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(54) **VISUAL CONTENT OVERLAY SYSTEM**

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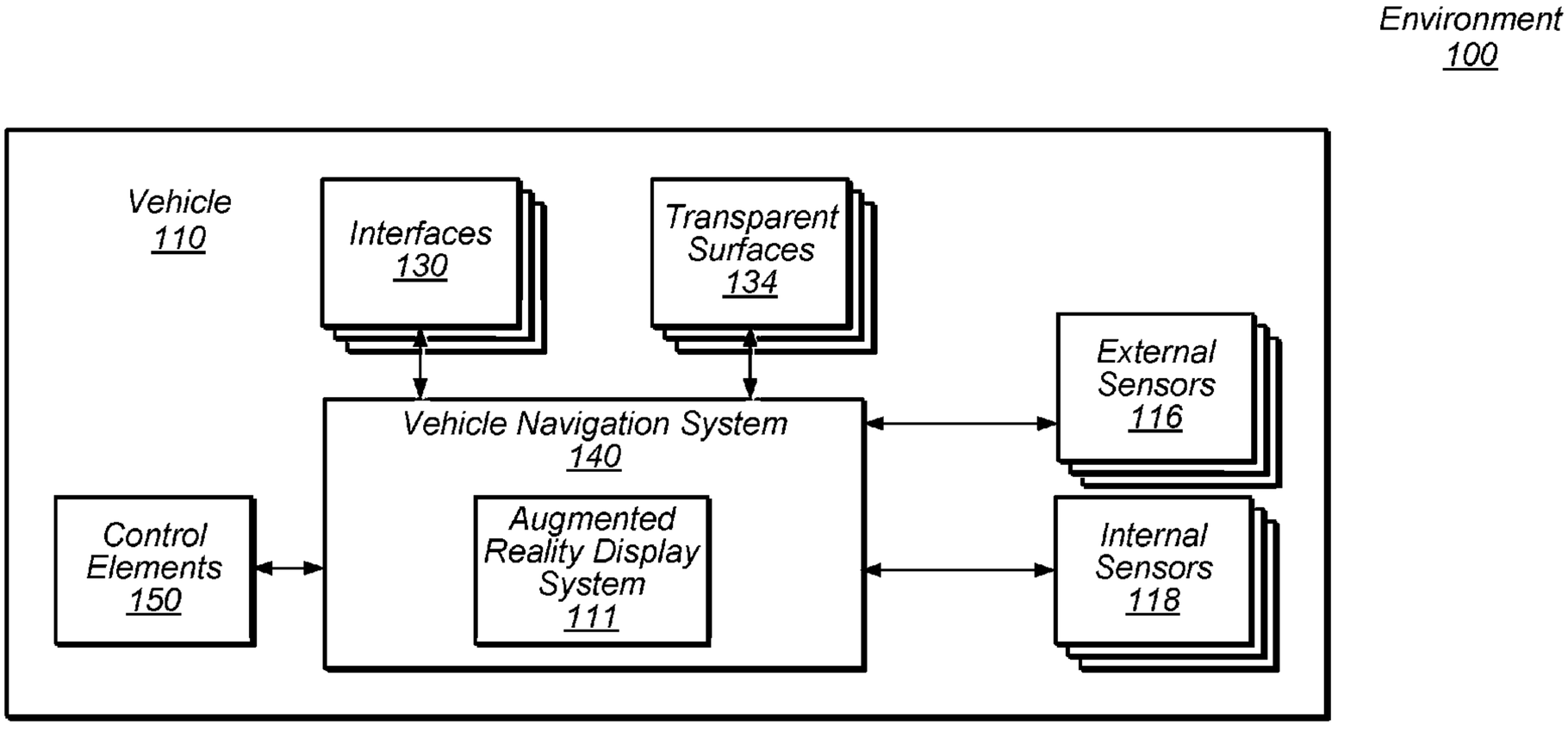
(57) **ABSTRACT**

An augmented reality display system included in a vehicle generates an augmented reality display, on one or more transparent surfaces of the vehicle. The augmented reality display can include an indicator of the vehicle speed which is spatially positioned according to the speed of the vehicle relative to the local speed limit. The augmented reality display can include display elements which conform to environmental objects and can obscure and replace content displayed on the objects. The augmented reality display can include display elements which indicate a position of environmental objects which are obscured from direct perception through the transparent surface. The augmented reality display can include display elements which simulate one or more particular environmental objects in the environment, based on monitoring manual driving performance of the vehicle by a driver. The augmented reality display can include display elements which identify environmental objects and particular zones in the environment.



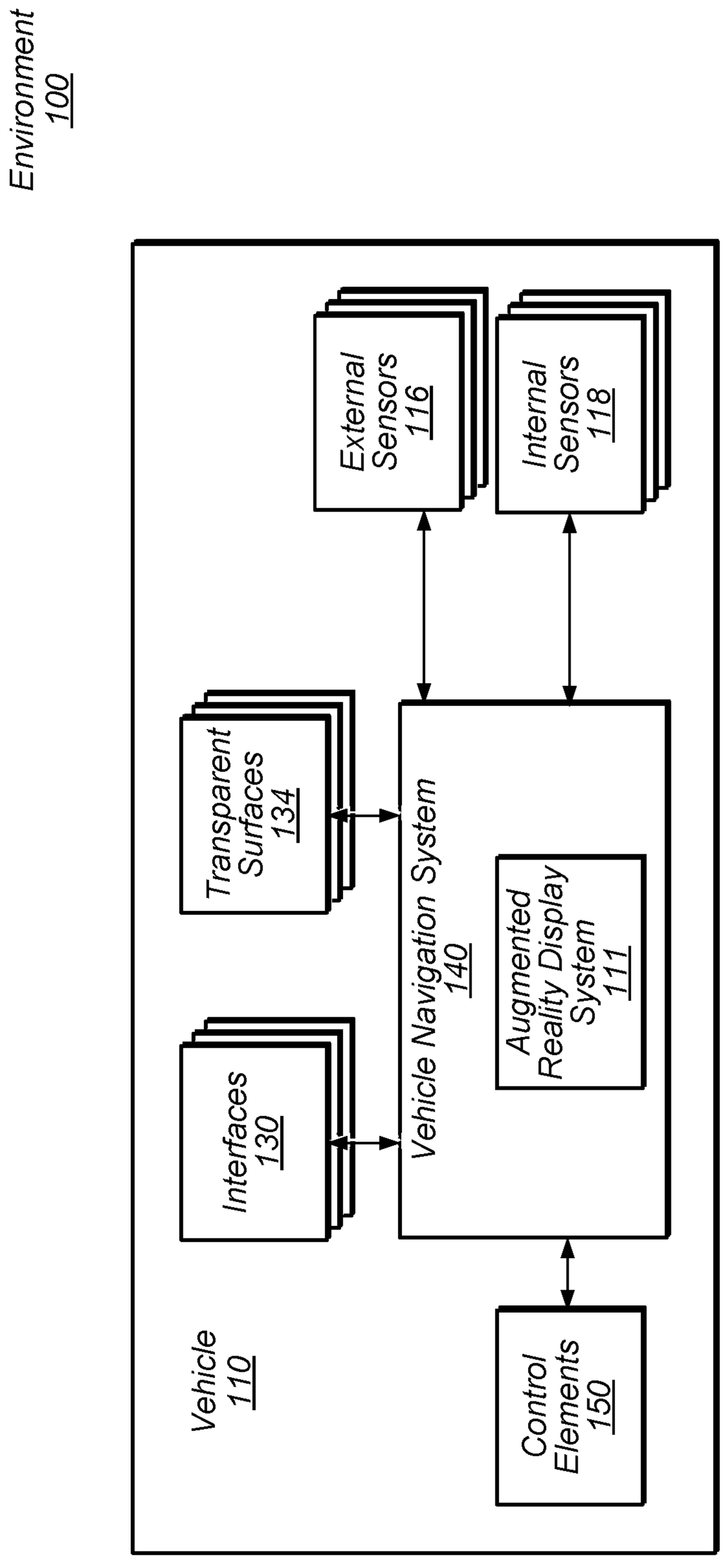

Environment
100
Vehicle
110
Interfaces
130
Transparent
Surfaces
134
Vehicle Navigation System
140
External
Sensors
116
Internal
Sensors
118
Augmented
Reality Display
System
111
Control
Elements
150

FIG. 1

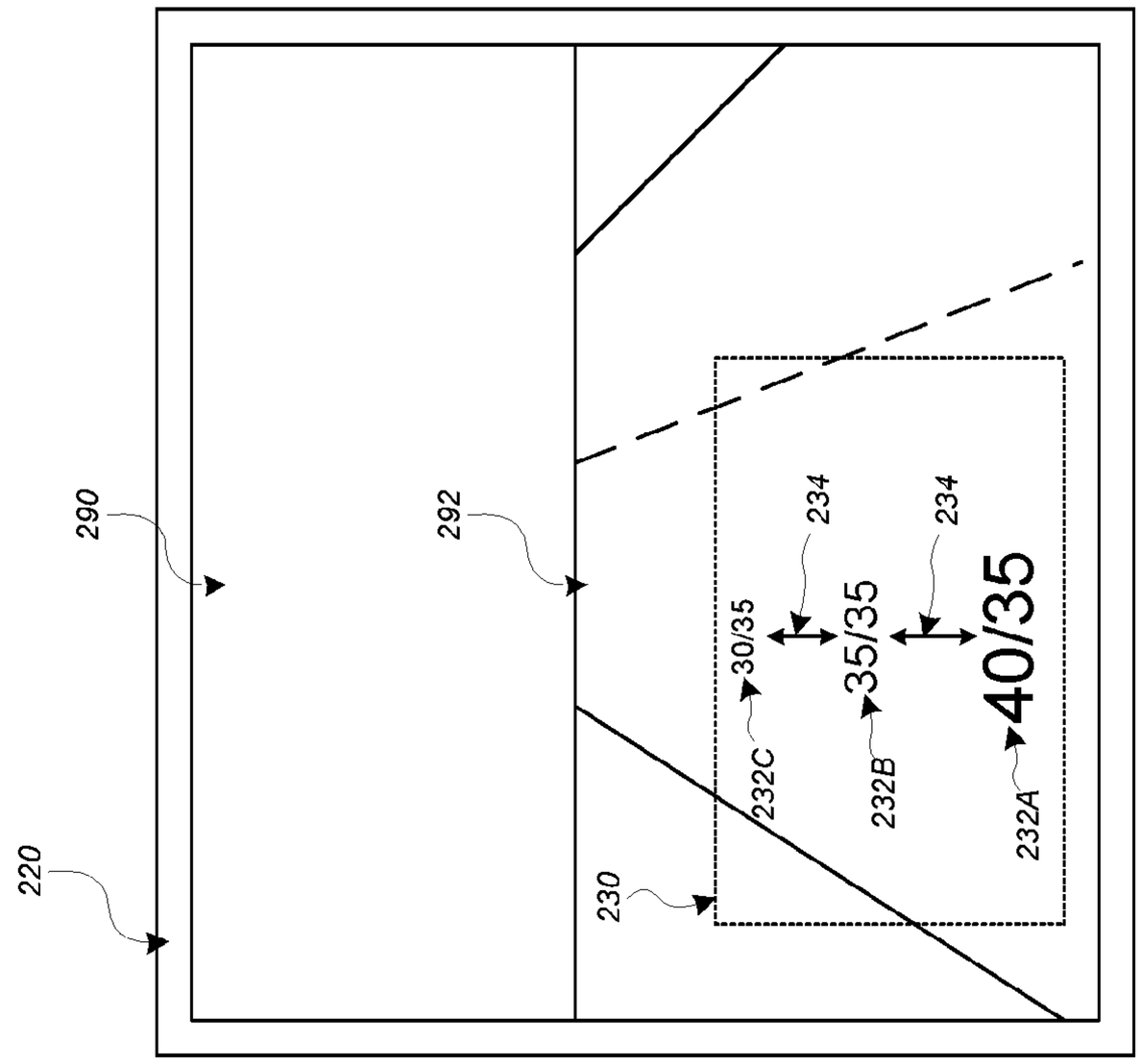

290
292
234
234
30/35
35/35
40/35
232C
232B
232A
220
230

FIG. 2B

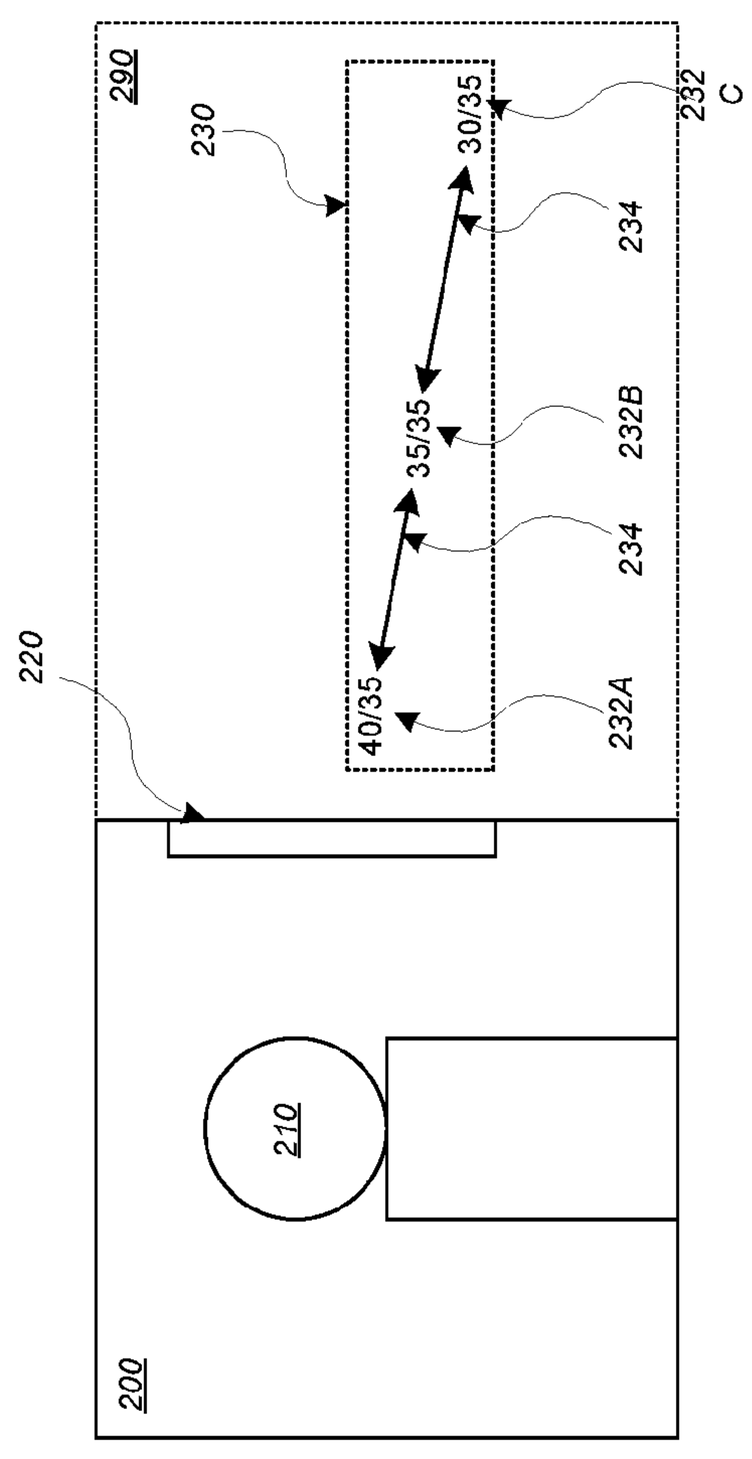

290
230
30/35
232C
234
35/35
232B
40/35
232A
220
210
200

FIG. 2A

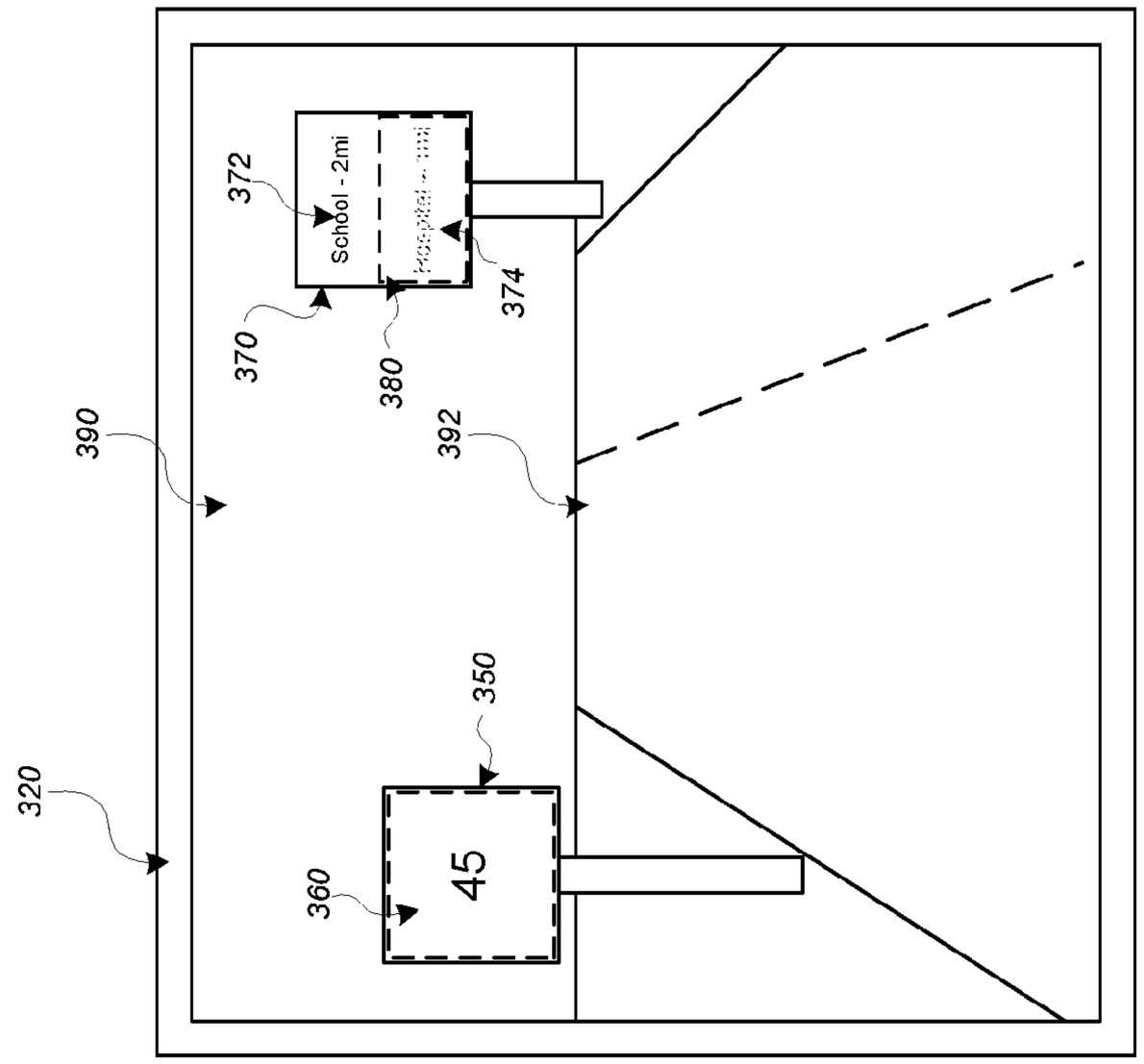

372
School - 2mi
374
370
380
390
392
350
320
360
45

FIG. 3B

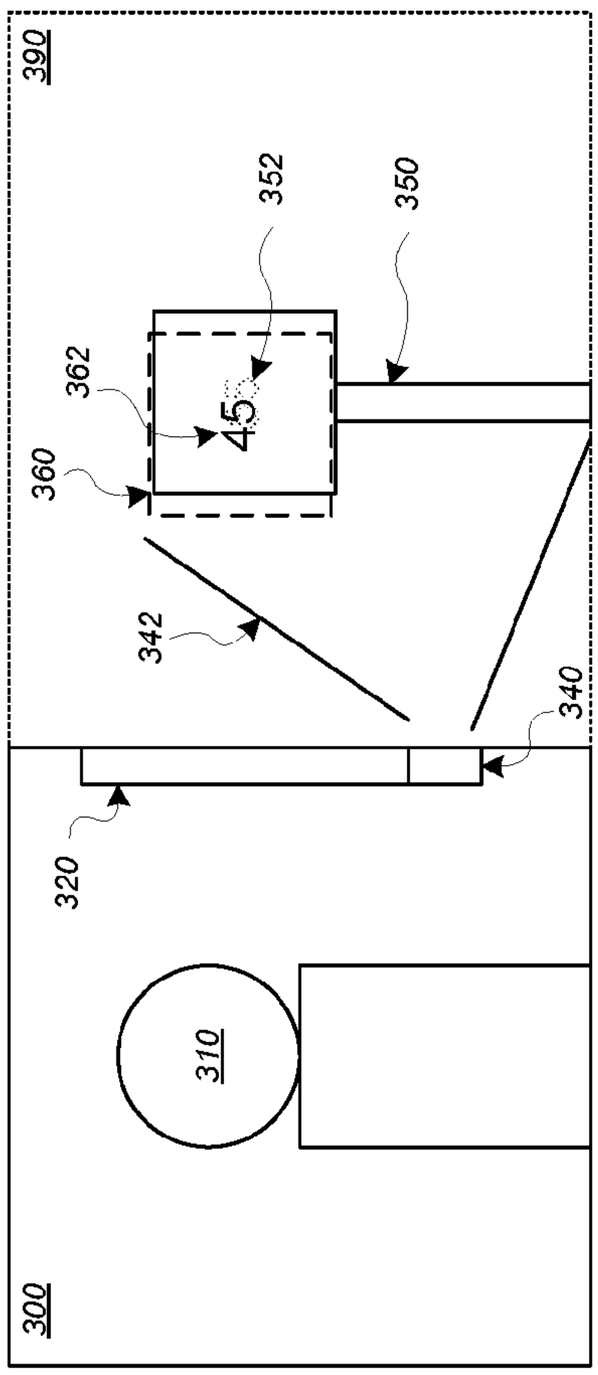

390
352
350
362
45
360
342
340
320
310
300

FIG. 3A

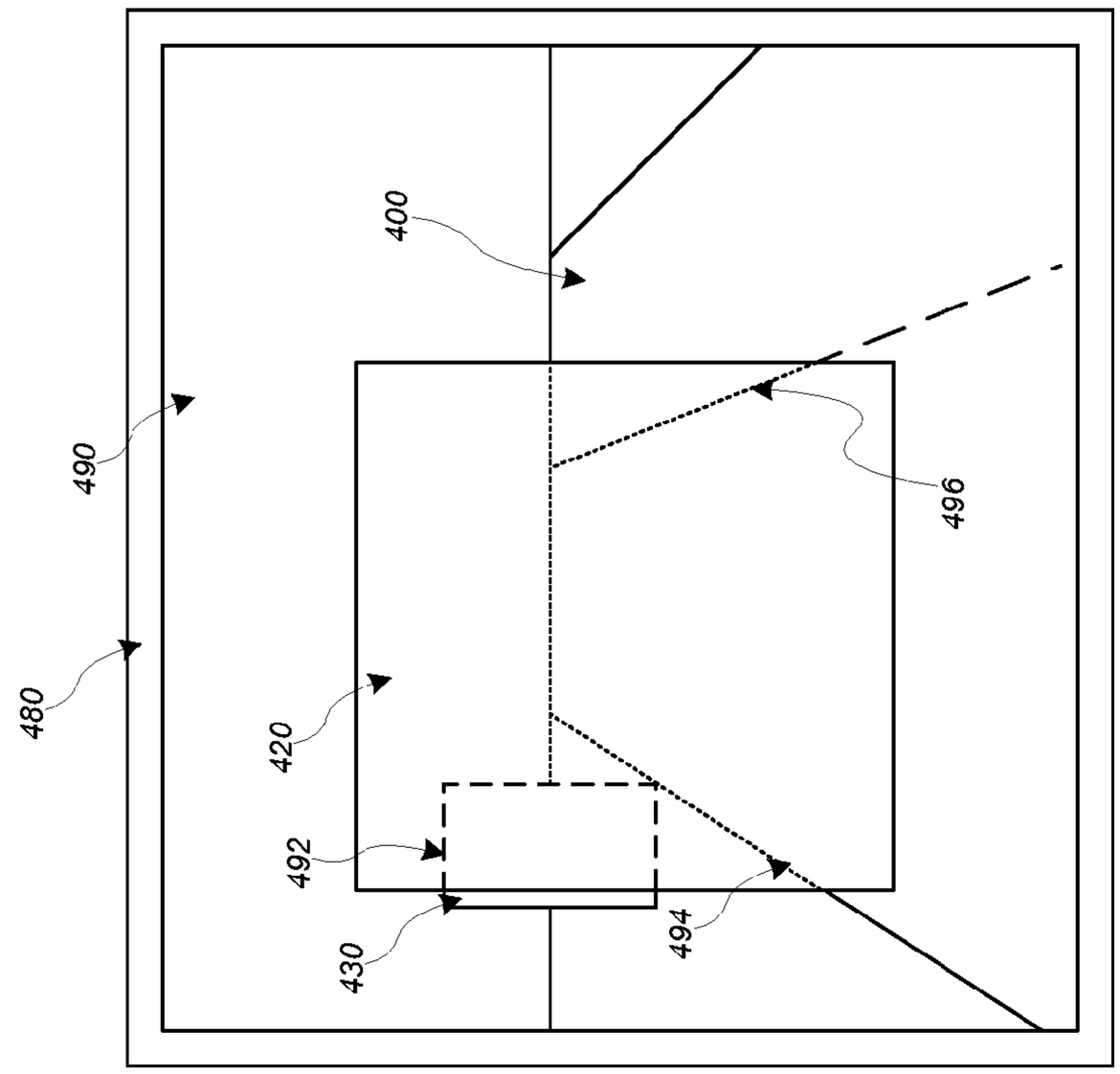


FIG. 4B

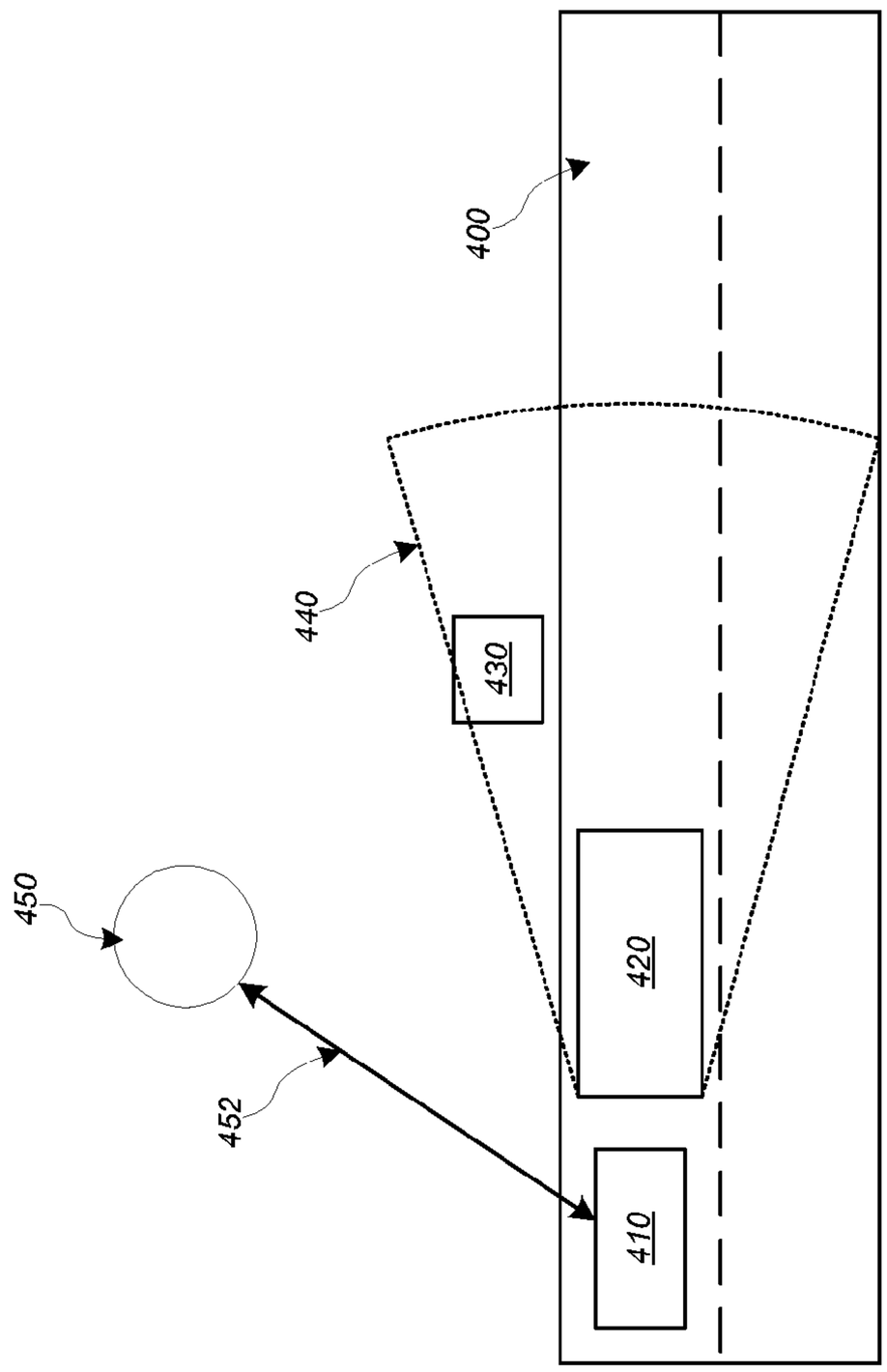


FIG. 4A

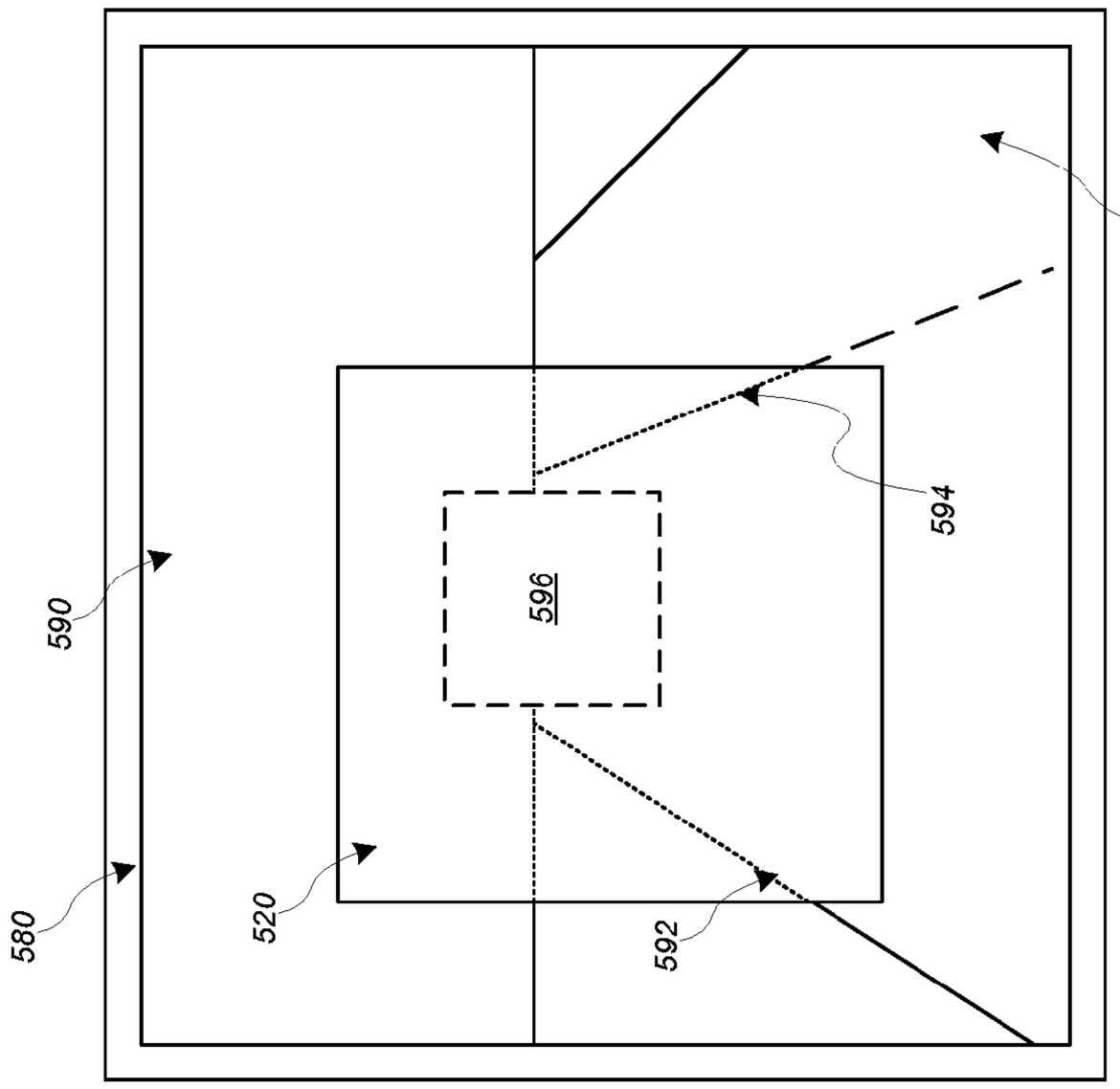

500
590
596
594
580
520
592

FIG. 5B

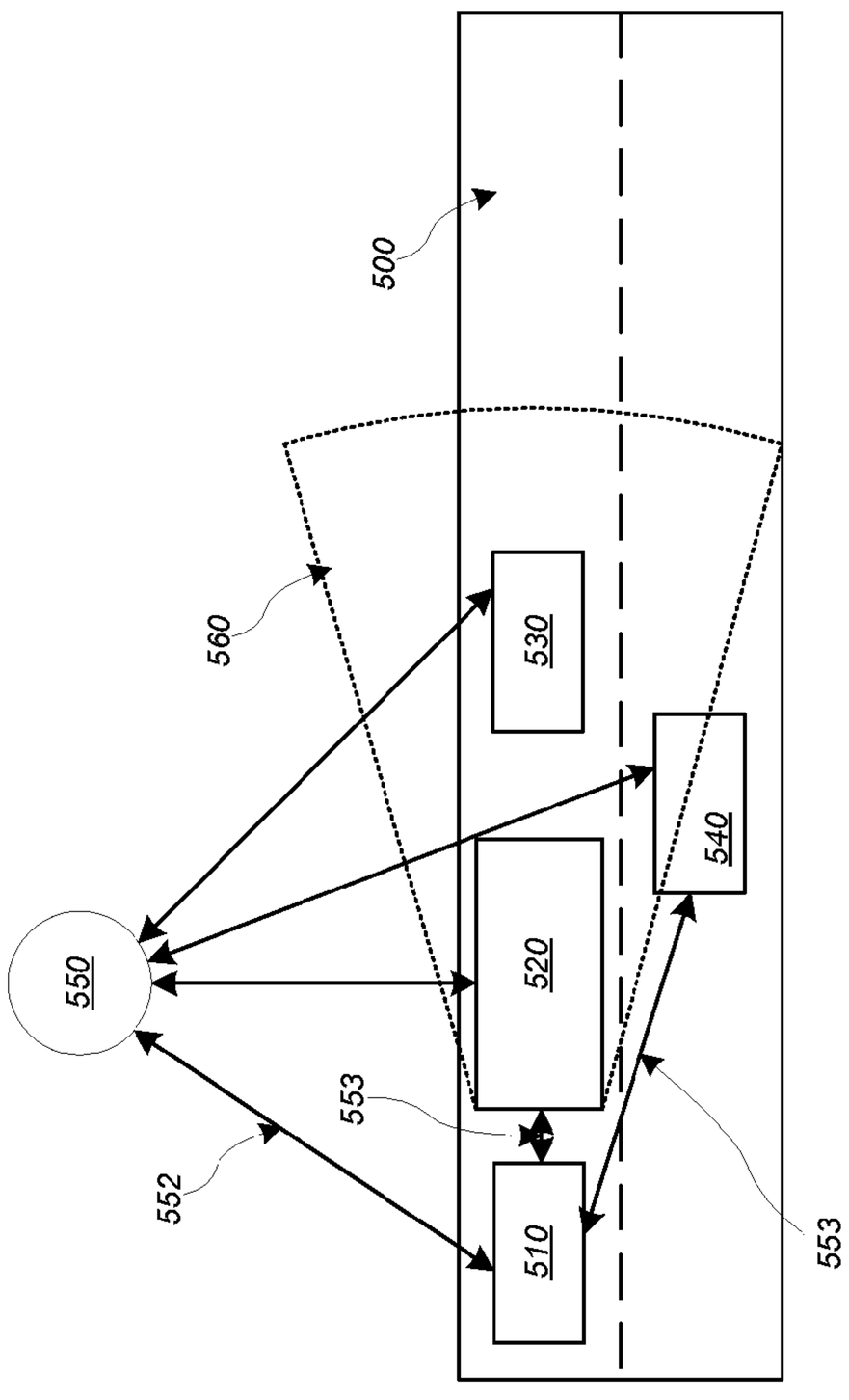

500
560
530
550
520
540
553
552
510
553

FIG. 5A

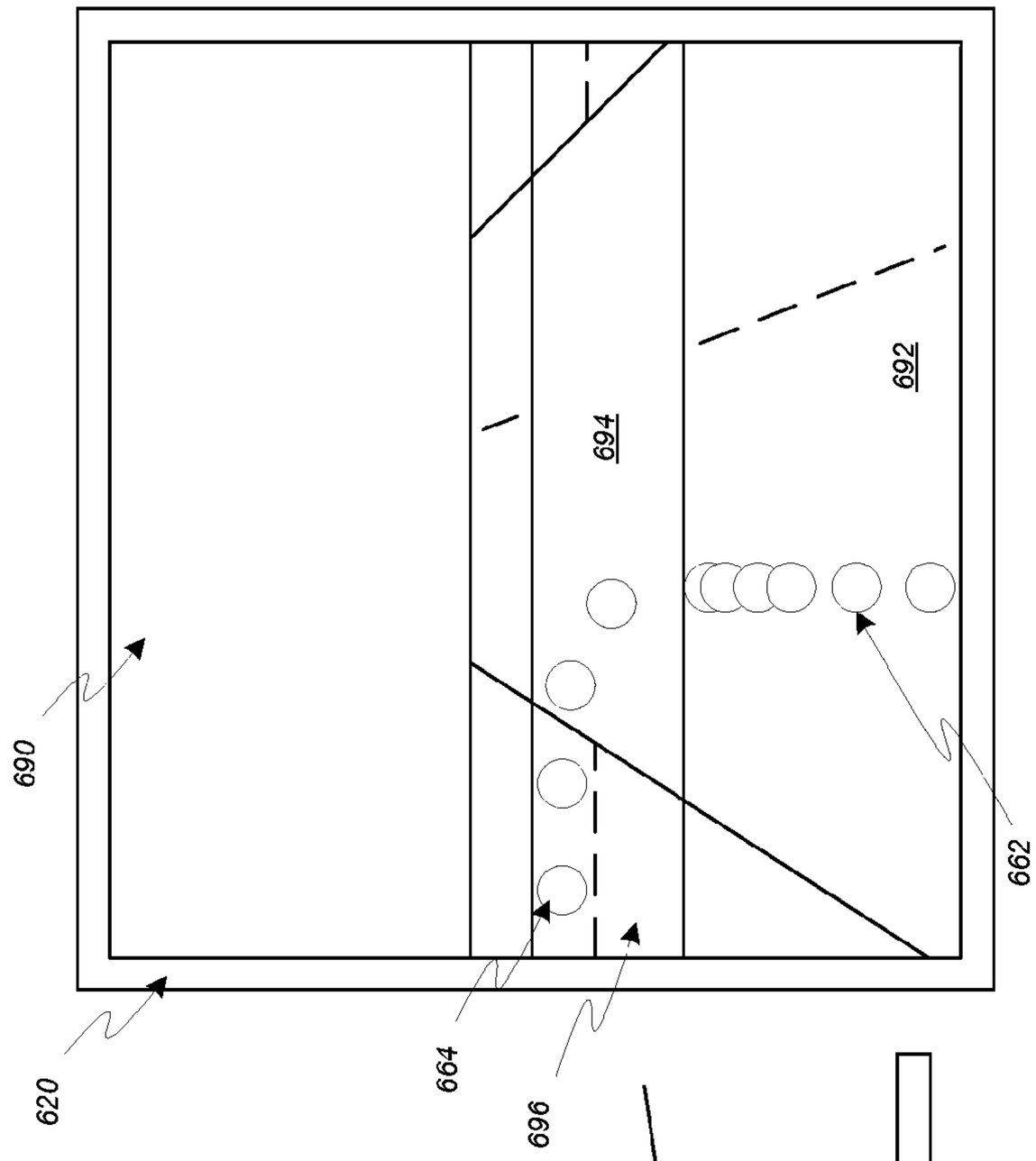


FIG. 6B

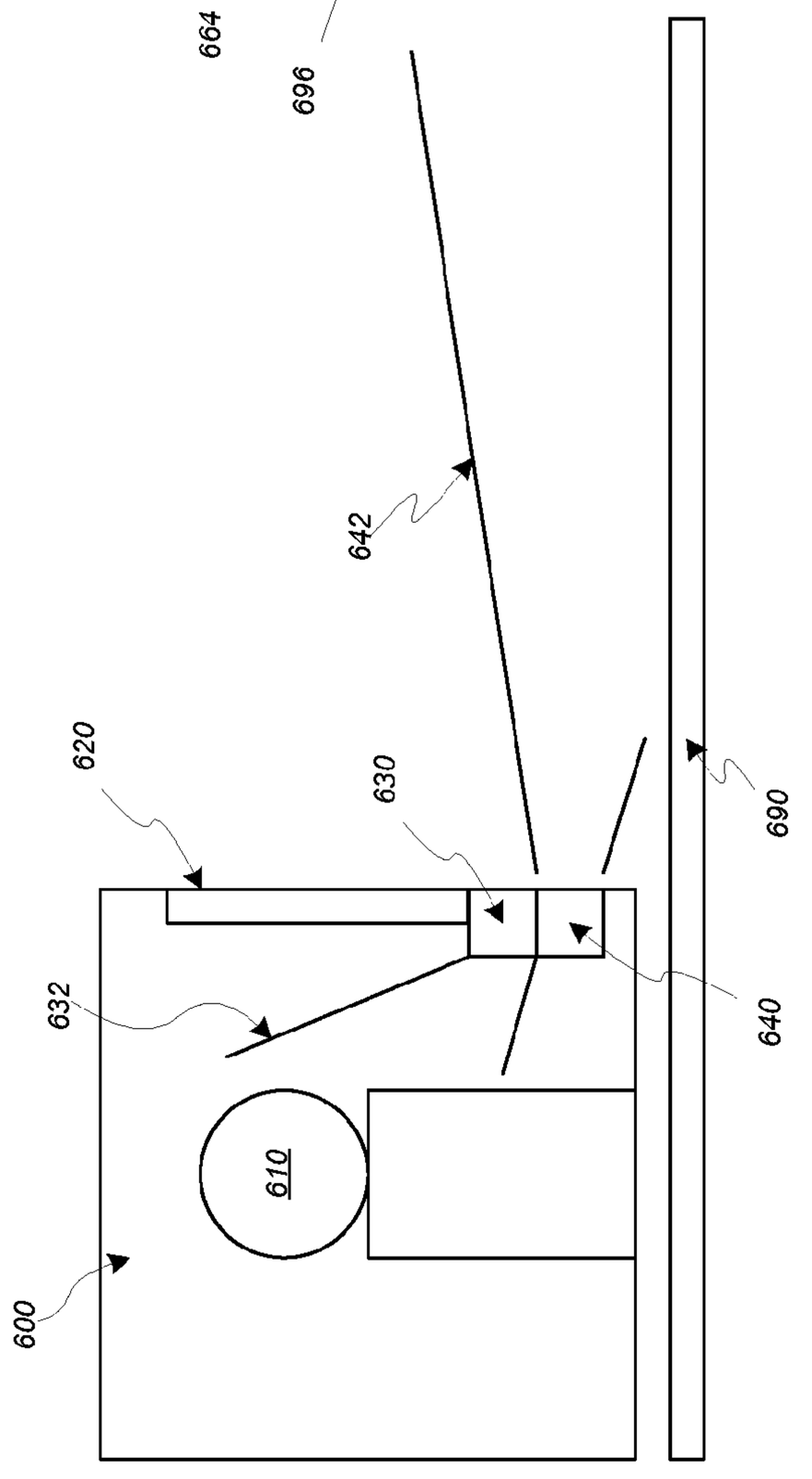


FIG. 6A

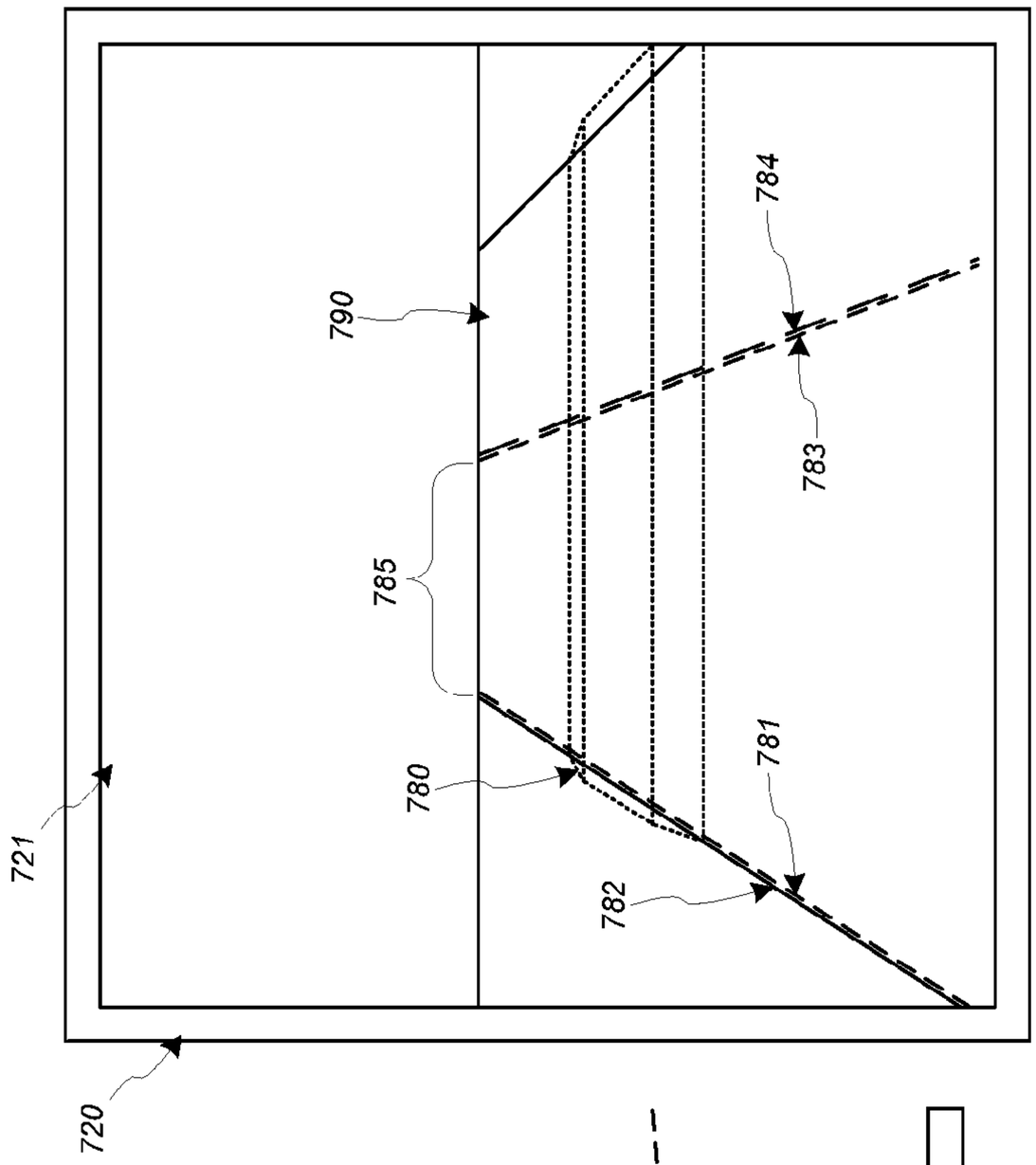

790
784
783
785
780
781
782
721
720

FIG. 7B

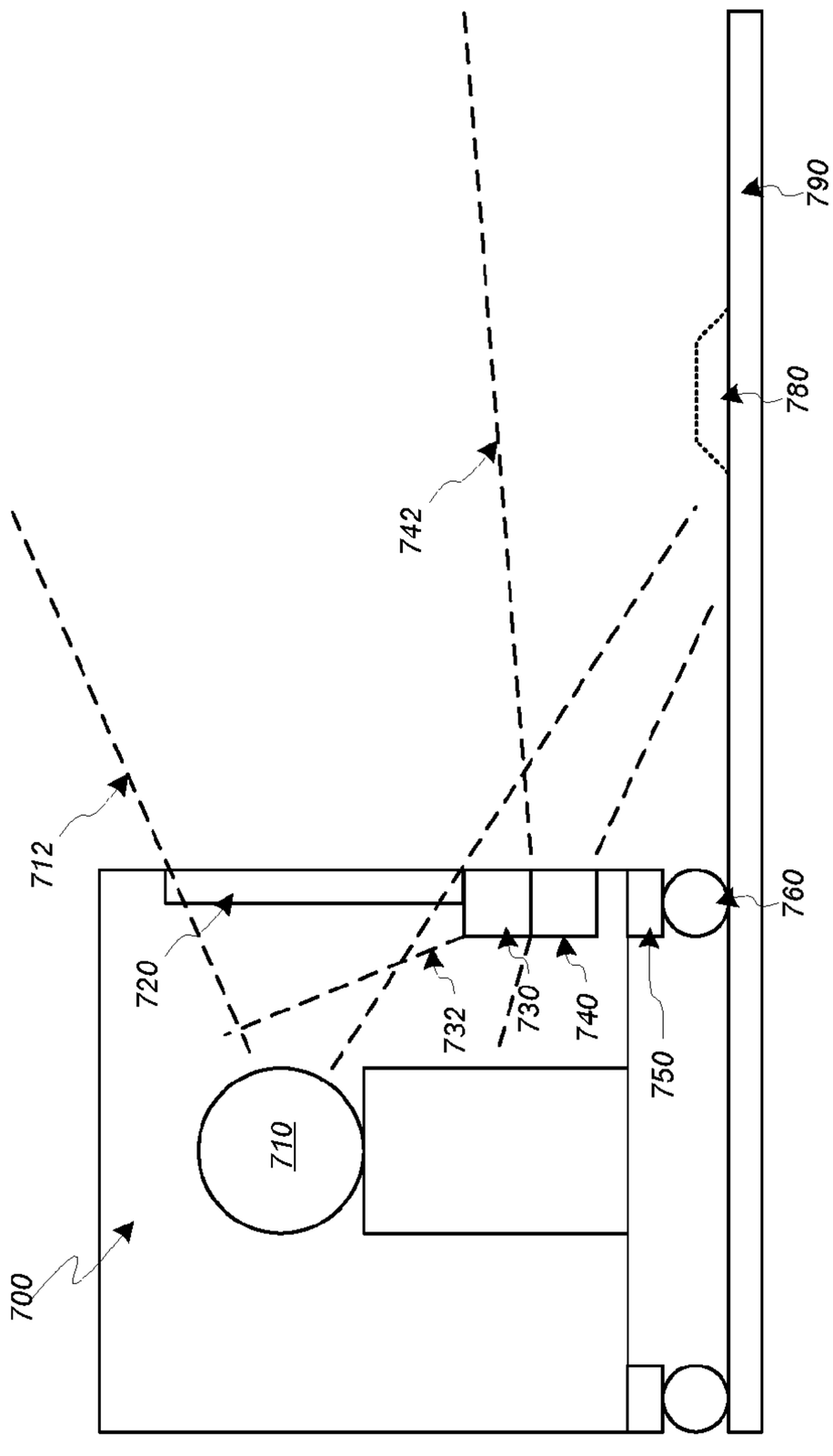

790
780
742
712
720
732
730
740
750
760
710
700

FIG. 7A

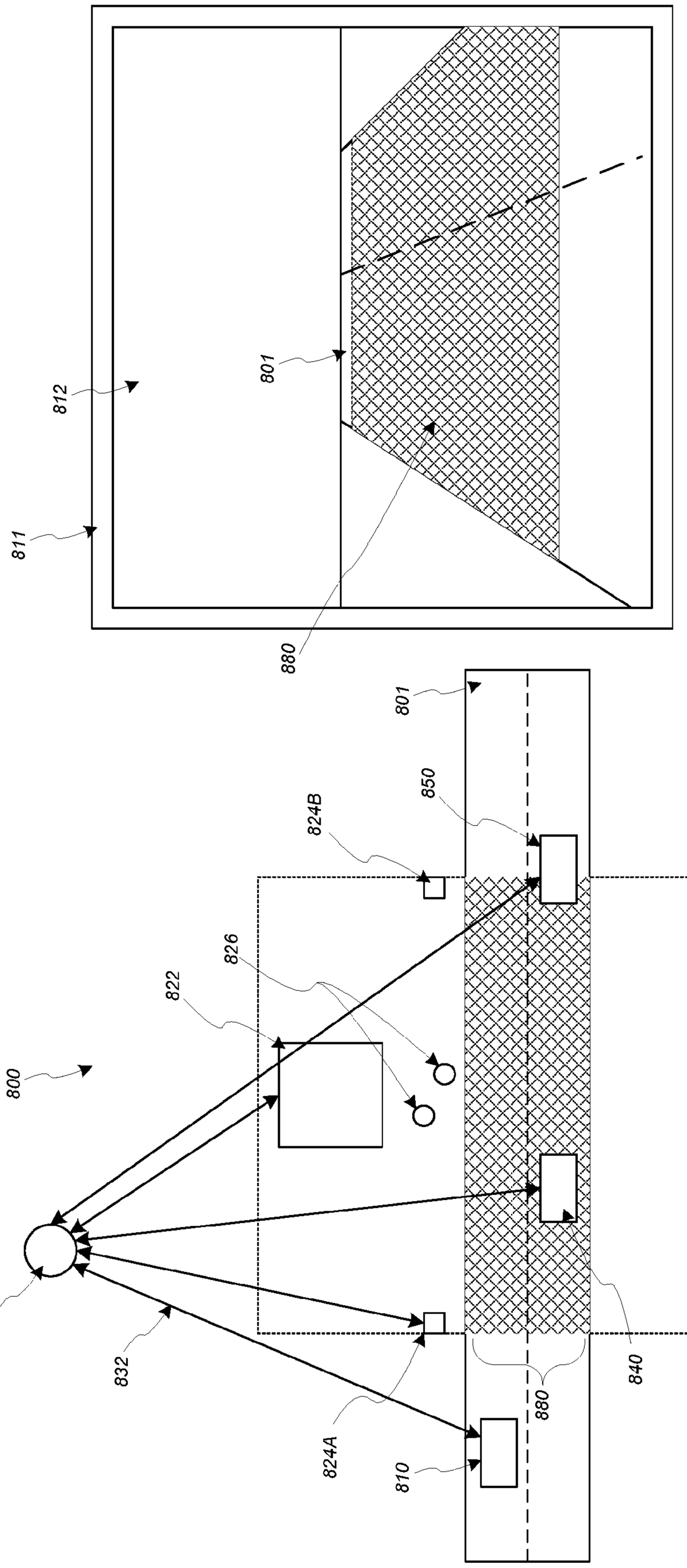

812
801
811
880
801
850
824B
820
826
822
800
830
832
824A
810
880
840

FIG. 8A

FIG. 8B

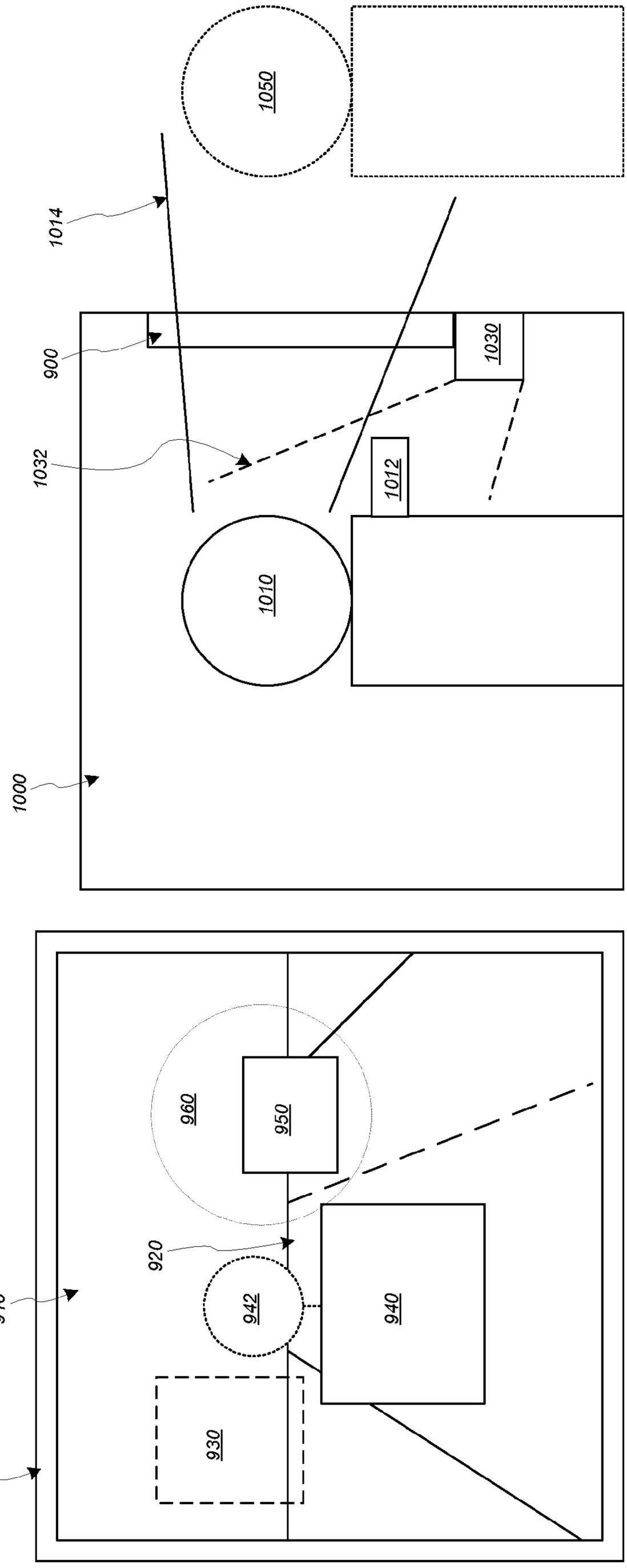

900
910
920
930
940
942
950
960
1000
1010
1012
1014
1030
1032
1050

FIG. 9

FIG. 10

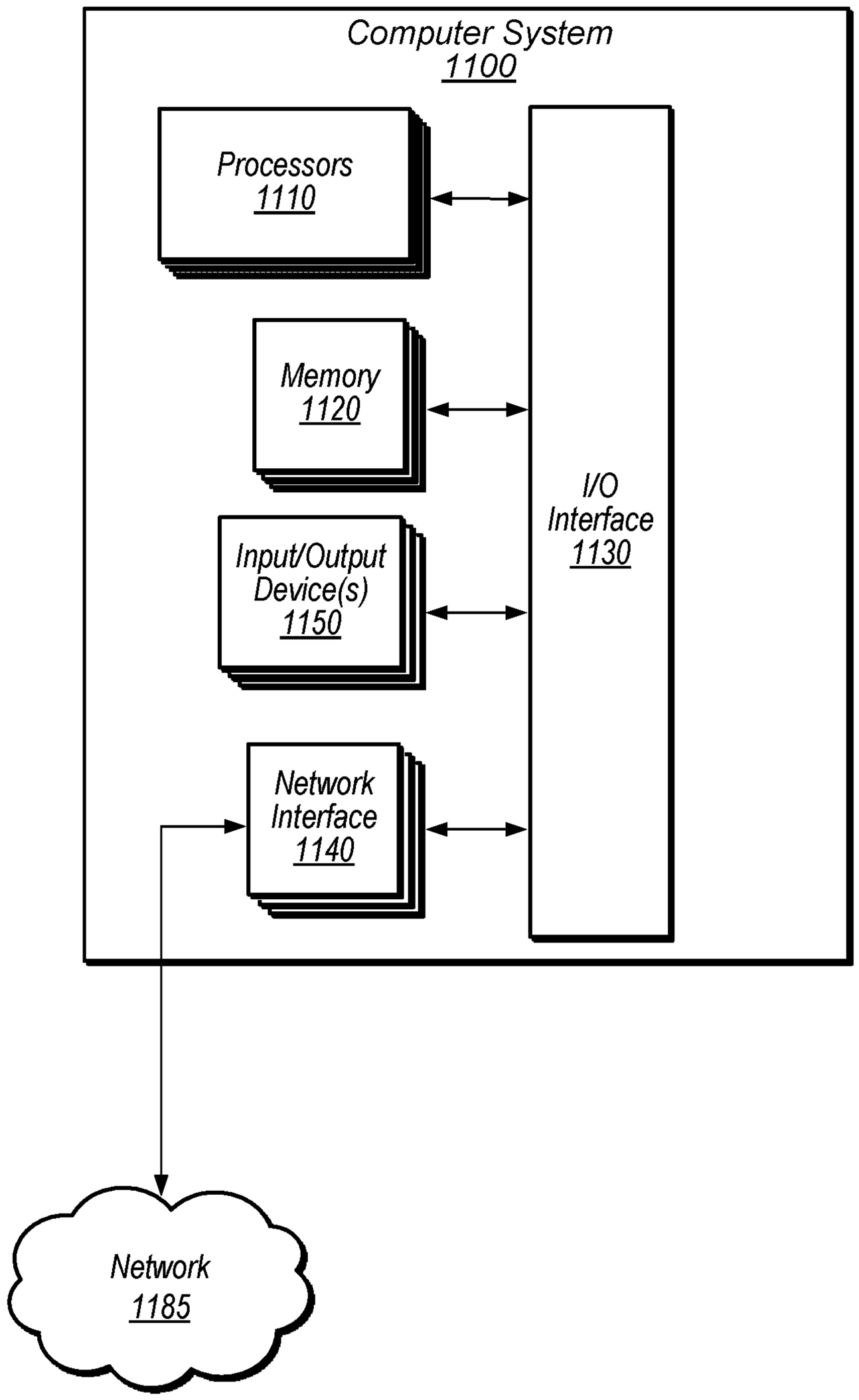

Computer System
1100
Processors
1110
Memory
1120
Input/Output
Device(s)
1150
Network
Interface
1140
I/O
Interface
1130
Network
1185

FIG. 11

VISUAL CONTENT OVERLAY SYSTEM

[0001] This application is a divisional of U.S. Pat. Application Serial No. 17/315,159, filed May 7, 2021, which is a divisional of U.S. Pat. Application Serial No. 15/762,543, filed Mar. 22, 2018, now U.S. Pat. No. 11,004,426, which is a 371 of PCT Application No. PCT/US2016/053182, filed Sep. 22, 2016, which claims benefit of priority to U.S. Provisional Pat. Application No. 62/232,855, filed Sep. 25, 2015. The above applications are incorporated herein by reference. To the extent that any material in the incorporated application conflicts with material expressly set forth herein, the material expressly set forth herein controls.

BACKGROUND

[0002] In many situations, a graphical overlay can be provided on an environment that is perceived through a transparent surface, including a window. A graphical overlay can provide information to an observer, including information which is relevant to one or more portions of the perceived environment. In some cases, a graphical overlay is used in a vehicle, where a graphical overlay can be perceived by an occupant of the vehicle and provides information relevant to one or more of the vehicle, including vehicle speed, and one or more portions of the environment in which the vehicle is located. Such information can be provided on a transparent surface, including a forward window, also referred to herein as a windscreen, windshield, etc., such that the information can be perceived by an operator of the vehicle, including a driver, near the line of sight of the operator as the operator observes the environment through which the vehicle is navigated, including an oncoming roadway.

[0003] In some cases, the graphics displayed should be able to overlay certain objects located in the environment perceived though the transparent surface and can augment, alter, control, information related to the environment which is provided to an observer via the transparent surface. Such graphical overlays can be referred to as an augmented reality display.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** illustrates a vehicle, according to some embodiments.

[0005] FIGS. **2**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display indicating a spatial indication of a speed of the vehicle relative to a local speed limit, according to some embodiments.

[0006] FIGS. **3**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which modifies occupant-perceived information presented by a sign located in the external environment, according to some embodiments.

[0007] FIGS. **4**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which provides a representation of a static object in the environment which is presently obscured from direct view through the transparent surface of the vehicle, according to some embodiments.

[0008] FIGS. **5**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which provides a representation of at least one dynamic object in the environment which is presently obscured from direct view through the transparent surface of the vehicle, according to some embodiments.

[0009] FIGS. **6**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which provides a dynamically controllable representation of a driving route along which a vehicle is being navigated, according to some embodiments.

[0010] FIGS. **7**A-B illustrate a vehicle which simulates, via one or more of a transparent surface which provides an augmented reality display and an active suspension system, one or more objects in the environment, according to some embodiments.

[0011] FIGS. **8**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which indicates a particular driving zone in the environment, according to some embodiments.

[0012] FIG. **9** illustrates a transparent surface which provides an augmented reality display of one or more portions of an environment, according to some embodiments.

[0013] FIG. **10** illustrates a vehicle comprising a transparent surface which provides an augmented reality display which enables user selection of a portion of the environment perceived via the transparent surface and which enables video communication with a remotely-located user via the transparent surface, according to some embodiments.

[0014] FIG. **11** illustrates an example computer system that may be configured to include or execute any or all of the embodiments described above.

DETAILED DESCRIPTION

[0015] This specification includes references to "one embodiment" or "an embodiment." The appearances of the phrases "in one embodiment" or "in an embodiment" do not necessarily refer to the same embodiment. Particular features, structures, or characteristics may be combined in any suitable manner consistent with this disclosure.

[0016] "Comprising." This term is open-ended. As used in the appended claims, this term does not foreclose additional structure or steps. Consider a claim that recites: "An apparatus comprising one or more processor units ...." Such a claim does not foreclose the apparatus from including additional components (e.g., a network interface unit, graphics circuitry, etc.).

[0017] "Configured To." Various units, circuits, or other components may be described or claimed as "configured to" perform a task or tasks. In such contexts, "configured to" is used to connote structure by indicating that the units/circuits/components include structure (e.g., circuitry) that performs those task or tasks during operation. As such, the unit/circuit/component can be said to be configured to perform the task even when the specified unit/circuit/component is not currently operational (e.g., is not on). The units/circuits/components used with the "configured to" language include hardware-for example, circuits, memory storing program instructions executable to implement the operation, etc. Reciting that a unit/circuit/component is "configured to" perform one or more tasks is expressly intended not to invoke 35 U.S.C. § 112, sixth paragraph, for that unit/circuit/component. Additionally, "configured to" can include generic structure (e.g., generic circuitry) that is manipulated by software and/or firmware (e.g., an FPGA or a general-purpose processor executing software) to operate in manner that is capable of performing the task(s) at issue. "Configure

to" may also include adapting a manufacturing process (e.g., a semiconductor fabrication facility) to fabricate devices (e.g., integrated circuits) that are adapted to implement or perform one or more tasks.

[0018] "First," "Second," etc. As used herein, these terms are used as labels for nouns that they precede, and do not imply any type of ordering (e.g., spatial, temporal, logical, etc.). For example, a buffer circuit may be described herein as performing write operations for "first" and "second" values. The terms "first" and "second" do not necessarily imply that the first value must be written before the second value.

[0019] "Based On." As used herein, this term is used to describe one or more factors that affect a determination. This term does not foreclose additional factors that may affect a determination. That is, a determination may be solely based on those factors or based, at least in part, on those factors. Consider the phrase "determine A based on B." While in this case, B is a factor that affects the determination of A, such a phrase does not foreclose the determination of A from also being based on C. In other instances, A may be determined based solely on B.

[0020] FIG. **1** illustrates a vehicle, according to some embodiments. The vehicle **110** is located in an external environment **100** and can include a vehicle navigation system (VNS) **140**. In some embodiments, the VNS **140** can autonomously control one or more vehicle control elements **150** to cause the vehicle **110** to be autonomously navigated along one or more driving routes through the environment **100**. In some embodiments, VNS **140** controls display of information to one or more occupants of the vehicle via one or more interfaces **130**. At least one of the interfaces **130** can include a transparent surface via which an occupant can perceive one or more portions of the environment **100**, and the VNS **140** can control a display of information to the occupant via a graphical overlay on the transparent surface which provides an augmented reality display of one or more portions of the environment perceived by the occupant via the transparent surface.

[0021] Vehicle **110** includes one or more sets of external sensors **116** which generate sensor data representations of one or more portions of the external environment **100**. The external sensors **116** can include one or more of visible light camera devices, infrared camera devices, near-infrared camera devices, light beam scanning devices, ultrasonic sensor devices, audio sensor devices, depth camera devices, radar devices, geographic position detection devices, some combination thereof, etc. Sensor data representations generated by one or more of the external sensors **116** can be communicated to the VNS **140**, and the VNS can generate and maintain a world model of one or more portions of the environment **100** based on the sensor data representations generated by the external sensors **116**. In some embodiments, the VNS **140** generates and maintains a world model based at least in part upon information received from a remote service, system, device, etc. via one or more communication networks.

[0022] Vehicle **110** includes a set of one or more internal sensors **118** which generate sensor data representations of one or more portions of a vehicle interior included in the vehicle **110**, including sensor data representations of one or more occupants of the vehicle, also referred to herein as users. The internal sensors **118** can include one or more of visible light camera devices, infrared camera devices, near-infrared camera devices, light beam scanning devices, ultrasonic sensor devices, audio sensor devices, depth camera devices, radar devices, some combination thereof, kinematic sensor devices, etc. In some embodiments, one or more internal sensors **118** generates sensor data associated with a state of one or more portions of the vehicle, including one or more of the control elements **150**. Such one or more internal sensors can include one or more of an accelerometer, a speedometer, etc.

[0023] Vehicle **110** includes one or more control elements **150** which cause the vehicle to be navigated. Control elements can include one or more of a steering control element, a motor, a throttle control element, a brake control element, etc.

[0024] Vehicle **110** includes one or more interfaces **130**, which can include one or more user interfaces installed in the vehicle with which one or more occupants can interact, one or more communication interfaces which can communicate with one or more remotely located devices, vehicles, services, systems, etc. via one or more communication networks. Vehicle **110** includes one or more transparent surfaces **134** via which one or more occupants can perceive one or more portions of the environment **100** from within the vehicle interior, etc. In some embodiments, VNS **140** can generate, manage, control, etc. one or more graphical displays, including one or more augmented reality displays, which are displayed on one or more particular transparent surfaces **134** in the vehicle.

[0025] As shown, the VNS **140** can include an augmented reality display module **111**, also referred to herein as an augmented reality display system. In some embodiments, one or more of the VNS **140** and the module **111** can be implemented by one or more computer systems. In some embodiments, the VNS **140** and the module **111** are implemented by separate computer systems. Module **111** can generate one or more various augmented reality displays which are provided to one or more occupants via one or more transparent surfaces **134** in the vehicle **110** based on information received via processing data received from one or more of the interfaces **130**, external sensors **116**, and internal sensors **118**.

[0026] FIGS. **2**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which includes a spatially positioned representation of a speed of the vehicle relative to a local speed limit, according to some embodiments. The vehicle and transparent surface illustrated in FIGS. **2**A-B can be included in any of the embodiments of vehicles and transparent surfaces included herein.

[0027] In some embodiments, an augmented reality display provided to an occupant of a vehicle, via being displayed on one or more transparent surfaces of the vehicle, includes a display element which provides a three-dimensional representation of a speed of the vehicle where representation of the speed is spatially positioned, in the environment, based on a difference between the vehicle speed and a local speed limit. The vehicle can include an augmented reality system which, based on sensor data generated by one or more internal sensors, external sensors interfaces, etc, can determine a present speed of the vehicle and a local speed limit in the portion of the environment through which the vehicle is presently being navigated.

[0028] The augmented reality display system can generate an augmented reality display on a transparent surface of the

vehicle which includes a display element which both indicates a speed of the vehicle and provides at least a spatial indication of the speed of the vehicle, relative to the local speed limit. In some embodiments, the display element includes a representation of at least the speed of the vehicle. The augmented reality display can comprise an overlay of at least a portion of the environment visible, also referred to herein as perceptible, via the transparent surface. The overlay can include display elements, also referred to herein as representations, which provide three-dimensional representations of one or more various graphical icons, such that the three-dimensional representations are perceptible as being positioned in the external environment when the environment is perceived via the augmented reality display presented on the transparent surface. A display element which provides a three-dimension representation of a graphical icon at a particular position in the environment can be referred to as being spatially positioned in the environment and can be referred to as being spatially positioned. Where the display element provides a three-dimensional representation of a graphical icon in a particular position in the environment based on relative vehicle speed, the display element can be referred to as providing a spatial indication of the relative vehicle speed. Spatial positioning of a representation presented by a display element in the augmented reality display can be implemented via controlling one or more of the size and position of the graphical icon comprised in the display element presented on the transparent surface, so that the graphical icon can appear to be further away from the transparent surface, nearer to the transparent surface, in different portions of the environment, etc., based on the relative speed of the vehicle.

[0029] As shown in FIGS. **2**A-B, a vehicle **200** in which an occupant **210** is located can include a transparent surface **220**, including a windshield, via which the occupant perceives at least a portion of the external environment **290**. The occupant **210** can be a driver of the vehicle **200**, positioned in a driver position in the vehicle, some combination thereof, etc., and the transparent surface **220** can include a windshield via which the occupant can perceive a portion of the environment **290** which is ahead of the vehicle along a direction of travel while the vehicle navigates along a roadway **292** in the environment.

[0030] As shown, an augmented reality display **230** can be displayed ("presented", "provided", etc.) on surface **220**, so that the display **230** is perceptible by occupant **210** monitoring the portion of the environment **290** via the surface **220** and the display **230** is perceptible as an overlay upon the environment perceptible by occupant **210** via surface **220**. As shown in FIGS. **2**A-B, the display **230** can include one or more display elements **232**A-C which include content which indicates at least a speed of the vehicle, such that the display elements comprise representations of at least the speed of the vehicle. For example, element **232**A indicates a speed of 40mph, element **232**B indicates a speed of 35 mph, and element **232**C indicates a speed of 30 mph. In some embodiments, the illustrated elements **232**A-C indicate different states and configuration of a single element when the vehicle **200** is navigating at different speeds, such that the individual element is perceptible as being spatially positioned at an individual position in the environment.

[0031] As further shown, in some embodiments, the element **232**A-C can include content indicating a local speed limit associated with the environment, including the local roadway **292**. FIGS. **2**A-B shows that the local speed limit is 35 mph, and the display **230** includes an element **232**A-C which indicates both the present speed of the vehicle and the local speed limit.

[0032] In some embodiments, the one or more display elements **232** presented via display **230** are adjustably controlled to cause the perceived elements **232** to provide three-dimensional representations of one or more graphical icons which are spatially positioned in one or more portions of the environment perceptible through surface **220** based on the relative speed of the vehicle relative to a local speed limit. The spatial positioning can include adjusting one or more various parameters of the one or more display elements **232**, including one or more of a size, color, position, etc. of the elements **232** in the display **230**, to cause the element **232** to be perceived as being spatially positioned in the environment **290** based on the relative speed of the vehicle **200**. The parameters of an individual display element **232** can be dynamically adjusted based on variations in the vehicle speed, local speed limit, etc., so that the three-dimensional representation of a spatial position of the graphical icon in the environment is dynamically adjusted.

[0033] As shown in FIGS. **2**A-B, the spatial positioned representation of an icon in the environment by the display element **232** in the display **230**, based on the relative speed of the vehicle **210**, can include adjustably controlling one or more parameters of the display element to cause the representation of the icon to be spatially positioned closer to the occupant **210** in the vehicle **200** as the speed of the vehicle **200** increases beyond the local speed limit and to cause the y controlling one or more parameters of the display element to cause the representation to be spatially positioned further from the occupant **210** in the vehicle **200** as the speed of the vehicle **200** decreases below the local speed limit.

[0034] For example, icon **232** is shown to be displayed in configuration **232**B, so that the icon **232** is displayed as being positioned a particular distance from the vehicle **200** along roadway **292**, where the vehicle speed matches the local speed limit, shown here as 35mph. In some embodiments, the display **230** can be controlled to cause the displayed icon **232** to be positioned **234** within a certain portion of the roadway **292**, so that the element **232** is repositioned in the display **230** to cause the three-dimensional representation of the graphical icon indicating the vehicle speed to appear to follow various turns, slopes, etc. of the roadway **292** while remaining a particular perceived distance from the vehicle in the environment **290**.

[0035] As shown in FIGS. **2**A-B, one or more parameters of the element **232** can be adjusted, via adjusting one or more parameters of the displayed element **232**, so that the three-dimensional representation of the icon is positioned in a configuration **232**A in the environment which is located closer to vehicle **200** as the vehicle speed increases beyond the local speed limit. The repositioning **234** can be dynamic, so that the icon is dynamically spatially repositioned in the environment **290** in accordance with the speed of the vehicle **200**. As shown in FIG. **2**B, spatial repositioning can include adjusting a size and position of the element **232** so that the representation of the icon appears larger and nearer as vehicle speed is greater than the local speed limit and smaller and further away as the vehicle speed is less than the local speed limit. The spatial positioning of the graphical icon in the environment provided by the three-dimensional representation of the icon presented by the display element **232**

can provide the occupant **210** with a visual cue with regards to the relative speed of the vehicle **200**, thereby augmenting the occupant's situational awareness, particularly where the occupant **210** is a driver of the vehicle **200**, thereby augmenting vehicle navigation by the driver occupant **210**.

[0036] As shown in FIGS. **2**A-B, the repositioning **234** of the perceived position of icon in the environment **290** by element **232** can be adjusted to cause a perceived elevation of the element **232** in the environment to be adjusted based on the relative speed of the vehicle, relative to a local speed limit. As shown in FIG. **2**A, for example, parameters of the displayed icon presented by element **232** can be adjusted to cause the displayed icon to appear at a higher elevation in accordance with the vehicle speed being greater than a local speed limit, as shown at **232**A, and to cause the displayed icon, which can also be referred to herein as a representation of the vehicle speed, to appear at a lower elevation in accordance with the vehicle speed being less than a local speed limit, as shown at **232**C. Such adjustment of perceived elevation can occur concurrently with adjustment of a perceived proximity of the icon from the vehicle, as shown in FIG. **2**A.

[0037] FIGS. **3**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which modifies occupant-perceived information presented by a sign located in the external environment, according to some embodiments. The vehicle and transparent surface illustrated in FIGS. **3**A-B can be included in any of the embodiments of vehicles and transparent surfaces included herein.

[0038] In some embodiments, an augmented reality display system generates, on a transparent surface, an augmented reality display of a portion of an external environment which can be perceived via the transparent surface, where the augmented reality display comprises display elements which overlay one or more portions of the environment which include one or more objects in the environment and which at least partially conform to one or more boundaries of the one or more objects in the environment. The display elements can overlay content included on the external surfaces of the objects and can include replacement content which can be generated by the augmented reality display system, such that the augmented reality display element which overlays at least a portion of the object, as perceived via the transparent surface, obscures at least a portion of the content included on the object in the environment with augmented reality content generated by the augmented reality display system.

[0039] As shown in FIGS. **3**A-B, vehicle **300** in which occupant **310** is located includes a transparent surface **320** and an external sensor **340** which monitors **342** one or more portions of environment **390** in which vehicle **300** is located, including a roadway **392** along which the vehicle **300** is navigated. Based on sensor data representations of the monitored environment, which are generated by the sensors **340**, an augmented reality display system included in vehicle **300** can identify one or more objects located in the environment **390**, including a roadway **392** and road signs **350**, **370**. Based on processing the sensor data, the augmented reality display system can identify content **352**, **372**, **374** presented on the signs. For example, the system can identify sign **350** as a speed limit sign and further identify that content **352** presented on the sign **350** includes a local speed limit of roadway **392**, and the system can further identify sign **370** as a distance indication sign and further identify that content **372** presented on the sign includes an indication of a distance to a particular landmark and that content **374** presented on the sign includes an indication of a distance to another particular landmark.

[0040] In some embodiments, the augmented reality system included in vehicle **300** generates an augmented reality display, on surface **320**, which includes display elements **360**, **380** which overlay and conform to one or more boundaries of one or more particular portions of particular objects **350**, **370** in the environment **390**.

[0041] The display elements can be selectively generated, and can include content selectively generated by the augmented reality display system, based on monitoring one or more of personal data associated with the occupant, a driving route along which the vehicle is being navigated, the environment **390**, etc. For example, the augmented reality display system can determine, based on monitoring environmental conditions via sensors **340**, that environmental conditions, that environmental conditions are associated with an adjustment to the local speed limit. Where the present environmental conditions are determines to include a rainstorm, for example, the augmented reality system can determine, based on comparing the determined environmental condition with a database of speed limit adjustments and associated environmental conditions, that the local speed limit is to be adjusted downwards by 5mph. As a result, the augmented reality display system can generate a display element **360** which is perceived by occupant **310** to overlay and conform to the dimensions, boundaries, etc. of the content-including portion of sign **350** and includes content **362** which includes a local speed limit which is adjusted from the speed limit **352** actually included on sign **350** in accordance with the detected environmental condition. The display element **360** can provide a representation of the sign **350** which overlays the portion of the sign **350** which includes content **352**, so that the content **352** is obscured and content **362** is visible when the sign **350** is perceived via the augmented reality display presented on surface **320**.

[0042] In another example, shown in FIG. **3**B, the augmented reality display system can process distance information presented on sign **370** and compare the information **372**, **374** with a driving route along which the vehicle **300** is being navigated. The augmented reality display system can generate one or more display elements which selectively highlight one or more indicated landmarks, directions, etc., selectively obscure one or more indicated landmarks, directions, etc. based on the driving route. In some embodiments, the system can translate content presented on a sign into another language, including a language associated with one or more of the vehicle, an occupant included in the vehicle, personal data associated with an occupant included in the vehicle, etc., and generate a display element which overlays the content and provides a translated version of the content on the sign.

[0043] As shown in FIG. **3**B, based on a determination that content **372** is associated with the present driving route along which the vehicle **300** is being navigated, for example, a destination of the driving route, a checkpoint along the driving route, some combination thereof, etc., the augmented reality display system included in vehicle **300** can generate a display element **380** which has a particular size, shape, and position on surface **320** to cause the element **380**, when perceived by occupant **310** via surface

320, to overlay and conform to a portion of sign **370** on which content **374** which is unrelated to the driving route is displayed, so that the element **380** obscures the unrelated content **374** so that the perceived content on the sign **370** is restricted to the relevant content **372**.

[0044] In some embodiments, based on a determination that one or more instances of content on the **370** is related to a driving route along which the vehicle **300** is being navigated, the augmented reality display system can generate a display element which highlights one or more instances of content displayed on a sign in the environment.

[0045] Display elements presented on surface **320** as part of the augmented reality display on surface **320** can be generated based on sensor data generated by sensors **340**, where the display elements are adjusted based on the dynamic relative positions of the objects **350**, **370** to vehicle **300**, so that the display elements **360**, **380** are perceived to remain conformed to the objects **350**, **370** as the vehicle changes position relative to the objects.

[0046] In some embodiments, the augmented reality display system generated display elements on surface **320** based on personal data associated with occupant **310**. For example, the display system can determine, based on processing sensor data representations of sign **370**, that content **372** indicates a landmark which is a commonly-navigated destination associated with personal data of the occupant **310**. As a result, the augmented reality display system can provide an augmented reality display of the environment **390** which is relevant to the occupant's **310** interests.

[0047] Users can selectively block use of, or access to, personal data. A system incorporating some or all of the technologies described herein can include hardware and/or software that prevents or blocks access to such personal data. For example, the system can allow users to "opt in" or "opt out" of participation in the collection of personal data or portions of portions thereof. Also, users can select not to provide location information, or permit provision of general location information (e.g., a geographic region or zone), but not precise location information.

[0048] Entities responsible for the collection, analysis, disclosure, transfer, storage, or other use of such personal data should comply with established privacy policies and/or practices. Such entities should safeguard and secure access to such personal data and ensure that others with access to the personal data also comply. Such entities should implement privacy policies and practices that meet or exceed industry or governmental requirements for maintaining the privacy and security of personal data. For example, an entity should collect users' personal data for legitimate and reasonable uses, and not share or sell the data outside of those legitimate uses. Such collection should occur only after receiving the users' informed consent. Furthermore, third parties can evaluate these entities to certify their adherence to established privacy policies and practices.

[0049] FIGS. **4**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which includes a display element which provides a representation of a static object in the environment which is presently obscured from direct view through the transparent surface of the vehicle, according to some embodiments. The representation can include a three-dimensional representation of the static object in the environment. The vehicle and transparent surface illustrated in FIGS. **4**A-B can be included in any of the embodiments of vehicles and transparent surfaces included herein.

[0050] In some embodiments, an augmented reality display system generates an augmented reality display, on a transparent surface, which includes display elements providing representations of objects, in an environment perceivable via the transparent surface, which are at least partially obscured from direct observation via the transparent surface.

[0051] In some embodiments, the augmented reality display system included in a vehicle **410** navigating along a roadway **400** through environment **490** receives information regarding various static objects, including one or more structures, signs, landmarks, plants, etc., in the environment **490**, via a communication link **452** with a remotely located system **450**. The information can include location information, dimensions, etc. associated with an object. For example, where environment **490** includes static object **430** located adjacent to roadway **400**, information indicating the location and dimensions of object **430** can be received at vehicle **410** via link **452**.

[0052] In some embodiments, the augmented reality display system included in vehicle **410** determines a blind spot **440** associated with sensor data representations of the environment **490** which are generated by sensor devices included in the vehicle **410**, based on a presence of one or more various objects, including the illustrated vehicle **420**, in the environment. In some embodiments, based on a determination that a dynamic object **420** is at least partially obscuring perception of a static object **430** via a transparent surface **480** in the vehicle **410**, the augmented reality display system included in the vehicle can generate an augmented reality display which includes display elements **492-496** which comprise representations of the position and boundaries of one or more portions of one or more obscured elements in the environment **492**, including an element **492** which indicates at least a portion of the obscured static object **430**. As also shown in FIG. **4**B, the display elements presented via the transparent surface **480** can include representations of portions **494-496** of the roadway which are obscured by object **420**.

[0053] In some embodiments, the augmented reality display system selectively generates display elements **492** which comprise representations of one or more of a position, boundary, etc. of at least a portion of an obscured static object in the environment based on a determination that the static object is associated with one or more of a driving route along which the vehicle is being navigated, one or more instances of personal data associated with one or more of the occupants of the vehicle **410**, some combination thereof, etc.

[0054] FIGS. **5**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which provides a representation of at least one dynamic object in the environment which is presently obscured from direct view through the transparent surface of the vehicle, according to some embodiments. The vehicle and transparent surface illustrated in FIGS. **5**A-B can be included in any of the embodiments of vehicles and transparent surfaces included herein.

[0055] In some embodiments, an augmented reality display system included in a vehicle **510** navigating through an environment **590** which includes a roadway can generate, on a transparent surface **580** included in the vehicle **510**, an

augmented reality display element **596** which represents a position and dimension of a dynamic element **530**, in the environment **590**, which is at least partially obscured **560** from monitoring by vehicle **510** by another dynamic element **520** in the environment **590**.

[0056] In some embodiments, the augmented reality display system receives information associated with the obscured object **530**, including sensor data representations of the object **530**, based on communication with one or more of a remote system **550** via a communication link **552**, vehicle-to-vehicle ("V2V") communication with one or more vehicles **520**, **540** which can directly monitor the object **530** via links **553**, etc. The augmented reality display system can generate the augmented reality display elements **592-596**, including the element **596** which indicates a position and dimensions of the dynamic element **430** in the environment, based on information received from one or more of the vehicles **520**, **540**, systems **550**, etc.

[0057] FIGS. **6**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which provides a dynamically controllable representation of a driving route along which a vehicle is being navigated, according to some embodiments. The vehicle and transparent surface illustrated in FIGS. **6**A-B can be included in any of the embodiments of vehicles and transparent surfaces included herein.

[0058] In some embodiments, an augmented reality display system included in a vehicle generates an augmented reality display, on one or more transparent surfaces of the vehicle, which includes display elements which comprise a representation of a driving route along which the vehicle is being navigated. As referred to herein, a representation comprised by a display element can include a three-dimensional representation. The display elements can comprise representations of various navigation actions which can be executed by control elements of the vehicle, including braking, accelerating, turning, etc.

[0059] As shown in FIGS. **6**A-B, where vehicle **600** navigates through an environment **690** which includes roadways **692-696**, a set of one or more external sensors **640** monitors **642** the environment, including the roadways **692-694** and generates sensor data representations of same. An augmented reality display system included in vehicle **600** can, based on the sensor data representations of the environment and a driving route, through the environment, along which the vehicle **600** is being navigate, generates an augmented reality display on a transparent surface **620** of the vehicle **600**. The augmented reality display includes elements **662**, **664** which provide visual indications of the route along which the vehicle **600** is being navigated. The display elements can be adjustably controlled to cause the elements **662**, **664** to be perceived as being located in the environment **690** along the driving route, and parameters of the display elements can be dynamically adjusted as the vehicle **600** navigates along the route to maintain a three-dimensional appearance of the elements **662**, **664** on the route.

[0060] As shown, the displayed elements **662**, **664** on the surface are arranged on the roadways **692-696** to illustrate a driving route which proceeds along roadway **692** to roadway intersection **694**, whereupon the route turns to the left to roadway **696**, thereby indicating that the driving route proceeds along the course illustrated in the display by elements **662**, **664**. In addition, the display elements **662**, **664** are displayed to be perceived as being spatially positioned along the route in accordance with the acceleration, velocity, etc. of the vehicle **600** along the route. As shown, the elements **662** are displayed as being spatially positioned proximate to each other proximate to roadway **692** terminating at intersection **694**, thereby providing a visual indication, to occupant **610**, that the driving route represented by elements **662** includes the vehicle **600** decelerating at the intersection of roadway **692** with roadway intersection **694**, including providing a visual indication that the vehicle **600**, being navigated along the represented driving route, will stop at the threshold of intersection **694**. In addition, elements **694** are displayed so that the elements are perceived as being spaced further apart in the environment **690**, relative to elements **662**, thereby providing a visual indication, to occupant **610**, that the vehicle **600** will accelerate through roadways **694-696** subsequent to decelerating to the threshold between roadways **692**, **694**.

[0061] In some embodiments, an augmented reality display system dynamically controls the display elements included in an augmented reality display which is presented on one or more transparent surfaces based on monitoring one or more occupants located proximate to the one or more transparent surfaces. The system can monitor occupant identity, stress level, cognitive load, etc. based on processing sensor data generated by one or more internal sensors **630** included in the vehicle **600** which monitor **632** one or more portions of the vehicle **600** interior in which one or more occupants **610** are located. Monitoring occupant identity can include comparing a sensor data representation of an occupant **610** with personal data to associate an occupant **610** of the vehicle with a particular user profile, account, etc. Augmented reality displays can be adjusted based on occupant display preferences which may be included in a user account, profile, etc. associated with a particular occupant identity.

[0062] In some embodiments, the augmented reality display system can adjust the display elements presented in the augmented reality display which can be perceived by a monitored occupant **610** based on an interaction history, indicated in personal data associated with the monitored occupant **610**, where the interaction history indicates a historical record of interaction between the occupant **610** and one or more of the vehicle **600**, the augmented reality display system included in the vehicle, one or more particular features of the vehicle **600**, including autonomous navigation of the vehicle along a driving route, some combination thereof, etc. For example, where the augmented reality display system determines, based on identifying occupant **610** and processing personal data associated with the occupant, that the occupant is associated with a quantity of interactions with features of the vehicle **600** associated with navigating the vehicle **600** along a driving route, and a display of elements **662**,664 on surface **620** which are associated with navigation along the route, which at least meets a threshold quantity, the augmented reality display system may refrain from displaying elements **662**, **664** in an augmented reality display on surface **620**, as the occupant may be determined to be sufficiently experienced with navigation along a driving route in vehicle **600** that the occupant **610** is determined to not require visual indications that the vehicle **600** is navigating along a driving route. In another example, where the augmented reality display system determines, based on identifying occupant **610** and processing personal data associated with the occupant, that the occupant is associated

with a quantity of interactions with features of the vehicle **600** associated with navigating the vehicle **600** along a driving route, and a display of elements **662**,664 on surface **620** which are associated with navigation along the route, which does not meet a threshold quantity, the augmented reality display system may display elements **662**, **664** in an augmented reality display on surface **620**, as the occupant may be determined to be insufficiently experienced with navigation along a driving route in vehicle **600** that the occupant **610** is determined to require visual affirmation that the vehicle **600** is navigating along a driving route.

[0063] In some embodiments, monitoring a stress level, cognitive load, etc. of an occupant can include monitoring one or more various features of an occupant, including eye motion, body posture, body gestures, body temperature, breathing rate, eye blink rate, head motion, eye motion, heart rate, some combination thereof, etc. Based on determining that one or more monitored features of an occupant **610** is associated with a determined value which at least meets a threshold level associated with a particular stress level, cogitative load level, etc. the augmented reality display system can determine that a monitored occupant **610** is associated with the particular stress level, cognitive load level, etc.

[0064] The augmented reality display system can dynamically adjust the augmented reality display, including which display elements are presented in the display, based on the monitored stress level, cognitive load level, etc. of one or more of the monitored occupants **610**. For example, where an occupant **610** is determined to be associated with a high cognitive load level, the augmented reality display system can adjust the augmented reality display to remote at least some of the display elements, for example removing elements **662**, **664**, to cause the occupant **610** cognitive load to be reduced. In another example, where an occupant **610** is determined to be associated with a high stress level, the augmented reality display system can adjust the augmented reality display to provide at least some elements, including elements **662**, **664**, which are associated with control of the vehicle, thereby providing indications to the occupant **610** of the navigation actions being executed during navigation of the vehicle and assurance that the vehicle is being navigated along a driving route to a destination.

[0065] FIGS. 7A-B illustrate a vehicle which simulates, via one or more of a transparent surface which provides an augmented reality display and an active suspension system, one or more objects in the environment, according to some embodiments. The vehicle and transparent surface illustrated in FIGS. 7A-B can be included in any of the embodiments of vehicles and transparent surfaces included herein.

[0066] In some embodiments, an augmented reality display system can display, in an augmented reality display on a transparent surface, a display element which comprises a representation of a simulated environmental object in the perceived environment. The representation can include a three-dimensional representation. The simulated environmental object can be represented based on monitoring manual navigation of a vehicle by an occupant of the vehicle, where the simulated environmental object is generated to cause the occupant to adjust the manual driving performance of the occupant. The augmented reality display system can monitor the driving performance of an occupant based on processing sensor data generated by one or more external sensors, internal sensors, etc. included in the vehicle.

[0067] For example, as shown in FIGS. 7A-B, an augmented reality system included in vehicle **700**, which is navigating along roadway **790** through environment **721**, can determine, based on processing sensor data generated by one or more external sensors **740** monitoring **742** the environment **721**, one or more internal sensors **730** monitoring **732** one or more portions of the vehicle **700**, some combination thereof, etc., that the occupant **710** is navigating the vehicle **700** along roadway **790** at a speed which at least meets an excessive speed threshold value. In response, the augmented reality display system can generate an augmented reality display, presented on surface **720**, which includes one or more display elements **780** which comprise a three-dimensional representation of a simulated environmental object, thereby simulating the presence of an environmental object, in the environment **721**, which is associated with reducing vehicle speed. The simulated environmental object **780** shown in FIGS. 7A-B simulates the presence of a "speed bump" element in a particular position on the roadway **790**. The augmented reality display system can initially generate the display element **780** to cause the simulated environmental object to be simulated to be positioned at a particular position on the roadway which is at a distance ahead of the vehicle **700**, based on one or more of the present vehicle **700** speed, an estimated reaction time of the occupant **710**, etc. The displayed element **780** can be dynamically adjusted in the display on surface **720** as the vehicle **700** is navigated along roadway **790**, so that the occupant **710** monitoring **712** the environment **721** through surface **720** can perceive the simulated speed bump **780** as a static element on the roadway **790** which remains at the particular position on the roadway as the vehicle **700** approaches the particular position. The augmented reality display system can display one or more simulated environmental object display elements **780** as the vehicle is navigated in response to manual navigation of the vehicle, occupant driving performance, etc., meeting one or more various thresholds, and the display of such simulated environmental object display elements **780** can be precluded in response to the manual navigation of the vehicle, occupant driving performance, etc., being determined to be below one or more various thresholds.

[0068] In some embodiments, the augmented reality display system can communicate with one or more control elements of the vehicle **700** to provide additional simulation of an environmental object in the environment **721**. As shown, vehicle **700** can include a set of wheels **760** which are coupled to the remainder of the vehicle **700** at least partially by one or more suspension systems **750**. In some embodiments, one or more of the suspension systems comprises an active suspension system which can actuate to simulate one or more of the wheels **760** passing over one or more environmental objects in the environment **721**. In some embodiments, the augmented reality display system in vehicle **700**, in addition to generating an augmented reality display element **780** which simulates a static object in the environment **721**, can command one or more active suspension **750** control elements in the vehicle **700** to actuate concurrently with the vehicle **700** passing over the position, in the environment **721**, in which the simulated environmental object is simulated to be located, so that the active suspension system **750** simulates the vehicle **700** passing over the simulated environmental object. The active suspension systems **750**

can be commanded to actuate differently based on different simulated environmental objects. For example, in the illustrated embodiment, where the augmented reality display system simulates a "speed bump" environmental object at a particular position in the roadway via display element **780**, the augmented reality display system can command one or more of the active suspension systems **750** to actuate the wheels **760** in a sequence which simulates the vehicle **700** passing over a large obstacle in the roadway **790** when the vehicle passes over the location in the roadway **790** in which the simulated speed bump is represented to be located by display element **780**. In another example, where the augmented reality display system simulates a sequential series of small "rumble strip" environmental objects arranged in parallel transversely across a particular position in the roadway via multiple display elements **780**, the augmented reality display system can command one or more of the active suspension systems **750** to actuate the wheels **760** in a sequence which simulates the vehicle **700** passing over a series of small obstacles in the roadway **790** when the vehicle passes over the location in the roadway **790** in which the simulated rumble strips are represented to be located by display elements **780**.

[0069] In some embodiments, the augmented reality display system dynamically adjusts one or more augmented reality display elements which are presented on a transparent surface **720** based on monitoring navigation performance of the vehicle **700**. For example, as shown in FIG. **7**B, the augmented reality display system can generate display elements **781**, **783** which conform to the lane boundaries **782**, **784** of the lane **785** in the roadway **790** along which the vehicle **700** is presently being navigated, and the augmented reality display system can dynamically adjust one or more parameters of the display elements **781**, **783** based on monitoring, via processing sensor data generated by one or more sensors **740**, **730**, one or more of the vehicle **700** position relative to one or more of the lane boundaries **782**, **784**, environmental conditions, occupant cognitive load, etc.

[0070] For example, in response to determining that ambient light levels in the environment **721** are below a threshold ambient light level, the augmented reality display system can adjust one or more of the color, brightness, etc. of elements **781**, **783** to cause the lane boundaries to be more easily perceptible by occupant **710** monitoring **712** the environment **721** through surface **720**. In another example, the augmented reality display system can dynamically adjust one or more of color, brightness, pattern, animation sequence, etc. of separate elements **781**, **783** based on relative distance between vehicle **700** and the respective lane boundaries **782**, **784** associated with the separate elements **781**, **783**, to that the occupant **710** is provided, via the augmented reality display on surface **720**, with a visual indication that the vehicle **700** is approaching one or more of the lane boundaries **782**, **784**.

[0071] Such visual indications can augment driver situational awareness and can mitigate a risk of the vehicle **700** drifting out of the lane **785** in which it is presently navigating.

[0072] FIGS. **8**A-B illustrate a vehicle comprising a transparent surface which provides an augmented reality display which includes a representation of a particular driving zone in the environment, according to some embodiments. The vehicle and transparent surface illustrated in FIGS. **8**A-B can be included in any of the embodiments of vehicles and transparent surfaces included herein.

[0073] In some embodiments, an augmented reality display system installed in a vehicle navigating through an environment can identify a particular zone in the environment and can, in response, generate an augmented reality display which comprises an overlay of one or more portions of the environment associated with the zone which can be perceived through a transparent surface.

[0074] In some embodiments, a particular zone can include one or more of a school zone, a crossing zone, a zone associated with a presence of children, a zone associated with differently-abled individuals, some combination thereof, etc. The augmented reality display system can determine a presence of a particular zone associated with one or more particular individuals, structures, events, etc., including determining one or more boundaries of the particular zone in the environment, based on one or more of communication with one or more remotely located vehicles, devices, systems, services, etc., monitoring of one or more portions of the environment by one or more sensors included in the vehicle, some combination thereof, etc.

[0075] FIGS. **8**A-B illustrate a vehicle **810** navigating through an environment **800** along a roadway **801** in which a region **820** is located. The region **820** can include one or more structures **822**, individuals **826**, zone identification elements **824**A-B, some combination thereof, etc. The augmented reality display system included in vehicle **810** can, based at least in part upon a determination that region **820** is associated with a particular zone, generate an augmented reality display **812**, presented on a transparent surface **811** of the vehicle **810**, which includes a display element **880** which highlights a portion of the roadway **801** which overlaps with the zone **820**. In some embodiments, the display element **880** overlaps an entirety of the zone **820**. The highlighted portion of the zone indicated by the display element **880** can conform to one or more boundaries of the zone in the environment, as shown by the highlighted portion of the zone indicated by display element **880** which terminates, at opposite ends, at boundaries of the zone **820**. As a result, the augmented reality display system provides, to one or more vehicle occupants perceiving the environment via the transparent surface on which the display is provided, a visual indication of the particular zone, which can augment occupant situational awareness of environmental features associated with the zone and can augment safe navigation of the vehicle through the environment. For example, where the particular zone is a zone associated with the presence of children, a visual indication of the zone in an augmented reality display can augment situational awareness, by a driver of the vehicle, of the possibility that children may be present in the environment, thereby augmenting safety to both the driver and any children in the zone.

[0076] In some embodiments, the augmented reality display system determines a location and one or more boundaries of a zone based on identifying one or more zone identification elements **824**A-B in the environment. A zone identification element **824** can include one or more of a sign, visual icon, symbol, transponder beacon, etc. which indicates one or more of a presence and boundary of the zone **820**. Identifying the zone identification element can include detecting a presence of the object in the environment **824**, processing content comprised in the element (e.g., text included on a sign element **824**, data comprised in a signal

generated by a transponder beacon element **824**, etc.), and identifying one or more of the presence of the zone, one or more boundaries of the zone, etc. based on processing the content.

[0077] In some embodiments, the augmented reality display system determines a location and one or more boundaries of a zone based on identifying one or more features located in the environment which are determined to be associated with one or more of the presence of the particular zone and one or more boundaries of the zone. Features which can be identified can include one or more static elements, dynamic elements, etc. which can be detected in the environment based on processing sensor data representations, of the environment, which are generated by one or more external sensors included in the vehicle.

[0078] In some embodiments, where environment **800** includes structure **822**, an augmented reality display system included in vehicle **810** can identify zone **820** based on detecting the structure **822** in the environment **800**, based on processing sensor data generated by external sensors in the vehicle **810**, and determining that the structure **822** is associated with one or more particular zones. For example, the augmented reality display system can determine that the detected structure **822** is a school structure and can determine, based at least in part upon determining that structure **822** is a school structure, that the structure **822** is associated with a school zone **820** in the environment **800** and can, in response, generate an augmented reality display which includes a display element **880** which overlays a portion of the roadway **801** which overlaps the school zone **820**.

[0079] In some embodiments, where environment **800** includes one or more individuals **826**, an augmented reality display system included in vehicle **810** can identify zone **820** based on detecting the one or more individuals **826** in the environment **800**, based on processing sensor data generated by external sensors in the vehicle **810**, and determining that the one or more individuals **826** are associated with one or more particular zones. For example, the augmented reality display system can determine that the detected individuals **826** are human child individuals and can determine, based at least in part upon determining that individuals **826** are human child individuals, that the portion of the environment in which the individuals **826** are located is associated with a child zone **820** in the environment **800** and can, in response, generate an augmented reality display which includes a display element **880** which overlays a portion of the roadway **801** which overlaps the child zone **820**.

[0080] In some embodiments, where environment **800** includes one or more remotely located elements **830**, which can include one or more remotely located systems, services, vehicles, devices, etc., an augmented reality display system included in vehicle **810** can identify zone **820** based on communicating **832** with the remotely located element **830** via one or more communication networks and receiving, from the element **830**, information identifying one or more of the location and one or more boundaries of the zone **820** in the environment **800**. For example, the augmented reality display system can determine an identity, location and boundaries of zone **820** based on receiving information from element **830** via an interface, included in the vehicle **810**, which can include one or more communication interfaces. In some embodiments, information identifying a location, boundaries, etc. of the zone at element **830** is generated based on sensor data generated by one or more vehicles **810**, **840**, **850** navigating through environment **800** and communicating said data to element **830** via one or more communication links. The element can determine one or more of an identity, location, boundaries, etc. of the zone **820** based on processing sensor data generated by the various vehicles navigating through the area, and the determined identity, location, boundaries, etc. of the zone **820** can be communicated to one or more vehicles navigating through the environment **800**.

[0081] In some embodiments, the display element **880** is associated with the particular zone identified in the environment, and can include content indicating the identity of the zone. For example, element **880** can be associated with one or more colors, animation sequences, instances of text content, instance of audio content, instances of video content, some combination thereof, etc. which indicates the identity of the particular zone indicated by the element **880** (e.g., school zone).

[0082] FIG. **9** illustrates a transparent surface which provides an augmented reality display of one or more portions of an environment, according to some embodiments. FIG. **10** illustrates a vehicle comprising a transparent surface which provides an augmented reality display which enables user selection of a portion of the environment perceived via the transparent surface and which enables video communication with a remotely-located user via the transparent surface, according to some embodiments. The vehicle and transparent surface illustrated in FIGS. **9-10** can be included in any of the embodiments of vehicles and transparent surfaces included herein.

[0083] In some embodiments, an augmented reality display system, in response to associating an element in the external environment with a particular user profile, account, etc. associated with a particular user, generates an augmented reality display element, presented on a transparent surface, which identifies the environmental object and includes an avatar icon associated with the particular user profile, account, etc., thereby providing a visual indicator of the user to an occupant perceiving the environment via the transparent surface. The augmented reality display system can selectively generate the avatar display element based on a determination that the particular user is associated with an occupant positioned proximate to the transparent surface through which the environmental object, which can include one or more static elements, dynamic elements, etc., can be perceived.

[0084] For example, where the augmented reality display system included in a vehicle (the "ego-vehicle") determines, based on processing external sensor data, that a vehicle **940** navigating proximate to the ego-vehicle is associated with a user profile of a particular user associated with a user profile of an occupant **1010** of the vehicle **1000**. In response, the augmented reality display system can generate, on transparent surface **900** of vehicle **1000** through which occupant **1010** can perceive the vehicle **940**, a display element **942** which identifies the vehicle **940** as being associated with the particular user. The element **942** can include an avatar icon which is associated with the particular user, thereby providing a recognizable visual indication of an association between the element **940** and the particular user.

[0085] In some embodiments, the augmented reality display system generates, on the transparent surface **900**, a display element **930** which simulates one or more of the location, dimensions, etc. of a future object in the environment

which is under construction, proposed for construction, etc. For example, where a future element includes a structure which is presently under construction, the augmented reality display system include in vehicle **110** can generate an augmented reality display **910**, on surface **900**, which includes a display element **930** which includes a representation of the outline and location, in the environment, of the future structure.

[0086] In some embodiments, display of elements **942**, **930** can be selectively implemented based on one or more instances of personal data associated with occupant **1010** which indicate whether to generate display elements **930** indicating future environmental objects, user identification elements **942**, some combination thereof, etc.

[0087] In some embodiments, an augmented reality display system generates a display element, on a transparent surface, which identifies ("highlights") an element located in the environment, so that an occupant perceiving the object in the environment via the transparent surface perceives that the element is identified by a display element presented on the transparent surface.

[0088] In some embodiments, the augmented reality display system generates a display element **960** which identifies an environmental object **950** based on determining, as a result of processing a sensor data representation of an occupant, that the occupant is selecting the particular environmental object in the environment. As shown in FIG. **10**, the vehicle **1000** can include one or more internal sensors **1030** which monitor **1032** a portion of an interior of the vehicle **1000** in which an occupant **1010** is located. The augmented reality display system can monitor one or more various body gestures, eye movements, etc. of the occupant **1010** based on processing internal sensor data representations of the occupant **1010** which are generated by the sensors **1030**. The system can process the internal sensor data representations, in addition to external sensor data representations generated by one or more external sensors included in the vehicle **1000** and can, based on the processing, determining that the occupant **1010** is selecting a particular environmental object **950** located in the environment **910**. Such a determination can include a determination that the occupant **1010** is pointing a limb **1012** in a direction towards the position of the element **950** in the environment, as perceived by the occupant **1010** via the transparent surface **900**, a determination that one or more portions of the occupant **1010**, including one or more eyes of the occupant **1010**, are pointed towards the element **950** in the environment, some combination thereof, etc.

[0089] In some embodiments, an augmented reality display system can generate various display elements to enable occupant interaction with one or more portions of the environment. For example, where an environmental object **950** is identified based on a determination that occupant **1010** is selecting the element **950**, the augmented reality display system can generate one or more instances of content, including one or more drawings, symbols, instances of text content, etc. which are included in an augmented reality display element indicating the environmental object **950**. Such content can be incorporated into a display element representing, indentifying, etc. the element **950**, based on occupant **1010** interaction with one or more user interfaces included in the vehicle **1010**.

[0090] In some embodiments, an augmented reality display system can generate various display elements, which are presented on a transparent surface of the vehicle, as part of implementing an entertainment program, game, etc. For example, based on receiving a command, as a result of occupant **1010** interaction with a user interface included in the vehicle **1000**, to play an instance of video content, the augmented reality display system can generate display elements which present the video content on a transparent surface **900** which can be perceived by the occupant **1010**. In another example, the augmented reality display system can generate various display elements as part of an interactive game, based at least in part upon occupant actions, gestures, interactions with one or more user interfaces, etc.

[0091] Based on generating a display element which identifies a particular object in the environment, the augmented reality display system can adjust the display element to follow the object in the environment, present information associated with the identified element, receive occupant commands associated with the identified element, etc.

[0092] In some embodiments, an augmented reality display system included in a vehicle enables visual communication between an occupant of the vehicle and a remotely located user, including an occupant of a separate vehicle, via generating an augmented reality display, on a proximate transparent surface of the vehicle, which presents a visual display of the remotely located user, based on sensor data generated by a sensor device monitoring the remotely located user and communicated to the vehicle via one or more communication networks. In some embodiments, where the remotely located user is an occupant of a separate vehicle which also includes a transparent surface and an augmented reality display system, the systems of the separate vehicles can each generate an augmented reality display, on a transparent surface of the respective vehicle, which presents a visual representation, which can include a video stream, of the user occupying the other vehicle.

[0093] As shown in FIG. **10**, for example, an augmented reality display system can generate, on surface **900**, an augmented reality display which comprises a visual representation of a remotely located user **1060**, so that occupant **1010** of vehicle **1000** can visually perceive **1014** user **1060** via the surface **900**.

[0094] FIG. **11** illustrates an example computer system **1100** that may be configured to include or execute any or all of the embodiments described above. In different embodiments, computer system **1100** may be any of various types of devices, including, but not limited to, a personal computer system, desktop computer, laptop, notebook, tablet, slate, pad, or netbook computer, cell phone, smartphone, PDA, portable media device, mainframe computer system, handheld computer, workstation, network computer, a camera or video camera, a set top box, a mobile device, a consumer device, video game console, handheld video game device, application server, storage device, a television, a video recording device, a peripheral device such as a switch, modem, router, or in general any type of computing or electronic device.

[0095] Various embodiments of an augmented reality display system as described herein, may be executed in one or more computer systems **1100**, which may interact with various other devices. Note that any component, action, or functionality described above with respect to FIGS. **1** through **11** may be implemented on one or more computers configured as computer system **1100** of FIG. **11**, according to various embodiments. In the illustrated embodiment,

computer system **1100** includes one or more processors **1110** coupled to a system memory **1120** via an input/output (I/O) interface **1130**. Computer system **1100** further includes a network interface **1140** coupled to I/O interface **1130**, and one or more input/output devices, which can include one or more user interface (also referred to as "input interface") devices. In some cases, it is contemplated that embodiments may be implemented using a single instance of computer system **1100**, while in other embodiments multiple such systems, or multiple nodes making up computer system **1100**, may be configured to host different portions or instances of embodiments. For example, in one embodiment some elements may be implemented via one or more nodes of computer system **1100** that are distinct from those nodes implementing other elements.

[0096] In various embodiments, computer system **1100** may be a uniprocessor system including one processor **1110**, or a multiprocessor system including several processors **1110** (e.g., two, four, eight, or another suitable number). Processors **1110** may be any suitable processor capable of executing instructions. For example, in various embodiments processors **1110** may be general-purpose or embedded processors implementing any of a variety of instruction set architectures (ISAs), such as the x86, PowerPC, SPARC, or MIPS ISAs, or any other suitable ISA. In multiprocessor systems, each of processors **1110** may commonly, but not necessarily, implement the same ISA.

[0097] System memory **1120** may be configured to store program instructions, data, etc. accessible by processor **1110**. In various embodiments, system memory **1120** may be implemented using any suitable memory technology, such as static random access memory (SRAM), synchronous dynamic RAM (SDRAM), nonvolatile/Flash-type memory, or any other type of memory. In the illustrated embodiment, program instructions included in memory **1120** may be configured to implement some or all of an ANS, incorporating any of the functionality described above. Additionally, existing automotive component control data of memory **1120** may include any of the information or data structures described above. In some embodiments, program instructions and/or data may be received, sent or stored upon different types of computer-accessible media or on similar media separate from system memory **1120** or computer system **1100**. While computer system **1100** is described as implementing the functionality of functional blocks of previous Figures, any of the functionality described herein may be implemented via such a computer system.

[0098] In one embodiment, I/O interface **1130** may be configured to coordinate I/O traffic between processor **1110**, system memory **1120**, and any peripheral devices in the device, including network interface **1140** or other peripheral interfaces, such as input/output devices **1150**. In some embodiments, I/O interface **1130** may perform any necessary protocol, timing or other data transformations to convert data signals from one component (e.g., system memory **1120**) into a format suitable for use by another component (e.g., processor **1110**). In some embodiments, I/O interface **1130** may include support for devices attached through various types of peripheral buses, such as a variant of the Peripheral Component Interconnect (PCI) bus standard or the Universal Serial Bus (USB) standard, for example. In some embodiments, the function of I/O interface **1130** may be split into two or more separate components, such as a north bridge and a south bridge, for example. Also, in some embodiments some or all of the functionality of I/O interface **1130**, such as an interface to system memory **1120**, may be incorporated directly into processor **1110**.

[0099] Network interface **1140** may be configured to allow data to be exchanged between computer system **1100** and other devices attached to a network **1185** (e.g., carrier or agent devices) or between nodes of computer system **1100**. Network **1185** may in various embodiments include one or more networks including but not limited to Local Area Networks (LANs) (e.g., an Ethernet or corporate network), Wide Area Networks (WANs) (e.g., the Internet), wireless data networks, some other electronic data network, or some combination thereof. In various embodiments, network interface **1140** may support communication via wired or wireless general data networks, such as any suitable type of Ethernet network, for example; via telecommunications/telephony networks such as analog voice networks or digital fiber communications networks; via storage area networks such as Fibre Channel SANs, or via any other suitable type of network and/or protocol.

[0100] Input/output devices may, in some embodiments, include one or more display terminals, keyboards, keypads, touchpads, scanning devices, voice or optical recognition devices, or any other devices suitable for entering or accessing data by one or more computer systems **1100**. Multiple input/output devices may be present in computer system **1100** or may be distributed on various nodes of computer system **1100**. In some embodiments, similar input/output devices may be separate from computer system **1100** and may interact with one or more nodes of computer system **1100** through a wired or wireless connection, such as over network interface **1140**.

[0101] Memory **1120** may include program instructions, which may be processor-executable to implement any element or action described above. In one embodiment, the program instructions may implement the methods described above. In other embodiments, different elements and data may be included. Note that data may include any data or information described above.

[0102] Those skilled in the art will appreciate that computer system **1100** is merely illustrative and is not intended to limit the scope of embodiments. In particular, the computer system and devices may include any combination of hardware or software that can perform the indicated functions, including computers, network devices, Internet appliances, PDAs, wireless phones, pagers, etc. Computer system **1100** may also be connected to other devices that are not illustrated, or instead may operate as a stand-alone system. In addition, the functionality provided by the illustrated components may in some embodiments be combined in fewer components or distributed in additional components. Similarly, in some embodiments, the functionality of some of the illustrated components may not be provided and/or other additional functionality may be available.

[0103] Those skilled in the art will also appreciate that, while various items are illustrated as being stored in memory or on storage while being used, these items or portions of them may be transferred between memory and other storage devices for purposes of memory management and data integrity. Alternatively, in other embodiments some or all of the software components may execute in memory on another device and communicate with the illustrated com-

puter system via inter-computer communication. Some or all of the system components or data structures may also be stored (e.g., as instructions or structured data) on a computer-accessible medium or a portable article to be read by an appropriate drive, various examples of which are described above. In some embodiments, instructions stored on a computer-accessible medium separate from computer system **1100** may be transmitted to computer system **1100** via transmission media or signals such as electrical, electromagnetic, or digital signals, conveyed via a communication medium such as a network and/or a wireless link. Various embodiments may further include receiving, sending or storing instructions and/or data implemented in accordance with the foregoing description upon a computer-accessible medium. Generally speaking, a computer-accessible medium may include a non-transitory, computer-readable storage medium or memory medium such as magnetic or optical media, e.g., disk or DVD/CD-ROM, volatile or non-volatile media such as RAM (e.g. SDRAM, DDR, RDRAM, SRAM, etc.), ROM, etc. In some embodiments, a computer-accessible medium may include transmission media or signals such as electrical, electromagnetic, or digital signals, conveyed via a communication medium such as network and/or a wireless link.

[0104] The methods described herein may be implemented in software, hardware, or a combination thereof, in different embodiments. In addition, the order of the blocks of the methods may be changed, and various elements may be added, reordered, combined, omitted, modified, etc. Various modifications and changes may be made as would be obvious to a person skilled in the art having the benefit of this disclosure. The various embodiments described herein are meant to be illustrative and not limiting. Many variations, modifications, additions, and improvements are possible. Accordingly, plural instances may be provided for components described herein as a single instance. Boundaries between various components, operations and data stores are somewhat arbitrary, and particular operations are illustrated in the context of specific illustrative configurations. Other allocations of functionality are envisioned and may fall within the scope of claims that follow. Finally, structures and functionality presented as discrete components in the example configurations may be implemented as a combined structure or component. These and other variations, modifications, additions, and improvements may fall within the scope of embodiments as defined in the claims that follow.

What is claimed:

1-8. (canceled)

9. An apparatus, comprising:

an augmented reality display system, installed in a vehicle, which is configured to:

determine an object in an environment outside the vehicle that is at least partially obscured from direct view through a transparent surface of the vehicle;

receive sensor data generated by a sensor device monitoring the object; and

generate an augmented reality display, on a display surface which comprises a representation of the object in the environment which is at least partially obscured from direct view through the transparent surface.

10. The apparatus of claim **9**, wherein the sensor data is received at the vehicle from a remotely located device.

11. The apparatus of claim **10**, wherein the object in the environment comprises another vehicle navigating through the environment, the remotely located device comprises an additional vehicle navigating through the environment, and the sensor device is installed in the additional vehicle.

12. The apparatus of claim **10**, wherein the augmented reality display system is configured to:

generate the augmented reality display which comprises the representation of the object in the environment, based on a determination that the object is associated with one or more of a driving route along which the vehicle is being navigated or one or more instances of personal data associated with an occupant of the vehicle.

13-20. (canceled)

21. The apparatus of claim **9**, wherein the augmented reality display system is configured to:

generate the representation of the object as a three-dimensional representation.

22. The apparatus of claim **9**, wherein the augmented reality display system is configured to:

generate the augmented reality display which comprises the representation of the object in the environment, based on a determination that the object is at least partially in a blind spot associated with sensor data representations of the environment which are generated by sensor devices included in the vehicle.

23. The apparatus of claim **9**, wherein the augmented reality display system is configured to:

generate the augmented reality display to comprise representations of a position of the at least partially obscured object in the environment.

24. The apparatus of claim **9**, wherein the augmented reality display system is configured to:

generate the augmented reality display to comprise representations of obscured portions of a roadway in the environment.

25. The apparatus of claim **9**, wherein the at least partially obscured object is a static object in the environment.

26. The apparatus of claim **9**, wherein the at least partially obscured object is a dynamic object in the environment.

27. The apparatus of claim **9**, wherein the augmented reality display system is configured to:

generate the augmented reality display to comprise a boundary of the at least partially obscured object in the environment.

28. The apparatus of claim **9**, wherein the display surface comprises at least a portion of the transparent surface.

29. A non-transitory, computer-readable storage medium storing program instructions that when executed cause one or more processors to:

determine an object in an environment outside a vehicle that is at least partially obscured from direct view through a transparent surface of the vehicle;

receive sensor data generated by a sensor device monitoring the object; and

generate an augmented reality display, on a display surface, which comprises a representation of the object in the environment which is at least partially obscured from direct view through the transparent surface.

30. The non-transitory, computer-readable storage medium as recited in claim **29**, wherein the sensor data is received at the vehicle from a remotely located device.

31. The non-transitory, computer-readable storage medium as recited in claim **30**, wherein the object in the environment comprises another vehicle navigating through the

environment, the remotely located device comprises an additional vehicle navigating through the environment, and the sensor device is installed in the additional vehicle.

32. The non-transitory, computer-readable storage medium as recited in claim **30** storing further program instructions that when executed cause one or more processors to:

generate the augmented reality display which comprises the representation of the object in the environment, based on a determination that the object is associated with one or more of a driving route along which the vehicle is being navigated or one or more instances of personal data associated with an occupant of the vehicle.

33. The non-transitory, computer-readable storage medium as recited in claim **29** storing further program instructions that when executed cause one or more processors to:

generate the representation of the object as a three-dimensional representation.

34. The non-transitory, computer-readable storage medium as recited in claim **29** storing further program instructions that when executed cause one or more processors to:

generate the augmented reality display which comprises the representation of the object in the environment, based on a determination that the object is at least partially in a blind spot associated with sensor data representations of the environment which are generated by sensor devices included in the vehicle.

35. The non-transitory, computer-readable storage medium as recited in claim **29** storing further program instructions that when executed cause one or more processors to:

generate the augmented reality display to comprise representations of a position of the at least partially obscured object in the environment.

36. A method, comprising:

determining an object in an environment outside a vehicle that is at least partially obscured from direct view through a transparent surface of the vehicle;

receiving sensor data generated by a sensor device monitoring the object; and

generating an augmented reality display, on a display surface, which comprises a representation of the object in the environment which is at least partially obscured from direct view through the transparent surface.

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