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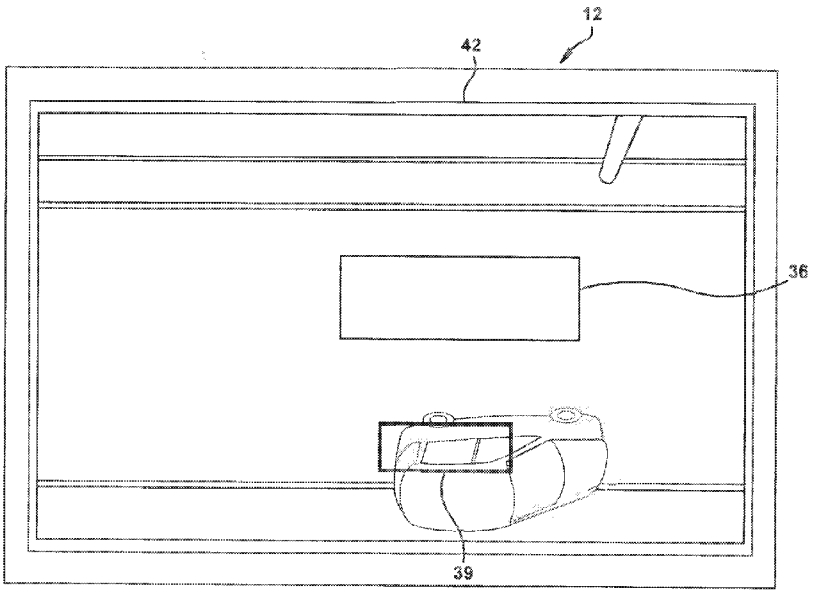

Fig. 10

(57) Abstract: A controller for synthesizing images for a vehicle display comprises a first image generator for generating a bird's eye image from a first set of cameras, the bird's eye image depicting the surroundings of a host vehicle and having a generally central portion. The controller includes a second image generator for generating a second image separate from the bird's eye image. The controller includes a synthesizer for synthesizing the bird's eye image and the second image for displaying the second image within the generally central portion of the bird's eye image.

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VEHICLE DISPLAY

Background

[0001] The present invention relates to embodiments of a display that illustrate a bird's eye image of a tractor-trailer or other vehicle. Prior art bird's eye image displays show the vehicle as an object on the display screen with the views captured by the camera calibrated to display the surroundings of the vehicle as if the driver were viewing the vehicle from above. The vehicle graphic itself is generally represented by a shape similar to the vehicle and may have markings to resemble the top view or roof of the vehicle. The shape is centrally located in the display to help the driver with orienting himself or herself with respect to the camera views. The shape is generally an unused space on the display screen.

[0002] **FIGURE 1** illustrates a prior art display **100**. The screen **104** is used to display a surround view of a vehicle. The vehicle image **102** is shown in the shape of the vehicle as would be seen from an overhead camera view. No other information about the vehicle **102** is shared on the display **100**. In some prior art displays, information about the vehicle would be shown by splitting the screen **104** into two portions, one portion showing the surround view of the vehicle and the other portion showing information about the vehicle or the view from a different camera. Splitting the screen **104** into two screens causes the information to be less comprehensible as the images must become smaller. There is a desire to improve utilization of the display.

Summary

[0003] Various embodiments of a controller for synthesizing images for a vehicle display comprise a first image generator for generating a bird's eye image from a first set of cameras, the bird's eye image depicting the surroundings of a host vehicle and having a generally central portion. The controller includes a second image generator for generating a second image separate from the bird's eye image. The controller also includes a synthesizer

for synthesizing the bird's eye image and the second image for displaying the second image within the generally central portion of the bird's eye image.

[0004] In accordance with another aspect, various embodiments of a method for synthesizing an image comprise receiving a bird's eye view of a surrounding of a vehicle from a first set of cameras and synthesizing the bird's eye view to create a bird's eye image having a generally central portion. The method also includes receiving a second view separate from the bird's eye view and synthesizing the second view to create a second image. The method includes displaying the second image within the generally central portion of the bird's eye image.

Brief Description of the Drawings

[0005] In the accompanying drawings which are incorporated in and constitute a part of the specification, embodiments of the invention are illustrated, which, together with a general description of the invention given above, and the detailed description given below, serve to exemplify the embodiments of this invention.

[0006] **FIGURE 1** illustrates a prior art display.

[0007] **FIGURE 2** illustrates a system according to one example of this invention.

[0008] **FIGURES 3-12** illustrate displays configured according to examples of this invention.

[0009] **FIGURES 13-14** illustrate methods of utilizing the display according to examples of this invention.

Detailed Description

[0010] **FIGURE 2** illustrates a surround view system **10** according to one example. The surround view system **10** is installed on host vehicle, such as a car, bus, truck or tractor-

trailer vehicle. The surround view system **10** captures a bird's eye view of the host vehicle on which the surround view system **10** is installed, in addition to other features, as will be explained.

[0011] The surround view system **10** includes at least one forward looking camera **16,** intended for installation on the front of the body of the host vehicle. The surround view system **10** also includes a rear camera **18**, intended for installation on the rear of the host vehicle. The surround view system **10** also includes a left side camera **20** and a right side camera **22** that may be mounted on the left and right sides of the host vehicle. The cameras may be mounted on the roof of the vehicle, along the perimeter of the vehicle, on the hood of the vehicle or other location that affords a view looking downward and around the host vehicle. The cameras **16, 18, 20, 22** may have a fish eye lens to facilitate capturing the bird's eye view.

[0012] The surround view system **10** may also include at least one alternate camera **24**. The at least one alternate camera **24** may be a driver facing camera, an undercarriage camera, a panorama camera, a cargo or passenger space camera or other camera that captures another view of the host vehicle or around the host vehicle that is not typically used to display a bird's eye image of a vehicle.

[0013] The surround view system **10** includes a display **12**. The display **12** is located in the host vehicle in view of a driver. The display **12** may be an UM-900/T display from Lilliput Electronics Inc. of City of Industry, California. The display **12** is in electrical communication with a surround view controller **14** either directly, wirelessly, through a vehicle communications bus **13** or other communications means. The vehicle communications bus **13** may be used to transmit or receive information from other controllers on the host vehicle.

[0014] The surround view controller **14** includes a processor with control logic **15** for controlling the display **12** and receiving information from the cameras **16, 18, 20, 22, 24**. The control logic **15** compiles each of the views from cameras **16, 18, 20, 22** in a first image

generator **28** to create the bird's eye view image. The control logic **15** compiles the view from alternate camera **24** and/or other information from other systems on the vehicle in a second image generator **30**. The control logic **15** synthesizes the information from the first image generator **28** and the second image generator **30** to display a unified image on the display **12.** A display screen of the display **12** is transformed to display the unified image.

[0015] The control logic **15** may include volatile, non-volatile memory, solid state memory, flash memory, random-access memory (RAM), read-only memory (ROM), electronic erasable programmable read-only memory (EEPROM), variants of the foregoing memory types, combinations thereof, and/or any other type(s) of memory suitable for providing the described functionality and/or storing computer-executable instructions for execution by the control logic **15**. The control logic **15** can save images to a memory location for later retrieval. The controller **14** may also include functionality for lane departure warning and other vehicle systems.

[0016] The surround view controller **14** may receive input from a driver input device **26**. Alternatively, the driver input device **26** may communicate directly with the display **12.** The driver input device **26** is used by the driver when he or she desires to change the view as shown on the display **12**.

[0017] Therefore, a controller for synthesizing images for a vehicle display comprise a first image generator for generating a bird's eye image from a first set of cameras, the bird's eye image depicting the surroundings of a host vehicle and having a generally central portion. The controller includes a second image generator for generating a second image separate from the bird's eye image. The controller also includes a synthesizer for synthesizing the bird's eye image and the second image for displaying the second image within the generally central portion of the bird's eye image.

[0018] Therefore, a system for synthesizing and displaying an image comprises a first set of cameras for capturing a bird's eye view of a surrounding of a vehicle. The system includes a controller capable of synthesizing the bird's eye view to create a bird's eye image

having a generally central portion and synthesizing a second image. The second image is placed in the generally central portion of the bird's eye image to create a unified image. The system also includes a display for displaying the unified image.

[0019] **FIGURE 3** illustrates a close up view of the screen **42** of display **12,** according to one example of the invention. Display **12** shows a bird's eye image around the host vehicle having the surround view system **10**. The control logic **15** receives views acquired by the cameras **16, 18, 20, 22** as arranged on the host vehicle. The cameras **16, 18, 20, 22** may be configured to capture views simultaneously and at the same frame rate. The fields of view of the cameras **16, 18, 20, 22** may and typically do have some overlap. The first image generator **28** transforms and stitches together views captured by the cameras **16, 18, 20, 22** to build the bird's eye image based on the known relative position between the cameras **16, 18, 20, 22**. The first image generator **28** then displays the bird's eye image on the screen **42**. Detected objects, such as a pedestrian object **38** and vehicle object **39**, may also be shown on the screen **42**. In this example, the pedestrian object **38** and vehicle object **39** are shown as outlines, but they may also be shown as icons, text or symbols.

[0020] The first image generator **28** creates a generally central portion **36** relative to which the bird's eye image as synthesized from cameras **16, 18, 20, 22** is oriented. In the prior art, a representation of the host vehicle roof would be displayed. In this example, the generally central portion **36** is used by the second image generator **30**, as will be explained. In Figure 3, the generally central portion **36** is left as a blank space approximating the size of unviewable space of the bird's eye image. Unviewable space is created due to the placement of the cameras **16, 18, 20, 22** in relationship with the body of the host vehicle. The generally central portion **36** may be generally rectangular in shape, indicating a larger host vehicle like a tractor-trailer or a bus, or the generally central portion **36** may be squarer in shape, indicating a smaller host vehicle like a tractor only or a car. While the bird's eye image on screen **42** may change as the object(s) move with respect to the host vehicle, the generally central portion **36** corresponds to the unviewable space of the bird's eye image and remains devoid of information or graphics. This unified image is displayed to the driver.

[0021] In **FIGURE 4**, the second image generator **30** is used to display a company logo in the generally central portion **36.** By displaying the company logo in this manner, the control logic **15** synthesizes the images from the first image generator **28** and the second image generator **30** on the screen to provide practical information about the manufacturer of the surround view system **10** as the unified image. This unified image uses the otherwise unviewable space, which is the generally central portion **36** on the screen **42** created by the first image generator **28**.

[0022] In **FIGURE 5**, the first image generator **28** is used to show the bird's eye image of the host vehicle on screen **42**. The generally central portion **36** is now used to display an image of the current time, the vehicle speed and the ambient temperature. The vehicle speed information may be received by the control logic **15** from another controller on the host vehicle via the vehicle serial communications bus **13**. The driver may use driver input device **26** to cycle through different information to be displayed in the generally central portion **36**. One display selection may include multiple points regarding current vehicle running information, as shown in the unified image of Figure 5. Another selection may present information individually, such as vehicle speed, ambient temperature, vehicle system activity and the like.

[0023] Utilization of generally central portion **36** in the manner disclosed precludes the second image generator **30** from overlapping information onto the bird's eye image generated by the first image generator **28.** Displaying text over any part of the image on the screen **42** may cause the driver to miss important information, such as pedestrian object **38** and vehicle object **39**. In addition, the full portion of the screen **42** is used for the bird's eye image rather than splitting the screen **42** into two smaller images as in the prior art.

[0024] In **FIGURE 6**, the first image generator **28** is used to show the bird's eye image of the host vehicle on screen **42**. The host vehicle in this example is a tractor-trailer vehicle. The bird's eye view image will change as the host vehicle moves or as the object(s) move in relationship to the host vehicle. The generally central portion **36** is split into two

segments, a first, or tractor, segment **40** and a second, or trailer, segment **32**. The tractor segment **40** and trailer segment **32** approximate the location of the tractor and trailer with respect to the camera view and may remain stationary on the screen **42** as the bird's eye image changes. Alternatively, the tractor segment **40** may move on the screen **42** when the controller **14** receives information that the tractor is articulating from the trailer.

[0025] In this example of a unified image, the tractor segment **40** is shown as moving to the left because the controller **14** received information from another controller or sensor that the host vehicle was turning to the left. Display **12** is used to indicate visually to a driver that his maneuvers may bring his vehicle close to vehicle object **39.**

[0026] In another example of a unified image, the generally central portion **36** may display information about the vehicle object **39,** such as the size of the detected object, the distance of the detected object from the host vehicle and the direction of travel of the detected object.

[0027] In **FIGURE** 7, the first image generator **28** is used to show the bird's eye image of the host vehicle on screen **42**. In this example, the tractor of the host vehicle is articulating from the trailer, similar to Figure 6. The generally central portion **36** is now used to display an image of a vehicle warning as received from the second image generator **30**. The controller **14** may generate the warning itself or may receive the warning from another controller via the vehicle serial communications bus **13**. In this example, a low tire pressure warning and location of the warning is displayed to the driver in the generally central portion **36**. The warning may be displayed the entire time the warning is active or multiple warnings may be cyclically displayed according to their priority. A color change of the generally central portion **36** may help the driver identify the priority of the warning. In the case of a low tire pressure warning, the background of the trailer segment **32** may turn yellow.

[0028] The tractor segment **40** may be used to visually display a graphic of the warning since the area of the tractor segment **40** is less than the area of the trailer segment **32.** In this example of a unified image, the graphic of a tire pressure warning is shown on the

tractor segment **40** in approximately the location of the tire pressure warning, the left front tire. The trailer segment **32** may continue to provide details about the warning since it has larger spatial area on the screen **42.**

[0029] The driver may use driver input device **26** to cycle through different displays, one of which would include active warnings and fault codes of the vehicle. In the case of warnings and alerts, the driver may use driver input device **26** to cycle through warnings, but the control logic **15** may default to displaying the warning(s) once no input is received from the driver input device **26** instead of remaining on a vehicle informational or alternate camera display.

[0030] In **FIGURE 8,** the first image generator **28** is used to show the bird's eye image of the host vehicle on screen **42.** Generally central portion **36** can be used to display an image from another camera on the host vehicle. The driver may use the driver input device **26** to choose which camera view to display in generally central portion **36.** Alternatively, the display may cycle through different views from different active cameras. In the unified image of Figure 8, the second image generator **30** uses the image from the alternate camera **24** to show a driver facing camera image in generally central portion **36**.

[0031] In yet another example, the generally central portion **36** may provide a space to display a live video link to an external party or to receive transmitted content.

[0032] In **FIGURE 9,** the first image generator **28** is used to show the bird's eye image of the host vehicle. Generally central portion **36** can be used to display yet another image from another alternate camera on the host vehicle. The driver may use the driver input device **26** to choose which camera image to display in generally central portion **36.** The display **12** may automatically cycle through different views from different cameras. The display **12** may auto-configure to match vehicular conditions. In one example, the control logic **15** may receive information regarding the host vehicle being in a reverse gear. As shown in the unified image of Figure 9, the second image generator **30** will then use the

image from the alternate camera **24** in response to the vehicle being in reverse gear to show a backup camera image in the generally central portion **36**.

[0033] Additional information may be gathered and displayed by the second image generator **30.** In one example, the driver uses the driver input device **26** to select an image from one of the cameras **16, 18, 20, 22**, **24** on which the driver wants to zoom in on an area of concern. The alternate camera **24** may be a camera arranged to determine the height of the vehicle and to generate warnings regarding upcoming bridge clearances. In addition to the driver using the driver input device **26** to change what is displayed in the generally central portion **36**, the second image generator **30** may change what is displayed based on the vehicle speed, time of day or state of the driver.

[0034] In **FIGURE 10**, the first image generator **28** is used to show the bird's eye image of the host vehicle with actual images produced by the cameras **16, 18, 20, 22** and synthesized by the first image generator **28**. In this unified image, the screen **42** shows an image of vehicle object **39** with the perspective of looking at the roof of the vehicle object **39**. The generally central portion **36** is white to clearly contrast with the surrounding bird's eye image. The generally central portion **36** may be left blank to promote "negative space" in order to draw attention to the more important information of the images of potential obstacles surrounding the host vehicle. In other words, by not showing the image of the host vehicle, the driver may focus on only the relevant, surrounding information.

[0035] In **FIGURE 11**, the first image generator **28** is used to show the bird's eye image of the host vehicle. In this unified image, the generally central portion **36** may be tinted so as to have less contrast with the surrounding bird's eye image. Additional information about the vehicle, such as the speed limit for the local area, may be displayed in different colors in the generally central portion **36.** Different colors may be used to draw attention to the information in the generally central portion **36** according to the priority of the information**.** The colors may also be changed according to the time of day, interior lighting or the preference of the driver.

[0036] In a situation where the first image generator **28** is unable to display the bird's eye view, the second image generator **30** may still display vehicle information and warnings in the generally central portion **36** of the screen **42**.

[0037] In **FIGURE 12,** the first image generator **28** is used to show the bird's eye image of the host vehicle as it is approaching an intersection. In this example of a unified image, the generally central portion **36** is not used to display information but rather is shown as an outline of the host vehicle. The outline may be filled with a color similar to the pavement on which the host vehicle is traveling. Figure 12 displays the bounds of the unviewable area with the minimal required spatial information, as the location of the front and rear of the host vehicle are understood. This display offers minimal distraction by using the same gray inside the vehicle outline as outside the vehicle outline. The coloring may be determined by looking at the average gray level or color along the viewable boundary. The color may also be predicted by using the background from previous frames when the host vehicle was in a different position. Gradient shading inside the outline may be used, for example if the nose is assigned a brighter color than the end, the coloring may be modulated to a darker coloring at the end of the outline. Gradient shading and smooth boundary matching may be done via interpolation. Alternatively, the second image generator **30** may utilize what is at the boundaries of the unviewable space in the bird's eye image and sytnthesize an image near to what the image would look like if the vehicle was not present. Otherwise, the generally central section **36** displays no other information about the host vehicle and is not representing the vehicle in any manner except by its general shape.

[0038] Each generally central portion **36** as depicted in Figures 3-12 may change according to the task the driver is completing, the driver status or driver preference.

[0039] **FIGURE 13** illustrates a method **50** of synthesizing and displaying an image. In step **52**, the bird's eye image of the host vehicle as generated by the first image generator **28** of the surround view system **10** is displayed on the screen **42**. In step **54**, basic vehicle

and ambient information, such as vehicle speed and temperature, is displayed in the generally central portion **36** of the display by the second image generator **30**, similar to Figure 5.

[0040] In step **56**, the control logic **15** determines if a fault occurred anywhere in the host vehicle via messages on the vehicle communications bus **13**. If there are no faults in the host vehicle, the method **50** returns to step **54** to continue to display the basic vehicle and ambient information. If the controller **14** receives a message that the host vehicle has a fault, the method **50** continues to step **58**. In step **58**, the second image generator **30** displays the fault, such as the low tire pressure warning, similar to Figure 7. The driver input device **26** may be disabled so that the driver cannot change the images on the display **12.**

[0041] In step **60**, the controller **14** determines if the fault has been cleared. Once the fault has been cleared, the method **50** returns to step **54** to display the vehicle and ambient information. The driver may then use the input device **26** to change the display as she chooses. If the fault has not been cleared, the method **50** returns to step **58** to continue to display the warning.

[0042] **FIGURE 14** illustrates another method **70** of changing the view in the display screen **42**. In step **72**, the bird's eye view of the vehicle as generated by the first image generator **28** is displayed on the screen **42**. In step **74**, the control logic **15** determines if the vehicle is in reverse gear, either by its own sensors, cameras **16, 18, 20, 22** or by means of receiving a message on the vehicle communications bus **13**. If the host vehicle is not in reverse gear, the basic vehicle and ambient information is displayed in generally central portion **36** in step **78,** similar to Figure 5.

[0043] If the vehicle is in reverse gear, then in step **76** the information from the alternate camera **24** is displayed by the second image generator in the generally central portion **36,** similar to Figure 9**.** The alternate camera **24** in this example is a backup camera. The method **60** returns to step **74** where the rear view image will continue to be displayed in generally central portion **36** as long as the host vehicle is in reverse gear.

[0044] In most situations, the driver of the host vehicle can modify the view in the generally central portion **36** by using the driver input device **26**. However, if an alert or warning message is generated, the control logic **15** can prevent the driver from changing the view back to the basic vehicle information or alternate camera view until the driver alert or warning is addressed.

[0045] In addition, the control logic **15** can save the composite image generated by the first image generator **28** and second image generator **30** exactly as how the image would have appeared on the screen **42** to the driver. The control logic **15** no longer saves "empty space" or unviewable space by saving the representative images of the top view or roof of a host vehicle, but rather saves the images generated by the second image generator **30** on the screen **42** in the generally central portion **36**. No additional frames are needed to capture warnings or other information that may have previously been on a separate display. Relevant information will not be lost due to the display switching between the bird's eye view and the warning screens, as in the prior art.

[0046] Therefore, a method for synthesizing an image comprises receiving a bird's eye view of a surrounding of a vehicle from a first set of cameras and synthesizing the bird's eye view to create a bird's eye image having a generally central portion. The method also includes receiving a second view separate from the bird's eye view and synthesizing the second view to create a second image. The method includes displaying the second image within the generally central portion of the bird's eye image.

[0047] While the present invention has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative apparatus, and illustrative examples shown and described. Accordingly,

departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.

We claim:

1. A controller for synthesizing images for a display comprising:

a first image generator for generating a bird's eye image from a first set of cameras, the bird's eye image depicting the surroundings of a host vehicle and having a generally central portion;

a second image generator for generating a second image separate from the bird's eye image; and

a synthesizer for synthesizing the bird's eye image and the second image for displaying the second image within the generally central portion of the bird's eye image.

2. The controller as in claim 1, wherein the generally central portion is placed at the location of the body of the host vehicle with respect to the views of the first set of cameras.

3. The controller as in claim 1, wherein the generally central portion has two segments, wherein a first segment approximates the location of a tractor of the host vehicle and a second segment approximates the location of a trailer of the host vehicle with respect to the first set of cameras.

4. The controller as in claim 3, wherein the first segment changes position on the display in response to articulation of the tractor from the trailer.

5. The controller as in claim 3, wherein the second image is displayed in the second segment of the generally central portion.

6. The controller as in claim 1, wherein the second image comprises a view from a camera, separate from the first set of cameras, having one of a driver facing camera view; an undercarriage camera view, a back-up camera view and a forward camera view.

7. The controller as in claim 1, wherein the second image comprises at least one of an informational display and a diagnostic display.

8. The controller as in claim 1, further comprising an operator input device, the operator input device controllable to change the second image.

9. The controller as in claim 1, wherein the second image is displayed entirely within the generally central portion of the bird's eye image.

10. The controller as in claim 1, wherein the generally central portion of the bird's eye image is displayed as a negative space by the second image generator.

11. The controller as in claim 1, wherein the controller is in communication with a display screen and the synthesizer transforms the display screen to display a unified image in response to synthesizing the bird's eye image and the second image.

12. A method for synthesizing an image comprising:

receiving a bird's eye view of a surrounding of a vehicle from a first set of cameras;

synthesizing the bird's eye view to create a bird's eye image having a generally central portion;

receiving a second view separate from the bird's eye view;

synthesizing the second view to create a second image; and

displaying the second image within the generally central portion of the bird's eye image.

13. The method as in claim 12, further comprising recording the synthesized bird's eye image and second image.

14. The method as in claim 12, further comprising manually changing the second view from one of an informational view, a back-up camera view, a driver facing camera view, a forward view.

15. The method as in claim 12, further comprising transforming a display screen to display the bird's eye view and the second image as a unified image.

16. A system for synthesizing and displaying an image comprising:

a first set of cameras for capturing a bird's eye view of a surrounding of a vehicle;

a controller, the controller capable of:

synthesizing the bird's eye view to create a bird's eye image having a generally central portion; and

synthesizing a second image, wherein the second image is placed in the generally central portion of the bird's eye image to create a unified image; and

a display for displaying the unified image.

17. The system as in claim 16, wherein the second image is synthesized from another controller on the vehicle.

18. The system as in claim 16, wherein the second image is synthesized from a second view received from a camera separate from the first set of cameras.

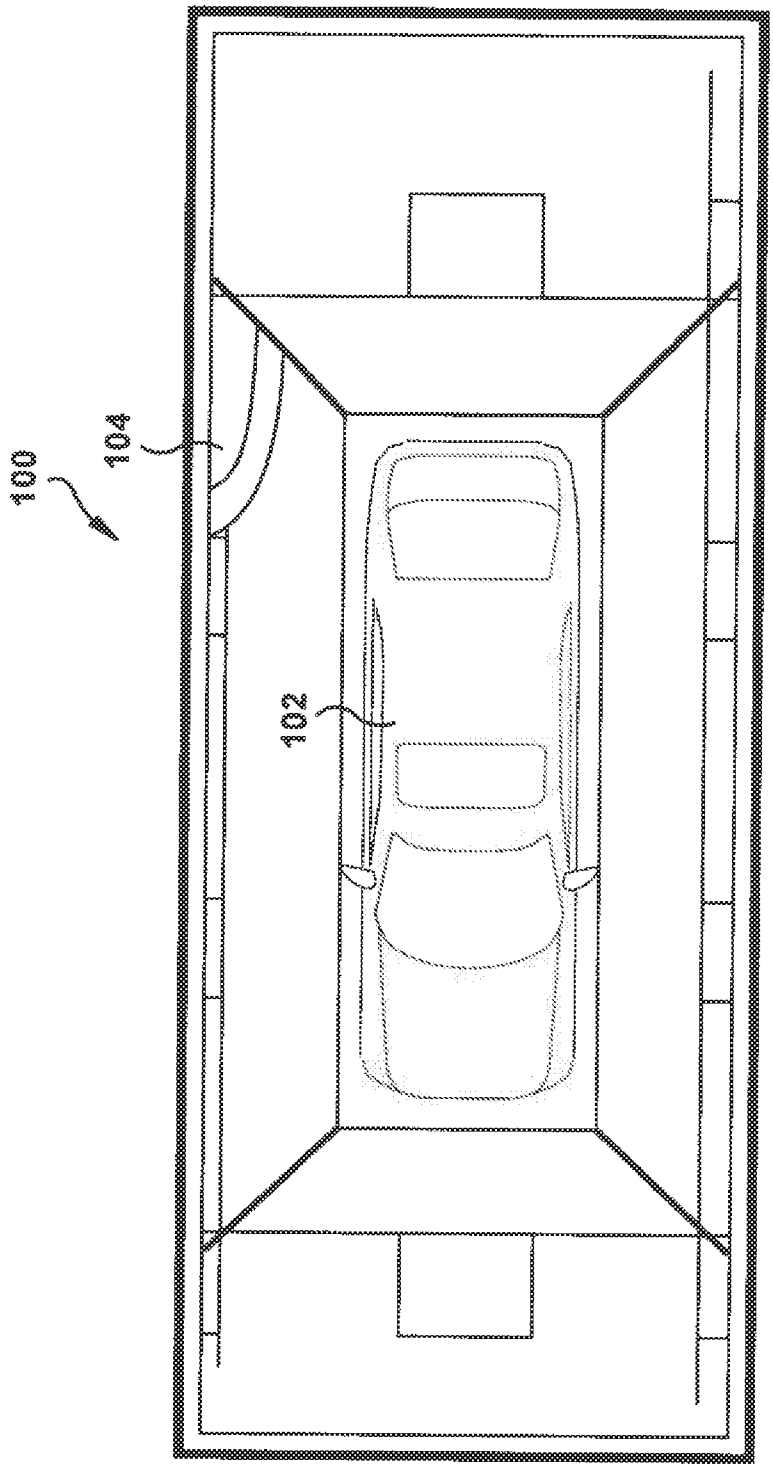

Fig. 1
(Prior Art)

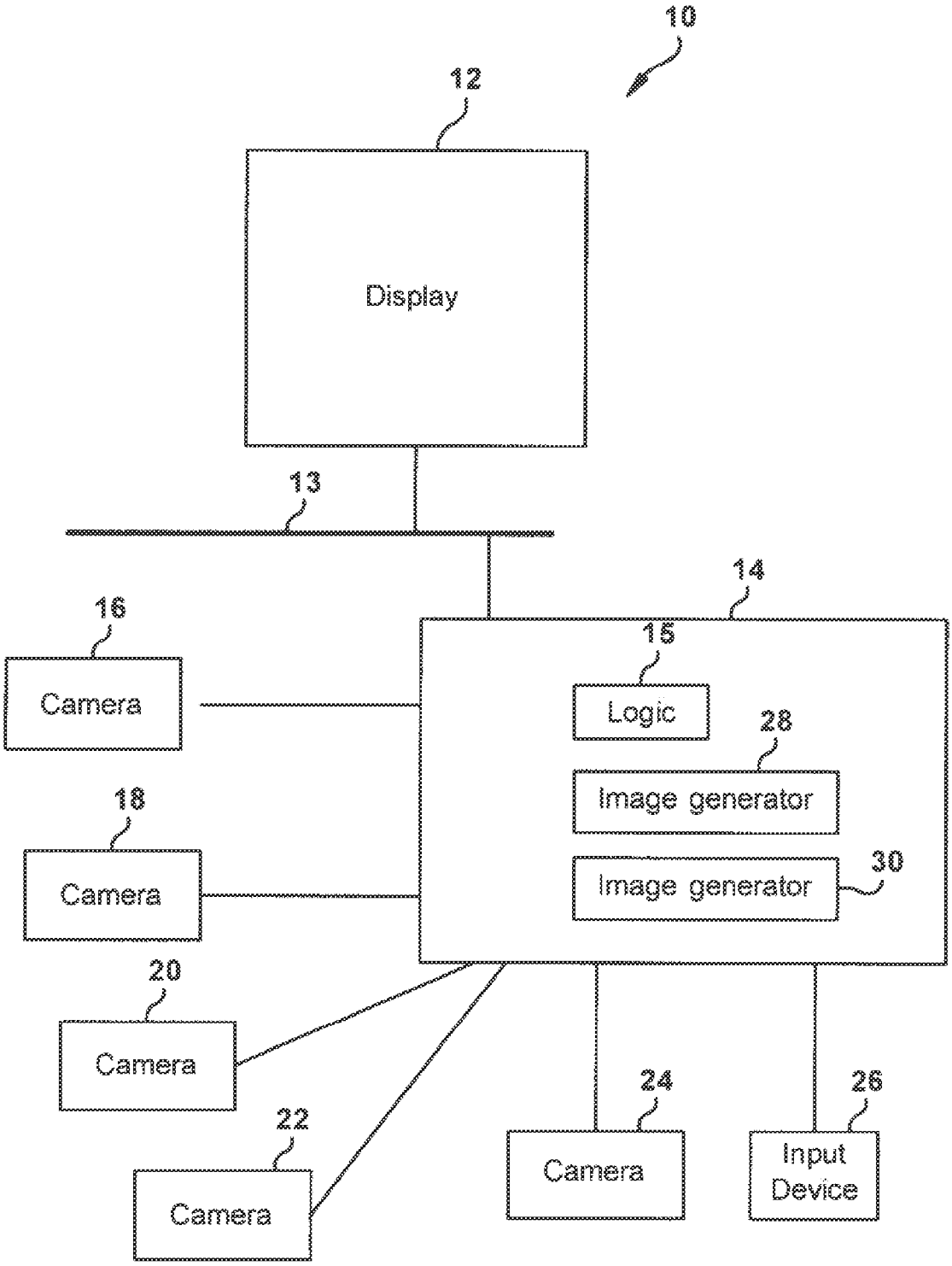
10
12
Display
13
14
16
Camera
15
Logic
28
Image generator
18
Camera
Image generator
30
20
Camera
24
26
22
Camera
Camera
Input Device

Fig. 2

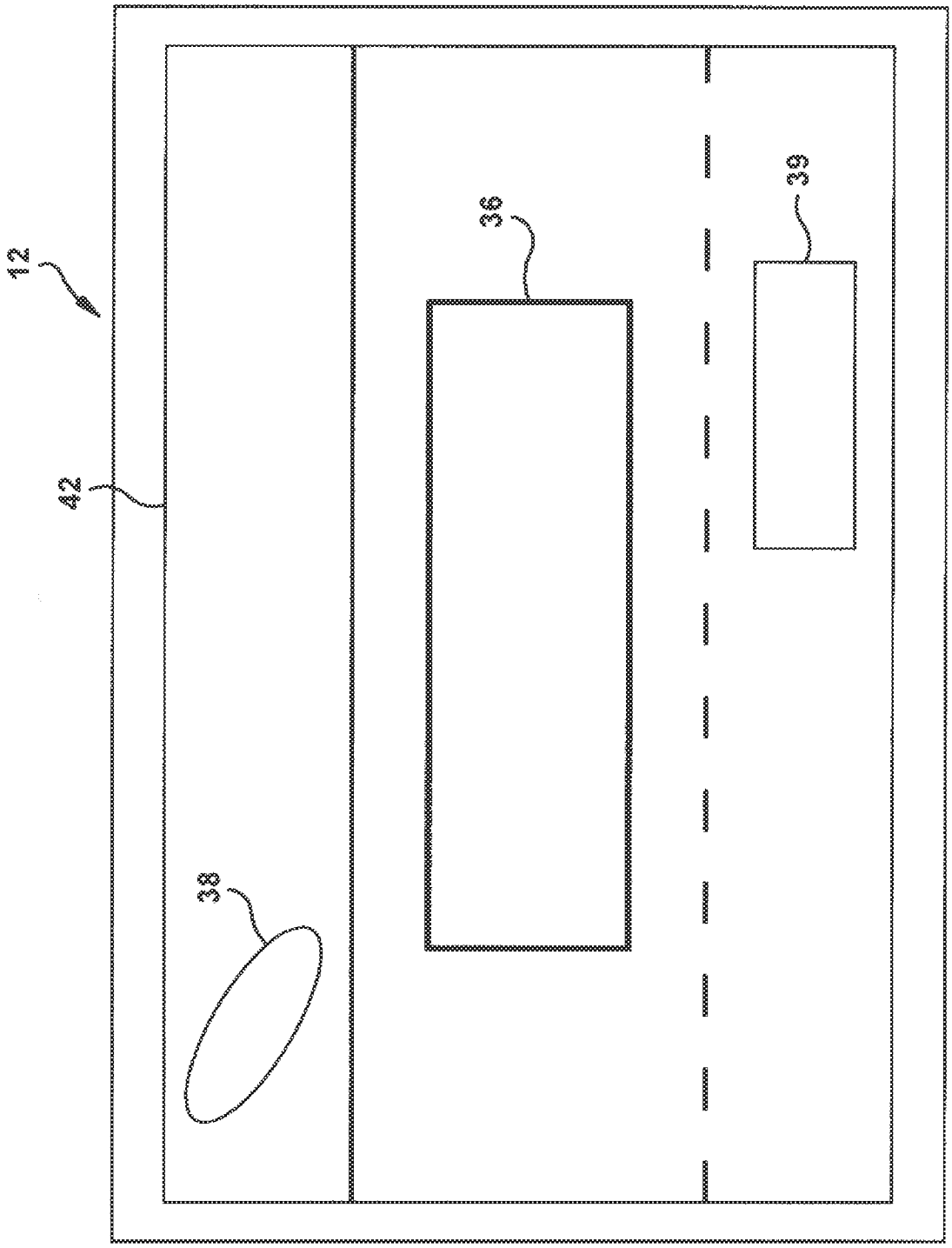

Fig. 3

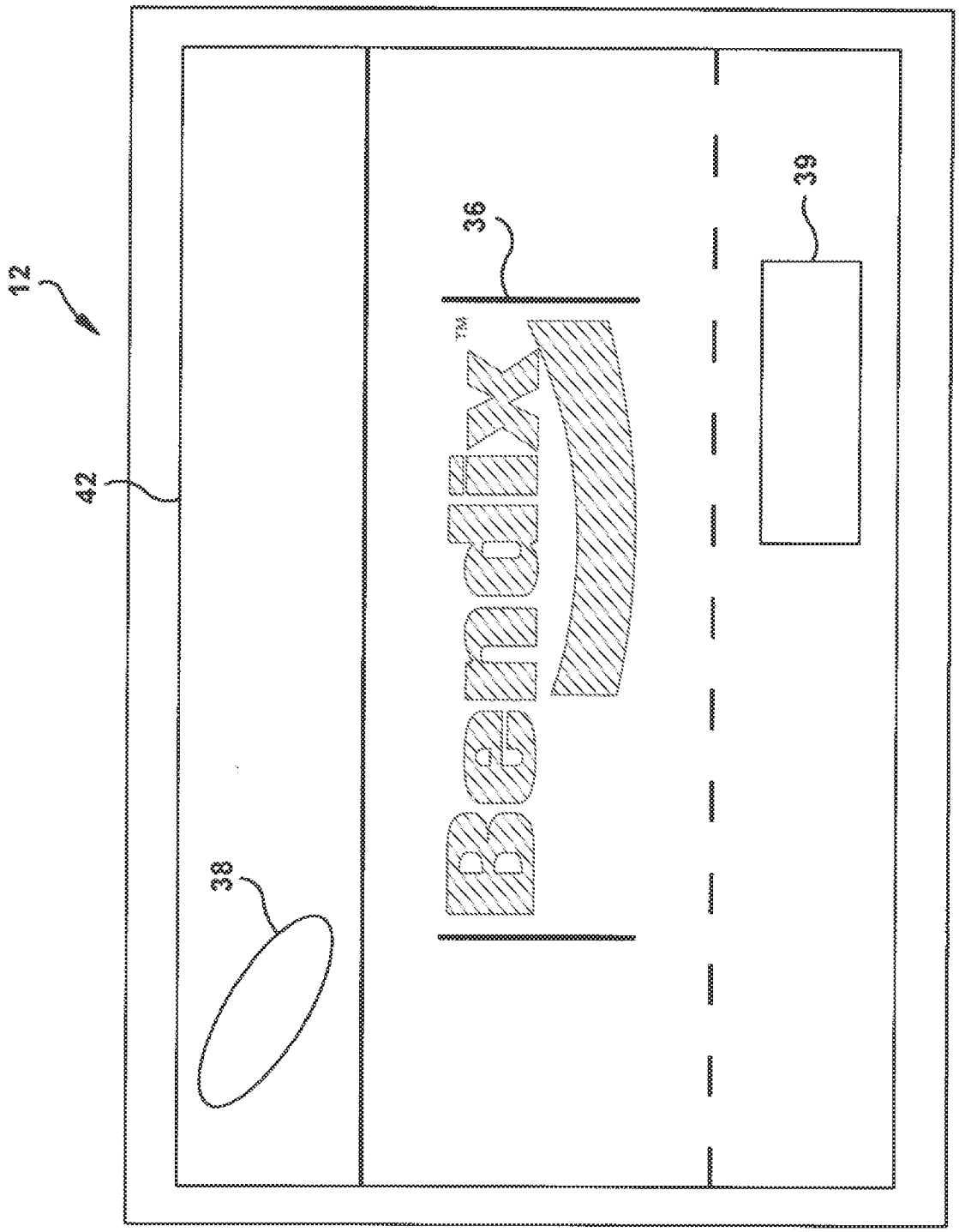

Fig. 4

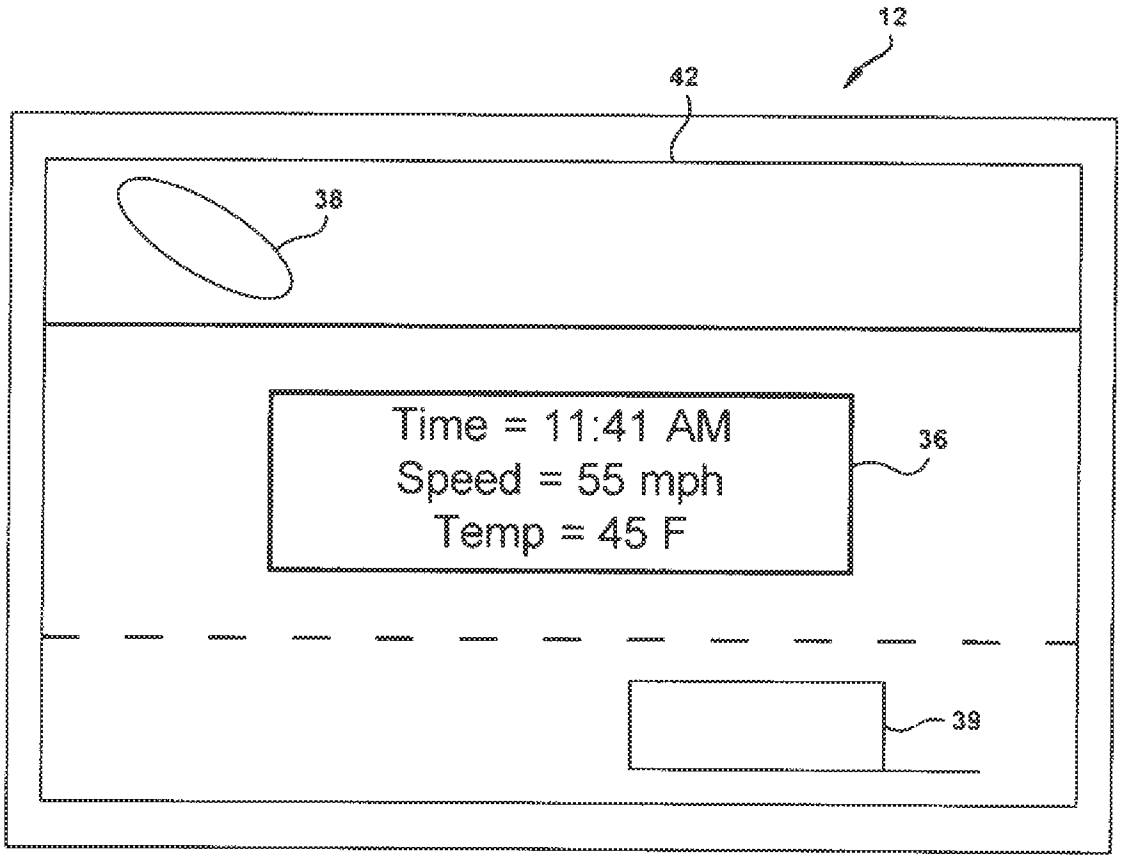

Fig. 5

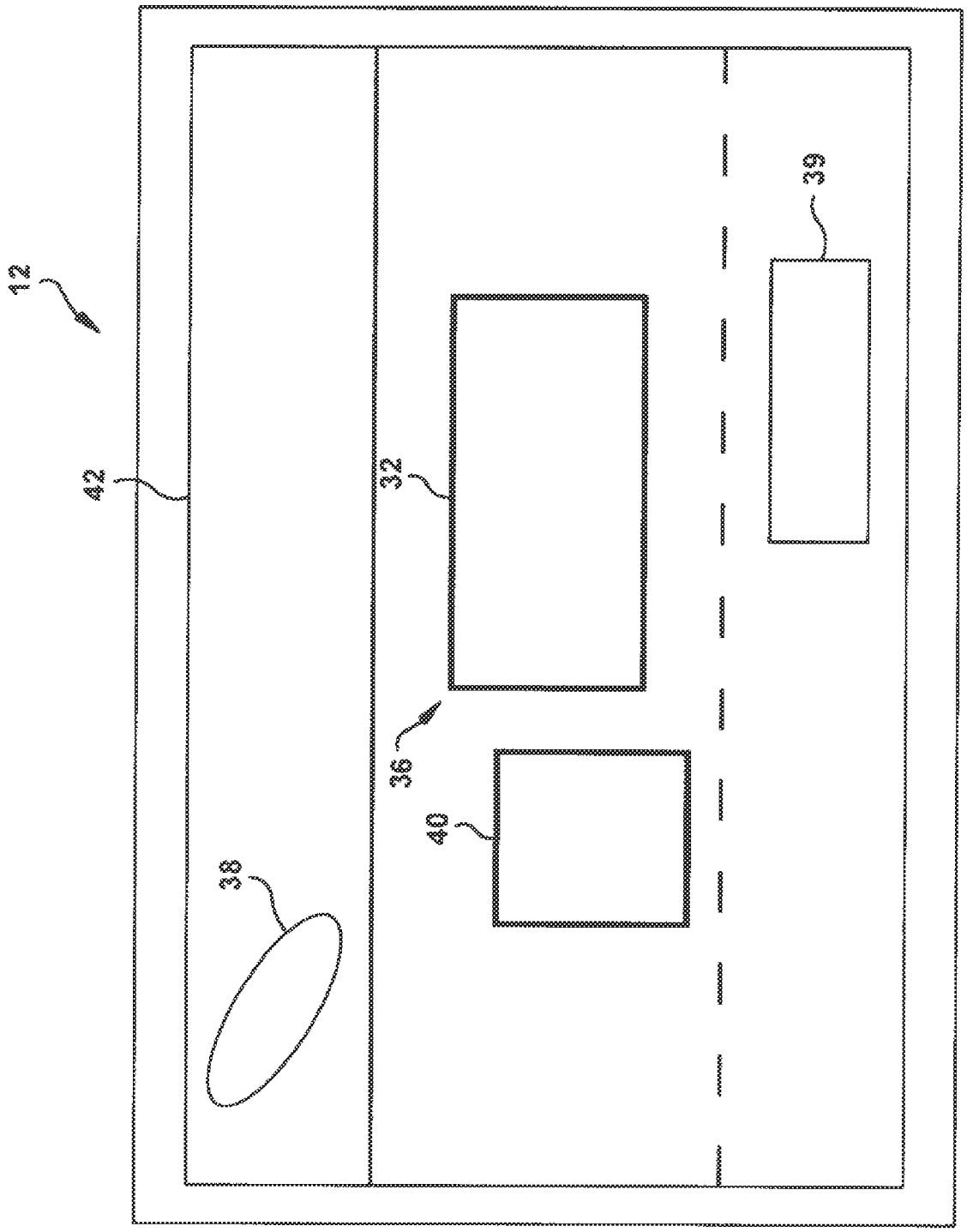

Fig. 6

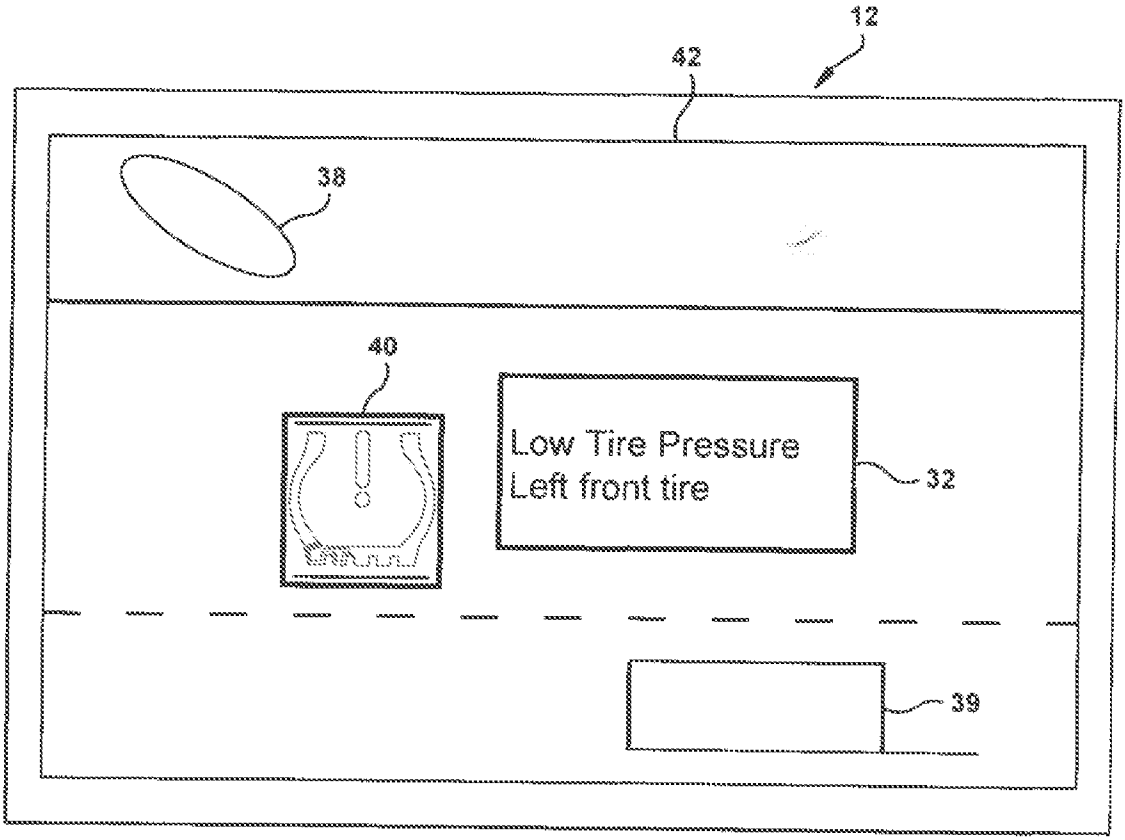

Fig. 7

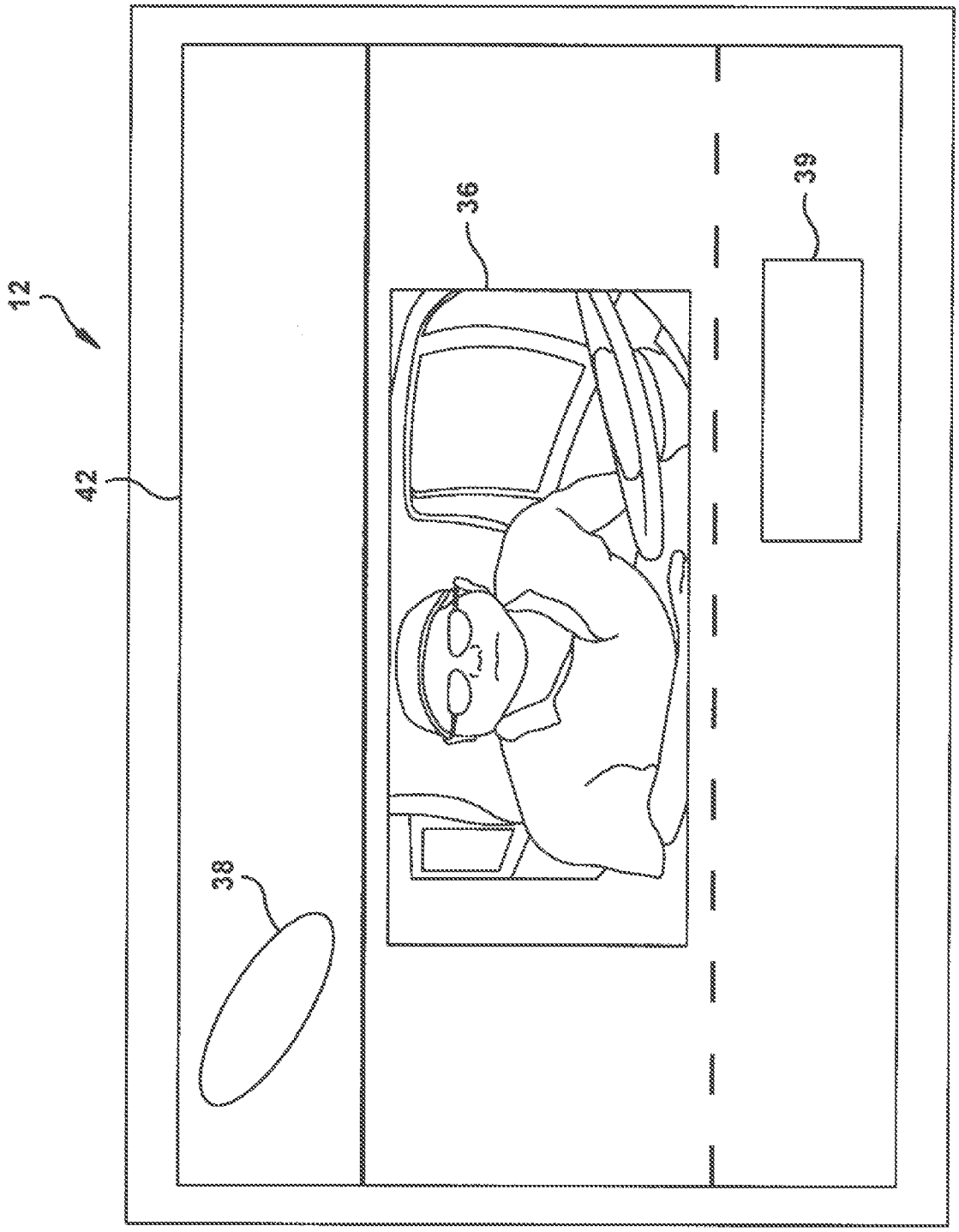

Fig. 8

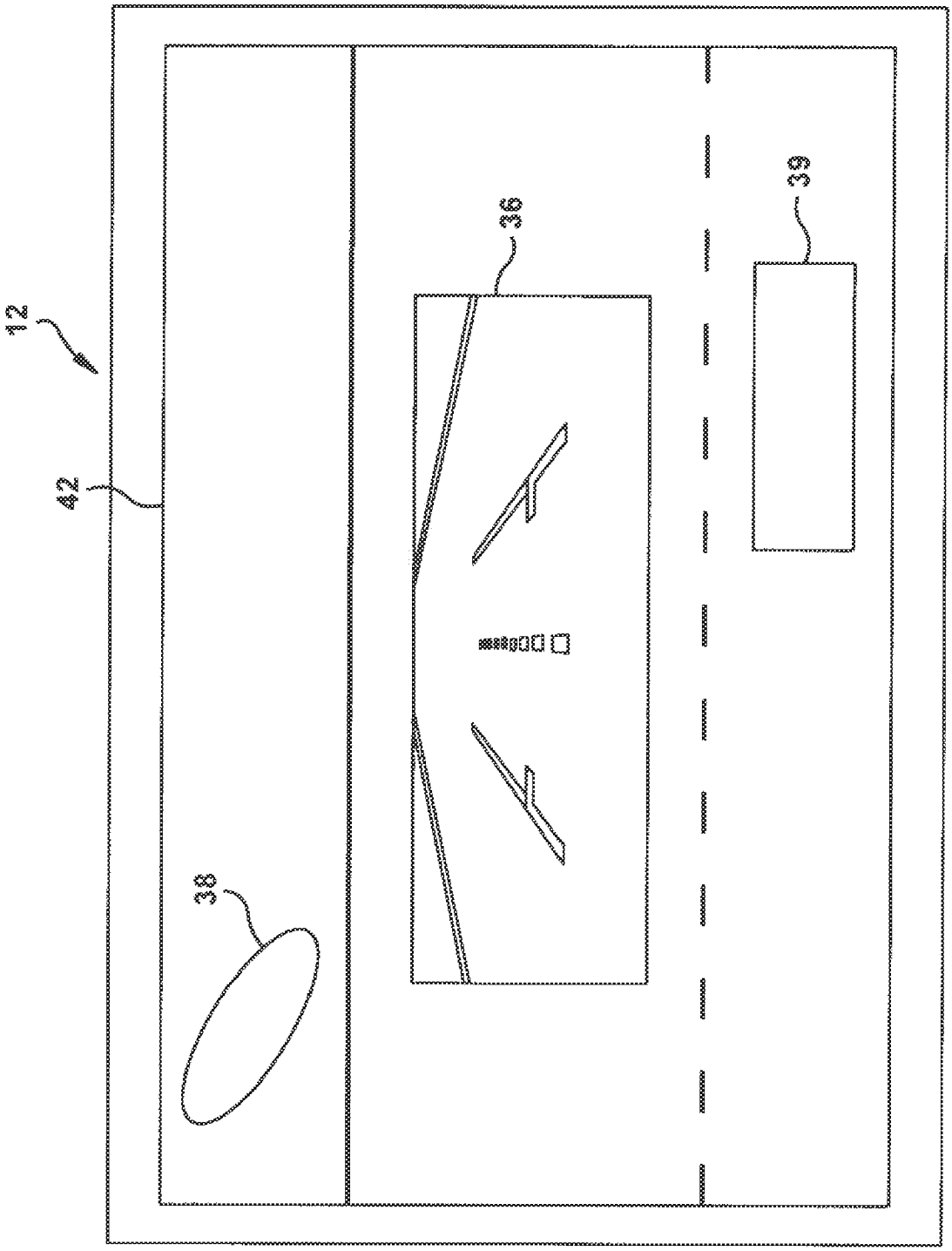

Fig. 9

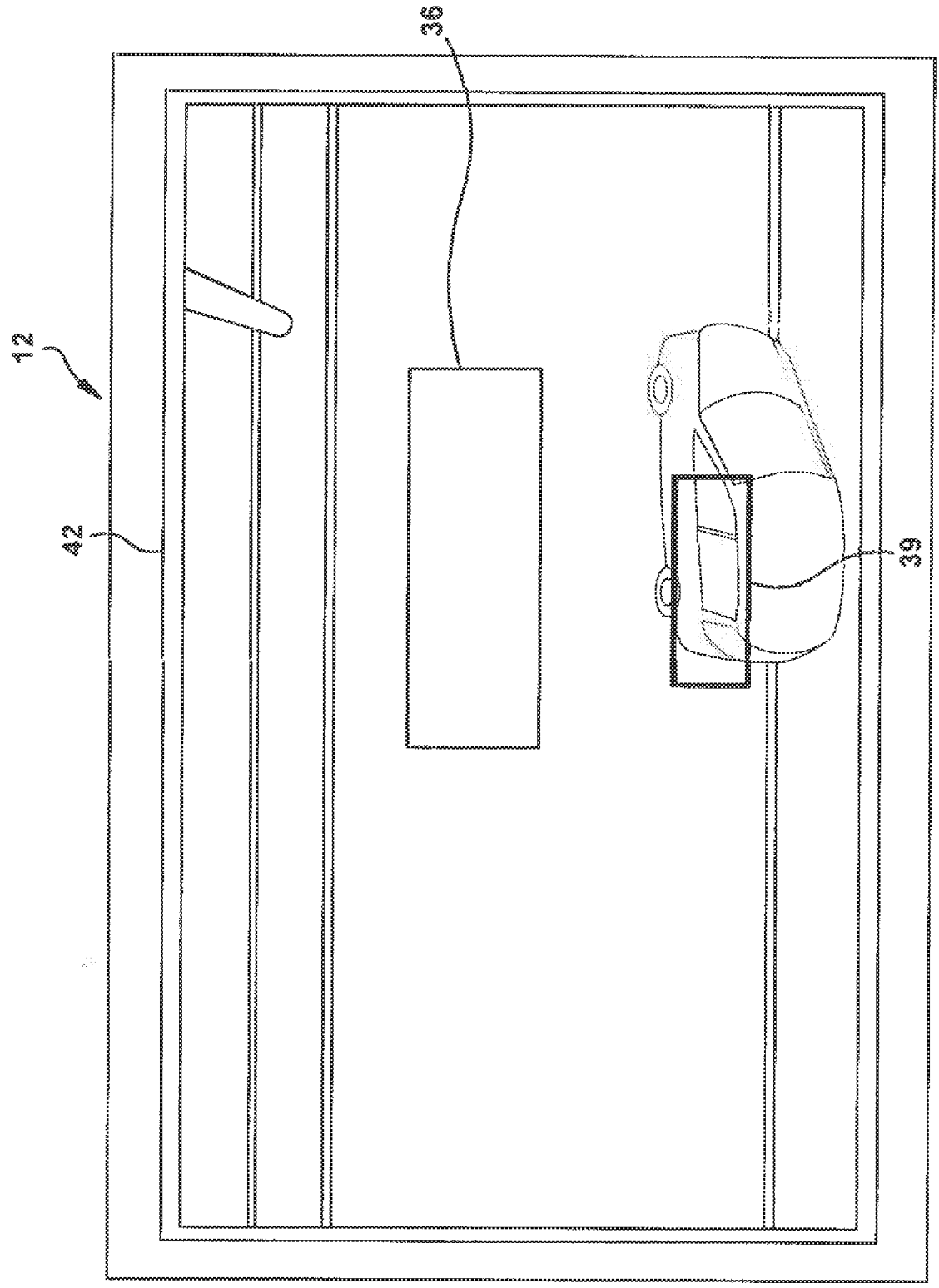

Fig. 10

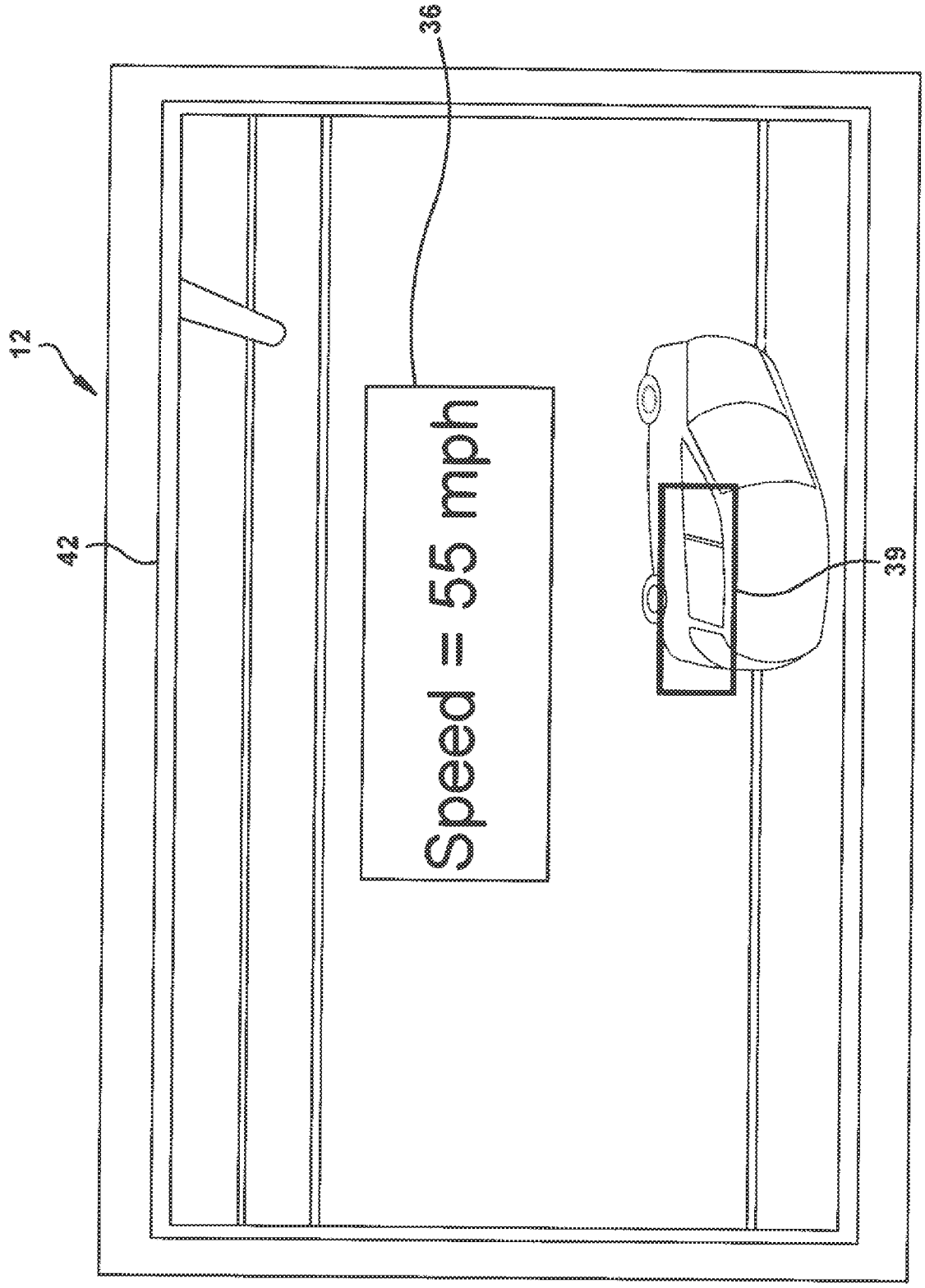

Fig. 11

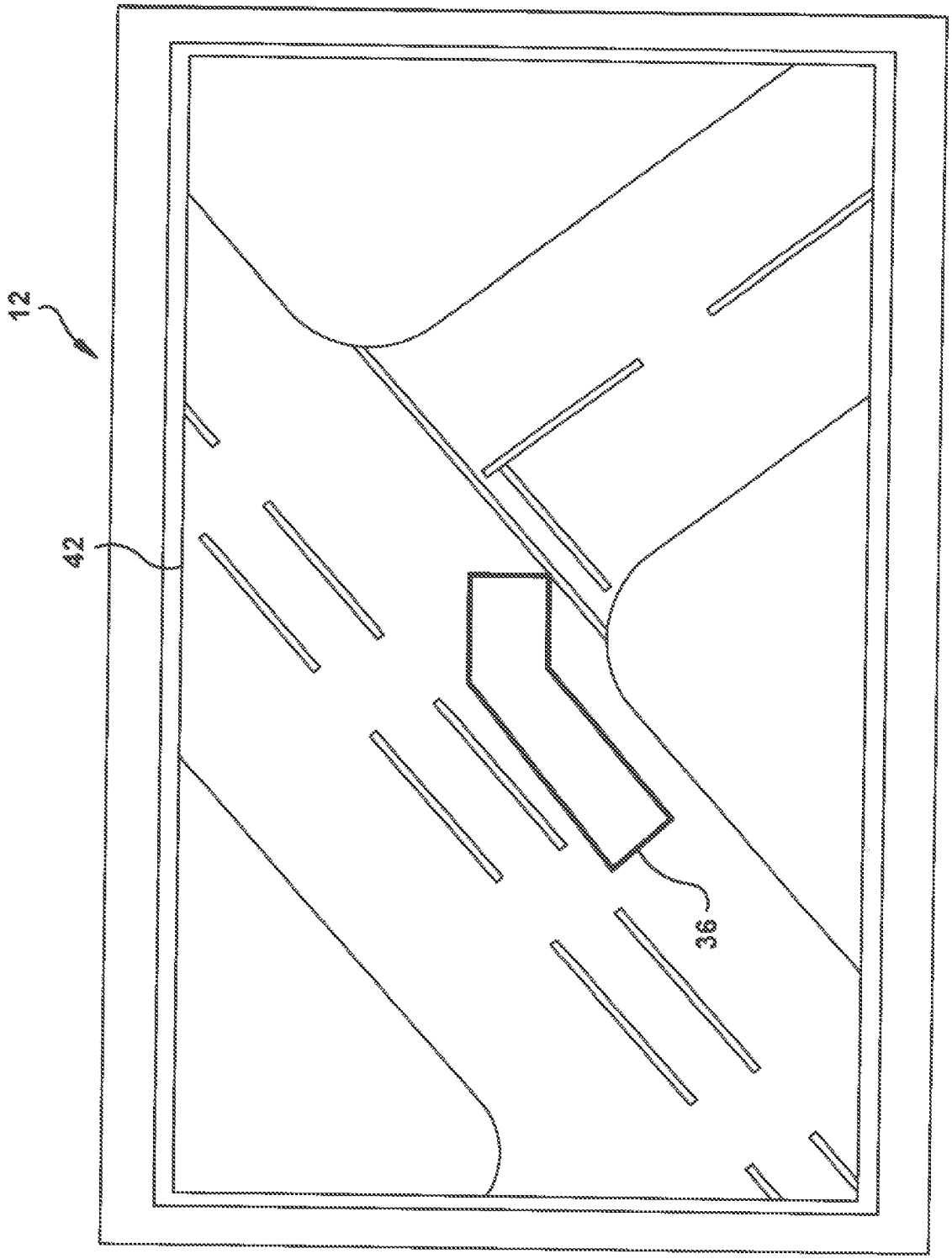

Fig. 12

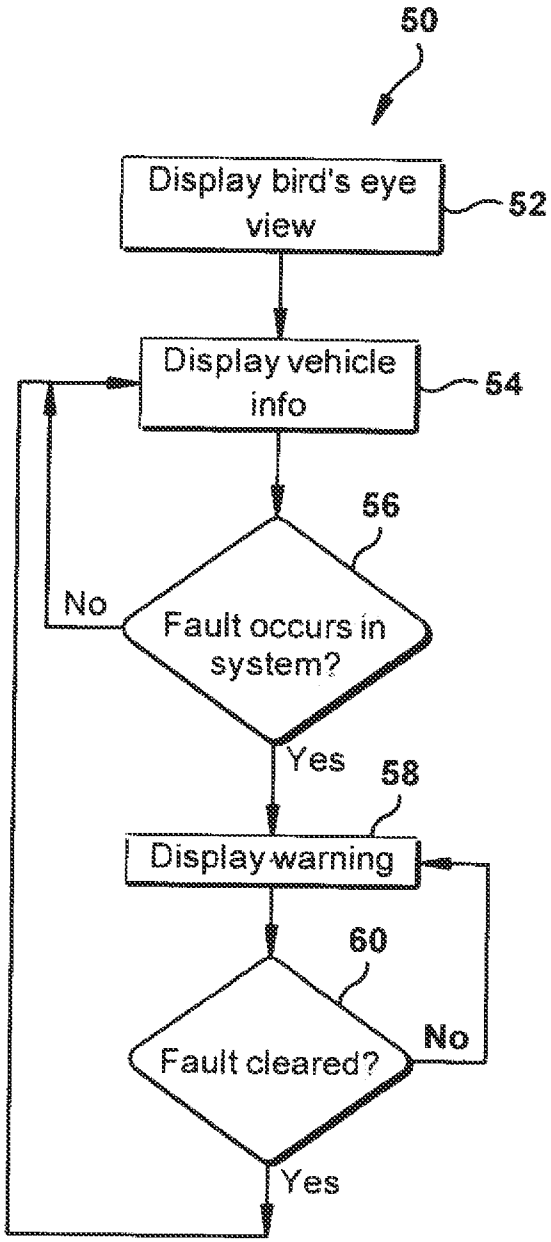
50
Display bird's eye view
52
Display vehicle info
54
56
Fault occurs in system?
No
Yes
58
Display warning
60
Fault cleared?
No
Yes

Fig. 13

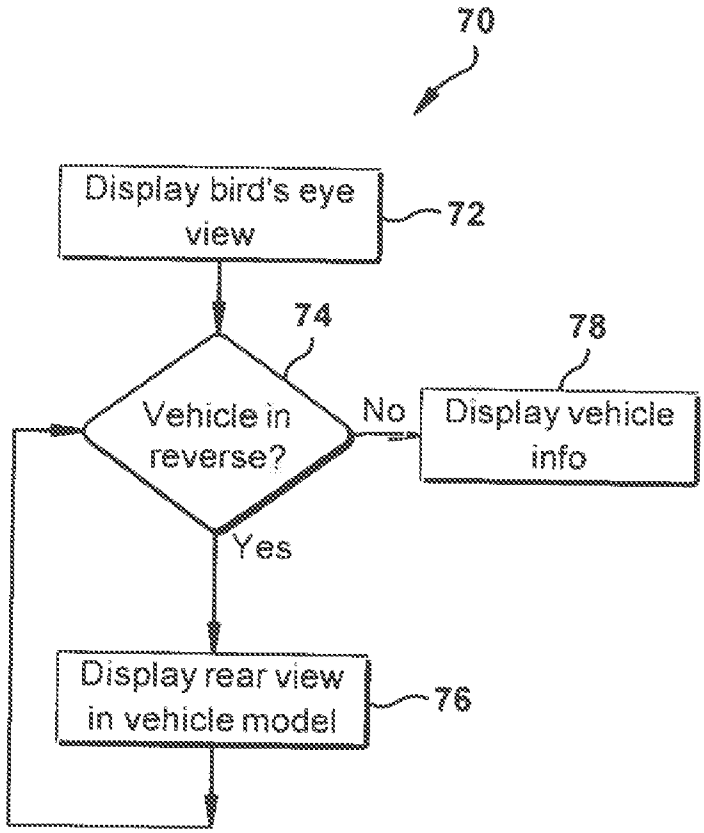
70
Display bird's eye view
72
74
Vehicle in reverse?
No
78
Display vehicle info
Yes
Display rear view in vehicle model
76

Fig. 14

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/058274

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60R1/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60R

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/217690 A1 (MITSUTA SHINJI [JP] ET AL) 6 August 2015 (2015-08-06) paragraphs [0034], [0040], [0043], [0047], [0054], [0055], [0067] - [0074], [0090] - [0103]	1,2,6-18
X	US 2014/088824 A1 (ISHIMOTO HIDEFUMI [JP]) 27 March 2014 (2014-03-27) paragraphs [0009], [0032] - [0053]	1-5,12, 13,15-18

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

☒ See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 March 2018	16/03/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Rapp, Alexander

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2017/058274

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		WO 2012157379 A1	22-11-2012