more than once without being detected. Once the absentee ballot is determined **430** to be a valid absentee ballot based upon the EVID, the envelope is opened and the ballot therein is counted **430** as described.

While a record of the VID of ballots sent as absentee ballots may be retained for verifying that the ballot is an authentic absentee ballot as part of it being counted, it is preferred that the VID and EVID be separate and independent of each other and not linked, so that the identity of the voter remains anonymous and his vote remains private. Voter anonymity and/or privacy may also be enhanced where substantial numbers of such ballots are processed together, e.g., where absentee and/or provisional ballots are removed from their envelopes. Ballots not validated may be retained either physically and/or electronically by storing images thereof, and such stored images may be related to the voter registration database, if desired

The verified (qualified) received ballots are then read as described herein (e.g., see FIGS. **7** and **8**) and tabulated **430**, without the need for being sorted by election and/or ballot style and/or jurisdiction before reading and tabulating **430**, to determine the result or outcome of the voting. Before and/or during the reading and tabulating **430**, the ballots may be verified/authenticated by comparing the complete VID number on each ballot against a list of valid VID numbers for the election, e.g., a computer database listing the VID of each issued ballot, and/or by manual inspection by an election official.

The result/outcome of the election is certified and/or published **432** as required by the applicable election laws. Preferably, the tabulating **430** of voted ballots preserves the specific voting selections read from each ballot and the associated VID (e.g., voting record) of that ballot, as well as tallying the vote totals for determining the election outcome, and a listing of the voting selections and VID (voting record) from all ballots are published where the public can access same, e.g., on a bulletin board, in a printed publication and/or on an Internet web site. Thus, each voter knowing his VID can access the listing and find the vote recorded from his ballot by its VID and can satisfy himself that his vote has been counted and nas been counted correctly and accurately. Where the voter retains a copy of his ballot and/or is issued a voting receipt, such may be utilized for correcting an incorrectly recorded vote and/or an improperly disqualified ballot where permitted by applicable law.

FIG. **12** is a schematic flow diagram of an example voting process **500** utilizing the ballot of FIGS. **1**, **3**A–**3**D and **4**. Voting district specific ballots are generated **510** and distributed **512** for being voted. Voters vote **514** by marking the mark spaces on the ballot corresponding to their desired voting selections (votes) and submit their ballots in accordance with applicable election procedure. A voter may copy **516** his marked ballot for later checking that his vote was counted and was counted properly. Voted ballots are received **520** and the received voted ballots are authenticated **522** before being read and counted. All the foregoing may be as described in relation to FIG. **11**.

Authenticated (valid) ballots are read (scanned) **524** to read the VID number printed thereon and the voting selections marked thereon, i.e. the voting selections marked on each ballot are read according to a ballot template corresponding to the jurisdictional portion of the VID selected based upon the jurisdictional portion of the VID read **524** from each ballot. Write-in votes are preferably read and processed **525** by optical character recognition (OCR) software for computer tabulation, and/or ballots having write-in votes may be separated for manual processing (e.g. manual deciphering and posting) **525** and/or inspection and/or verification. As described, ballots are read **524** according to ballot templates selected based upon the read VID and so do not need to be sorted by jurisdiction and/or style prior to reading **524**.

Ballots over-voted (i.e. wherein more mark spaces than are permitted to be marked have been marked) may be disposed **526** by being separated or ejected for manual inspection and/or invalidation, and/or the valid portions of the voting selections may be recorded and tabulated **530**, depending on the treatment of over-voted ballots under applicable law. Some jurisdictions invalidate only the voting selections made in over-voted contests and other jurisdictions invalidate an entire ballot containing any over-vote. Ballots under-voted (i.e. wherein fewer mark spaces than are permitted to be marked have been marked) may be recorded separately **526** and/or the under-vote may be recorded sepa-

rately **526** (e.g., for review and/or for statistical purposes), and the voting selections thereon are recorded and tabulated **530**, and/or under-voted ballots may be separated for manual inspection, depending on the treatment of under-voted ballots under applicable law. Further, the read and/or imaged information for each under- and/or over-voted ballot may be printed out for review by election officials.

The voting selections from read **524** ballots is recorded **530** including the VID number from each ballot, i.e. the voting selections and VID of each ballot are recorded and stored as an individual voting record, and the voting selections therefrom are also tabulated **530** to determine the result of voting. Preferably, the information read from each ballot, e.g., voting record of voting selections and VID, are stored in plural separate and independent memory devices, e.g., hard drives, flash memories, optical CD-ROM and the like, as described in incorporated patent applications Ser. Nos. 09/737,306 and 10/255,348, for preservation with the original paper ballots in accordance with applicable procedures.

When the voting results tabulations are properly verified, the result is certified **532** as official. Thereafter, the certified results may be posted/published **534**, e.g., on an Internet web site, including both the tabulated **530** result and/or the voting records including VID of each individual ballot, thereby enabling any voter knowing his VID, e.g., from a ballot copy and/or a printed voting receipt, to review **540** the voting record corresponding to that VID to ascertain whether it was counted and, if counted, whether it was correctly counted. The posted/published **534** voting records can include not only those voting records for ballots that were authenticated **522** and thus counted **524**, **530**, but may also include the voting records for ballots that were disqualified or otherwise not counted and/or not completely counted and/or the fact that the ballot of that VID was disqualified or was not counted and/or not completely counted.

In connection with the steps of reading **524**, recording and tabulating **530** and/or the processing of write-in, under and over-votes **525**, **526**, **528**, for example, election officials may be provided with administrative and management tools, such as user rights and levels of access, passwords and the like, the keeping of logs of events and/or actions performed, functions to export (e.g., by electronic file transfer and/or via floppy disks, CD-ROMs and other tangible media) all or part of the files of vote tabulations, voting records, vote statistics and the like, and/or for the printing of various reports and/or forms, such as vote tallies, voting reports, vote certification forms and the like.

While the VID information may be provided to the voter on a paper ballot and/or on a paper or other identification card, or may be entered by an election official at the election office and/or polling place for printing on a ballot, VID information may be coded into the memory of a smart card and the voting machine may include a smart card reader for reading the coded VID stored therein where the voting machine is utilized to print an optically scan-able ballot including the VID. Identification of the voter at the time for voting may utilize the VID information stored in the voter's smart card, or may be by traditional identification methods, such as signature verification, conventionally utilized by various jurisdictions.

Alternatively, a unique identifier stored in the voting machine may be read into the voter's smart card and may either supplement or replace the voter number stored therein at issuance, whereby the pre-stored voter number may be used to verify registration and/or the unique identifier may be utilized to preserve voter anonymity and privacy. Preferably for voter privacy, only the unique identifier, e.g., VID, is stored in the voter smart card and/or on a printed allot at the completion of a voting session. A database of unique identifiers valid only for a particular election may be preloaded into the voting machines and/or vote tabulating machines prior to that election, and/or smart cards may be collected when voted, for security.

While the present invention has been described in terms of the foregoing exemplary embodiments, variations within the scope and spirit of the present invention as defined by the claims following will be apparent to those skilled in the art. For example, while the identifier (e.g., VID number) of a ballot must be machine readable for automatic tabulation of votes, the machine-readable VID may be the same as the desirable human-readable VID, i.e. alphanumeric characters readable by people as well as machines (e.g., readers having OCR) may be utilized.

Moreover, any arrangement described in relation to a particular form of voting (e.g., absentee or provisional voting) may be utilized in relation to any other form of voting (e.g., regular or early voting) as well.

Further, the identifier (VID) may include any one or more of the fields described and/or additional or different fields, as may be appropriate and/or desirable. Each identifier (VID) includes one or more fields containing a representation of jurisdictional information and/or a ballot form, and may include one or more fields containing a unique random portion. Herein, an identifier may be or be referred to as a ballot identifier and/or a voting session identifier, e.g., where the ballot is generated with an identifier in a voting session of an election, i.e. in recording a voter's vote or is generated apart from a voting session and any voter, and/or may be referred to as a voter identifier in relation to a particular voter (even if random and anonymous).

Also, and optionally, for weighted and/or ranked voting, the ballot may provide for the voter to write-in the weighting and/or rank for each candidate and/or response in a marking space **112** provided therefor and the write-in portion may be read and translated into machine readable form manually. Further, the reader may include an OCR function for translating the written weight and/or rank into machine readable form, and in such case, means for writing in the selection in a common font easily understood by the reader may be provided. Voter over-voting errors in making weighting and/or ranking preferences may be proportionately corrected automatically, e.g., normalized to the proper weight, if the law allows. Under votes may be counted insofar as they are voted.

While ballots are generally referred to herein as "paper" ballots, it is understood that while present day sheet ballots are typically of paper or of a somewhat heavier stock, paper ballot as used herein is intended to include paper, heavy paper, card stock, cardboard, plastic, punch card and other

forms of ballots on a sheet of material. While sheet ballots are most commonly read by optical scanning when the ballot passes a light source and the marked/unmarked state of the mark regions is sensed by an associated light detector, marking may be detected by other means such as a mechanical and/or electrical sensing and detecting means.

Where ballots are separately processed, such processing may be automated or manual, or may be a combination thereof. Separate processing may be utilized where ballots include a write-in vote, an overvote, an undervote, and/o where a ballot appears to be missing voting mark spaces, ballot identifier and/or fiducial marks, and/or wherein such features have not been properly read and/or imaged.

In any of the arrangements described herein, a printer may be associated with a ballot reader, e.g., such as reader **1000** described in relation to FIG. **7**, for providing a voting receipt and/or confirmation that a ballot has been properly read. Such receipt may be a simple confirmation of a readable ballot, a listing of voting selections and/or may include a printout of a full ballot image, or anything in between. In the latter case, it may be desirable for the printed version of the voter's ballot to be submitted as the official vote after the voter has opportunity to verify its accuracy and completeness. The printed ballot version would have fully blackened mark spaces for each voting selection made thereby to further reduce the already extremely low rate of questionable vote counting error typically obtained with the described arrangements.

In addition, while the apparatus and method herein are typically described in relation to voting apparatus having a user interface, e.g., a display and a data entry device such as a touch screen, either or both may be eliminated and/or rendered inoperative, if desired, and replaced by the optical ballot reading apparatus such as that described. Further, the apparatus and method herein may be utilized in fields and applications other than elections and voting, e.g., in the grading/marking of examinations and tests such as school and university tests, professional tests, and the like, wherein the voter is a test taker and an answer sheet replaces the ballot, in the tallying and tabulating of surveys and questionnaires (replacing the ballots), in the reading and tabulation of gaming sheets (replacing the ballots) such as for races and lotteries, and the like.

What is claimed is:

1. A machine readable ballot comprising: a ballot sheet having an identifier region thereon wherein an identifier includes at least a representation of jurisdiction information, said ballot sheet having two or more fiducial marks thereon for defining the orientation and the scale of the ballot sheet, said ballot sheet also having a plurality of contest regions thereon, each contest region having two or more mark spaces therein for making voting selections, wherein one of the mark spaces in a contest region represents an abstention selection; wherein the contest regions correspond to contests in the jurisdiction represented by the jurisdiction information, and wherein the representation of jurisdiction information and the mark spaces are machine readable.

2. The machine readable ballot of claim **1** wherein the identifier includes one or more of a bar code, a two-dimensional bar code, a prescribed font, optical character recognition (OCR) characters, alphanumeric characters, non-alphanumeric characters, and symbols.

3. The machine readable ballot of claim **1** wherein machine readable includes optically readable, and wherein the representation of jurisdiction information and the mark spaces are optically readable.

4. The machine readable ballot of claim **1** wherein the jurisdiction information of the identifier identifies a template corresponding to the two or more mark spaces for making voting selections in each of the plurality of contest regions.

5. The machine readable ballot of claim **1** wherein the jurisdiction information relates to any two or more of a country, a state, a county, a city, a town, a municipality, a voting precinct, a voting district, a voting ward, a polling location, and a political party.

6. The machine readable ballot of claim **1** wherein the mark space representing an abstention selection includes a mark space for one or more of a "no vote," an "abstain," and a "skip contest" selection.

7. The machine readable ballot of claim **1** wherein the identifier further includes a unique ballot identifier, and wherein the jurisdiction information and the unique ballot identifier are not related to the identity of any individual voter.

8. The machine readable ballot of claim **7** wherein the jurisdiction information and the unique ballot identifier are represented by characters that are machine readable and are human readable.

9. The machine readable ballot of claim **1** wherein a plurality of mark spaces are provided for each voting selection of at least one contest, wherein the plurality of mark spaces for each voting selection are for one or more of cumulative voting, ranked voting, and instant run-off voting.

10. The machine-readable ballot of claim **1**:

wherein said two or more fiducial marks include at least two orientation indicia spaced apart by a predetermined distance for defining a dimension of said ballot sheet; or

wherein said two or more fiducial marks include one or more of cross-hair lines, cross-hair lines in a circle, targets, bulls-eye shapes, bullets, "+" marks, "X" marks, boxes, any of the foregoing with one or more black, darkened or contrasting adjacent sections, and any combination thereof; or

wherein said two or more fiducial marks include at least two orientation indicia spaced apart by a predetermined distance for defining a dimension of said ballot sheet and include one or more of cross-hair lines, cross-hair lines in a circle, targets, bulls-eye shapes, bullets, "+" marks, "X" marks, boxes, any of the foregoing with one or more black, darkened or contrasting adjacent sections, and any combination thereof.

11. The machine-readable ballot of claim **1** wherein said machine-readable ballot comprises a plurality of ballot sheets, each ballot sheet having a machine-readable indicia representative of the page number thereof.

12. The machine readable ballot of claim **1** wherein said ballot sheet includes one or more of paper, heavy paper, card stock, cardboard and plastic.

13. A method for reading paper ballots comprising:

(a) imaging each of a plurality of paper ballots transported along a transport path of an image document scanner to provide a ballot image in a pixelated or bitmapped format for each ballot;

(b) selecting a template for decoding voting selections marked on each paper ballot responsive to the pixelated or bitmapped format ballot image of each paper ballot;

(c) decoding from the pixelated or bitmapped format ballot image of each paper ballot the voting selections marked on each paper ballot in accordance with the selected template; and

(d) tabulating the decoded voting selections decoded from each of the paper ballots consistent with the selected template;

whereby the voting selections marked on each paper ballot are decoded and tabulated in accordance with a selected template.

14. The method of claim **13** wherein each paper ballot has a jurisdiction identifier, and wherein the paper ballots are not sorted according to the jurisdiction identifier prior to said imaging, said method further comprising:

decoding the jurisdiction identifier of each paper ballot from the image thereof; and

selecting responsive to the decoded jurisdiction identifier the template for decoding the voting selections marked on each paper ballot.

15. The method of claim **14** wherein the jurisdiction identifier includes one or more of a bar code, a two-dimensional bar code, a prescribed font, optical character recognition (OCR) characters, alphanumeric characters, non-alphanumeric characters, and symbols.

16. The method of claim **13** wherein each paper ballot has orientation indicia and may be in an orientation different from other ones of the paper ballots, and wherein the paper ballots are not sorted according to orientation prior to said transporting, said method further comprising:

determining from the orientation indicia the orientation of each paper ballot;

said decoding from the image of each paper ballot the voting selections marked on each paper ballot in accordance with the selected template comprising decoding consistent with the determined orientation of each paper ballot the voting selections marked on each paper ballot in accordance with the selected template.

17. The method of claim **16**:

wherein the orientation indicia include at least two orientation indicia spaced apart by a predetermined distance for defining a dimension of the paper ballot; or

wherein the orientation indicia include one or more of cross-hair lines, cross-hair lines in a circle, targets, bulls-eye shapes, bullets, "+" marks, "X" marks, boxes, any of the foregoing with one or more black, darkened or contrasting adjacent sections, and any combination thereof; or

wherein the orientation indicia include at least two orientation indicia spaced apart by a predetermined distance for defining a dimension of the paper ballot and include one or more of cross-hair lines, cross-hair lines in a circle, targets, bulls-eye shapes, bullets, "+" marks, "X" marks, boxes, any of the foregoing with one or more black, darkened or contrasting adjacent sections, and any combination thereof.

18. The method of claim **13** wherein the document image scanner includes one or more of a copier, a scanner, a facsimile machine, a commercial imaging device and a commercial scanning device.

19. The method of claim **13** wherein each paper ballot has a plurality of mark spaces in which voting selections may be made, further comprising:

determining from the image of each paper ballot and the selected template whether the mark spaces of each paper ballot correspond to mark spaces of the selected template,

if the mark spaces correspond, then performing said decoding voting selections and said tabulating the decoded voting selections for that paper ballot; and

if the mark spaces do not correspond, then rejecting the ballot and not performing said decoding voting selections and said tabulating the decoded voting selections for that paper ballot.

20. The method of claim **13** wherein each paper ballot has a plurality of mark spaces in which voting selections may be marked and wherein said decoding the voting selections marked on each paper ballot comprises:

determining a reference value representative of a mark space on each paper ballot that is not marked as a voting selection;

determining a marked value representative of each mark space on each paper ballot; and

comparing the reference value and the marked value for determining whether a mark space is marked as a voting selection.

21. The method of claim **13** wherein ones of the plurality of paper ballots are each enclosed in a ballot envelope having a machine-readable ballot identifier and voter information including a signature thereon, said method further comprising, prior to performing the steps (a) through (d):

imaging each of the ballot envelopes transported along a transport path of an office image document scanner to provide a ballot envelope image in a pixelated or bitmapped format for each ballot envelope;

decoding the ballot identifier marked on each ballot envelope responsive to the pixelated or bitmapped format ballot envelope image thereof;

displaying the decoded ballot identifier and voter signature for determining whether the ballot identifier and signature represent a valid ballot; and

if the ballot is determined to be valid, removing the paper ballot from the ballot envelope and performing the steps (a) through (d) thereon.

22. The method of claim **13** further comprising prior to said tabulating step:

determining from the decoded voting selections whether each paper ballot contains an undervote, an overvote, a missing voting selection, a write-in voting selection, or a combination thereof;

separating each paper ballot determined to contain an undervote, an overvote, a missing voting selection, a write-in voting selection, or a combination thereof from other paper ballots not determined to contain an undervote, an overvote, a missing voting selection, or a write-in voting selection; and then:

performing said tabulating step for the other paper ballots not determined to contain an undervote, an overvote, a missing voting selection, or a write-in voting selection; and

separately processing each separated paper ballot determined to contain an undervote, an overvote, a missing voting selection, a write-in voting selection, or a combination thereof.

23. A method for optically reading paper ballots having a jurisdiction identifier and fiducial marks thereon and having voting selections marked thereon, said method comprising:

(a) transporting paper ballots along a transport path;

(b) determining from the fiducial marks the orientation of each paper ballot;

(c) reading consistent with the determined orientation of each paper ballot the jurisdiction identifier of each paper ballot transported along the transport path;

(d) selecting a template responsive to the read jurisdiction identifier and determined orientation of each paper ballot for reading the voting selections marked thereon; and

(e) reading in accordance with the selected template and consistent with the determined orientation of each paper ballot the voting selections marked on each paper ballot transported along the transport path,

whereby the voting selections marked on each paper ballot are read in accordance with a selected template corresponding to the jurisdiction identifier for that paper ballot irrespective of the orientation of the paper ballot.

24. The method of claim **23**:

wherein the paper ballots have different jurisdiction identifiers, and wherein the paper ballots are not sorted according to the jurisdiction identifier prior to said transporting; or

wherein the paper ballots may have different orientations, and wherein the paper ballots are not sorted according to orientation prior to said transporting, or

wherein the paper ballots have different jurisdiction identifiers and may have different orientations, and wherein the paper ballots are not sorted according to the jurisdiction identifier or to orientation prior to said transporting.

25. The method of claim **23** wherein said selecting and said reading the voting selections marked on each paper ballot are performed substantially contemporaneously with said transporting of the paper ballots.

26. The method of claim **23** further comprising:

comparing the voting selections read from each paper ballot to the selected template for providing an indication of an under vote, an over vote or both of each paper ballot; or

tabulating the voting selections read from each of the paper ballots; or

comparing the voting selections read from each ballot to the selected template for providing an indication of an under vote, an over vote or both of each paper ballot, and tabulating the voting selections read from each of the paper ballots.

27. The method of claim **26** wherein said tabulating the voting selections read from each of the paper ballots includes tabulating the voting selections according to a jurisdiction represented by each jurisdiction identifier.

28. The method of claim **23** wherein the paper ballots each have a corresponding unique ballot identifier, and wherein said reading the jurisdiction identifier includes reading the corresponding unique ballot identifier.

29. The method of claim **28** further comprising:

storing a representation of the voting selections marked on each paper ballot and the unique ballot identifier associated therewith; or

publishing the voting selections read from each paper ballot and the corresponding jurisdiction identifier and unique ballot identifier of that paper ballot; or

storing a representation of the voting selections marked on each paper ballot and the unique ballot identifier associated therewith and publishing the voting selections read from each paper ballot and the corresponding jurisdiction identifier and unique ballot identifier of that paper ballot.

30. The method of claim **23** wherein each paper ballot has a plurality of mark spaces in which voting selections may be marked and wherein said reading the voting selections marked on each paper ballot comprises:

determining a reference value representative of a mark space on each paper ballot that is not marked as a voting selection;

determining a marked value representative of each mark space on each paper ballot; and

comparing the reference value and the marked value for determining whether a mark space is marked as a voting selection.

31. The method of claim **23** wherein ones of the paper ballots are each enclosed in a ballot envelope having a machine-readable ballot identifier and voter information including a signature thereon, said method further comprising, prior to performing the steps (a) through (e):

reading the ballot identifier and signature marked on each ballot envelope;

displaying the read ballot identifier and signature for determining whether the ballot identifier and signature represent a valid ballot; and

if the ballot is determined to be valid, removing the paper ballot from the ballot envelope and then performing the steps (a) through (e) thereon.

32. The method of claim **23** further comprising:

determining from the voting selections read from each paper ballot whether each paper ballot contains any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection;

separating each paper ballot determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection from other paper ballots not determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection;

tabulating the voting selections read from the other paper ballots not determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection; and

separately processing each separated paper ballot determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection.

33. A method for reading paper ballots having a jurisdiction identifier and fiducial marks thereon and having voting selections marked thereon, said method comprising:

(a) transporting paper ballots along a transport path;

(b) imaging each paper ballot transported along the transport path;

(c) determining from the fiducial marks the orientation of each paper ballot;

(d) decoding consistent with the determined orientation of each paper ballot the jurisdiction identifier of the image of each paper ballot;

(e) selecting responsive to the decoded jurisdiction identifier a template for decoding the voting selections marked on each paper ballot; and

(f) decoding consistent with the determined orientation of each paper ballot the voting selections marked on each paper ballot in accordance with the selected template,

whereby the voting selections marked on each paper ballot are decoded in accordance with a template corresponding to the jurisdiction identifier for that paper ballot irrespective of the orientation of the paper ballot.

34. The method of claim **33**:

wherein the paper ballots have different jurisdiction identifiers, and wherein the paper ballots are not sorted according to the jurisdiction identifier prior to said transporting; or

wherein the paper ballots may have different orientations, and wherein the paper ballots are not sorted according to orientation prior to said transporting; or

wherein the paper ballots have different jurisdiction identifiers and are not sorted according to the jurisdiction identifier prior to said transporting, and wherein the paper ballots may have different orientations and are not sorted according to orientation prior to said transporting.

35. The method of claim **33** wherein said selecting and said decoding the voting selections marked on each paper ballot are performed substantially contemporaneously with said transporting of the paper ballots.

36. The method of claim **33** further comprising:

comparing the voting selections decoded from each ballot to the selected template for providing an indication of an under vote, an over vote or both of each paper ballot; or

tabulating the voting selections decoded from each of the paper ballots; or

comparing the voting selections decoded from each ballot to the selected template for providing an indication of an under vote, an over vote or both of each paper ballot, and tabulating the voting selections decoded from each of the paper ballots.

37. The method of claim **36** wherein said tabulating the voting selections decoded from each of the paper ballots includes tabulating the voting selections according to a jurisdiction represented by each jurisdiction identifier.

38. The method of claim **33** wherein the paper ballots each have a corresponding unique ballot identifier, and wherein said decoding the jurisdiction identifier includes decoding the corresponding unique ballot identifier.

39. The method of claim **38** further comprising:

storing a representation of the voting selections marked on each paper ballot and the unique ballot identifier associated therewith; or

publishing the voting selections decoded from each paper ballot and the corresponding jurisdiction identifier and unique ballot identifier decoded from that paper ballot; or

storing a representation of the voting selections marked on each paper ballot and the unique ballot identifier associated therewith and publishing the voting selections decoded from each paper ballot and the corresponding jurisdiction identifier and unique ballot identifier decoded from that paper ballot.

40. The method of claim **33** wherein each paper ballot has a plurality of mark spaces in which voting selections may be marked and wherein said decoding the voting selections marked on each paper ballot comprises:

determining a reference value representative of a mark space on each paper ballot that is not marked as a voting selection;

determining a marked value representative of each mark space on each paper ballot; and

comparing the reference value and the marked value for determining whether a mark space is marked as a voting selection.

41. The method of claim **33** wherein ones of the paper ballots are each enclosed in a ballot envelope having a machine-readable ballot identifier and voter information including a signature thereon, said method further comprising, prior to performing the steps (a) through (f):

decoding the ballot identifier and signature marked on each ballot envelope;

displaying the decoded ballot identifier and signature for determining whether the ballot identifier and signature represent a valid ballot; and

if the ballot is determined to be valid, removing the paper ballot from the ballot envelope and then performing the steps (a) through (f) thereon.

42. The method of claim **33** further comprising:

determining from the voting selections decoded from each paper ballot whether each paper ballot contains any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection;

separating each paper ballot determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection from other paper ballots not determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection;

tabulating the voting selections read from the other paper ballots not determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection; and

separately processing each separated paper ballot determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection.

43. A method for reading ballots comprising:

(a) transporting the ballots on a reader transport path;

(b) reading each ballot transported on said transport path including reading fiducial marks and a jurisdiction identifier thereof and voting selections marked thereon;

(c) determining from the fiducial marks the orientation of each ballot;

(d) processing the jurisdiction identifier for each ballot for selecting a template; and

(e) recording the voting selections marked on each ballot in accordance with the selected template and the determined orientation of the ballot,

whereby the voting selections marked on each ballot are read and recorded in accordance with a template corresponding to the jurisdiction identifier for that ballot.

44. The method of claim **43** wherein each paper ballot has a plurality of mark spaces in which voting selections may be marked and wherein said recording the voting selections marked on each paper ballot comprises:

determining a reference value representative of a mark space on each paper ballot that is not marked as a voting selection;

determining a marked value representative of each mark space on each paper ballot; and

comparing the reference value and the marked value for determining whether a mark space is marked as a voting selection.

45. The method of claim **43** wherein ones of the ballots are each enclosed in a ballot envelope having a machine-readable ballot identifier and voter information including a signature thereon, said method further comprising, prior to performing the steps (a) through (e):

reading the ballot identifier and signature marked on each ballot envelope;

displaying the read ballot identifier and signature for determining whether the ballot identifier and signature represent a valid ballot; and

if the ballot is determined to be valid, removing the ballot from the ballot envelope and then performing the steps (a) through (e) thereon.

46. The method of claim 43 further comprising:

determining from the voting selections read from each ballot whether each ballot contains any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection;

separating each ballot determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection from other ballots not determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection;

tabulating the voting selections read from the other ballots not determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection; and

separately processing each separated ballot determined to contain any one or more of an undervote, an overvote, a missing voting selection, and a write-in voting selection.

47. A method for reading a ballot having one or more contest regions and a plurality of mark spaces thereon in which voting selections may be marked for one or more contests, each mark space being defined by an outline thereof the method comprising:

imaging the ballot having one or more contest regions and a plurality of mark spaces thereon wherein the image of the ballot includes all of the mark spaces for the contest regions thereon and is in a pixelated or bitmapped format including a plurality of pixels;

defining for each ballot the one or more contest regions each containing a plurality of reading regions each including the outline of one mark space;

processing the image of the ballot for decoding from the image of the ballot the defined one or more contest regions and for decoding from the image of the ballot the plurality of reading regions including the outline of one mark space thereof; and

for each decoded contest region:

counting the number of light pixels and dark pixels for each reading region;

determining from the counts of light and dark pixels for each reading region whether the mark space therein is an unmarked outline or is marked as a voting selection; and

counting each determined marked voting selection.

48. The method of claim 47 wherein said determining comprises:

determining the difference between a number of dark pixels representative of the outline of a mark space and a total number of pixels for a reading region, and

determining whether the counted number of dark pixels for that reading region exceeds a predetermined portion of the difference between the number of dark pixels representative of the outline of a mark space and the total number of pixels for that reading region.

49. The method of claim 47 wherein two or more of the mark spaces are associated with a contest, each contest having a given number of voting selections that may be made therein, the method comprising:

counting the number of mark spaces for the contest that are determined from the counts of light and dark pixels for each reading region to be marked as a voting selection;

comparing the number of voting selections marked to the given number of voting selections; and

if the number of voting selections marked equals the given number, then performing said counting each determined voting selection,

if the number of voting selections marked is less than the given number, then providing an indication of an under vote, and

if the number of voting selections marked exceeds the given number, then providing an indication of an over vote and not performing said counting each determined voting selection.

50. The method of claim 49 wherein an indication of an under vote or an over vote or both is provided, further comprising providing at least an image including any under voted voting selection, any over voted voting selection or any under voted voting selection and any over voted voting selection for separate processing.

51. The method of claim 47 wherein two or more of the mark spaces and a write-in voting selection space are associated with a contest, the method comprising:

determining whether a write-in selection space has been marked; and

if a write in voting selection space has been marked, providing at least an image including the write-in voting selection for separate processing.

52. The method of claim 51 wherein the separate processing comprises:

storing the images of write-in voting selections; and

displaying the stored image of a write-in voting selection, accumulated stored images of a plurality of write-in voting selections or both.

53. The method of claim 51 wherein the separate processing comprises:

determining the characters of the write-in voting selection by optical character recognition; and

displaying the determined characters of the write-in voting selection, an image of a write-in voting selection or both.

54. The method of claim 51 wherein each contest has a given number of voting selections that may be made therein, the method comprising:

counting the number of voting selections made for the contest including mark spaces and write-in voting selection spaces that are determined to be marked as a voting selection;

comparing the number of voting selections marked to the given number of voting selections; and

if the number of voting selections marked equals the given number, then said counting each determined voting selection,

if the number of voting selections marked is less than the given number, then providing an indication of an under vote, and

if the number of voting selections marked exceeds the given number, then providing an indication of an over vote and not performing said counting each determined voting selection.

55. The method of claim 47 wherein said determining from the counts of light and dark pixels for each reading region whether the mark space therein is marked as a voting selection comprises:

(a) comparing the relative numbers of light and dark pixels to a first predetermined value to determine whether the mark space is marked as a voting selection;

the method further comprising:

(b) comparing the relative numbers of light and dark pixels to a second predetermined value that is higher or lower than the first predetermined value to determine whether the mark space is marked as a voting selection; and

(c) providing an indication of the difference, if any, in the determinations of step (a) and step (b).

56. The method of claim **55** wherein each ballot has a corresponding unique ballot identifier, and wherein said providing an indication includes providing the unique ballot identifier.

57. The method of claim **47** further comprising, prior to said counting each determined marked voting selection, determining from the counts of light and dark pixels for each reading region whether at least the outlines of all mark spaces are present in the image of the ballot.

58. The method of claim **57** further comprising separating the ballot for separate processing if at least the outlines of all mark spaces are not present in the image of the ballot.

59. The method of claim **47** wherein each ballot has a ballot identifier thereon or has two or more fiducial marks thereon or has a ballot identifier and two or more fiducial marks thereon, further comprising, prior to said counting each determined marked voting selection:

defining for each ballot one or more second reading regions each including one or more of the ballot identifier and fiducial marks;

counting the number of light pixels and dark pixels for each second reading region;

determining from the counts of light and dark pixels for each reading region and for each second reading region whether at least the outlines of all mark spaces and all of the ballot identifier and fiducial marks are present in the image of the ballot.

60. The method of claim **59** further comprising separating the ballot for separate processing if at least the outlines of all mark spaces are not present in the image of the ballot or if all of the ballot identifier and the fiducial marks are not present in the image of the ballot.

61. A method for reading a ballot having a plurality of mark spaces thereon in which voting selections may be marked, the method comprising:

defining first and second predetermined values related to counts of light pixels and dark pixels for a mark space being considered marked as a voting selection, wherein the second predetermined value is greater than or less than the first predetermined value;

imaging the ballot having a plurality of mark spaces thereon wherein the image is in a format including a plurality of pixels;

defining for each ballot a plurality of reading regions each including the outline of one mark space;

counting the number of light pixels and dark pixels for each reading region;

determining from the counts of light and dark pixels for each reading region and the first predetermined value whether the mark space therein is marked as a voting selection;

determining from the counts of light and dark pixels for each reading region and the second predetermined value whether the mark space therein is marked as a voting selection;

identifying each ballot wherein the determination of a marked voting selection based on the first predetermined value differs from the determination of a marked voting selection based on the second predetermined value.

62. A method for reading ballots comprising:

transporting the ballots on a reader transport path wherein the reader is located at a place accessible to a voter before the voter submits the ballot;

reading each ballot transported on said transport path including reading fiducial marks and a jurisdiction identifier thereof for selecting a template and reading voting selections marked on the ballot;

displaying the voting selections marked on each ballot in accordance with the selected template, but not recording or storing the voting selections; and

thereafter, submitting the ballot for counting,

whereby the voting selections marked on the ballot are read and displayed in accordance with the template for review by a voter prior to submitting the ballot for counting.

63. A method for reading a ballot having one or more contest regions and a plurality of mark spaces thereon in which voting selections may be marked for one or more contests, each mark space being defined by an outline thereof and having a machine-readable ballot identifier or fiducial marks or both a machine-readable ballot identifier and fiducial marks thereon, the method comprising:

imaging the ballot having one or more contest regions wherein the image of the ballot includes all of the mark spaces thereon for the contest regions thereon and is in a pixelated or bitmapped format including a plurality of pixels;

defining for each ballot a plurality of first reading regions each including the outline of one mark space and one or more second reading regions each including one of the ballot identifier or a fiducial mark;

processing the image of the ballot for decoding from the image of the ballot the plurality of first reading regions including the outline of one mark space;

counting at least the number of dark pixels for each of the first and second reading regions;

determining from the counts of dark pixels for each of the first and second reading regions whether at least the outlines of all mark spaces are present in the image of the ballot and whether the ballot identifier or fiducial marks or both are present in the image of the ballot; and

if the outlines of all mark spaces and all of the ballot identifier or fiducial marks or both are present in the image of the ballot, then counting each determined marked voting selection.

64. A method for reading a ballot having one or more contest regions and a plurality of mark spaces thereon in which voting selections may be marked for one or more contests, each mark space being defined by an outline thereof, the method comprising:

imaging a ballot having one or more contest regions wherein the image of that ballot includes all of the mark spaces thereon for the contest regions thereon and is in a pixelated or bitmapped format including a plurality of pixels;

defining for that ballot a plurality of reading regions each including the outline of one mark space, whereby the number of mark spaces that should be on that ballot is defined;

processing the image of that ballot for decoding from the image of that ballot the plurality of reading regions including the outline of one mark space;

counting at least the number of dark pixels for each of the reading regions;

determining from the counts of dark pixels for each of the reading regions whether at least the outlines of all mark spaces that should be on that ballot are in the image of that ballot; and

if the outlines of all mark spaces that should be on that ballot are in the image of that ballot, then processing the image of that ballot for counting each mark space determined from the count of dark pixels to be a marked voting selection,

whereby the ballot is counted only if all of the mark spaces that should be on the ballot are determined to be in the image of that ballot.

65. The method of claim **64** further comprising, if the outlines of all mark spaces for all of the contest regions that should be on that ballot are not in the image of that ballot, then separating that ballot for separate processing.

66. A method for reading a ballot having one or more contest regions and a plurality of mark spaces thereon in which voting selections may be marked for one or more contests, each mark space being defined by an outline thereof, and having a machine-readable ballot identifier and optionally having fiducial marks thereon, the method comprising:

imaging a ballot wherein the image of that ballot includes all of the mark spaces thereon for the contest regions that are on that ballot as imaged, and wherein the image of the ballot is in a pixelated or bitmapped format including a plurality of pixels;

processing the image of that ballot for decoding from the image of that ballot the ballot identifier thereon;

defining for that ballot a plurality of first reading regions each including the outline of one mark space and one or more second reading regions including a fiducial marks, if any, whereby the number of mark spaces that should be on the ballot and the number of fiducial marks, if any, that should be on that ballot are defined;

processing the image of that ballot for decoding from the image of that ballot the plurality of first reading regions thereon including the outline of the one mark space thereof and for decoding from the image of that ballot the fiducial marks, if any, thereon;

counting at least the number of dark pixels for each of the first and second reading regions;

determining from the counts of dark pixels for each of the first and second reading regions whether at least the outlines of all mark spaces for all contest regions that should be on that ballot are in the image of that ballot and whether the fiducial marks, if any, that should be on that ballot are in the image of that ballot;

if the outlines of all mark spaces for all of the contest regions are in the image of that ballot, and if the fiducial marks, if any, that should be on that ballot are in the image of that ballot, then counting each determined marked voting selection for that ballot,

whereby the ballot is counted only if all of the mark spaces that should be on that ballot are determined to be in the image of that ballot.

67. The method of claim **66** further comprising, if the outlines of all mark spaces for all of the contest regions are not in the image of that ballot, or if the fiducial marks, if any, are not in the image of that ballot, then separating that ballot for separate processing.

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