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(54) METHODS AND APPARATUS FOR CONTROLLING ACCESS TO A VIRTUAL WHITE LINE (VWL) IMAGE FOR AN EXCAVATION PROJECT

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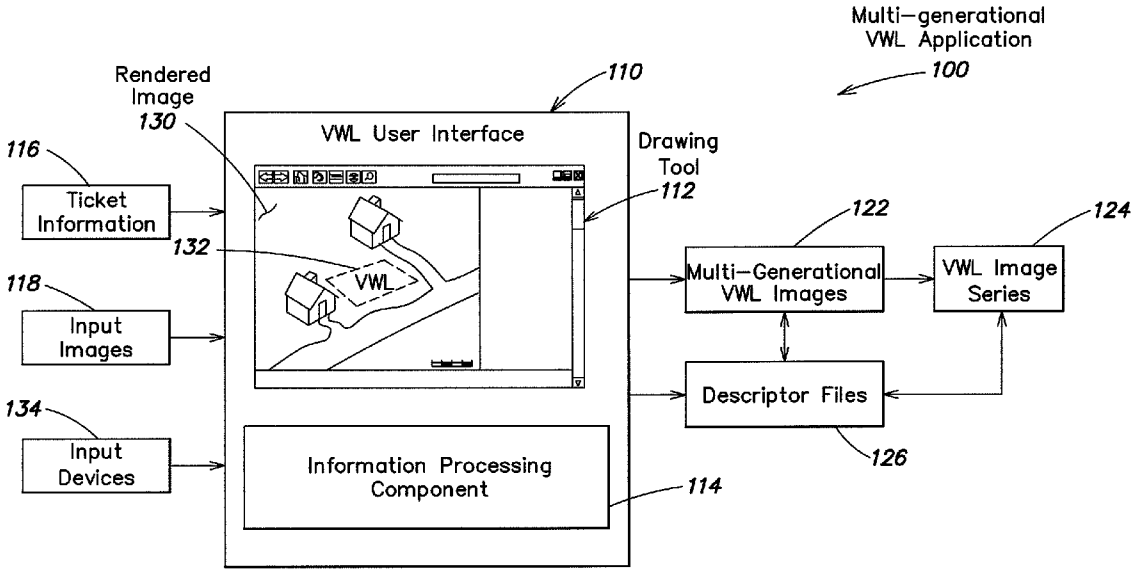
(57) **ABSTRACT**

Methods and apparatus for facilitating detection of a presence or an absence of at least one underground facility within a dig area. Source data representing one or more input images of a geographic area including the dig area is electronically received at a first user location, which may be remote from the dig area. The source data is processed so as to display at least a portion of the input image(s) on a display device. One or more indicators are added to the displayed input image(s), via a user input device associated with the display device, to provide at least one indication of the dig area and thereby generate a marked-up digital image. A limited access file comprising information relating to the marked-up image may be transmitted to at least one party associated with the at least one underground facility.



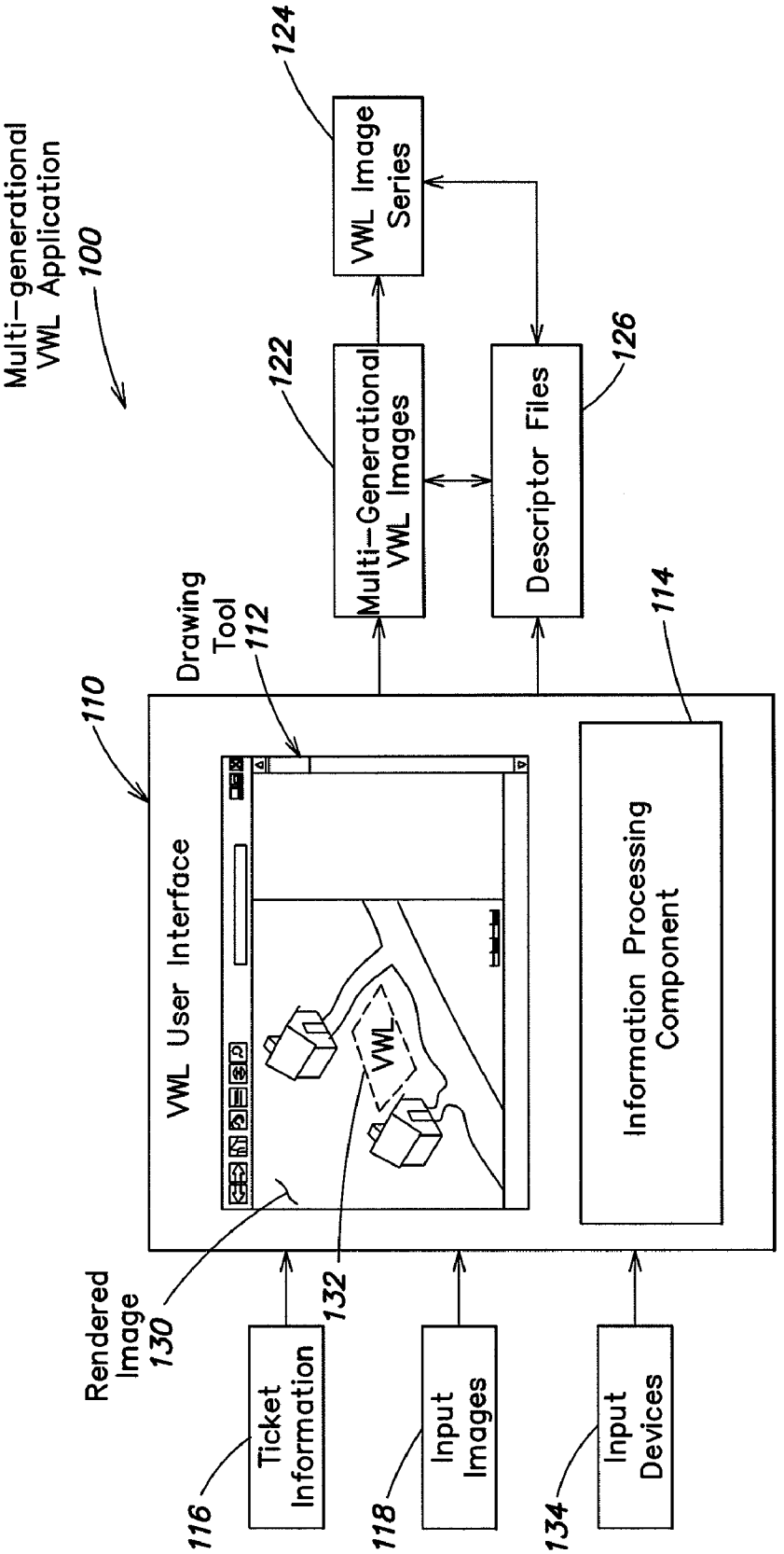

Multi-generational VWL Application
100
VWL Image Series
124
Multi-Generational VWL Images
122
Descriptor Files
126
Drawing Tool
112
110
VWL User Interface
VWL
Information Processing Component
114
Rendered Image
130
132
Ticket Information
116
Input Images
118
Input Devices
134

FIG. 1

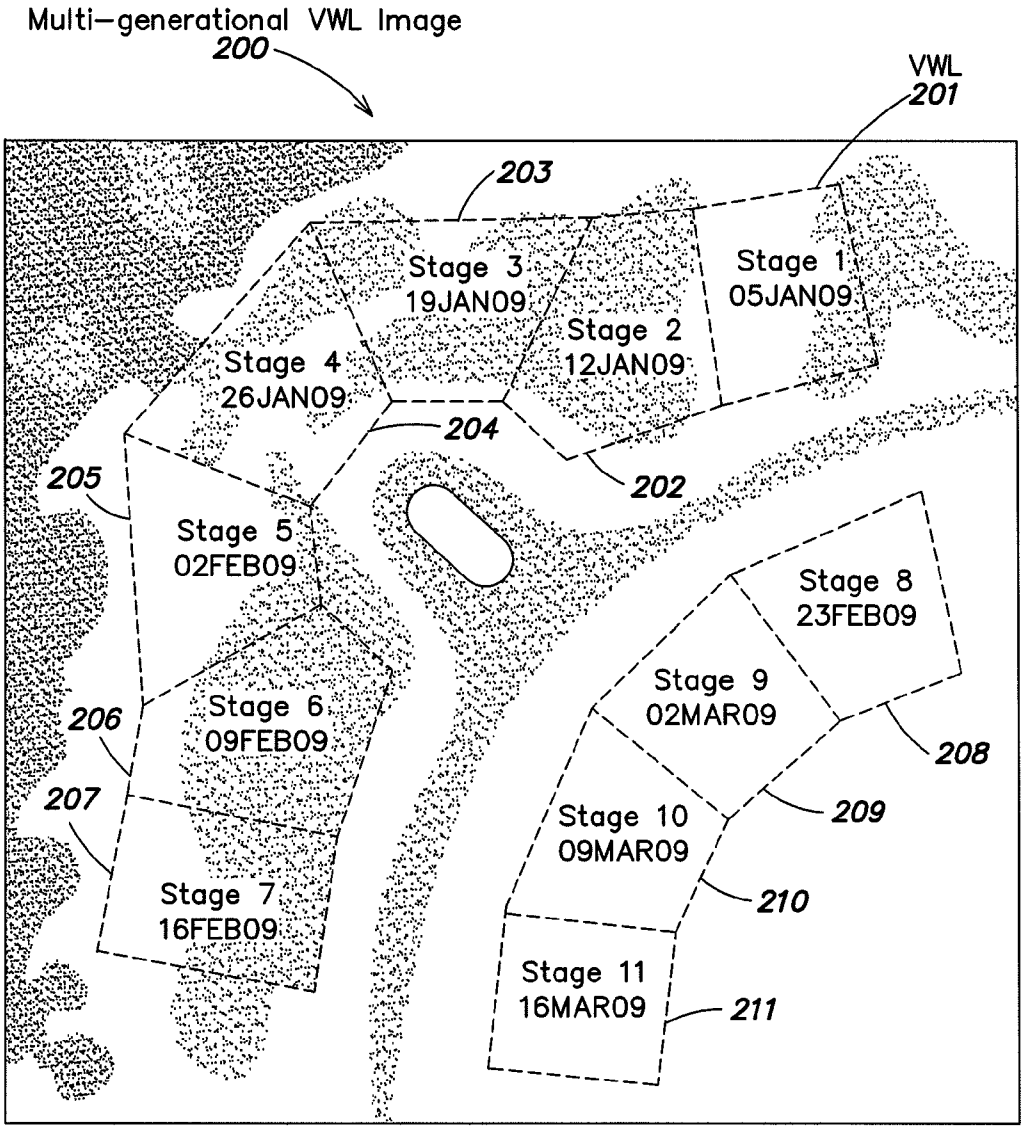

Multi–generational VWL Image
200
VWL
201
203
Stage 3
19JAN09
Stage 1
05JAN09
Stage 2
12JAN09
Stage 4
26JAN09
204
202
205
Stage 5
02FEB09
Stage 8
23FEB09
Stage 9
02MAR09
206
Stage 6
09FEB09
208
207
209
Stage 10
09MAR09
210
Stage 7
16FEB09
Stage 11
16MAR09
211

FIG. 2

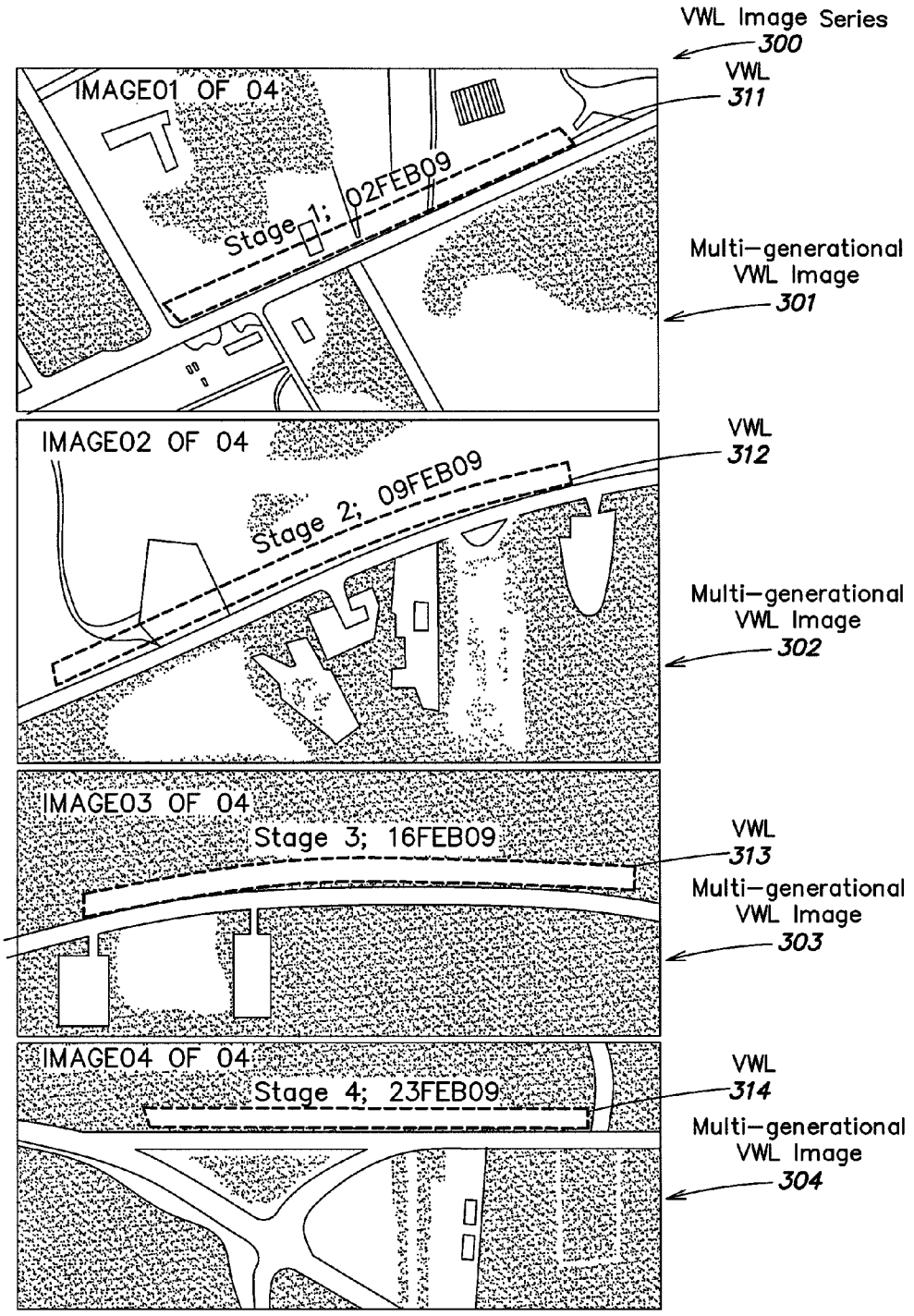

VWL Image Series
300
IMAGE01 OF 04
Stage 1; 02FEB09
VWL
311
Multi-generational
VWL Image
301
IMAGE02 OF 04
Stage 2; 09FEB09
VWL
312
Multi-generational
VWL Image
302
IMAGE03 OF 04
Stage 3; 16FEB09
VWL
313
Multi-generational
VWL Image
303
IMAGE04 OF 04
Stage 4; 23FEB09
VWL
314
Multi-generational
VWL Image
304

FIG. 3

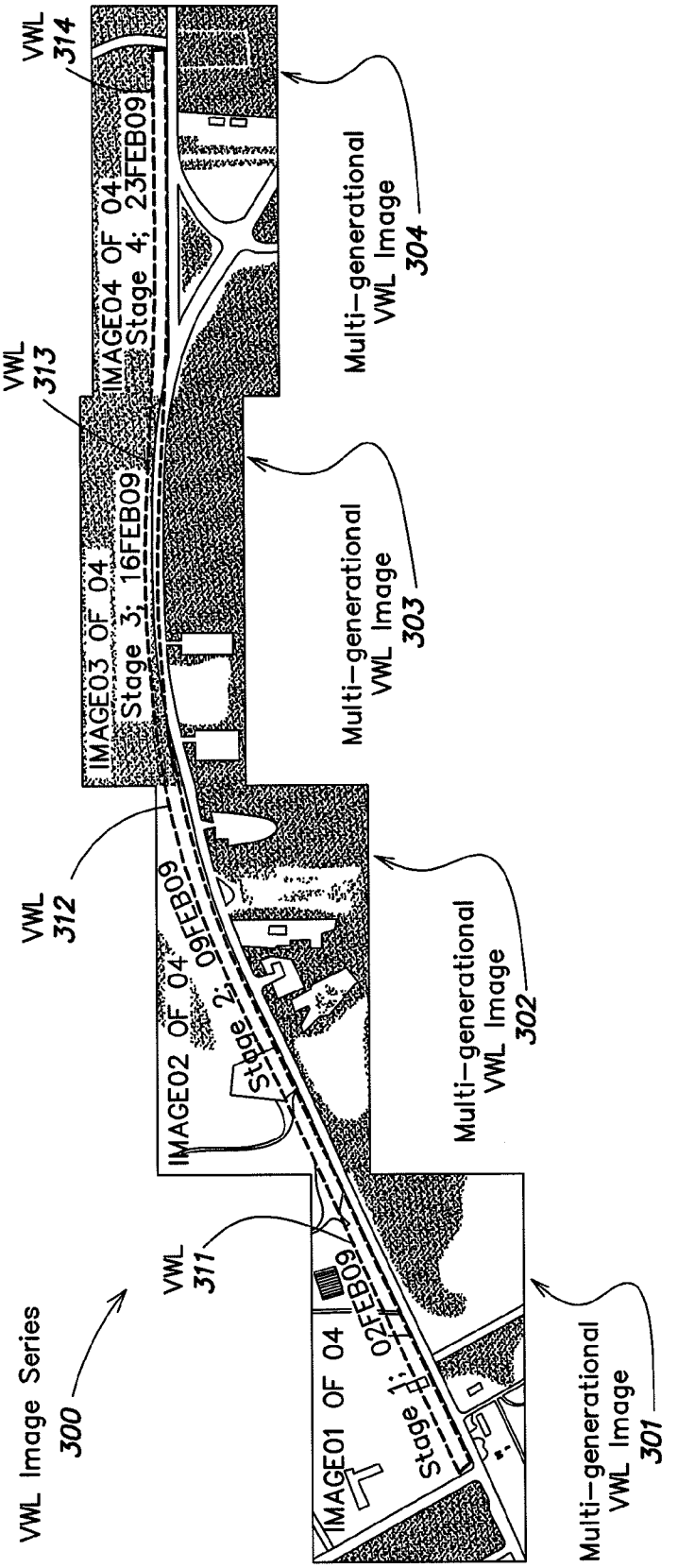

VWL Image Series
300
VWL
311
VWL
312
VWL
313
VWL
314
IMAGE01 OF 04
Stage 1; 02FEB09
IMAGE02 OF 04
Stage 2; 09FEB09
IMAGE03 OF 04
Stage 3; 16FEB09
IMAGE04 OF 04
Stage 4; 23FEB09
Multi-generational VWL Image
301
Multi-generational VWL Image
302
Multi-generational VWL Image
303
Multi-generational VWL Image
304

FIG. 4

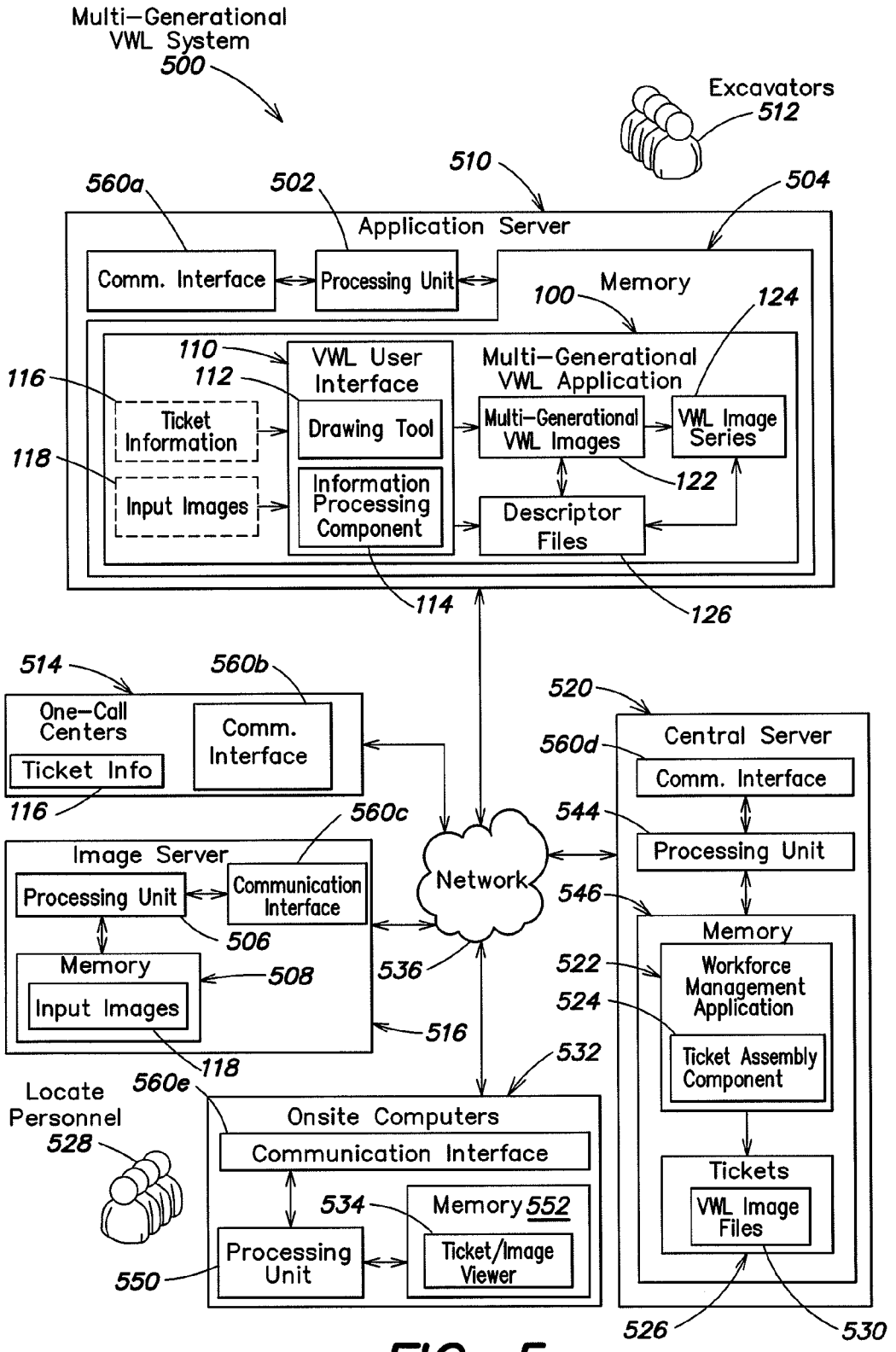

Multi-Generational VWL System
500
Excavators
512
510
560a
502
504
Application Server
Comm. Interface
Processing Unit
Memory
100
124
110
VWL User Interface
Multi-Generational VWL Application
116
112
Ticket Information
Drawing Tool
Multi-Generational VWL Images
VWL Image Series
118
Input Images
Information Processing Component
122
Descriptor Files
114
126
514
560b
520
One-Call Centers
Comm. Interface
Central Server
560d
Ticket Info
116
Comm. Interface
544
560c
Processing Unit
Image Server
Network
Processing Unit
Communication Interface
546
506
Memory
522
Workforce Management Application
Memory
508
524
Input Images
Ticket Assembly Component
536
516
532
118
Tickets
560e
Locate Personnel
528
Onsite Computers
VWL Image Files
Communication Interface
534
Memory 552
Processing Unit
Ticket/Image Viewer
550
526
530

FIG. 5

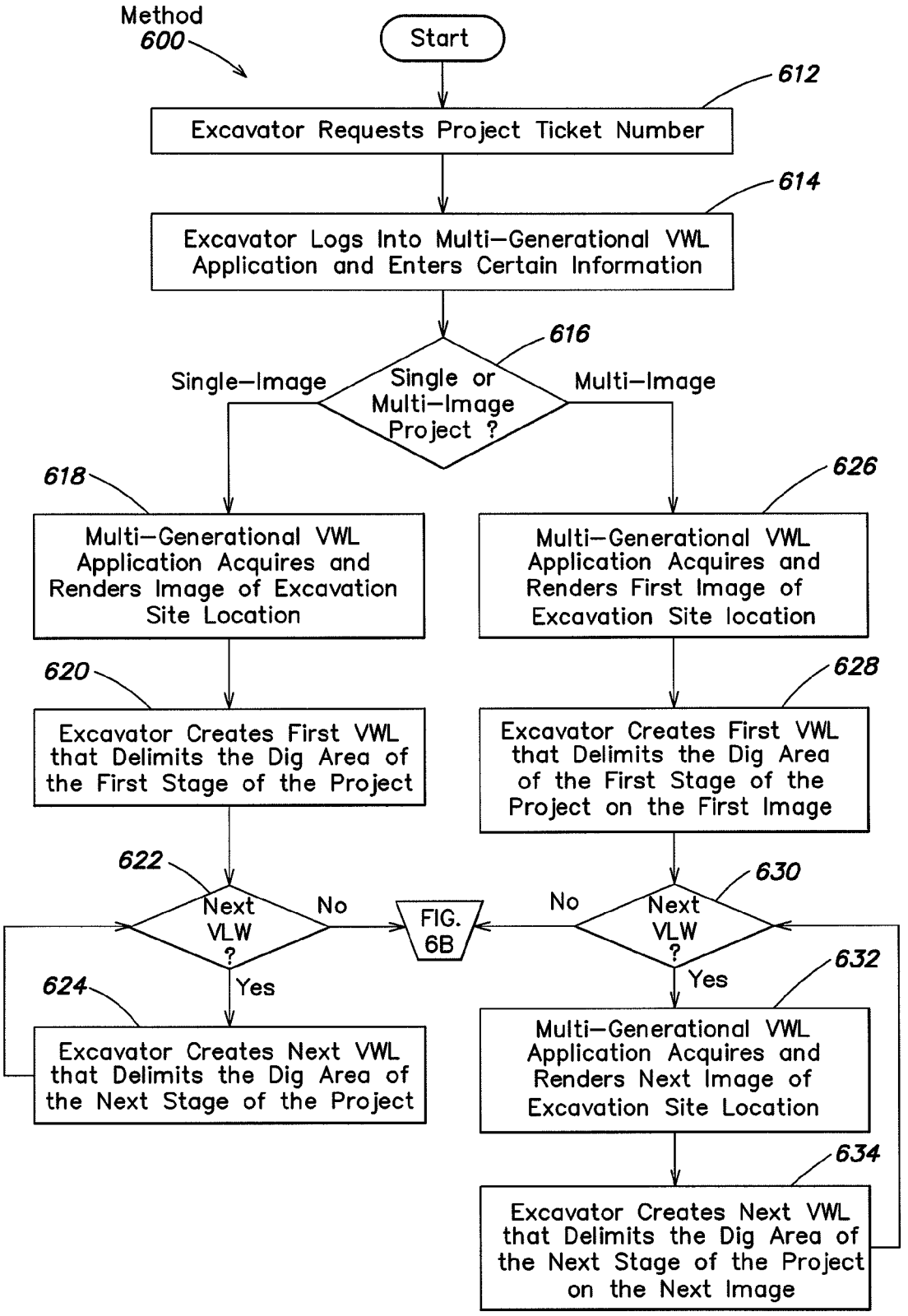

Method
600
Start
612
Excavator Requests Project Ticket Number
614
Excavator Logs Into Multi-Generational VWL Application and Enters Certain Information
616
Single or Multi-Image Project ?
Single-Image
Multi-Image
618
Multi-Generational VWL Application Acquires and Renders Image of Excavation Site Location
626
Multi-Generational VWL Application Acquires and Renders First Image of Excavation Site location
620
Excavator Creates First VWL that Delimits the Dig Area of the First Stage of the Project
628
Excavator Creates First VWL that Delimits the Dig Area of the First Stage of the Project on the First Image
622
Next VLW ?
No
FIG. 6B
630
Next VLW ?
No
Yes
624
Excavator Creates Next VWL that Delimits the Dig Area of the Next Stage of the Project
Yes
632
Multi-Generational VWL Application Acquires and Renders Next Image of Excavation Site Location
634
Excavator Creates Next VWL that Delimits the Dig Area of the Next Stage of the Project on the Next Image

FIG. 6A

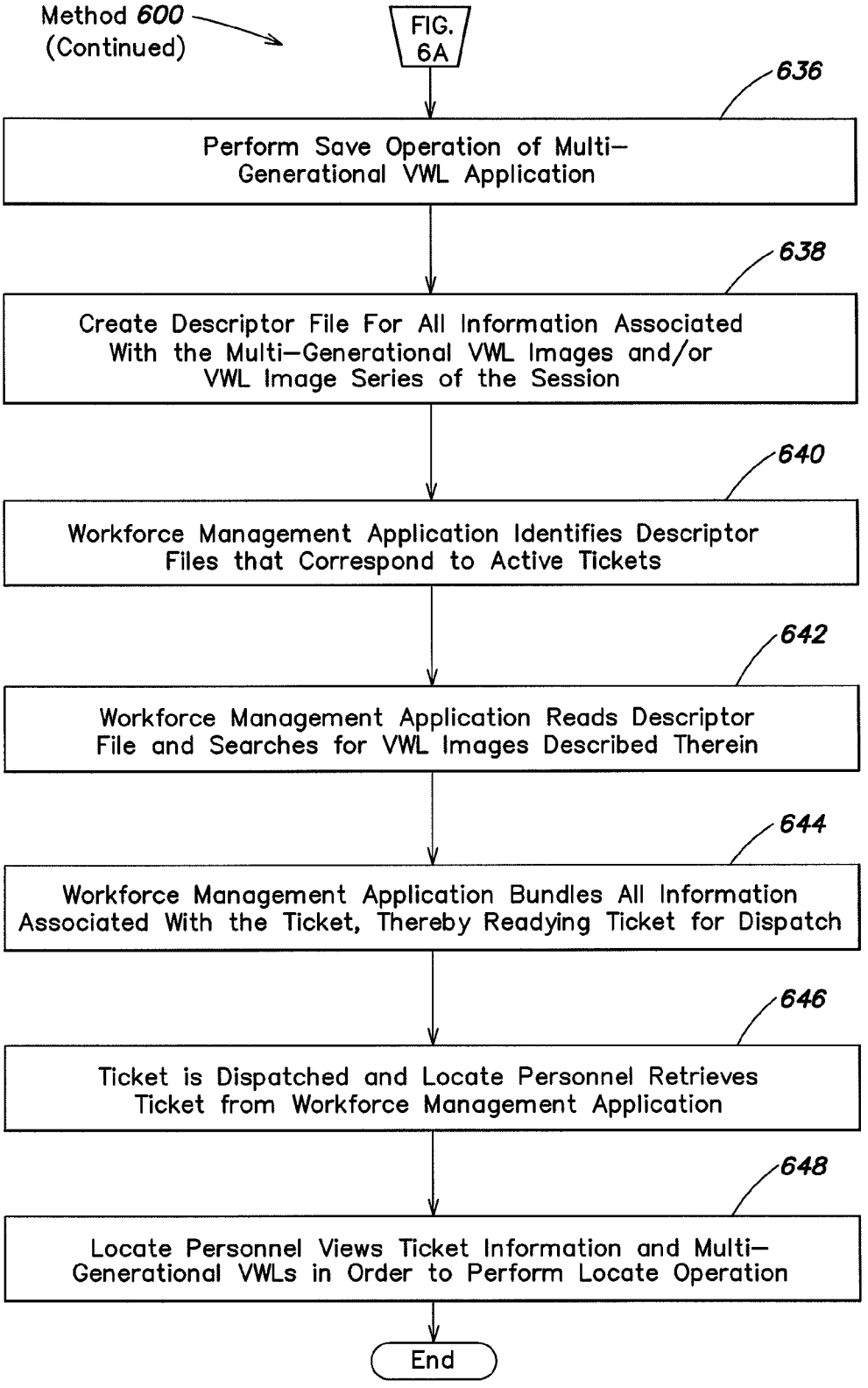

Method 600
(Continued)
FIG. 6A
636
Perform Save Operation of Multi-Generational VWL Application
638
Create Descriptor File For All Information Associated With the Multi-Generational VWL Images and/or VWL Image Series of the Session
640
Workforce Management Application Identifies Descriptor Files that Correspond to Active Tickets
642
Workforce Management Application Reads Descriptor File and Searches for VWL Images Described Therein
644
Workforce Management Application Bundles All Information Associated With the Ticket, Thereby Readying Ticket for Dispatch
646
Ticket is Dispatched and Locate Personnel Retrieves Ticket from Workforce Management Application
648
Locate Personnel Views Ticket Information and Multi-Generational VWLs in Order to Perform Locate Operation
End

FIG. 6B

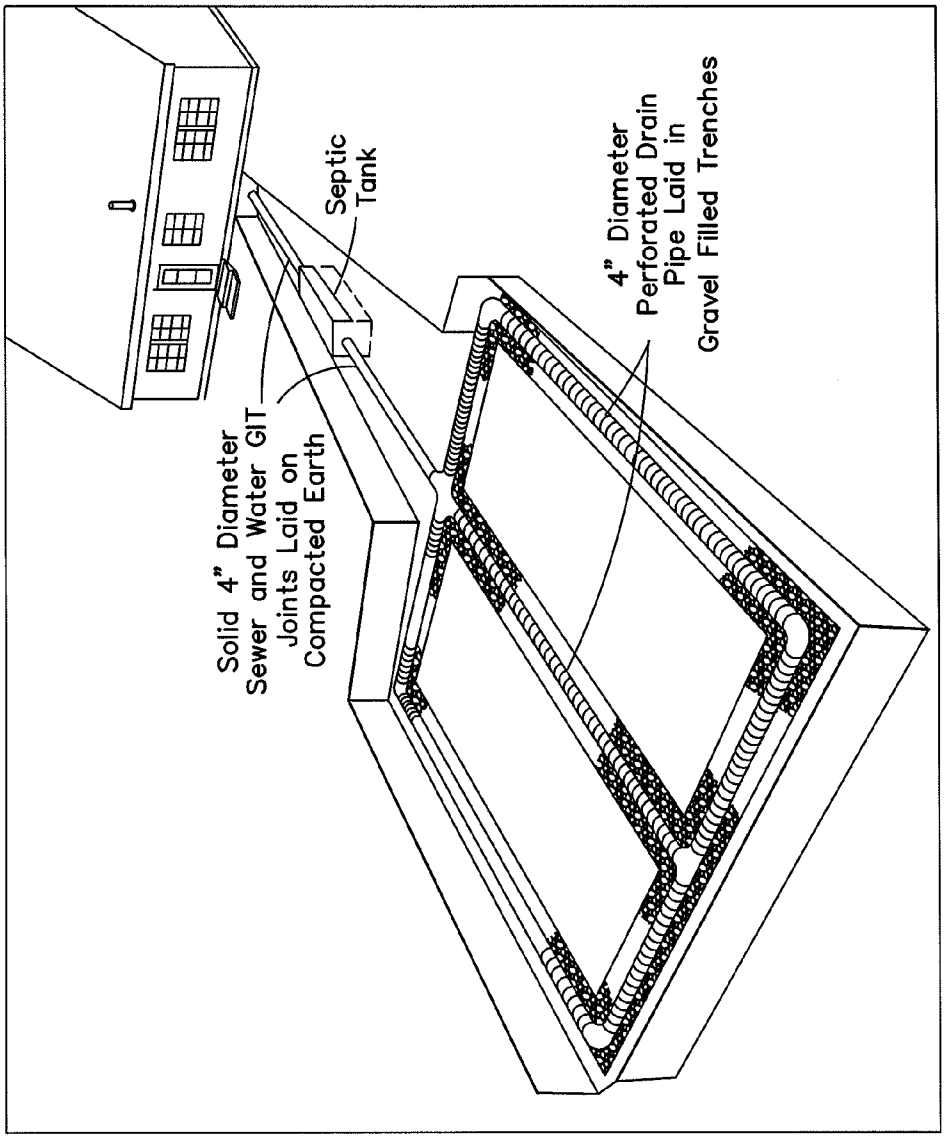

Septic Tank
4" Diameter Perforated Drain Pipe Laid in Gravel Filled Trenches
Solid 4" Diameter Sewer and Water GIT Joints Laid on Compacted Earth
700

FIG. 7

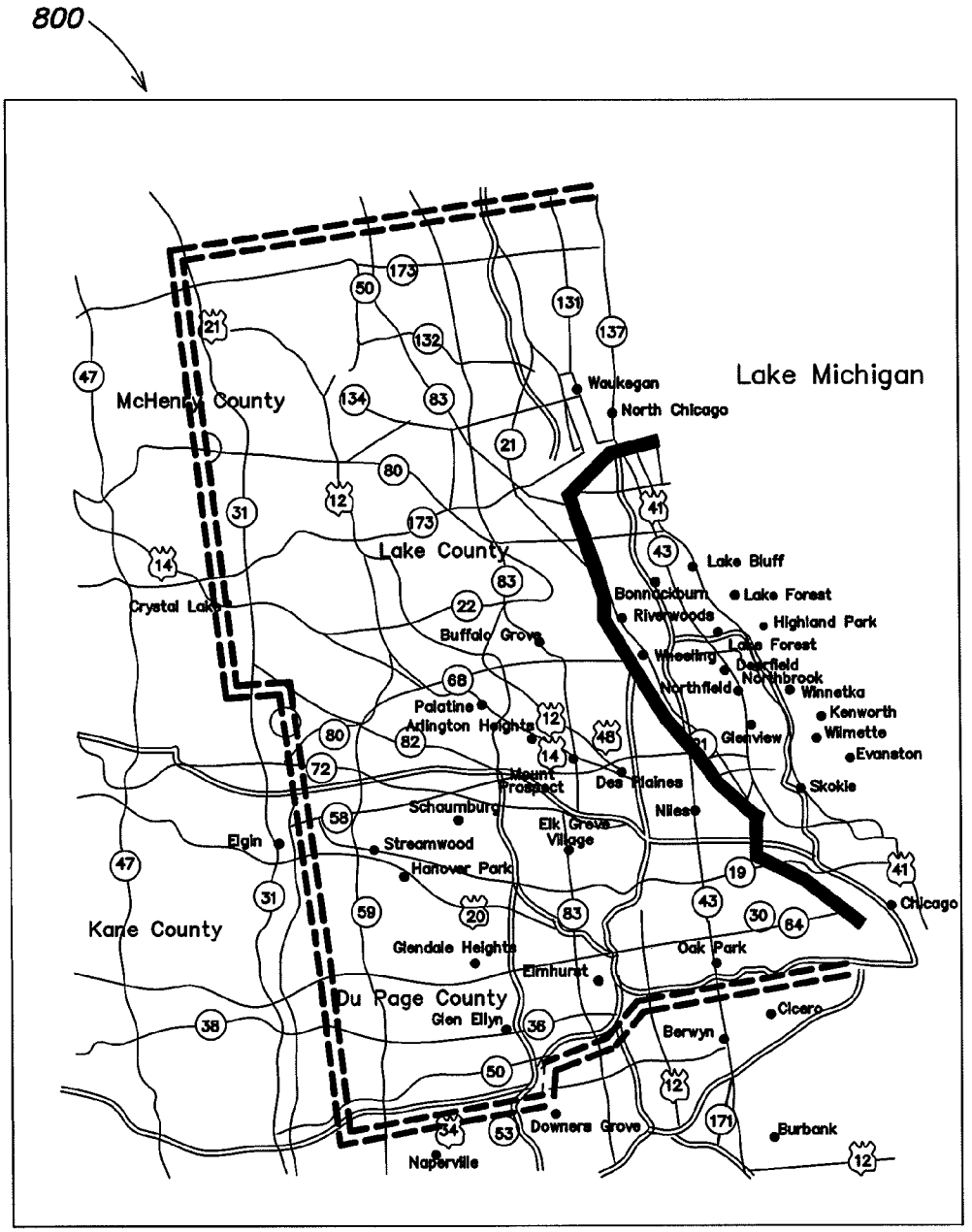

800
Lake Michigan
McHenry County
Lake County
Kane County
Du Page County
Waukegan
North Chicago
Lake Bluff
Lake Forest
Highland Park
Wheeling
Deerfield
Northbrook
Northfield
Winnetka
Kenworth
Wilmette
Evanston
Skokie
Glenview
Des Plaines
Niles
Mount Prospect
Elk Grove Village
Schaumburg
Palatine
Arlington Heights
Buffalo Grove
Crystal Lake
Elgin
Streamwood
Hanover Park
Glendale Heights
Elmhurst
Oak Park
Glen Ellyn
Berwyn
Cicero
Downers Grove
Naperville
Burbank
Chicago

FIG. 8

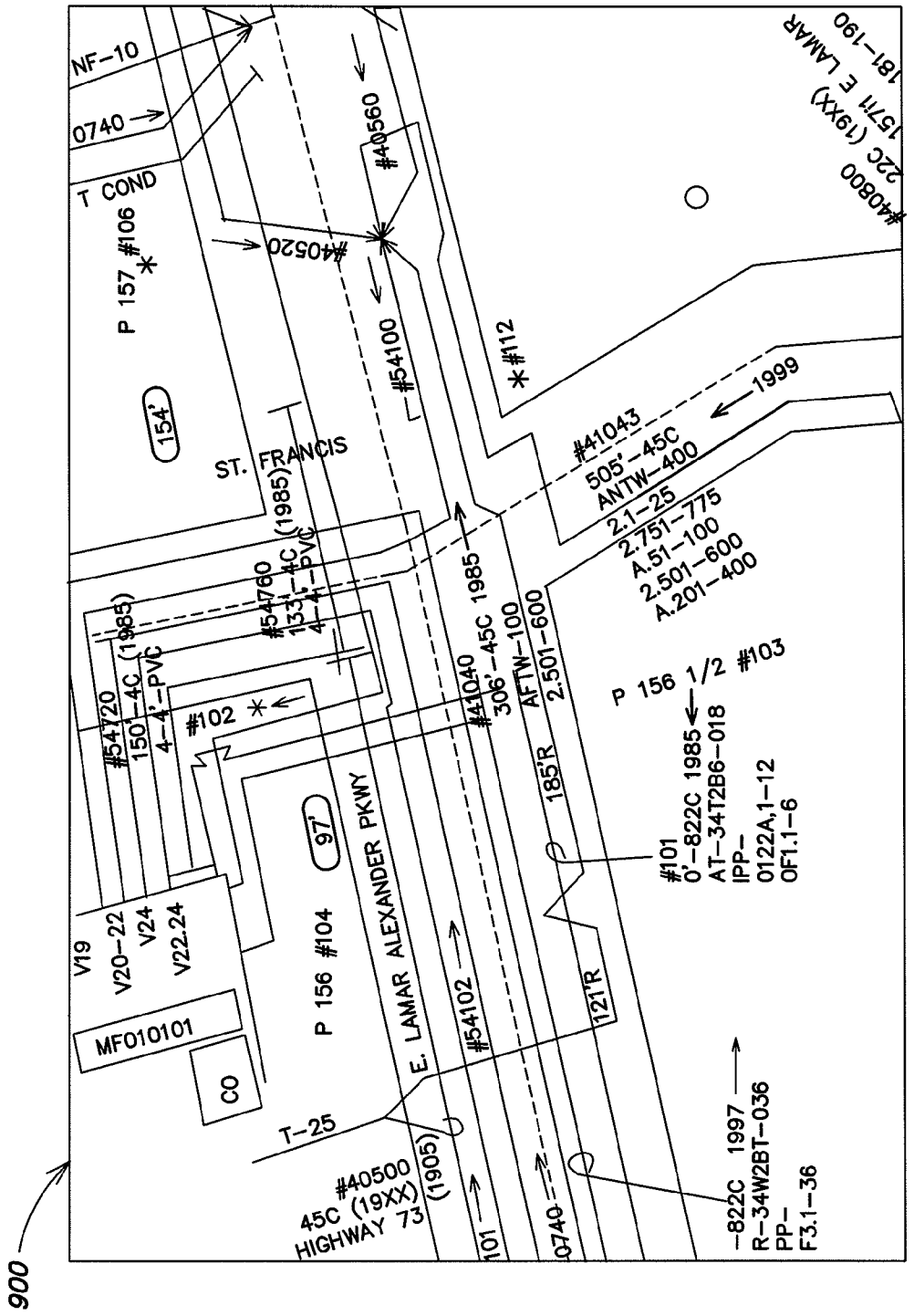

900
NF-10
0740
T COND
P 157 #106
#40560
#40520
#54100
#112
#40800
22C (19XX)
157\ E LAMAR
181-190
154'
ST. FRANCIS
#54760
133'-4C (1985)
4-4"-PVC
#54720
150'-4C (1985)
4-4'-PVC
#102
#41040
306'-45C 1985
AFTW-100
2.501-600
#41043
505'-45C
ANTW-400
2.1-25
2.751-775
A.51-100
2.501-600
A.201-400
1999
P 156 1/2 #103
185'R
#101
0'-822C 1985
AT-34T2B6-018
IPP-
0122A,1-12
OF1.1-6
V19
V20-22
V24
V22.24
MF010101
CO
P 156 #104
97'
E. LAMAR ALEXANDER PKWY
#54102
121'R
T-25
#40500
45C (19XX)
HIGHWAY 73
(1905)
101
0740
-822C 1997
R-34W2BT-036
PP-
F3.1-36

FIG. 9

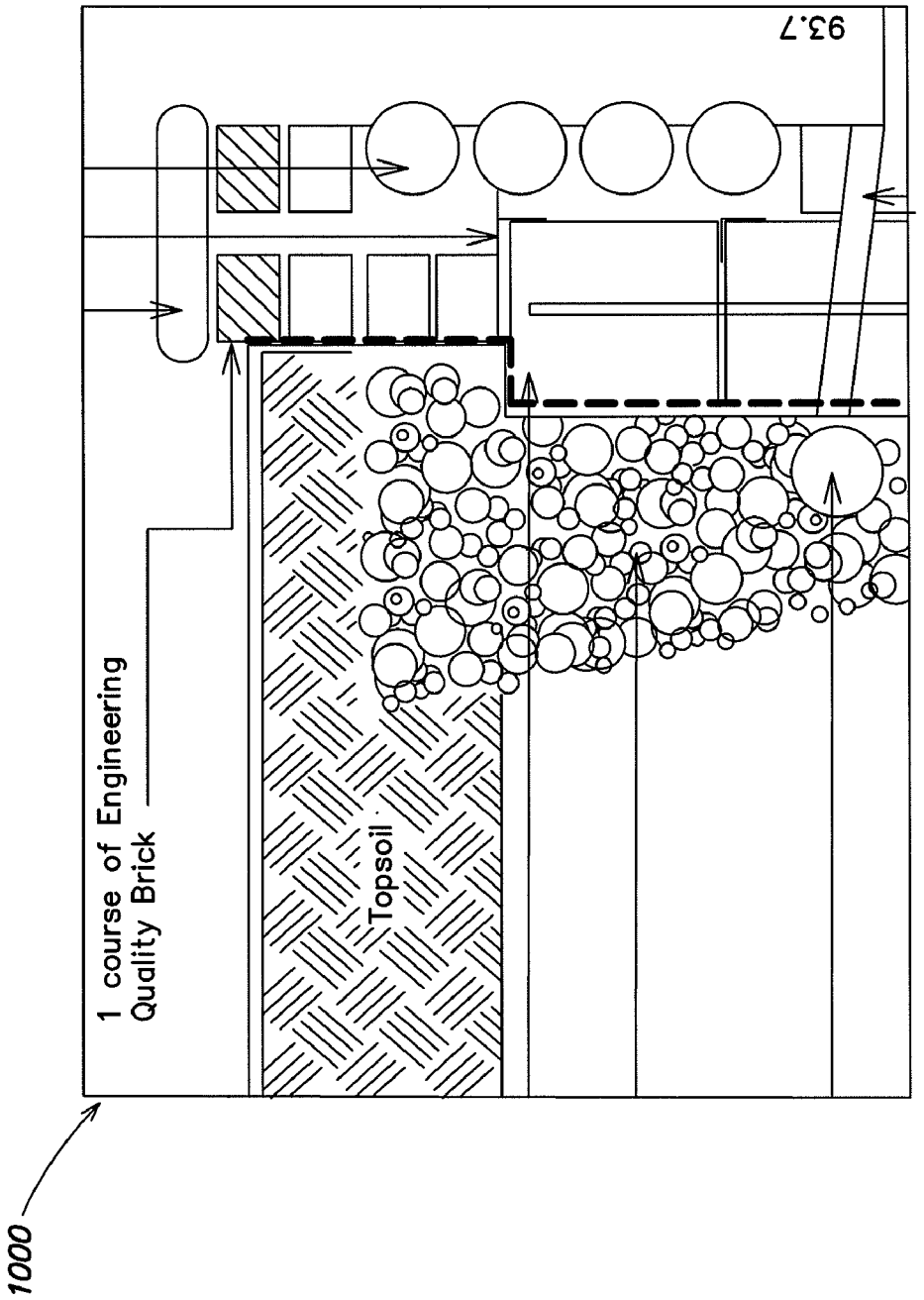


FIG. 10

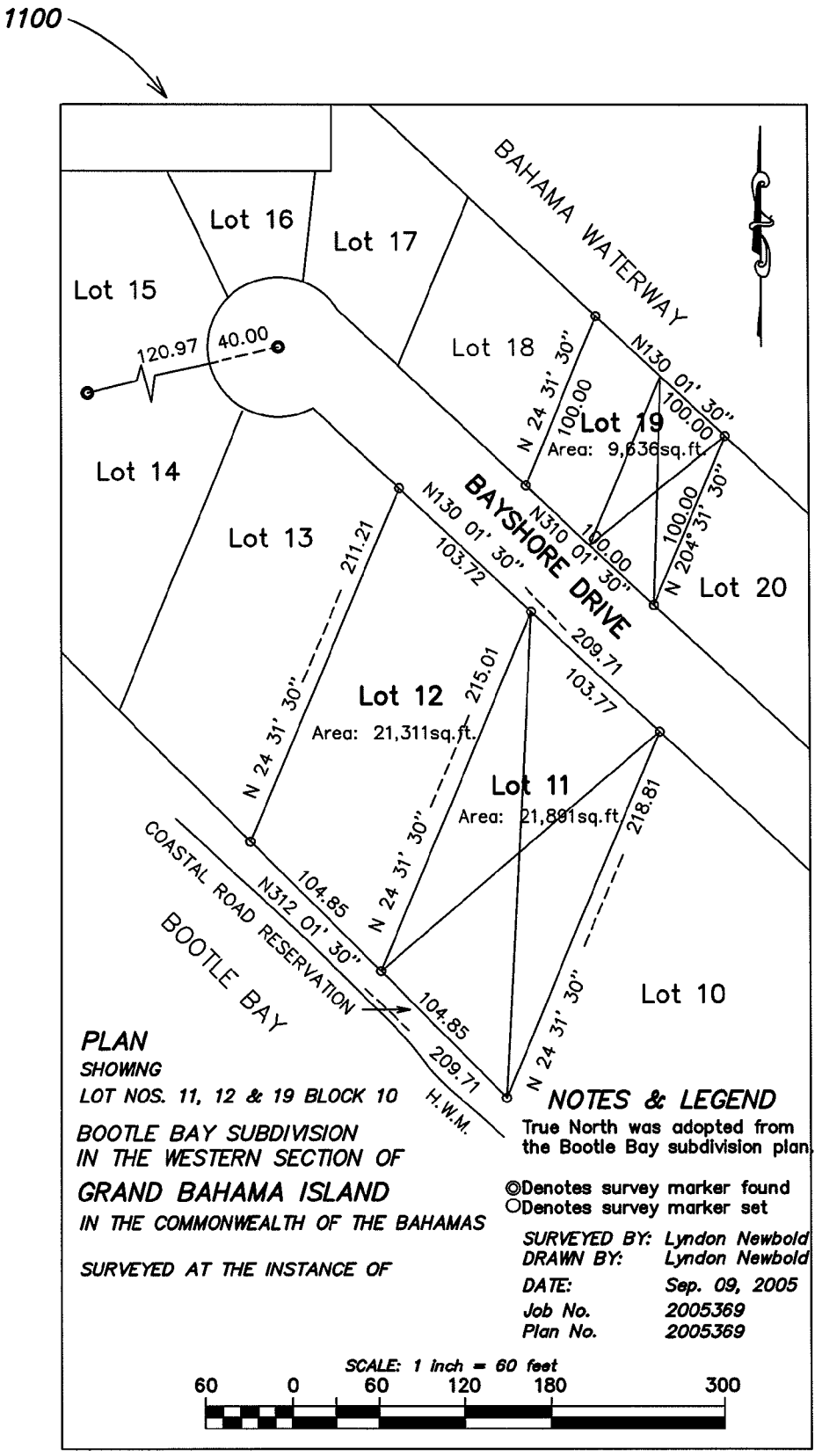

1100
BAHAMA WATERWAY
Lot 16
Lot 17
Lot 15
Lot 18
120.97
40.00
N130 01' 30"
N 24 31' 30"
100.00
Lot 19
Area: 9,636sq.ft.
Lot 14
BAYSHORE DRIVE
N310 01' 30"
N 204° 31' 30"
Lot 13
211.21
N130 01' 30"
103.72
Lot 20
209.71
103.77
Lot 12
Area: 21,311sq.ft.
215.01
N 24 31' 30"
Lot 11
Area: 21,881sq.ft.
218.81
COASTAL ROAD RESERVATION
N312 01' 30"
104.85
BOOTLE BAY
Lot 10
H.W.M.
PLAN
SHOWING
LOT NOS. 11, 12 & 19 BLOCK 10
BOOTLE BAY SUBDIVISION
IN THE WESTERN SECTION OF
GRAND BAHAMA ISLAND
IN THE COMMONWEALTH OF THE BAHAMAS
SURVEYED AT THE INSTANCE OF
NOTES & LEGEND
True North was adopted from the Bootle Bay subdivision plan.
◎Denotes survey marker found
○Denotes survey marker set
SURVEYED BY: Lyndon Newbold
DRAWN BY: Lyndon Newbold
DATE: Sep. 09, 2005
Job No. 2005369
Plan No. 2005369
SCALE: 1 inch = 60 feet
60 0 60 120 180 300

FIG. 11

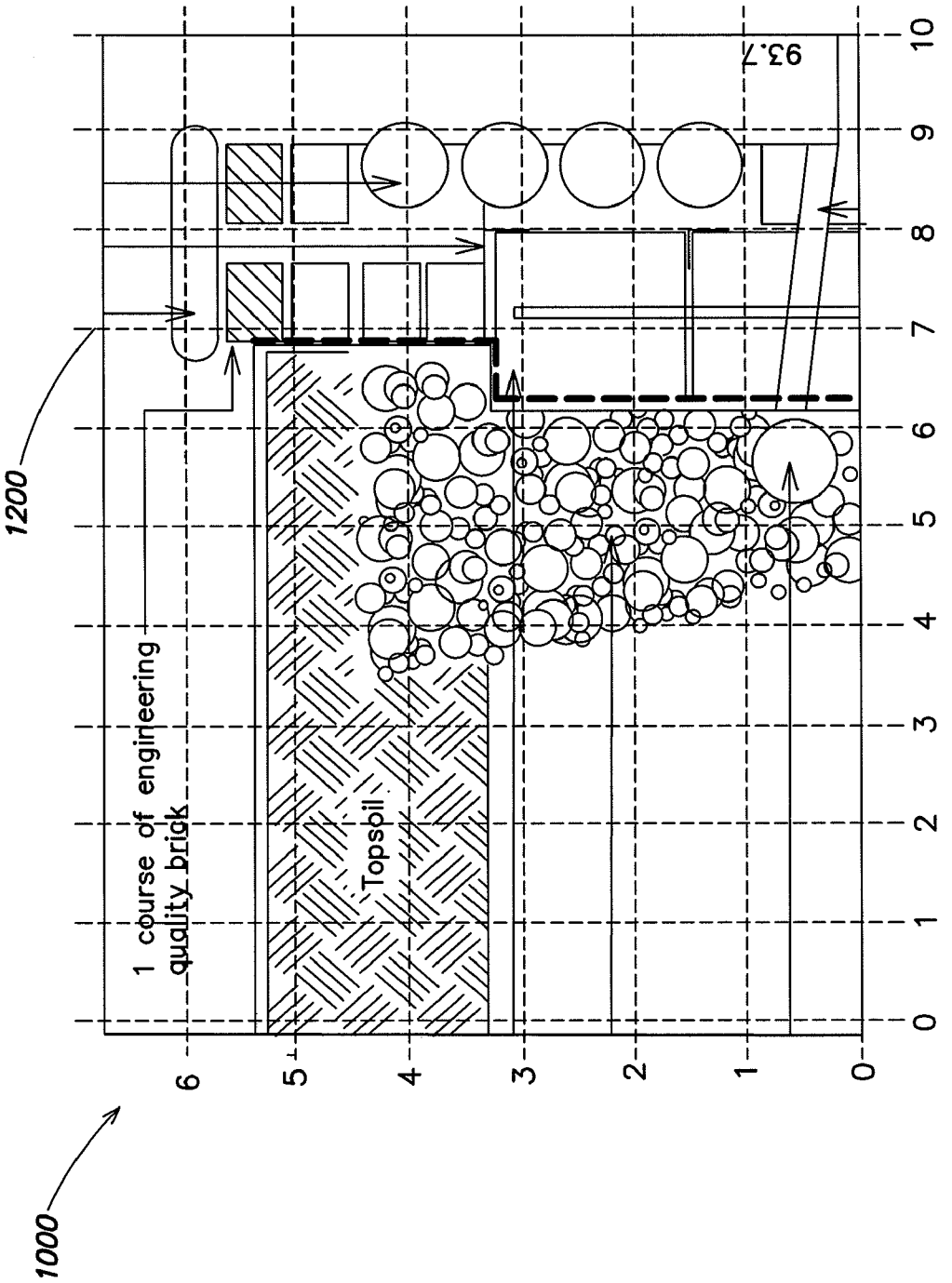

1000
1200
93.7
1 course of engineering quality brick
Topsoil
0
1
2
3
4
5
6
7
8
9
10

FIG. 12

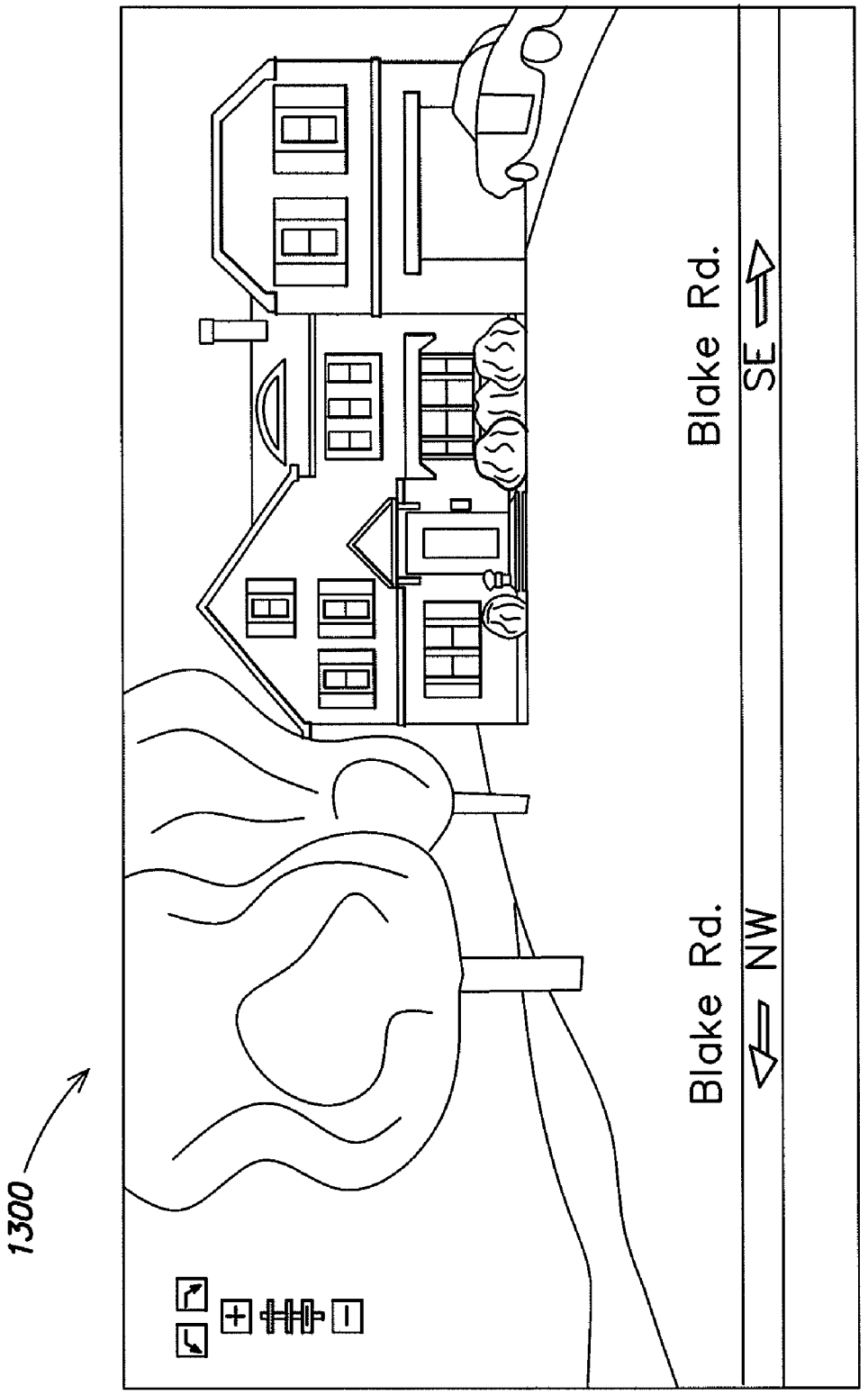


FIG. 13

METHODS AND APPARATUS FOR CONTROLLING ACCESS TO A VIRTUAL WHITE LINE (VWL) IMAGE FOR AN EXCAVATION PROJECT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit, under 35 U.S.C. §119(e), of U.S. Provisional Application Ser. No. 61/151,769, entitled "MULTI-GENERATIONAL VIRTUAL WHITE LINES (VWL) FOR DELIMITING PLANNED EXCAVATION SITES OF STAGED EXCAVATION PROJECTS," filed on Feb. 11, 2009, which is hereby incorporated herein by reference in its entirety.

BACKGROUND

[0002] Excavators are required to notify underground facility owners in advance of their excavation activities and to describe and communicate the geographic area of those activities to the underground facility owners. As a result, excavators may submit a work order (i.e., locate request or ticket) to, for example, a one-call center, which serves as notification to underground facility owners. A locate request (or ticket) may be any communication or instruction to perform a locate operation at a certain dig area, which is any specified geographic area within which excavation may occur. One call centers may receive locate requests from excavators via electronic delivery or verbally through a telephone conversation between the excavator and a human call center operator. Whether communicated electronically or verbally, excavators must describe the planned geographic locations of dig areas. This description may be ultimately reduced to text, which, along with other data about a locate request, is communicated to the appropriate locate service provider.

[0003] Textual descriptions of dig areas can be very imprecise as to exact physical locations. In addition, addresses which are provided may be unclear, indicating only cross streets and vague descriptions of the extent of the dig area. Therefore, when a locate request is submitted by an excavator, it may be beneficial for the excavator to supplement the locate request with a visit to the site of the dig area for the purpose of delimiting and/or otherwise indicating the particular geographic location of the proposed excavation. For example, marks may be used to physically delimit a dig area. These marks may consist of chalk or paint that is applied to the surface of the ground, and are generally known as "white lines." The delimited dig area indicates to a locate technician the extent of the boundaries where a locate operation is to be performed according to the locate request that was submitted by the excavator.

[0004] However, the use of these physical white lines to physically delimit the dig area may be limited. For example, these physical white lines provide only a temporary indication of the dig area, as the physical white lines may deteriorate or be eliminated over time by such events as precipitation, excessive pedestrian or vehicle traffic, erosion, the excavation process, or numerous other events. Therefore, a need exists for improved ways of delimiting and/or otherwise indicating the proposed excavation site in a more permanent and/or reproducible manner.

[0005] Further, certain excavation projects may be suitably large to require that locate operations be performed in multiple stages and/or phases over a period of time. In one example, an excavation project along several miles of a highway may be performed over several days, weeks, and/or months. In another example, an excavation project of a large residential or commercial subdivision again may be performed over several days, weeks, and/or months. The request for locate operations with respect to a multiple-stage excavation project that spans a period of time may be submitted via multiple individual tickets. Alternatively, this request for may be submitted under a single ticket, which is hereafter referred to as a "project ticket." The locate operations with respect to multiple-stage excavation projects must be coordinated between excavators and locate personnel, such as locate technicians. For example, throughout the multiple stages of the excavation project, there may be communication between excavators and locate technicians about the location of the respective subsections of the overall dig area to be located and about the timing of the respective locate operations. Further, at each stage of the project excavators may delimit and/or otherwise indicate the respective subsections of the overall dig area to be located using physical white lines.

[0006] Currently, with respect to multiple-stage excavation projects, the communication process between excavators and locate technicians may be poorly coordinated due to poor infrastructure and, therefore, the day-to-day activities of excavators and locate personnel may be poorly synchronized. As a result, there is a risk of locate operations occurring at the wrong subsections of the project dig area and/or at the wrong times. This leads to poor operating efficiencies and, perhaps, lost profit with respect to both excavation companies and locate companies. Furthermore, excavators may perform the planned excavation with a certain amount of uncertainty as to whether a certain locate operation of the project ticket is complete and with limited confidence that the certain locate operation of the project ticket has been performed satisfactorily. As a result, there is a certain amount of risk of damage to underground facilities.

[0007] Consequently, a need exists for improved synchronization between excavators and locate personnel with respect to multiple-stage excavation projects in order to better coordinate the day-to-day activities, thereby improving operating efficiency. Further, a need exists for improved communication mechanisms between excavators and locate personnel with respect to project tickets in order to improve efficiency; reduce uncertainty and, thereby, reduce the risk of damage to underground facilities; and improve information exchange for making better and more timely decisions with respect to allocating resources.

SUMMARY

[0008] Various embodiments of the present invention are directed to methods, apparatus and systems for creating an electronic record relating to a geographic area including one or more dig areas to be excavated or otherwise disturbed. As part of the electronic record, the dig areas are somehow identified with respect to its immediate surroundings in the geographic area. For example, to create such an electronic record, one or more input images relating to the geographic area including the dig areas may be utilized. For example, source data representing one or more input images of a geographic area including the dig area is received and/or processed so that the input image(s) may be displayed on a display device. At least one dig area is then indicated in some manner on the

displayed input image(s) so as to generate one or more marked-up images constituting at least a portion of the electronic record.

[0009] In some implementations of the inventive concepts disclosed herein, the electronic record may include a variety of non-image information, such as to facilitate identification of a dig area and/or provide information concerning a multi-stage excavation process. Such non-image information may include, for example, a text description of the dig area, an address or lot number of a property within which the dig area is located, geo-encoded information such as geographic coordinates relating to the dig area and/or various aspects of the geographic area surrounding the dig area, one or more ticket numbers, etc. The marked-up image(s) and the non-image information may be formatted in a variety of manners in the electronic record; for example, in one implementation the non-image information may be included as metadata associated with the marked-up image(s), while in other implementations the marked-up image(s) and the non-image information may be formatted as separate data sets. These separate data sets may be transmitted and/or stored separately, but may nonetheless be linked together in some manner as relating to a common electronic record.

[0010] One embodiment described herein is directed to a method for facilitating detection of a presence or an absence of at least one underground facility within a plurality of dig areas comprising a first dig area and at least one additional dig area, wherein at least a portion of the plurality of dig areas may be excavated or disturbed during excavation activities. The method comprises: A) electronically receiving source data representing at least one input image of a geographic area including the first dig area and the at least one additional dig area, wherein the first dig area corresponds to a first stage of an staged excavation project and the at least one additional dig area corresponds to at least one subsequent stage of the staged excavation project; B) processing the source data so as to display at least a portion of the at least one input image on a display device; C) adding, via at least one user input device associated with the display device, at least one first indicator to the displayed at least one input image to provide at least one indication of the first dig area and thereby generate a first generation marked-up digital image; D) adding, via the at least one user input device, at least one additional indicator to the first generation marked-up digital image to provide at least one indication of the at least one additional dig area and thereby generate a multi-generational marked-up digital image; and E) electronically transmitting and/or electronically storing information relating to the multi-generational marked-up digital image so as to facilitate the detection of the presence or the absence of the at least one underground facility within the plurality of dig areas.

[0011] Another embodiment is directed to at least one computer-readable medium encoded with instructions that, when executed by at least one processing unit, perform a method for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The method comprises: A) electronically receiving source data representing at least one input image of a geographic area including the first dig area and the at least one additional dig area, wherein the first dig area corresponds to a first stage of an staged excavation project and the at least one additional dig area corresponds to at least one subsequent stage of the staged excavation project; B) processing the source data so as to display at least a portion of the at least one input image on a display device; C) receiving at least one first user input via at least one user input device associated with the display device; D) adding, based on the at least one first user input, at least one first indicator to the displayed at least one input image to provide at least one indication of the first dig area and thereby generate a first generation marked-up digital image; E) receiving at least one second user input via the at least one user input device; F) adding, based on the at least one second user input, at least one additional indicator to the first generation marked-up digital image to provide at least one indication of the at least one additional dig area and thereby generate a multi-generational marked-up digital image; and G) electronically transmitting and/or electronically storing information relating to the multi-generational marked-up digital image so as to facilitate the detection of the presence or the absence of the at least one underground facility within the plurality of dig areas,

[0012] A further embodiment is directed to an apparatus for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The apparatus comprises: a communication interface; a display device; at least one user input device; a memory to store processor-executable instructions; and a processing unit coupled to the communication interface, the display device, the at least one user input device, and the memory, wherein upon execution of the processor-executable instructions by the processing unit. The processing unit: controls the communication interface to electronically receive source data representing at least one input image of a geographic area including the first dig area and the at least one additional dig area, wherein the first dig area corresponds to a first stage of an staged excavation project and the at least one additional dig area corresponds to at least one subsequent stage of the staged excavation project; controls the display device to display at least a portion of the at least one input image; acquires at least one first user input from the at least one user input device; generates a first generation marked-up digital image including at least one first indicator overlaid on the at least one input image to provide at least one indication of the first dig area; acquires at least one second user input from the at least one user input device; generates a multi-generational marked-up digital image including at least one additional indicator overlaid on the first generation marked-up digital image to provide at least one indication of the at least one additional dig area; and further controls the communication interface and/or the memory to electronically transmit and/or electronically store information relating to the multi-generational marked-up digital image so as to facilitate the detection of the presence or the absence of the at least one underground facility within the plurality of dig areas.

[0013] Another embodiment is directed to a method for facilitating detection of a presence or an absence of at least one underground facility within a plurality of dig areas comprising a first dig area and a second dig area, wherein at least a portion of the first and second dig areas may be excavated or disturbed during excavation activities. The method comprises: A) electronically receiving first source data representing a first input image of a geographic area including a first dig area, wherein the first dig area corresponds to a first stage of an staged excavation project; B) processing the first source data so as to display at least a portion of the first input image

on the display device; C) adding, via at least one user input device associated with the display device, at least one first indicator to the displayed first input image to provide at least one indication of the first dig area and thereby generate a first marked-up digital image; D) electronically receiving second source data representing a second input image of a geographic area including a second dig area, wherein the second dig area corresponds to a subsequent stage of the staged excavation project; E) processing the second source data so as to display at least a portion of the second input image on the display device; F) adding, via the at least one user input device, at least one second indicator to the displayed second input image to provide at least one indication of the second dig area and thereby generate a second marked-up digital image; and G) electronically transmitting and/or electronically storing first information relating to the first marked-up digital image together with second information relating to the second marked-up digital image so as to facilitate the detection of the presence or the absence of the at least one underground facility within the first and second dig areas.

[0014] A further embodiment is directed to at least one computer-readable medium encoded with instructions that, when executed by at least one processing unit, perform a method for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The method comprises: A) electronically receiving first source data representing a first input image of a geographic area including a first dig area, wherein the first dig area corresponds to a first stage of an staged excavation project; B) processing the first source data so as to display at least a portion of the first input image on the display device; C) receiving at least one first user input via at least one user input device associated with the display device; D) adding, based on the at least one first user input, at least one first indicator to the displayed first input image to provide at least one indication of the first dig area and thereby generate a first marked-up digital image; E) electronically receiving second source data representing a second input image of a geographic area including a second dig area, wherein the second dig area corresponds to a subsequent stage of the staged excavation project; F) processing the second source data so as to display at least a portion of the second input image on the display device; G) receiving at least one second user input via the at least one user input device; H) adding, based on the at least one second user input, at least one second indicator to the displayed second input image to provide at least one indication of the second dig area and thereby generate a second marked-up digital image; and I) electronically transmitting and/or electronically storing first information relating to the first marked-up digital image together with second information relating to the second marked-up digital image so as to facilitate the detection of the presence or the absence of the at least one underground facility within the first and second dig areas.

[0015] Another embodiment is directed to an apparatus for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The apparatus comprises: a communication interface; a display device; at least one user input device; a memory to store processor-executable instructions; and a processing unit coupled to the communication interface, the display device, the at least one user input device, and the memory, wherein upon execution of the processor-executable instructions by the processing unit. The processing unit: controls the communication interface to electronically receive first source data representing a first input image of a geographic area including a first dig area, wherein the first dig area corresponds to a first stage of an staged excavation project; controls the display device to display at least a portion of the first input image on the display device; acquires at least one first user input from the at least one user input device; generates a first marked-up digital image including at least one first indicator overlaid on the first input image to provide at least one indication of the first dig area; controls the communication interface to electronically receive second source data representing a second input image of a geographic area including a second dig area, wherein the second dig area corresponds to a subsequent stage of the staged excavation project; controls the display device to display at least a portion of the second input image on the display device; acquires at least one second user input from the at least one user input device; generates a second marked-up digital image including at least one second indicator overlaid on the second input image to provide at least one indication of the second dig area; and further controls the communication interface and/or the memory to electronically transmit and/or electronically store first information relating to the first marked-up digital image together with second information relating to the second marked-up digital image so as to facilitate the detection of the presence or the absence of the at least one underground facility within the first and second dig areas.

[0016] One embodiment is directed to an apparatus for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The apparatus comprises a communication interface; a memory to store processor-executable instructions; and a processing unit coupled to the communication interface and the memory. Upon execution of the processor-executable instructions by the processing unit, the processing unit digitally searches the memory to identify a descriptor file corresponding to a ticket; based on identifying information in the descriptor file, identifies at least one image corresponding to the ticket, the at least one image comprising at least one indication of at least one dig area; electronically bundles the at least one image with ticket information from the ticket to generate the ticket bundle; and provides the ticket bundle to at least one party associated with the at least one underground facility.

[0017] Another embodiment is directed to at least one computer-readable medium encoded with instructions that, when executed by at least one processing unit, perform a method for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The method comprises A) digitally searching a memory to identify a descriptor file corresponding to a ticket; B) based on identifying information in the descriptor file, digitally searching for at least one image corresponding to the ticket, the at least one image comprising at least one indication of at least one dig area; C) electronically bundling the at least one image with ticket information from the ticket to generate a ticket bundle; and D) providing the ticket bundle to at least one party associated with the at least one underground facility.

[0018] A further embodiment is directed to a method for facilitating detection of a presence or an absence of at least one underground facility within at least one dig area, wherein at least a portion of the at least one dig areas may be excavated or disturbed during excavation activities. The method comprises A) digitally searching a memory to identify a descriptor file corresponding to a ticket; B) based on identifying information in the descriptor file, digitally searching for at least one image corresponding to the ticket, the at least one image comprising at least one indication of at least one dig area; C) electronically bundling the at least one image with ticket information from the ticket to generate a ticket bundle; and D) providing the ticket bundle to at least one party associated with the at least one underground facility.

[0019] Another embodiment is directed to an apparatus for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The apparatus comprises a communication interface; a memory to store processor-executable instructions; and a processing unit coupled to the communication interface and the memory. Upon execution of the processor-executable instructions by the processing unit, the processing unit: electronically receives, via the communication interface, at least one image corresponding to at least one ticket or at least one link to the at least one image, the at least one image comprising at least one indication of at least one dig area, and data relating to the at least one image; based on the data relating to the at least one image, identifies ticket information in the memory corresponding to the at least one ticket; electronically bundles the at least one image or the at least one link with the ticket information to generate a ticket bundle; and provides the ticket bundle, via the communication interface, to at least one party associated with the at least one underground facility.

[0020] A further embodiment is directed to at least one computer-readable medium encoded with instructions that, when executed by at least one processing unit, perform a method for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The method comprises A) electronically receiving at least one image corresponding to at least one ticket or at least one link to the at least one image, the at least one image comprising at least one indication of at least one dig area, and data relating to the at least one image; B) based on the data relating to the at least one image, identifying ticket information corresponding to the at least one ticket; C) electronically bundling the at least one image or the at least one link with the ticket information to generate a ticket bundle; and D) providing the ticket bundle to at least one party associated with the at least one underground facility.

[0021] Another embodiment is directed to a method for facilitating detection of a presence or an absence of at least one underground facility within at least one dig area, wherein at least a portion of the at least one dig areas may be excavated or disturbed during excavation activities. The method comprises A) receiving at least one image corresponding to at least one ticket or at least one link to the at least one image, the at least one image comprising at least one indication of at least one dig area, and data relating to the at least one image; B) based on the data relating to the at least one image, identifying ticket information corresponding to the at least one ticket; C) electronically bundling the at least one image or the at least one link with the ticket information to generate a ticket bundle; and D) providing the ticket bundle to at least one party associated with the at least one underground facility.

[0022] A further embodiment is directed to an apparatus for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The apparatus comprises a communication interface; a memory to store processor-executable instructions; and a processing unit coupled to the communication interface and the memory. Upon execution of the processor-executable instructions by the processing unit, the processing unit: electronically receives, via the communication interface, at least one user input relating to the dig area; based on the at least one user input, renders a digital virtual white line image including at least one indicator to provide at least one indication of the dig area with respect to a geographic area; and transmits a limited access file comprising information relating to the digital virtual white line image, via the communication interface, to at least one party associated with the at least one underground facility so as to facilitate the detection of the presence or the absence of the at least one underground facility within the dig area.

[0023] Another embodiment is directed to a method for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The method comprises A) electronically receiving at least one user input relating to the dig area; B) based on the at least one user input, rendering a digital virtual white line image including at least one indicator to provide at least one indication of the dig area with respect to a geographic area; and C) electronically transmitting a limited access file comprising information relating to the digital virtual white line image to at least one party associated with the at least one underground facility so as to facilitate the detection of the presence or the absence of the at least one underground facility within the dig area.

[0024] A further embodiment is directed to at least one computer-readable medium encoded with instructions that when executed by at least one processing unit, perform a method for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities. The method comprises A) electronically receiving at least one user input relating to the dig area; B) based on the at least one user input, rendering a digital virtual white line image including at least one indicator to provide at least one indication of the dig area with respect to a geographic area; and C) electronically transmitting a limited access file comprising information relating to the digital virtual white line image to at least one party associated with the at least one underground facility so as to facilitate the detection of the presence or the absence of the at least one underground facility within the dig area.

[0025] This application incorporates by reference the following U.S. published patent applications: U.S. publication no. 2008-0228294-A1, published Sep. 18, 2008, filed Mar. 13, 2007, and entitled "Marking System and Method With Location and/or Time Tracking;" and U.S. publication no. 2008-0245299-A1, published Oct. 9, 2008, filed Apr. 4, 2007, and entitled "Marking System and Method." Further, this application incorporates by reference the following co-pending U.S. patent application: U.S. patent application Ser. No.

12/422,364, entitled "VIRTUAL WHITE LINES (VWL) APPLICATION FOR INDICATING A PLANNED EXCAVATION OR LOCATE PATH," filed on Apr. 13, 2009.

[0026] It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below (provided such concepts are not mutually inconsistent) are contemplated as being part of the inventive subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the inventive subject matter disclosed herein. It should also be appreciated that terminology explicitly employed herein that also may appear in any disclosure incorporated by reference should be accorded a meaning most consistent with the particular concepts disclosed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention.

[0028] The objects and features of the present disclosure, which are believed to be novel, are set forth with particularity in the appended claims. The present disclosure, both as to its organization and manner of operation, together with further objectives and advantages, may be best understood by reference to the following description, taken in connection with the accompanying drawings as set forth below:

[0029] FIG. **1** illustrates a functional block diagram of a multi-generational virtual white lines application for delimiting planned excavation sites of staged excavation projects, according to the present disclosure;

[0030] FIG. **12** illustrates a view of a multi-generational virtual white lines image, which shows the one image-to-multiple virtual white lines scenario of the multi-generational virtual white lines application, according to the present disclosure;

[0031] FIGS. **3** and **4** illustrate views of a virtual white lines image series, which shows the multiple image-to-multiple virtual white lines scenario of the multi-generational virtual white lines application, according to the present disclosure;

[0032] FIG. **5** illustrates a functional block diagram of a multi-generational virtual white lines system that includes the multi-generational virtual white lines application, according to the present disclosure;

[0033] FIGS. **6**A and **6**B illustrate a flow diagram of an example of a method of operation and/or of using the multi-generational virtual white lines system, according to the present disclosure;

[0034] FIG. **7** shows a sketch **700**, representing an exemplary input image;

[0035] FIG. **8** shows a map **800**, representing an exemplary input image;

[0036] FIG. **9** shows a facility map **900**, representing an exemplary input image;

[0037] FIG. **10** shows a construction/engineering drawing **1000**, representing an exemplary input image;

[0038] FIG. **11** shows a land survey map **1100**, representing an exemplary input image;

[0039] FIG. **12** shows a grid **1200**, overlaid on the land survey map **1100** of FIG. **11**, representing an exemplary input image; and

[0040] FIG. **13** shows a street level image **1300**, representing an exemplary input image.

DETAILED DESCRIPTION

[0041] Following below are more detailed descriptions of various concepts related to, and embodiments of, inventive methods and apparatus according to the present disclosure for associating one or more virtual white line images with corresponding ticket information for a given excavation project. It should be appreciated that various concepts introduced above and discussed in greater detail below may be implemented in any of numerous ways, as the disclosed concepts are not limited to any particular manner of implementation. Examples of specific implementations and applications are provided primarily for illustrative purposes.

[0042] Various embodiments described herein are directed to methods, apparatus and systems for creating an electronic record relating to a geographic area including a dig area to be excavated or otherwise disturbed. The electronic record may comprise one or more virtual white line (VWL) images for delimiting one or more planned excavation sites. In some examples, the excavation projects are staged excavation projects, and the term "multi-generational" refers to the excavation stages of multiple related tickets and/or a project ticket. One or more VWL images may be created using a VWL application that allows a user to generate (e.g., draw) one or more virtual white lines for electronically delimiting one or more dig areas. The virtual white line(s) may be overlaid on an input image depicting a geographic area including one or more dig areas, for example. In a multistage excavation project, each of the multiple virtual white lines may be manually and/or automatically ordered and dated with respect to a timetable of the multiple-stage excavation project. In embodiments described herein relating to multi-generational staged excavation projects, as well as in other embodiments relating to more limited excavation projects in connection with a given dig area (e.g., as described in some embodiments of methods and apparatus disclosed in U.S. Patent Publication Nos. 2008-0228294-A1 and 2008-0245299-A1, hereby incorporated herein by reference), methods and apparatus according to the present disclosure allow the image(s) and other information associated with one or more virtual white lines to be electronically bundled with the ticket information and dispatched to the locate personnel for viewing when performing the locate operation(s).

[0043] The multi-generational VWL application, system and/or method described herein may provide tools for clearly conveying information about planned excavation, such as a multiple-stage excavation project. The information may comprise, for example, the limits of one or more dig areas. The information about the planned excavation may be provided in a substantially permanent and/or reproducible manner so that the information may be referenced throughout the duration of the planned excavation. Plans for staged excavation may be documented with respect to, for example, multiple related tickets and/or project tickets.

[0044] Further, the multi-generational VWL application, system and/or method described herein may provide improved communication mechanisms between excavators and locate personnel for synchronizing staged excavation activities and locate operations. As a result, improved operating efficiency may be achieved for both excavation companies and locate service providers. Improved information exchange allows excavation companies and locate service

providers to make better and more timely decisions with respect to allocating resources.

[0045] The improved tools and communication mechanisms between excavators and locate personnel may reduce or eliminate the uncertainty for excavators about the status and/or quality of locate operations, and thereby reduce or eliminate the risk of damage to underground facilities.

[0046] FIG. **1** illustrates a functional block diagram of an exemplary multi-generational VWL application **100** for delimiting planned excavation sites of staged excavation projects. Multi-generational VWL application **100** may be, for example, a web-based application that is accessible via the Internet. In another embodiment multi-generational VWL application **100** may be a desktop application that is running on the user's local computing device.

[0047] Multi-generational VWL application **100** may include, but is not limited to, a VWL user interface **110** that may farther include a drawing tool **112** and an information processing component **114**. Certain inputs to the VWL application may include, but are not limited to, one-call center information **116**, input images **118**, and user inputs received via one or more user input devices **134**. Certain outputs of multi-generational VWL application **100** may include, but are not limited to, one or more multi-generational VWL images **122** and/or a collection of multi-generational VWL images **122** that are arranged in a series, such as VWL image series **124**, along with a corresponding set of descriptor files **126**.

[0048] VWL user interface **110** may be a web-based graphical user interface (GUI) that is accessible via the Internet. VWL user interface **110** may provide a secure login function, which allows users, such as excavators and/or system administrators, to access the functions of multi-generational VWL application **100**. In one example, excavators may login to multi-generational VWL application **100** via VWL user interface **110** and enter user-specific information which may be saved in, for example, a user profile. The user-specific information may include, for example, the excavators name, user-ID, and excavation company name.

[0049] Drawing tool **112** may be a drawing application, which, in excavation applications, may be used by excavators as a dig area marking tool. More specifically, drawing tool **112** may be used by the excavator to add markings to any digital image that corresponds to the geographic location of the dig area, which may be read into multi-generational VWL application **100** from input images **118**.

[0050] It should be appreciated that the multi-generational virtual white lines application described in connection with FIG. **1** is merely exemplary and that many implementations of such an application are possible. For example, the drawing application or dig area marking tool application described in each of U.S. patent application Ser. No. 12/366,853 entitled "VIRTUAL WHITE LINES FOR INDICATING PLANNED EXCAVATION SITES ON ELECTRONIC IMAGES" filed on Feb. 6, 2009, and U.S. patent application Ser. No. 12/050,555 entitled "VIRTUAL WHITE LINES FOR DELIMITING PLANNED EXCAVATION SITES" filed on Mar. 18, 2008, which are hereby incorporated by reference herein in their entireties, may be configured to create single or multi-generational virtual white line images. In addition, the user device described in each of U.S. patent application Ser. Nos. 12/366,853 and 12/050,555 may be used as a hardware interface to create the multi-generational VWL images described herein.

[0051] For purposes of the present disclosure, an input image **118** is any image represented by source data that is electronically processed (e.g., the source data is in a computer-readable format) to display the image on a display device. An input image **118** may include any of a variety of paper/tangible image sources that are scanned (e.g., via an electronic scanner) or otherwise converted so as to create source data (e.g., in various formats such as XML, PDF, JPG, BMP, etc.) that can be processed to display the input image **118**. An input image **118** also may include an image that originates as source data or an electronic file without necessarily having a corresponding paper/tangible copy of the image (e.g., an image of a "real-world" scene acquired by a digital still frame or video camera or other image acquisition device, in which the source data, at least in part, represents pixel information from the image acquisition device).

[0052] In some exemplary implementations, input images **118** described herein may be created, provided, and/or processed by a geographic information system (GIS) that captures, stores, analyzes, manages and presents data referring to (or linked to) location, such that the source data representing the input image **118** includes pixel information from an image acquisition device (corresponding to an acquired "real world" scene or representation thereof), and/or spatial/geographic information ("geo-encoded information"). In this manner, a GIS provides a framework for data manipulation and display of images that may facilitate one or more of (a) location verification, (b) location correlation, (c) locational relationships, (d) district coding, (e) route analysis, (f) area analysis and (g) mapping/display creation, for example.

[0053] In view of the foregoing, various examples of input images and source data representing input images **118** described herein, to which the inventive concepts disclosed herein may be applied, include but are not limited to:

- **[0054]** Manual "free-hand" paper sketches of the geographic area (which may include one or more buildings, natural or man-made landmarks, property boundaries, streets/intersections, public works or facilities such as street lighting, signage, fire hydrants, mail boxes, parking meters, etc.). FIG. **7** shows an exemplary sketch **700**;
- **[0055]** Various maps indicating surface features and/or extents of geographical areas, such as street/road maps (e.g., map **800** of FIG. **8**), topographical maps, military maps, parcel maps, tax maps, town and county planning maps, call-center and/or facility polygon maps, virtual maps, etc. (such maps may or may not include geo-encoded information);
- **[0056]** Facility maps illustrating installed underground facilities, such as gas, power, telephone, cable, fiber optics, water, sewer, drainage, etc. Facility maps may also indicate street-level features (streets, buildings, public facilities, etc.) in relation to the depicted underground facilities. Examples of facility maps include CAD drawings that may be created and viewed with a GIS to include geo-encoded information (e.g., metadata) that provides location information (e.g., infrastructure vectors) for represented items on the facility map. An exemplary facility map **900** is shown in FIG. **9**;
- **[0057]** Architectural, construction and/or engineering drawings and virtual renditions of a space/geographic area (including "as built" or post-construction drawings). An exemplary construction/engineering drawing **1000** is shown in FIG. **10**;

[0058] Land surveys, i.e., plots produced at ground level using references to known points such as the center line of a street to plot the metes and bounds and related location data regarding a building, parcel, utility, roadway, or other object or installation. FIG. **11** shows an exemplary land survey map **1100**;

[0059] A grid (a pattern of horizontal and vertical lines used as a reference) to provide representational geographic information (which may be used "as is" for an input image **118** or as an overlay for an acquired "real world" scene, drawing, map, etc.). An exemplary grid **1200**, overlaid on construction/engineering drawing **1000**, is shown in FIG. **12**. It should be appreciated that the grid **1200** may itself serve as the input image (i.e., a "bare" grid), or be used together with another underlying input image;

[0060] "Bare" data representing geo-encoded information (geographical data points) and not necessarily derived from an acquired/captured real-world scene (e.g., not pixel information from a digital camera or other digital image acquisition device). Such "bare" data may be nonetheless used to construct a displayed input image **118**, and may be in any of a variety of computer-readable formats, including XML); and

[0061] Photographic renderings/images, including street level (see e.g., street level image **1300** of FIG. **13**), topographical, satellite, and aerial photographic renderings/images, any of which may be updated periodically to capture changes in a given geographic area over time (e.g., seasonal changes such as foliage density, which may variably impact the ability to see some aspects of the image).

[0062] It should also be appreciated that source data representing an input image **118** may be compiled from multiple data/information sources; for example, any two or more of the examples provided above for input images and source data representing input images **118**, or any two or more other data sources, can provide information that can be combined or integrated to form source data that is electronically processed to display an image on a display device.

[0063] Once read into multi-generational VWL application **100** from input images **118**, a digital image may be rendered in the viewing window of drawing tool **112**. In one example, FIG. **1** shows a rendered image **130** that is displayed in the viewing window of drawing tool **112**. The markings that the excavator adds to rendered image **130** are used to graphically delimit and/or otherwise indicate the dig area. For example and referring to FIG. **1**, drawing tool **112** may be used to superimpose over or otherwise display one or more "virtual white lines" (VWL) **132** for delimiting and/or otherwise indicating the planned excavation upon rendered image **130**.

[0064] Creating a "single-generational" VWL image is described in U.S. patent application Ser. Nos. 12/366,853 and 12/050,055 and may involve the steps of sending an image to a user via a network; receiving a marked-up version of the image from the user via the network that includes one or more virtual white lines added to the image that indicate a dig area in which excavation is planned; and providing the marked-up version of the image, via one of an electronic or tangible delivery system, to another entity. The virtual white lines may include two-dimensional (2D) drawing shapes, shades, points, lines, symbols, coordinates, data sets, or other indicators to indicate on a digital image the dig area in which excavation is to occur. A drawing tool may be provided that allows the user to provide one or more dig area indicators to indicate the dig area (e.g., delimit or mark lines that indicate a line or path of planned excavation) and to enter textual information on the image. The marked-up image may be saved as a VWL image, associated with a certain locate request (or ticket), transmitted to locate personnel, and used by locate personnel during locate operations with respect to the line or path of planned excavation.

[0065] In addition to creating "single-generational" VWL images, the multi-generational VWL application **100** described herein provides the capability to create multi-generational virtual white lines for delimiting and/or otherwise indicating planned excavation with respect to multiple-stage excavation projects. For example, the virtual white lines may indicate a line or path of planned excavation with respect to multiple-stage excavation projects.

[0066] As used herein, "virtual white lines" (VWLs) may include lines, such as single-segment lines, multiple-segment lines, substantially straight lines, curved lines, and the like; 2D drawing shapes; shades; points; symbols; coordinates; data sets; or other indicators to delimit and/or otherwise indicate on an image one or more dig areas in which excavation is to occur. With respect to multiple-stage excavation projects, examples of multi-generational virtual white lines that may be created using drawing tool **112** are shown with reference to FIGS. **2**, **3**, and **4**.

[0067] Information processing component **114** may be a software component of multi-generational VWL application **100** (e.g., a processing unit executing processor-executable instructions stored in memory) for entering and/or associating other information with the multi-generational virtual white lines that are created using drawing tool **112**. This information may include excavator-specific, one-call center-specific, and/or other ticket information.

[0068] Ticket information **116** provides a source of information that may be processed using VWL user interface **110** of multi-generational VWL application **100**. For example, ticket information **116** may include the geographic location (s) of one or more dig areas designated for excavation, for which a locate operation is being requested. Ticket information **116** generally is provided by a one-call center and may include one or more addresses of dig areas, or other location information (e.g., GPS latitude and longitude coordinates). Also, the ticket information **116** may specify a project or multi-stage excavation. Based on address and/or other information, the ticket information **116** may be filtered when presented to the user of multi-generational VWL application **100**.

[0069] When an excavator completes the sketch of the virtual white lines of the proposed dig area, e.g., VWL **132** on rendered image **130**, the marked-up image may be saved as one or more multi-generational VWL images **122**. One or more multi-generational VWL images **122** may be associated with multiple related tickets and/or a project ticket, as discussed in greater detail below. In particular, multiple multi-generational VWL images **122** that are associated with staged excavation may be aggregated and saved as a VWL image series **124**.

[0070] In one exemplary implementation, each multi-generational VWL image **122** and/or each multi-generational VWL image **122** of a VWL image series **124** may have one or more corresponding descriptor files **126**. When each VWL image series **124** is saved, the corresponding descriptor files **126** include(s) information about the multi-generational

VWL images **122** of the VWL image series **124**. For example and with respect to multiple-stage excavation projects, each descriptor file **126** may include, for example, the ticket numbers, the names of multi-generational VWL images **122** of the VWL image series **124**, the stage number and stage date with respect to the ticket, and the like. Other information that may be included in one or more descriptor files **126** includes, but is not limited to date and time information indicating when the VWL image was created, an identifier for the creator of the VWL image (e.g., the excavator), location information (geocoordinates) for the VWL indicating the dig area (dig area indicators), provider information relating to a service (e.g., the image server **516**) for the underlying image on which a VWL is created, latitude/longitude and/or altitude information relating to the underlying image, and the like. Descriptor files **126** provide a mechanism by which the multi-generational VWL application **100** may be queried by another application, such as a ticket management application, for processing multi-generational VWL images **122** of the VWL image series **124**. In one example, descriptor file(s) **126** may be extensible markup language (XML) files that are created during a save process for the multi-generational VWL images **122**. More details of a system and method of using multi-generational VWL application **100** are described with reference to FIGS. **5**, **6**A, and **6**B,

[0071] In a "one image-to-multiple VWL" scenario, when the geographic area of the ticket is suitably small to be shown fully on a single image, only one image need be read from input images **118** into multi-generational VWL application **100** and then multiple virtual white lines are created thereon in order to delimit the multiple dig areas, respectively, of staged excavation of multiple related tickets and/or project ticket. An example of this scenario is described with reference to FIG. **2**.

[0072] In a "multiple image-to-multiple VWL" scenario, when the geographic area of the multiple related tickets and/or project ticket is suitably large that it cannot be shown fully with a sufficient level of detail on a single image, multiple images may be read from input images **118** into multi-generational VWL application **100** and then at least one virtual white line (at least one dig area indicator) is created on each image in succession. An example of this scenario is described with reference to FIGS. **3** and **4**.

[0073] Referring to FIG. **2**, a view of a multi-generational VWL image **200**, which shows the "one image-to-multiple VWL" scenario of multi-generational VWL application **100**, is presented. More specifically, FIG. **2** shows an example in which the geographic area of a certain ticket is suitably small to be shown fully on a single image, such as multi-generational VWL image **200**. Multi-generational VWL image **200** further shows multiple virtual white lines that delimit multiple planned excavations that are staged to occur over time with respect to the multiple related tickets and/or project ticket. For example, multi-generational VWL image **200** shows a VWL **201**, which may be the VWL for the first stage of excavation; a VWL **202**, which may be the VWL for the second stage of excavation; a VWL **203**, which may be the VWL for the third stage of excavation; and so on through a VWL **211**, which may be the VWL for the eleventh stage of excavation. VWL **201** through VWL **211** correspond to contiguous stages of the multiple-stage project. VWL **201** through VWL **211** are created by use of VWL user interface **110** of multi-generational VWL application **100**.

[0074] Further, each VWL may be automatically labeled and dated according to the planned excavation order and dates of the multiple related tickets and/or project ticket. For example, VWL **201** may be labeled "Stage 1" and dated 05JAN09; VWL **202** may be labeled "Stage 2" and dated 12JAN09; VWL **203** may be labeled "Stage 3" and dated 19JAN09; and so on through VWL **211**, which may be labeled "Stage 11" and dated 16MAR09.

[0075] Referring again to FIG. **2**, when made available to locate personnel, a multi-generational VWL image, such as multi-generational VWL image **200**, and the information associated therewith provides precise clarity as to the order and timing of locate operations that are associated with the multiple related tickets and/or project ticket. As a result, the multi-generational VWL image of this scenario, which is created using the multi-generational VWL application **100** described herein, provides a mechanism by which excavators can clearly communicate to locate personnel information about the staged excavation, which is useful for optimally synchronizing the day-to-day activities of excavators and locate personnel.

[0076] Referring to FIGS. **3** and **4**, views of a VWL image series **300**, which shows the "multiple image-to-multiple VWL" scenario of multi-generational VWL application **100** are presented. More specifically, FIG. **3** shows an example in which the geographic area of a certain ticket is suitably large to require it to be shown across a series of images, such as VWL image series **300**. Further, each image of VWL image series **300** shows at least one set of virtual white lines. Collectively, the virtual white lines included in VWL image series **300** delimit multiple planned excavations that are staged to occur over time. For example, VWL image series **300** may include a multi-generational VWL image **301**, a multi-generational VWL image **302**, a multi-generational VWL image **303**, and a multi-generational VWL image **304**.

[0077] Additionally, multi-generational VWL image **301** shows a VWL **311**, which may be the VWL for the first stage of excavation. Multi-generational VWL image **302** shows a VWL **312**, which may be the VWL for the second stage of excavation. Multi-generational VWL image **303** shows a VWL **313**, which may be the VWL for the third stage of excavation. Multi-generational VWL image **304** shows a VWL **314**, which may be the VWL for the fourth stage of excavation. VWL **311** through VWL **314** correspond to contiguous stages of the multiple-stage project. VWL **311** through VWL **314** are created by use of VWL user interface **110** of multi-generational VWL application **100**.

[0078] Further, each multi-generational VWL image and each VWL of VWL image series **300** may be automatically labeled and dated by the multigenerational VWL application **100** according to the planned excavation order and dates of the multiple related tickets and/or project ticket. For example, multi-generational VWL image **301** may be labeled "IMAGE01 OF 04" and VWL **311** may be labeled "Stage 1" and dated 02FEB09; multi-generational VWL image **302** may be labeled "IMAGE02 OF 04" and VWL **312** may be labeled "Stage 2" and dated 09FEB09; multi-generational VWL image **303** may be labeled "IMAGE03 OF 04" and VWL **313** may be labeled "Stage 37" and dated 16FEB09; and multi-generational VWL image **304** may be labeled "IMAGE04 OF 04" and VWL **314** may be labeled "Stage 4" and dated 23FEB09.

[0079] While FIG. **3** shows details of each multi-generational VWL image of VWL image series **300** separately, FIG.

4 shows multi-generational VWL images **301**, **302**, **303**, and **304** overlaid in a fashion that shows the full scope of the staged excavations of the multiple related tickets and/or project ticket.

[0080] Referring again to FIGS. **3** and **4**, when made available to locate personnel, a VWL image series, such as VWL image series **300**, and the information associated therewith provides precise clarity as to the order and timing of locate operations that are associated with the multiple related tickets and/or project ticket. As a result, the VWL image series of this scenario, which is created using the multi-generational VWL application **100** described herein, provides a mechanism by which excavators can clearly communicate to locate personnel information about the staged excavation, which is useful for optimally synchronizing the day-to-day activities of excavators and locate personnel.

[0081] Referring to FIGS. **1** through **4**, during the save operation of multi-generational VWL application **100**, any multi-generational VWL images created therein may be converted to any standard digital image file format, such as JPG file format, and saved to an associated file system (not shown).

[0082] Referring to FIG. **5**, a functional block diagram of a multi-generational VWL system **500** that includes multi-generational VWL application **100** is presented. The multi-generational VWL system **500** described herein may include an application server **510**, which includes processing unit **502** and memory **504** (memory **504** may include one or more storage media components). In one exemplary implementation, multi-generational VWL application **100**, which is described with reference to FIGS. **1** through **4**, is stored in memory **504** (e.g., as processor-executable instructions and data associated with execution of these instructions) and executed by processing unit **502**. Application server **510** may be any application server, such as a web application server and/or web portal, by which one or more excavators **512** may access multi-generational VWL application **100** with respect to generating multi-generational virtual white lines. Application server **510** may be accessed by excavators **512** via any networked computing device (not shown). Excavators **512** may be any personnel associated with excavation companies (not shown), such as, but not limited to, individuals who are requesting and/or performing excavation activities.

[0083] Multi-generational VWL system **500** may further include one or more one-call centers **514**. One-call centers **514** may be any organizations, entities, and/or systems that receive, process, and/or transmit locate requests. The locate request (or ticket) may be any communication or instruction to perform a locate operation compiled as ticket information **116**. One-call centers are generally owned, controlled, or funded by underground facility owners, such as telephone companies, cable television multiple system operators, electric utilities, gas utilities, or others. One-call center operations may be managed by a non-profit entity or outsourced to a for-profit firm. Excavators, such as excavators **512**, are required to notify one-call centers in advance of their excavation activities and identify through the locate request the dig area where individual excavating activities will be performed. Locate requests include information supplied by the excavator to the one-call center regarding the specific geographic location of the dig area, date, time, purpose of excavation, and so on. The locate request, in turn, requires activity from an underground facility owner (or a locate contractor) to perform a locate operation in the specified dig area pursuant to the ticket information **116**.

[0084] With respect to multi-generational VWL system **500**, one type of locate request that may be processed by one-call centers **514** is a project ticket that may warrant a multi-generational VWL image and/or a VWL image series associated therewith.

[0085] Multi-generational VWL system **500** may further include an image server **516**. Image server **516**, which includes processing unit **506** and memory **508**, stores and provides input images **118**. For example, image server **516** may be associated with a party that provides aerial images of geographic locations for a fee. Image server **516** is one example of an entity supplying input images **118** to multi-generational VWL application **100** residing on application server **510**.

[0086] Multi-generational VWL system **500** may further include a central server **520** of, for example, a locate service provider. The central server includes processing unit **544** and memory **546**, which may include one or more storage media components. A workforce management application **522** is stored on memory **546** (e.g., as processor-executable instructions) and executed by processor **544**. In one exemplary implementation, the workforce management application **522** may include a ticket assembly component **524** which processes the output of the multi-generational VWL application **100** and dispatches tickets **526** to locate personnel **528**. Locate personnel **528** may be, for example, locate technicians and/or quality control technicians that, for example, perform locate operations.

[0087] More specifically, workforce management application **522** of central server **520** may be used to process the locate requests, such as multiple related tickets and/or project tickets that are received from one-call centers **514**, and dispatch tickets **526** to locate personnel **528** that are in the field. In particular, ticket assembly component **524** associates one or more descriptor files **126** with active tickets provided by one-call centers **514**, identifies and/or assembles the multi-generational VWL image(s) **122** (in the form of image files **530**) that are specified in descriptor file(s) **126** along with its corresponding ticket information, and bundles all image files and information (e.g., in some cases the descriptor file(s) themselves) in order to create tickets **526**, stored in memory **546**. In particular, one or more machine-readable VWL image files **530** (and optionally their associated descriptor file(s)) may be bundled with the ticket information provided by the one-call center to generate tickets **526** via ticket assembly component **524**.

[0088] Tickets **526** that are dispatched from central server **520** may be received by locate personnel **528** via one or more onsite computers **532**. Each onsite computer **532** may be a computer including processing unit **532** and memory **552**, such as, but not limited to, a computer that is present in the vehicle that is being used by locate personnel **528**. Each onsite computer **532** may be, for example, any computing device, such as portable computer, a personal computer, a tablet device, a PDA, a cellular radiotelephone, a mobile computing device, a touch-screen device, a touchpad device, or generally any device including, or connected to, a processor and a user interface. Preferably, onsite computer **532** is a portable computing device, such as laptop computer or tablet device. Residing in memory **552** of onsite computer **532**, may be certain tools, such as a viewer **534**, which may be executed

by processing unit **550**. Viewer **534** may be any viewer application that is capable of reading and displaying ticket information and/or digital images, such as VWL image files **530**. In one exemplary implementation, one or more VWL image files **530** bundled in a ticket **526** may be "limited access files," e.g., encoded, encrypted, formatted, compiled and/or named in some particular fashion (e.g., having a proprietary filename extension), and the viewer **534** may be particularly designed (i.e., a "custom or proprietary" viewer) such that access to the VWL image files is limited in some manner (e.g., the image files may only be opened/viewed by the customized/proprietary viewer that recognizes the proprietary filename extension). Additional details of a method of operation and/or using multi-generational VWL system **500** are described with reference to FIGS. **6**A and **6**B.

[0089] A network **536** provides the communication link between any and/or all entities of multi-generational VWL system **500**. For example, network **536** provides the communication network by which information may be exchanged between application server **510**, one-call centers **514**, image server **516**, central server **520** and onsite computers **532**. Network **536** may be, for example, any local area network (LAN) and/or wide area network (WAN) for connecting to the Internet.

[0090] In order to connect to network **536**, each entity of multi-generational VWL system **500** includes a communication interface. For example, the respective communication interfaces **560***a-e* of application server **510**, one-call centers **514**, image server **516**, central server **520** and onsite computers **532** may be any wired and/or wireless communication interface by which information may be exchanged between any entities of multi-generational VWL system **500**. Examples of wired communication interfaces may include, but are not limited to, USB ports, RS232 connectors, RJ45 connectors, Ethernet, and any combinations thereof. Examples of wireless communication interfaces may include, but are not limited to, an Intranet connection, Internet, Bluetooth® technology, Wi-Fi, Wi-Max, IEEE 802.11 technology, radio frequency (RF), Infrared Data Association (IrDA) compatible protocols, Local Area Networks (LAN), Wide Area Networks (WAN), Shared Wireless Access Protocol (SWAP), any combinations thereof, and other types of wireless networking protocols.

[0091] Multi-generational VWL system **500** is not limited to the types and numbers of entities that are shown in FIG. **5**. Any types and numbers of entities that may be useful in underground facilities locate applications may be included in multi-generational VWL system **500**. Further, the distribution of storage and processing of data shown in FIG. **5** is merely exemplary, as described below.

[0092] For example, in another alternative implementation, rather than employing central server **520** in the VWL system **500**, a one-call center **514** may include and maintain the ticket assembly component **524** (shown in FIG. **5** as part of the workforce management application **522**), and may receive from the multi-generational VWL application **100** one or more of multi-generational VWL images **122**, VWL image series **124** (e.g., in the form of image files **530**) and/or descriptor file(s) **126** to be associated with ticket information **116**.

[0093] In this example, excavators may initiate locate requests with the one-call center **514** and provide ticket information **116**. The one-call center **514** may in turn pass the ticket information **116** to the VWL application **100**, and redirect the excavator to the VWL application **100** for creation of one or more VWL images **122** and/or image series **124**. Upon completion of the VWL images, the VWL application **100** transmits back to the ticket assembly component **524** resident at the one-call center **514** one or more image files **530** and descriptor file(s) **126**, which the ticket assembly component **524** then bundles with the ticket information **116** prior to dispatching tickets **526** to locate personnel **528**.

[0094] It should be appreciated that the methods described above in connection with ticket assembly (i.e., bundling of ticket information, one or more VWL images, and optionally one or more descriptor files) and dispatch of assembled tickets may be employed for excavation projects involving a single dig area as well as multi-generational staged excavation projects. For single-stage projects in which only one VWL image is created to identify a single dig area, a VWL application (e.g., as described in U.S. patent application Ser. No. 12/366,853 and 12/050,055) may provide to the ticket assembly component (wherever resident) a VWL image file and in some cases a descriptor file (e.g., an XML file), and/or metadata forming part of the VWL image file, including information associated with the VWL image. Examples of information that may be included as metadata in the VWL image file or included in the descriptor file may include, but is not limited to, date and time information indicating when the VWL image was created, an identifier for the creator of the VWL image (e.g., the excavator), location information (geo-coordinates) for the VWL indicating the dig area (dig area indicators), provider information relating to a service (e.g., the image server **516**) for the underlying image on which a VWL is created, latitude/longitude and/or altitude information relating to the underlying image, and the like. As in the multi-generational VWL implementation described above, ticket assembly component bundles the VWL image and optionally the metadata and/or descriptor file with the ticket information so as to compile a ticket for dispatching to locate personnel.

[0095] In some instances, for either single-stage or multi-generational staged excavation projects, it may be desirable for a single entity or a limited number of entities to retain control over the VWL image file(s) **530** and any associated metadata and/or descriptor file(s). For example, it may be desirable for the entity that provides access to a VWL creation application (e.g., the multi-generational VWL application **100**) and has initial control of one or more created VWL images (e.g., application server **510**) to retain control of such VWL images. One potential benefit of retaining control of the VWL image(s) once created is avoiding unauthorized edits to or unauthorized use of the image(s).

[0096] According to one example, a "controlling" entity that provides access to a VWL creation application (e.g., the multi-generational VWL application **100**) retains control of one or more created images, but allows other entities to access the images in some instances in a limited manner. For example, the controlling entity may provide a link (e.g., a hyperlink) to one or more VWL images (e.g., via an e-mail) or otherwise provide an interface allowing the VWL image(s) to be accessed (e.g., via a customized or proprietary image viewing application). To maintain the integrity of the VWL image(s), the application providing access to the VWL image (s) may prohibit copying of, saving of, or writing to the images. For example, the VWL image may be viewable only using a corresponding image file viewer that allows limited access to the VWL image. In particular, copy, save and/or write access to the VWL image may be prohibited. In these

and other respects discussed below, one or more VWL image files may be stored and/or transmitted as "limited access files."

[0097] The VWL image may, for example, be transmitted to a party associated with the at least one underground facility with the corresponding image file viewer so that the party may view the VWL image. For example, an executable file comprising the VWL image and image file viewer may be transmitted (e.g., a customized image viewer **534** may be transmitted to one or more onsite computers **532**). Alternatively, the image file viewer may be downloaded/installed separately, e.g., from a website of the controlling entity, or the VWL image may be viewed using an image file viewer stored and executed on a server of the controlling entity.

[0098] In one implementation, the controlling entity may allow access to the VWL image(s) only when a certain condition or conditions are met. For example, the controlling entity may require a password protected log-in procedure for access to the VWL image(s). In particular, the image file viewer may require a password to permit access to the VWL image. As another example, the controlling entity may require acceptance of certain terms and/or conditions to permit access to the VWL image. According to one implementation, the image file viewer may be programmed to require an indication of acceptance of terms and/or conditions prior to permitting access to the VWL image. According to yet another example, the controlling entity may charge a fee for permitting a third party to access one or more VWL images, such as a per-transaction fee or a subscription fee.

[0099] To prevent access to the VWL image unless or until a condition or conditions are met, the VWL image may be encrypted and require decryption to be readable. A corresponding image file viewer may be required to decrypt the VWL image. The VWL image and/or the corresponding image file viewer may also or alternatively be proprietary, and may have a format specific to the controlling entity. The image file viewer may optionally be programmed to determine whether an updated version of the image file viewer is available. For example, the image file viewer may interrogate information associated with the VWL image to determine a corresponding version of the image file viewer. If an updated version is found, the viewer may prompt the user to upgrade the application or otherwise facilitate an update.

[0100] The VWL image may be transmitted in a variety of different formats. For example, the VWL image may be transmitted as an image including virtual white lines thereon. Alternatively, the VWL image may be transmitted as a base image with associated metadata and/or a separate file (e.g., an XML file) including information that allows virtual white lines to be rendered on or in connection with the base image. Such information may comprise geographic coordinates specifying the virtual white lines to be displayed on the base image. The information included in the metadata and/or separate file may also specify access permissions for the virtual white lines. For example, in the case where the information that allows virtual white lines to be rendered relates to a plurality of dig sites, virtual white line information for one or more dig sites may have restricted access such that the corresponding virtual white lines are not rendered unless certain access conditions are met.

[0101] Since the workforce management application **522** may require access to one or more VWL image file(s) **530** to assemble, attach or otherwise integrate the image file(s) with ticket information, it may be desirable in some implementations to store and execute the workforce management application **522** on the application server **510**, which facilitates creation of one or more VWL images. Alternatively, the workforce management application **522** may be stored and executed on the central server **520** or at one-call centers **514**, but the VWL image(s) may be stored remotely. In this case, the bundling performed by the ticket assembly component (wherever resident) may involve, e.g., bundling the information of tickets **526** with a link to one or more VWL images or other information specifying or permitting access to the VWL image(s). According to another arrangement, the central server **520** or the one-call centers **514** may control one or more VWL images by storing the VWL image(s) and also storing and executing the workforce management application **522**.

[0102] Referring to FIGS. **6**A and **6**B, a flow diagram of an example of a method **600** of operation and/or of using multi-generational VWL system **500** is presented. Method **600** may include, but is not limited to, the following steps, which are not limited to any order.

[0103] At step **612**, a certain excavator **512** requests a ticket number from any controlling entity. For example, the excavator **512** calls and/or accesses a web portal of the one-call center **514** and requests, for example, a project ticket number because the planned excavation is related to a project wherein excavation is to be performed in multiple stages over time (e.g., over several days, weeks, and/or months).

[0104] At step **614**, the certain excavator **512** logs into multi-generational VWL application **100** and enters certain information. For example, using the Internet browser of any networked computer, the excavator **512** logs into multi-generational VWL application **100** at application server **510** in order to access VWL user interface **110** and certain information, such as, but not limited to, the excavator's name, excavation company name, excavation company location, ticket number, and the dig area address and/or other location information. Alternatively, the excavator may enter this information via the one-call center web portal, and the one-call center may redirect the excavator to the multi-generational VWL application and pass on to the application some or all of the information provided by the excavator (e.g., as an XML file). Information processing component **114** temporarily caches this information in order to later associate this information as may be necessary or desirable with multi-generational VWL images **122** and/or VWL image series **124** that are created by multi-generational VWL application **100**.

[0105] At decision step **616**, based on the address and/or other location information of the proposed dig area, it may be determined whether a single input image **118** from image server **516** is needed or multiple input images **118** are needed in order to render the full scope of the multiple related tickets and/or project ticket. If a single input image **118** only is needed to filly render the project (i.e., the "one image-to-multiple VWL" scenario), method **600** proceeds to step **618**. However, if multiple input images **118** are needed to fully render the project (i.e., the "multiple image-to-multiple VWL" scenario), method **600** proceeds to step **626**.

[0106] At step **618**, multi-generational VWL application **100** acquires and renders an input image **118**, which may be an aerial image, of the excavation site location. In one example, using VWL user interface **110**, the excavator **512** may enter the address and/or other location information (e.g., latitude/longitude coordinates) of the proposed dig area and multi-generational VWL application **100** automatically que-

ries image server **516** for the corresponding input image **118** which is read into the application and rendered in drawing tool **112**. In another example, multi-generational VWL application **100** provides a mechanism by which the excavator **512** may view and pan over an aerial map of a region and then manually identify the location of the proposed dig area. Once manually identified, the corresponding input image **118** is read into the application and rendered in drawing tool **112**. By way of example and referring again to FIG. **2**, an input image **118**, such as multi-generational VWL image **200**, is read into the application and rendered in drawing tool **112**.

[0107] At step **620**, the excavator **512** creates the first virtual white line that delimits the dig area of the first stage of the project. By way of example and referring again to FIG. **2**, the excavator **512** creates VWL **201** on multi-generational VWL image **200** using drawing tool **112**, which delimits the dig area of the first stage of the project. Additionally, the excavator **512** is prompted for or otherwise enters information that is automatically associated with VWL **201**. For example, the excavator **512** enters the stage number (e.g., stage 1) and the stage date (e.g., 05JAN09), which may be superimposed on multi-generational VWL image **200** at VWL **201**.

[0108] At decision step **622**, the excavator **512** is prompted or otherwise indicates whether another virtual white line is to be created. If yes, method **600** proceeds to step **624**. If no, method **600** proceeds to step **636**.

[0109] At step **624**, the excavator **512** creates the next virtual white line that delimits the dig area of the next stage of the project. By way of example and referring again to FIG. **2**, the excavator **512** creates the next virtual white line, such as VWL **202** (then VWL **203**, then VWL **204**, and so on) on multi-generational VWL image **200** using drawing tool **112**, which delimits the dig area of the next stage of the project. Additionally, the excavator **512** is prompted for or otherwise enters information that is automatically associated with the next virtual white line, such as VWL **202**. For example, for VWL **202**, the excavator **512** enters the stage number (e.g., stage 2) and the stage date (e.g., 12JAN09), which may be superimposed on multi-generational VWL image **200** at VWL **202**. Method **600** returns to step **622**.

[0110] At step **626**, multi-generational VWL application **100** acquires and renders the first input image **118**, which may be an aerial image, of the excavation site location. In one example, using VWL user interface **110**, the excavator **512** may enter the address and/or other location information (e.g., latitude/longitude coordinates) of the first proposed dig area and multi-generational VWL application **100** automatically queries image server **516** for the corresponding input image **118** which is read into the application and rendered in drawing tool **112**. In another example, multi-generational VWL application **100** provides a mechanism by which the excavator **512** may view and pan over an aerial map of a region and then manually identify the location of the proposed dig area. Once manually identified, the corresponding input image **118** is read into the application and rendered in drawing tool **112**. By way of example and referring again to FIGS. **3** and **4**, an input image **118**, such as multi-generational VWL image **301**, is read into the application and rendered in drawing tool **112**.

[0111] At step **628**, the excavator **512** creates the first virtual white line that delimits the dig area of the first stage of the project on the first input image **118**. By way of example and referring again to FIGS. **3** and **4**, the excavator **512** creates VWL **311** on multi-generational VWL image **301** using drawing tool **112**, which delimits the dig area of the first stage of the project. Additionally, the excavator **512** is prompted for or otherwise enters information that is automatically associated with VWL **311**. For example, the excavator **512** enters the stage number (e.g., stage 1) and the stage date (e.g., 02FEB09), which may be superimposed on multi-generational VWL image **301** at VWL **311**.

[0112] At decision step **630**, the excavator **512** is prompted or otherwise indicates whether another virtual white line is to be created. If yes, method **600** proceeds to step **632**. If no, the VWL image series is complete and method **600** proceeds to step **636**.

[0113] At step **632**, multi-generational VWL application **100** acquires and renders the next input image **118**, which may be an aerial image, of the excavation site location. In one example, using VWL user interface **110**, the excavator **512** may enter the address and/or other location information (e.g., latitude/longitude coordinates) of the next proposed dig area and multi-generational VWL application **100** automatically queries image server **516** for the corresponding input image **118** which is read into the application and rendered in drawing tool **112**. In another example, multi-generational VWL application **100** provides a mechanism by which the excavator **512** may view and pan over an aerial map of a region and then manually identify the location of the next proposed dig area. Once manually identified, the corresponding input image **118** is read into the application and rendered in drawing tool **112**. By way of example and referring again to FIGS. **3** and **4**, an input image **118**, such as multi-generational VWL image **302** (then multi-generational VWL image **303**, then multi-generational VWL image **304**), is read into the application and rendered in drawing tool **112**.

[0114] At step **634**, the excavator **512** creates the next virtual white line that delimits the dig area of the next stage of the project on the next input image **118**. By way of example and referring again to FIGS. **3** and **4**, the excavator **512** creates the next virtual white line, such as VWL **312** (then VWL **313**, then VWL **314**) on multi-generational VWL image **302** (then multi-generational VWL image **303**, then multi-generational VWL image **304**) using drawing tool **112**, which delimits the dig area of the next stage of the project. Additionally, the excavator **512** is prompted for or otherwise enters information that is automatically associated with the next virtual white line, such as VWL **312**. For example, for VWL **312**, the excavator **512** enters the stage number (e.g., stage 2) and the stage date (e.g., 09FEB09), which may be superimposed on multi-generational VWL image **302** at VWL **312**. The transition from one multi-generational VWL image to the next may be assisted via geo-coding or other geographical identification metadata therein for "stitching" the images together in a contiguous fashion. Method **600** returns to step **630**.

[0115] At step **636** shown in FIG. **6**B, a save operation of multi-generational VWL application **100** is performed. In particular, one or more virtual white lines, one or more multi-generational VWL images, one or more VWL image series, and/or other information is saved in multi-generational VWL application **100**. For example, the excavator **512** may initiate a save operation by selecting a SAVE button of VWL user interface **110** in order to save the contents of the session at application server **510** and/or central server **520**. In particular, all of the multi-generational VWL images showing the multi-generational virtual white lines that delimit or otherwise indicate the respective stages of the multiple related tickets and/or project ticket are saved as standard machine-readable image files, such as JPG files, which are hereafter referred to as

VWL image files. During the save operation, the excavator **512** may be prompted to enter certain information. For example, the excavator **512** may be prompted to enter the ticket number that was provided by the one-call center **514** at step **612**. Additionally, in order to log the one-call center **514** for this ticket, the excavator **512** may be prompted to select the originating one-call center **514**.

[0116] At step **638**, multi-generational VWL application **100** creates one or more descriptor files **126** for all information associated with the multi-generational VWL images and/or VWL image series of the session. For example, when each multi-generational VWL image and/or VWL image series is saved, a corresponding descriptor file **126** (e.g., corresponding XML file) is created that includes information about the multi-generational VWL images and/or VWL image series, such as multi-generational VWL image **200** of FIG. **2** and/or VWL image series **300** of FIG. **3** and **4**. For example and with respect to multiple-stage excavation projects, each descriptor file **126** may include the ticket number, the name of multi-generational VWL image, the name of the VWL image series, the stage number and stage date with respect to each virtual while line of the multiple related tickets and/or project ticket, and other information as discussed above.

[0117] At step **640**, ticket assembly component **524** queries the file directory of application server **510** in order to identify descriptor files **126** that correspond to active tickets of one-call centers **514**. This may be accomplished by matching the ticket number information of descriptor files **126** to active tickets of one-call centers **514**.

[0118] At step **642**, once a descriptor file **126** that corresponds to an active ticket is identified, ticket assembly component **524** reads the identified descriptor file **126** and searches for the VWL image files **530** of the multi-generational VWL images that are specified therein for the ticket of interest. In one example and referring to FIG. **2**, multi-generational VWL image **200** may be specified in the identified descriptor file **126**. In another example and referring to FIGS. **3** and **4**, multi-generational VWL images **301**, **302**, **303**, and **304** of VWL image series **300** may be specified in the identified descriptor file **126**.

[0119] At step **644**, ticket assembly component **524** bundles the multi-generational VWL images (in the form of VWL image files **530**) that are specified in the identified descriptor file **126** along with its corresponding ticket information in order to create a certain ticket **526**. In one example and referring to FIG. **2**, a VWL image file **530** of multi-generational VWL image **200** may be bundled along with its corresponding ticket information in order to create a certain ticket **526**. In another example and referring to FIGS. **3** and **4**, VWL image files **530** of multi-generational VWL images **301**, **302**, **303**, and **304** of VWL image series **300** may be bundled in the correct order along with the corresponding ticket information in order to create a certain ticket **526**.

[0120] According to one example, the ticket assembly component **524** forms a ticket bundle by assembling a file including the at least one image and the ticket information. Alternatively, the ticket assembly component **524** may form the ticket bundle by associating a file including the at least one image and a file including the ticket information. The ticket bundle need not include the actual at least one image. Instead, the ticket bundle may comprise information specifying or permitting access to the at least one image (e.g., a link to the at least one image). Thus, the ticket bundle may comprise a file including the ticket information and a link (e.g., a hyperlink) to the at least one image. In some implementations, the ticket bundle may include one or more descriptor files themselves.

[0121] At step **646**, one or more tickets **526** are dispatched and locate personnel **528** retrieve the one or more tickets **526** (e.g., from central server **520**) via their respective onsite computers **532**. For example, the tickets **526** may be electronically transmitted to the locate personnel **528** from the central server **520**. Alternatively, the tickets **526** may be made accessible to the locate personnel **528** on the central server **520**. In one example and referring to FIG. **2**, a certain locate personnel **528** retrieves a ticket **526** that includes the VWL image file **530** of multi-generational VWL image **200** along with its corresponding ticket information. In another example and referring to FIGS. **3** and **4**, a certain locate personnel **528** retrieves a ticket **526** that includes the VWL image files **530** of multi-generational VWL images **301**, **302**, **303**, and **304** of VWL image series **300** along with the corresponding ticket information. According to yet another example, the ticket may include a link to the one or more VWL images or other information specifying or permitting access to the one or more VWL images, rather than including the image or images themselves. As noted above, custom viewers also may be employed by ticket recipients to provide limited access to VWL images,

[0122] At step **648**, locate personnel **528** views the ticket information and the multi-generational VWLs in order to perform a locate operation. In one example and referring to FIG. **2**, a certain locate personnel **528** uses viewer **534** to view information of ticket **526** and to view VWL **201** through **211** of multi-generational VWL image **200** in order to perform the locate operation according to the order and date specified thereon. In another example and referring to FIGS. **3** and **4**, a certain locate personnel **528** uses viewer **534** to view information of ticket **526** and to view VWL **311** of multi-generational VWL image **301**, VWL **312** of multi-generational VWL image **302**, VWL **313** of multi-generational VWL image **303**, and VWL **314** of multi-generational VWL image **304** in order to perform the locate operation according to the order and date specified thereon.

[0123] It should be appreciate that while the foregoing example relates to a method of operation and/or of using a multi-generational VWL system, the method may also apply to single stage projects and single VWL image files.

[0124] In summary, multi-generational VWL application **100**, multi-generational VWL system **500**, and/or method **600** may provide improved tools for clearly documenting plans for staged excavation with respect to, for example, multiple related tickets and/or project tickets that is not otherwise available using current processes.

[0125] Further, multi-generational VWL application **100**, multi-generational VWL system **500**, and/or method **600** may provide improved communication mechanisms between excavators and locate personnel for synchronizing staged excavation activities and locate operations that are not otherwise available using current processes.

[0126] Yet further, because of the improved communication mechanisms between excavators and locate personnel, multi-generational VWL application **100**, multi-generational VWL system **500**, and/or method **600** may provide improved operating efficiency for both excavation companies and locate service providers. Still further, because of the improved tools and communication mechanisms between excavators and locate personnel, multi-generational VWL

application **100**, multi-generational VWL system **500**, and/or method **600** may reduce or entirely eliminate the uncertainty for excavators about the status and/or quality of locate operations, which may reduce or entirely eliminate the risk of damage to underground facilities.

[0127] While various inventive embodiments have been described and illustrated herein, those of ordinary skill in the art will readily envision a variety of other means and/or structures for performing the function and/or obtaining the results and/or one or more of the advantages described herein, and each of such variations and/or modifications is deemed to be within the scope of the inventive embodiments described herein. More generally, those skilled in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the inventive teachings is/are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific inventive embodiments described herein. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, inventive embodiments may be practiced otherwise than as specifically described and claimed. Inventive embodiments of the present disclosure are directed to each individual feature, system, article, material, kit, and/or method described herein. In addition, any combination of two or more such features, systems, articles, materials, kits, and/or methods, if such features, systems, articles, materials, kits, and/or methods are not mutually inconsistent, is included within the inventive scope of the present disclosure. All definitions, as defined and used herein, should be understood to control over dictionary definitions, definitions in documents incorporated by reference, and/or ordinary meanings of the defined terms. The indefinite articles "a" and "an," as used herein in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean "at least one."

[0128] The phrase "and/or," as used herein in the specification and in the claims, should be understood to mean "either or both" of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements listed with "and/or" should be construed in the same fashion, i.e., "one or more" of the elements so conjoined. Other elements may optionally be present other than the elements specifically identified by the "and/or" clause, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, a reference to "A and/or B", when used in conjunction with open-ended language such as "comprising" can refer, in one embodiment, to A only (optionally including elements other than B); in another embodiment, to B only (optionally including elements other than A); in yet another embodiment, to both A and B (optionally including other elements); etc.

[0129] As used herein in the specification and in the claims, "or" should be understood to have the same meaning as "and/or" as defined above. For example, when separating items in a list, "or" or "and/or" shall be interpreted as being inclusive, i.e., the inclusion of at least one, but also including more than one, of a number or list of elements, and, optionally, additional unlisted items. Only terms clearly indicated to the contrary, such as "only one of" or "exactly one of,", or, when used in the claims, "consisting of," will refer to the inclusion of exactly one element of a number or list of elements. In general, the term "or" as used herein shall only be interpreted as indicating exclusive alternatives (i.e. "one or the other but not both") when preceded by terms of exclusivity, such as "either," "one of," "only one of," or "exactly one of." "Consisting essentially of," when used in the claims, shall have its ordinary meaning as used in the field of patent law.

[0130] As used herein in the specification and in the claims, the phrase "at least one," in reference to a list of one or more elements, should be understood to mean at least one element selected from any one or more of the elements in the list of elements, but not necessarily including at least one of each and every element specifically listed within the list of elements and not excluding any combinations of elements in the list of elements. This definition also allows that elements may optionally be present other than the elements specifically identified within the list of elements to which the phrase "at least one" refers, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, "at least one of A and B" (or, equivalently, "at least one of A or B," or, equivalently "at least one of A and/or B") can refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including elements other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including elements other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other elements); etc.

[0131] It should also be understood that, unless clearly indicated to the contrary, in any methods claimed herein that include more than one step or act, the order of the steps or acts of the method is not necessarily limited to the order in which the steps or acts of the method are recited.

[0132] In the claims, as well as in the specification above, all transitional phrases such as "comprising," "including," "carrying," "having," "containing," "involving," "holding," "composed of," and the like are to be understood to be open-ended, i.e., to mean including but not limited to. Only the transitional phrases "consisting of" and "consisting essentially of" shall be closed or semi-closed transitional phrases, respectively, as set forth in the United States Patent Office Manual of Patent Examining Procedures, Section 2111.03.

What is claimed is:

1. An apparatus for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities, the apparatus comprising:

a communication interface;

a memory to store processor-executable instructions; and

a processing unit coupled to the communication interface and the memory, wherein upon execution of the processor-executable instructions by the processing unit, the processing unit:

electronically receives, via the communication interface, at least one user input relating to the dig area;

based on the at least one user input, renders a digital virtual white line image including at least one dig area indicator to provide at least one indication of the dig area with respect to a geographic area; and

transmits a limited access file comprising information relating to the digital virtual white line image, via the

communication interface, to at least one party associated with the at least one underground facility so as to facilitate the detection of the presence or the absence of the at least one underground facility within the dig area.

2. The apparatus of claim **1**, wherein the limited access file is a password protected file.

3. The apparatus of claim **1**, wherein the limited access file has a proprietary format.

4. The apparatus of claim **1**, wherein the limited access file has a proprietary filename extension.

5. The apparatus of claim **1**, wherein the limited access file is an encrypted file.

6. The apparatus of claim **1**, wherein the information related to the digital virtual white line image comprises a limited access virtual white line image or data usable to render the limited access virtual white line image.

7. The apparatus of claim **6**, wherein the limited access file is configured so as to facilitate viewing of the digital virtual white line image only via a corresponding image file viewer.

8. The apparatus of claim **7**, wherein the limited access file comprises version information identifying a corresponding version of the image file viewer to facilitate viewing of the digital virtual white line image.

9. The apparatus of claim **7**, wherein the processing unit transmits the corresponding image file viewer, via the communication interface, to the at least one party associated with the at least one underground facility.

10. The apparatus of claim **9**, wherein the image file viewer prevents write access to the limited access virtual white line image,

11. The apparatus of claim **9**, wherein the image file viewer prevents save access to the limited access virtual white line image.

12. The apparatus of claim **9**, wherein the image file viewer prevents copy access to the limited access virtual white line image.

13. The apparatus of claim **9**, wherein the image file viewer is programmed to require an indication of acceptance of terms and/or conditions prior to permitting the limited access virtual white line image to be viewed.

14. The apparatus of claim **9**, wherein the image file viewer is programmed to determine whether an updated version of the image file viewer is available.

15. The apparatus of claim **1**, wherein the information relating to the digital virtual white line image comprises an image and dig area information relating to the at least one dig area indicator.

16. The apparatus of claim **15**, wherein the dig area information comprises geographic coordinates of the dig area.

17. The apparatus of claim **15**, wherein the dig area information specifies virtual white lines to be rendered on the image.

18. The apparatus of claim **15**, wherein the dig area information comprises access permission information specifying access permissions for the dig area information.

19. The apparatus of claim **15**, wherein the information relating to the digital virtual white line image comprises an XML file including the dig area information.

20. The apparatus of claim **15**, wherein the information relating to the digital virtual white line image comprises metadata including the dig area information.

21. The apparatus of claim **15**, wherein the information relating to the digital virtual white line image comprises metadata including at least one of:

date and/or time information indicating when the digital virtual white line image was created;

creator information indicating a creator of the digital virtual white line image;

geographic location information identifying a location of the dig area;

provider information identifying a service used to create the digital virtual white line image; and

geographic coordinate information identifying geographic coordinates corresponding to the digital virtual white line image.

22. The apparatus of claim **15**, wherein the information relating to the digital virtual white line image comprises a descriptor file including at least one of:

date and/or time information indicating when the digital virtual white line image was created;

creator information indicating a creator of the digital virtual white line image;

geographic location information identifying a location of the dig area;

provider information identifying a service used to create the digital virtual white line image; and

geographic coordinate information identifying geographic coordinates corresponding to the digital virtual white line image.

23. The apparatus of claim **1**, wherein the processing unit transmits the limited access file with data identifying a ticket with which the digital virtual white line image is associated.

24. The apparatus of claim **23**, wherein the data identifying the ticket comprises metadata associated with the digital virtual white line image.

25. The apparatus of claim **23**, wherein the data identifying the ticket comprises a descriptor file.

26. The apparatus of claim **23**, wherein the data identifying the ticket comprises a ticket number,

27. A method for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities, the method comprising:

A) electronically receiving at least one user input relating to the dig area;

B) based on the at least one user input, rendering a digital virtual white line image including at least one dig area indicator to provide at least one indication of the dig area with respect to a geographic area; and

C) electronically transmitting a limited access file comprising information relating to the digital virtual white line image to at least one party associated with the at least one underground facility so as to facilitate the detection of the presence or the absence of the at least one underground facility within the dig area.

28. At least one computer-readable medium encoded with instructions that, when executed by at least one processing unit, perform a method for facilitating detection of a presence or an absence of at least one underground facility within a dig area, wherein at least a portion of the dig area may be excavated or disturbed during excavation activities, the method comprising:

A) electronically receiving at least one user input relating to the dig area;

B) based on the at least one user input, rendering a digital virtual white line image including at least one dig area indicator to provide at least one indication of the dig area with respect to a geographic area; and

C) electronically transmitting a limited access file comprising information relating to the digital virtual white line image to at least one party associated with the at least one underground facility so as to facilitate the detection of the presence or the absence of the at least one underground facility within the dig area.

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