(12) UK Patent Application (19) GB (11) 2513960 (13) A

(43) Date of A Publication 12.11.2014

(21) Application No: 1403667.7

(22) Date of Filing: 03.03.2014

(30) Priority Data:
(31) 102013203659 (32) 04.03.2013 (33) DE

(71) Applicant(s):
Robert Bosch GmbH
(Incorporated in the Federal Republic of Germany)
Postfach 30 02 20, Wernerstrasse 1,
D-70442 Stuttgart, Germany

(72) Inventor(s):
Marc Luther
Ulrich-Lorenz Benzler
Peter Biber
Christoph Koch

(74) Agent and/or Address for Service:
A A Thornton & Co
10 Old Bailey, LONDON, EC4M 7NG, United Kingdom

(51) INT CL:
A01D 34/00 (2006.01)

(56) Documents Cited:
EP 2236069 A2 **WO 2009/077239 A1**
DE 102011053975 A1 **US 5467273 A**
US 20110040409 A1 **US 20030070852 A1**

(58) Field of Search:
INT CL **A01D, A47L, G05D**
Other: **EPODOC, WPI, TXTE, TXTG**

(54) Title of the Invention: **Vehicle apparatus**
Abstract Title: **Work surface evaluation system for autonomous vehicle**

(57) An autonomous vehicle 10 for machining a work surface 14, for example a robotic lawnmower or automated vacuum floor cleaner, comprises at least one light input element 16 that is provided for receiving light reflected by the work surface, at least one sensor unit 18 for detecting light received by the light input element, and at least one evaluation unit 20 that is provided for evaluating light detected by the sensor unit. It is proposed that the light input element and the sensor unit are arranged spaced by a distance of more than 5 cm. The light input element may be an optical lens and a waveguide 22 is preferably positioned between the light input element and the sensor for transmitting received light to the sensor and also for transmitting emitted light from a light emitter (24, figure 2), e.g. LED, to the light input element. Received light reflected form the work surface is analysed to determine a normalized difference vegetation index, NDVI, which gives an indication as to whether the work surface contains live green vegetation.

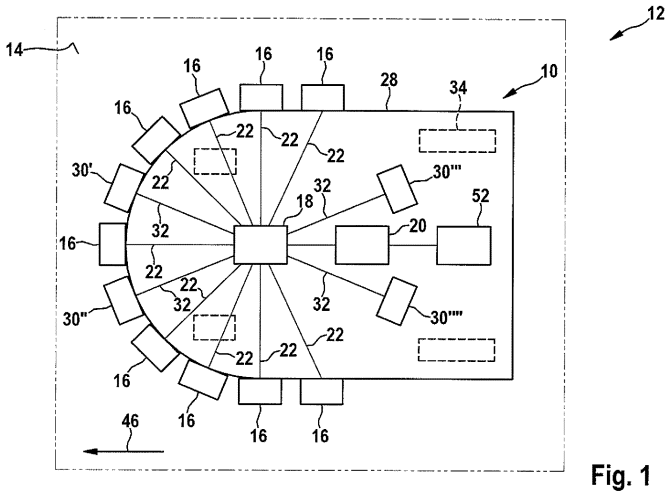

Fig. 1

GB 2513960 A

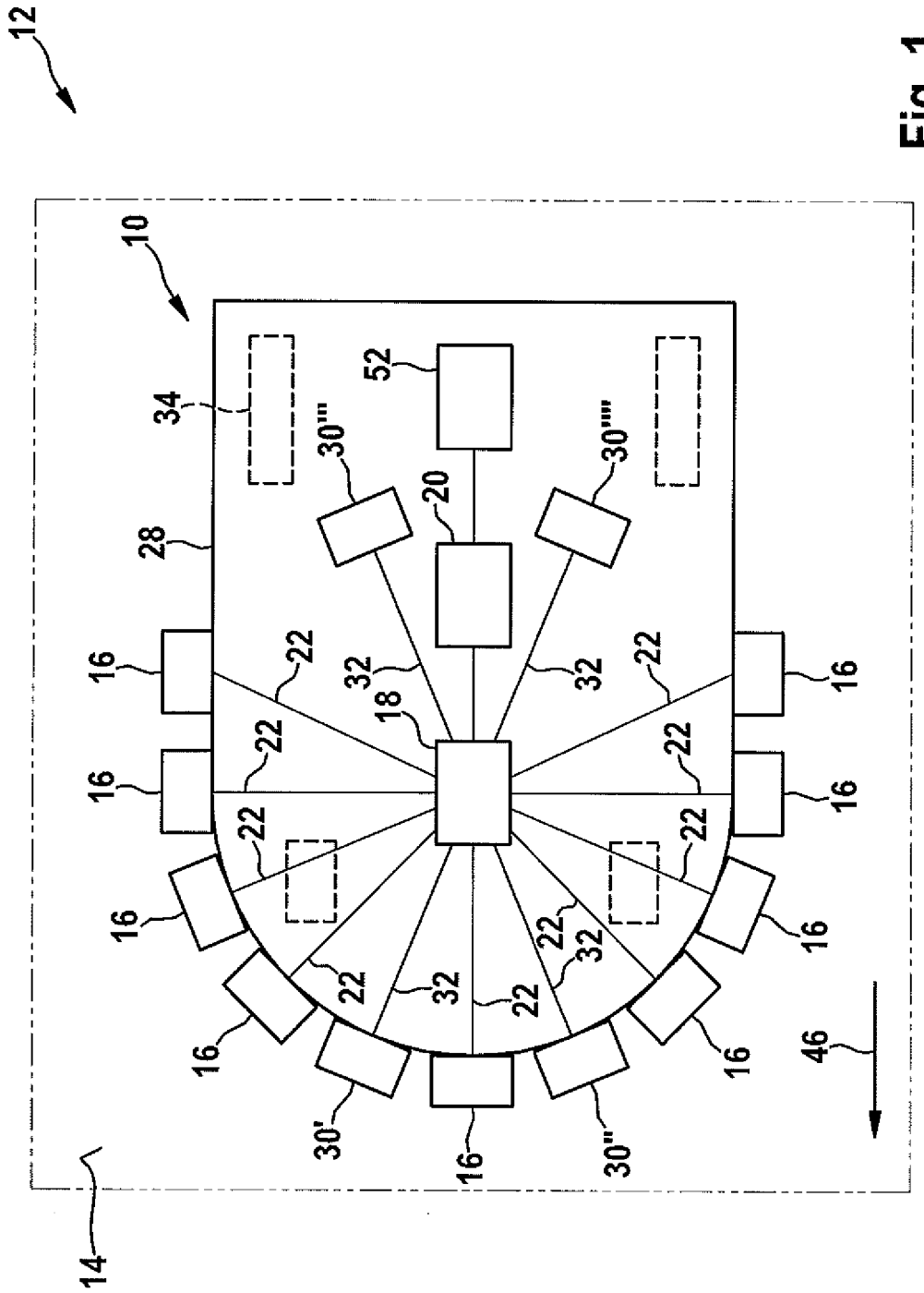

Fig. 1

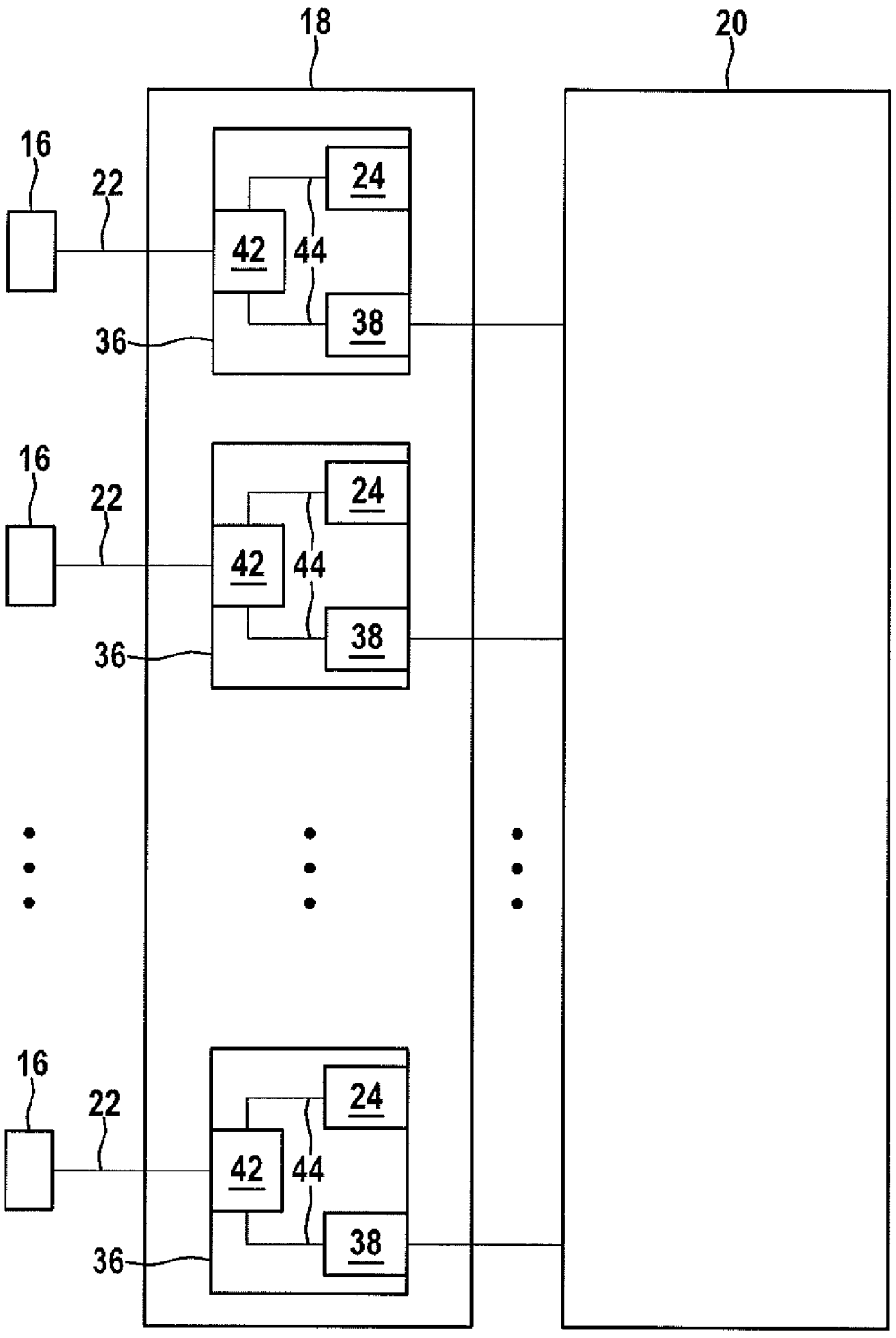

Fig. 2

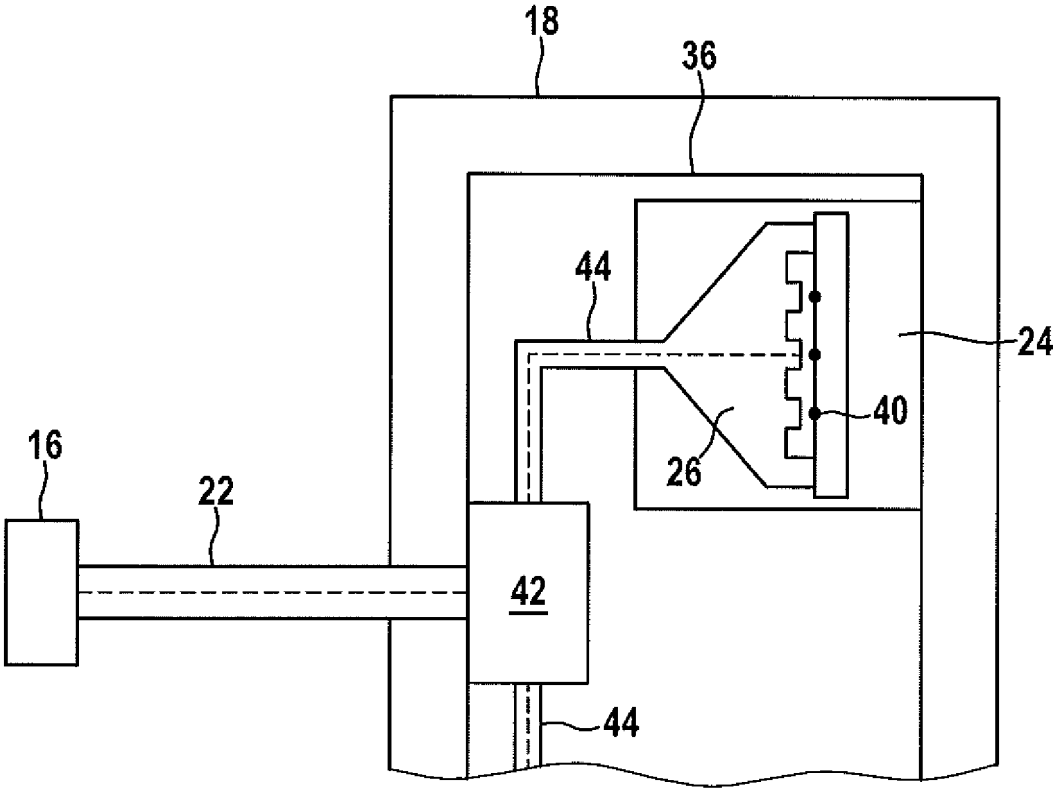

Fig. 3

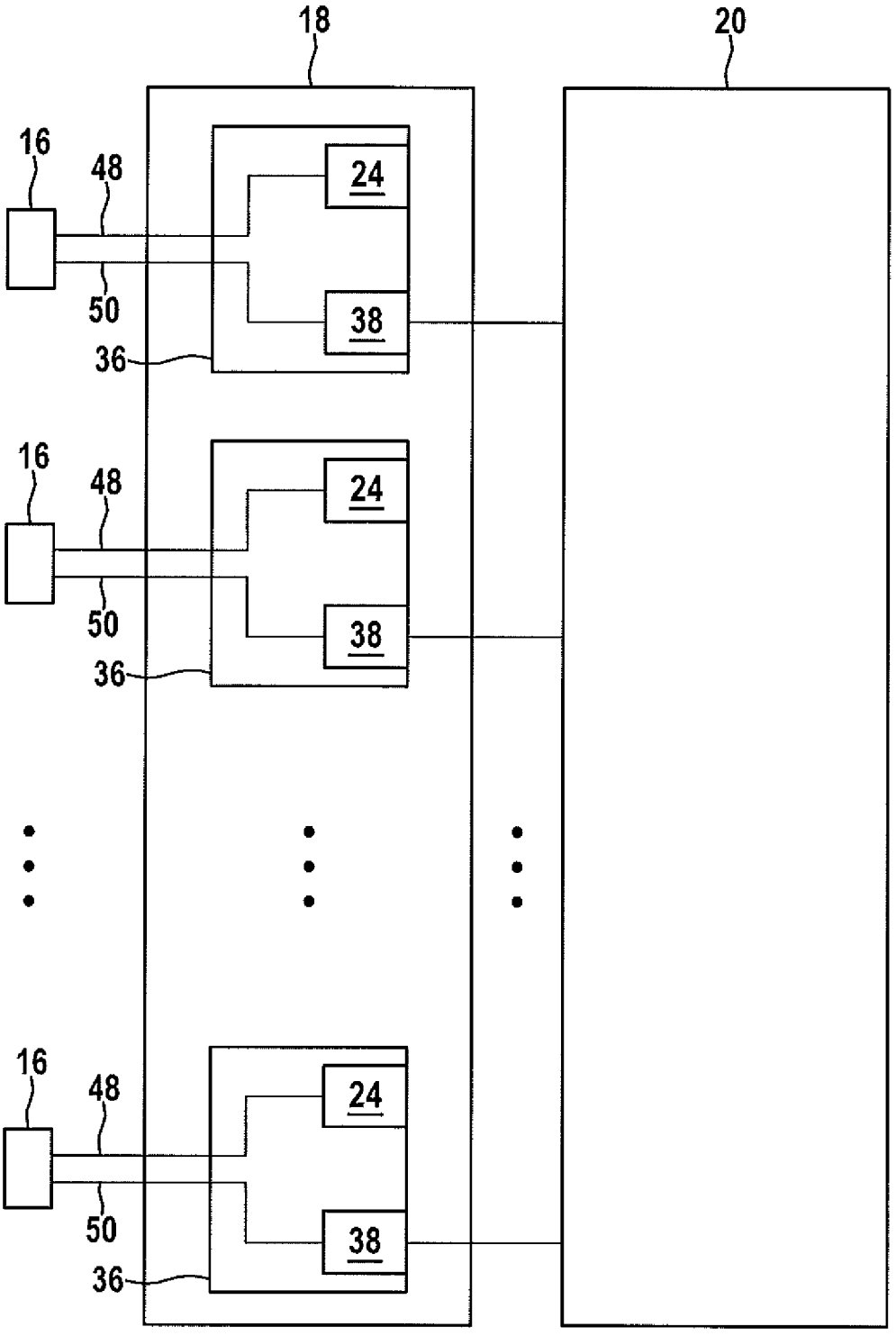

Fig. 4

Description

Vehicle apparatus

Background art

A vehicle apparatus of an autonomous operating device at least for machining a work surface, in particular for an autonomous lawn mower has already been proposed, having at least one light input element that is provided for receiving at least an electromagnetic radiation reflected by the work surface, having at least one sensor unit at least for detecting an electromagnetic radiation received by the light input element, and having at least one evaluation unit that is provided for evaluating at least an electromagnetic radiation reflected at the work surface and detected by the sensor unit.

Disclosure of the invention

The invention proceeds from a vehicle apparatus of an autonomous operating device at least for machining a work surface, in particular for an autonomous lawn mower, having at least one light input element that is provided for receiving at least an electromagnetic radiation reflected by the work surface, having at least one sensor unit at least for detecting an electromagnetic radiation received by the light input element, and having at least one

evaluation unit that is provided for evaluating at least an electromagnetic radiation reflected at the work surface and detected by the sensor unit.

It is proposed that the light input element and the sensor unit are arranged spaced at a distance of more than 5 cm, in particular of more than 7 cm and advantageously of more than 10 cm. In particular the vehicle apparatus has at least two, in particular at least four and advantageously at least eight light input elements. In particular the light input elements, in a projection onto at least one plane that is aligned at least substantially parallel to the work surface, are arranged distributed, in particular uniformly distributed, over an angular range of more than 90°, in particular of more than 120°, advantageously of more than 180° and preferentially of more than 210° in relation to the sensor unit. In particular the sensor unit is provided for detecting by means of the distributed arrangement of light input elements an electromagnetic radiation reflected by the work surface over an angular range of more than 90°, in particular of more than 120°, advantageously of more than 180° and preferentially of more than 210° with reference to the sensor unit. By an "autonomous operating device" is meant in particular a device that is provided for carrying out at least one task at least partially automatically. In particular the autonomous operating device is provided for automatically starting the task, automatically ending the task and/or automatically selecting at least one parameter. In particular the parameter takes the form of a distance parameter and/or a reversal point. In particular the autonomous operating device is provided for travelling over

a work surface and in particular machining the work surface. For example the autonomous operating device might be provided for sweeping, vacuuming and/or cleaning the work surface. In particular the autonomous operating device is provided for mowing a lawn situated on the work surface and/or a meadow situated on the work surface. In this case various autonomous operating devices that are deemed meaningful by the person skilled in the art are conceivable, such as for example an autonomous sweeping machine, an autonomous vacuum cleaner or an autonomous swimming-pool cleaning machine. Further autonomous operating tools deemed meaningful by the person skilled in the art are alternatively conceivable. In particular the autonomous operating tool is formed by an autonomous lawn mower. By a "work surface" is meant in particular a surface that defines an operating range. By a "light input element" is meant in particular an element that is provided for at least receiving an electromagnetic radiation that is reflected by the work surface and an electromagnetic radiation that is emitted from the work surface. In particular the light input element is at least partially, in particular for the most part, of a transparent design. In particular the light input element is provided for directing electromagnetic radiation at least onto the work surface. In particular the light input element takes the form of a light entry region of at least one at least substantially transparent component. For example the light input element is configured as an optical lens, made for example of glass and/or plastics material. Further developments of the light input element that are deemed meaningful by the person skilled in the art are alternatively conceivable. By a "sensor unit" is meant in

particular a unit having at least one receiver module at least for detecting the electromagnetic radiation received by the light input element and reflected by at the work surface. In particular the receiver module is provided for detecting an electromagnetic radiation reflected by the work surface and an electromagnetic radiation emitted from the work surface. In particular the sensor unit is provided for transmitting in dependence upon the electromagnetic radiation received by the receiver module at least one characteristic quantity to the evaluation unit. In particular the characteristic quantity is at least dependent upon an intensity and/or wavelength of the electromagnetic radiation received by the receiver module. By an "evaluation unit" is meant in particular a unit comprising at least one electronic evaluator. In particular the evaluation unit is provided for evaluating the electromagnetic radiation received by the receiver module. By an "electronic evaluator" is meant in particular a unit comprising a processor unit and comprising a memory unit as well as comprising an operating program stored in the memory unit. By the phrase, that the evaluation unit is provided for "evaluating" at least an electromagnetic radiation reflected at the work surface and detected by the sensor unit, is meant in particular that the evaluation unit is provided for determining at least one performance characteristic and/or making at least one comparison in dependence upon the electromagnetic radiation absorbed by the sensor unit. In particular the evaluation unit is provided for executing at least one arithmetic operation in order to determine the performance characteristic. In particular the performance characteristic takes the form of a reflection behaviour of

the work surface. Further performance characteristics deemed meaningful by a person skilled in the art are alternatively conceivable. By the phrase, that the light input element and the sensor unit are arranged, in particular positioned, "spaced" by a distance of more than 5 cm, is meant in particular that a path which electromagnetic radiation, in particular visible light, travels between the light input element and the sensor unit is more than 5 cm. In particular the light input element and the sensor unit are arranged spaced by a distance of less than 200 cm, in particular of less than 100 cm, advantageously of less than 50 cm and preferentially of less than 30 cm. By a "connecting direction" is meant in particular a direction that is aligned at least substantially parallel to a shortest straight line connecting the light input element and the sensor unit. By the phrase, that a straight line and/or plane is aligned "at least substantially parallel" to a further straight line and/or plane formed separately from the one straight line and/or plane, is meant in particular that the straight line and/or plane with the further straight line and/or plane forms an angle that differs preferably by less than 15°, advantageously by less than 10° and in particular by less than 5° from an angle of 0°.

By virtue of the development according to the invention of the vehicle apparatus a high degree of flexibility may advantageously be achieved. In particular the sensor unit may be arranged spaced relative to the light input element at a secure, central location, with the result that a serviceable and durable vehicle apparatus may be achieved. Furthermore, an electromagnetic radiation reflected at the

work surface and detected by the sensor unit may be evaluated economically by means of the evaluation unit. By virtue of a central sensor unit it is advantageously possible to dispense with a plurality of sensor units and hence achieve a low outlay for cabling, a low number of components, low EMC protection and/or low ingress protection, and moreover electromagnetic radiation reflected by the work surface may advantageously be received from at least two different directions, with the result that a high degree of flexibility may be achieved.

It is further proposed that the vehicle apparatus comprises at least one optical waveguide for transmitting electromagnetic radiation between the light input element and the sensor unit. In particular the vehicle apparatus comprises at least two, in particular at least four and advantageously at least eight optical waveguides. For example it is conceivable for the light input element to be configured as a light entry region of at least one optical waveguide, wherein the light input element forms a region of the optical waveguide remote from the sensor unit. By an "optical waveguide" is meant in particular an at least substantially transparent unit for transmitting electromagnetic radiation, in particular of visible light. In particular the optical waveguide is provided for transmitting the electromagnetic radiation by means of a reflection at at least one in particular lateral boundary surface of the optical waveguide. In particular the optical waveguide has a diameter of more than 1 µm, in particular of more than 10 µm and advantageously of more than 50 µm. In particular the optical waveguide has a diameter of less than 50 mm, in particular of less than 30

mm and advantageously of less than 10 mm. For example the optical waveguide is configured as a bar, a tube and/or advantageously as a fibre, in particular as a glass fibre. For example the optical guide element is formed from silica glass and/or plastics material. By an "at least substantially transparent" element is meant in particular an element that is provided for transmitting a component of more than 60%, in particular of more than 70% and advantageously of more than 90% of an electromagnetic radiation, in particular of at least visible light, occurring at a first side of the element to at least a second side of the element that is disposed in particular opposite the first side, in particular with at least substantially uniform transparency over a specific spectral range. Thus, the electromagnetic radiation received by the optical guide may advantageously be transmitted in a purposeful and reliable manner to the sensor unit. What is more, electromagnetic radiation may be transmitted advantageously with low loss between the light input element and the sensor unit.

It is moreover proposed that the sensor unit comprises at least one emitter module for generating and/or emitting electromagnetic radiation. As a result, a sensor unit that is independent of ambient lighting may advantageously be achieved.

It is further proposed that the optical waveguide is provided for transmitting the electromagnetic radiation generated by the emitter module to the light input element. In particular the sensor unit comprises at least one beam splitter, which is provided for diverting electromagnetic

radiation generated by the emitter module into the optical waveguide. In particular the beam splitter is provided for diverting an electromagnetic radiation reflected at the work surface to the receiver module. As a result, a low number of optical waveguides may advantageously be achieved. Furthermore, the sensor unit may advantageously both receive and emit electromagnetic radiation, with the result that a high degree of flexibility may be achieved. It is moreover advantageously possible to achieve a low susceptibility to faults and/or easy fault recognition.

It is further proposed that the sensor unit comprises at least one light-bundling element, which is provided for bundling electromagnetic radiation generated by at least one emitter module for transmission by means of the optical waveguide. By a "light-bundling element" is meant in particular an element that is provided for combining electromagnetic radiation generated by at least one emitter module into a light bundle. Consequently, the electromagnetic radiation bundled by the light-bundling element may be transmitted advantageously in a reliable and purposeful manner by means of the optical waveguide.

It is further proposed that the light input element is provided for being mounted at least in an operating state on at least one surface of a chassis. In particular the vehicle apparatus comprises the chassis. By a "chassis" is meant in particular running gear and/or a body in particular of the autonomous operating device. In particular the chassis comprises at least bearing parts of the autonomous operating device. In particular the chassis establishes a connection between functional components, for

example a machining unit such as a cutter and/or sickle, and drive element, for example wheels. Thus, in an advantageous manner electromagnetic radiation may be received from the work surface through the light input element and/or electromagnetic radiation may be directed by the light input element onto the work surface.

It is further proposed that the vehicle apparatus comprises at least one further light input element and at least one further optical waveguide for transmitting electromagnetic radiation between the sensor unit and the further light input element. In particular the vehicle apparatus comprises at least two, in particular at least three and advantageously at least four further optical waveguides. In particular the vehicle apparatus comprises at least two, in particular at least three and advantageously at least four further light input elements. In this way a high degree of flexibility may advantageously be achieved. Furthermore the work surface may advantageously be precisely examined.

It is further proposed that the evaluation unit is provided for a function independent of work surface determination. By the phrase, that the evaluation unit is provided for a "function independent of work surface determination", is meant in particular that the evaluation unit is provided for evaluating at least one light signal, wherein an evaluation of the light signal differs from an examination of the work surface, in particular from a determination of a reflection behaviour of the work surface and/or from a determination of a work surface boundary of the work surface. In particular the evaluation unit is provided for

issuing at least one instruction to at least one control unit in dependence upon the evaluation of the light signal. In particular the light signal takes the form of an electromagnetic radiation transmitted by the further optical waveguide between the further light input element and the sensor unit. In particular the evaluation unit is provided for determining at least one precipitation parameter, for example a volume of precipitation per unit area, in dependence upon an electromagnetic radiation transmitted by the further optical waveguide between the further light input element and the sensor unit. In particular the evaluation unit is provided for determining in dependence upon an electromagnetic radiation transmitted by the further optical waveguide between the further light input element and the sensor unit at least a clearance of the chassis from the work surface that is aligned at least substantially at right angles to the work surface. In particular the evaluation unit is provided for receiving in dependence upon an electromagnetic radiation transmitted by the further optical wave guide between the further light input element and the sensor unit at least one signal, in particular of a remote control, and for executing in dependence upon the received signal at least one action, for example a change of direction and/or a change of speed and/or a deactivating of a functional component. In particular the evaluation unit is provided for providing in dependence upon an electromagnetic radiation transmitted by the further optical wave guide between the further light input element and the sensor unit at least one form of lighting, in particular of the chassis and/or of the work surface. For example the lighting is configured as undercarriage lighting and/or as a headlamp. Further

actions deemed meaningful by a person skilled in the art are alternatively conceivable. By the phrase, that a straight line and/or plane is aligned "at least substantially at right angles" to a further straight line and/or plane formed separately from the one straight line and/or plane, is meant in particular that the straight line and/or plane with the further straight line and/or plane in a projection onto at least one projection plane, in which at least the straight line and/or the plane is disposed, forms an angle that preferably differs by less than 15°, advantageously by less than 10° and in particular by less than 5° from an angle of 90°. By a "control unit" is meant in particular a unit comprising at least one electronic control device. By an "electronic control device" is meant in particular a unit comprising a processor unit and comprising a memory unit as well as comprising an operating program stored in the memory unit.
In this way it is advantageously possible to achieve a high degree of flexibility and a comfortable, versatile vehicle apparatus.

The vehicle apparatus according to the invention is not to be limited hereby to the application and embodiment described above. In particular the vehicle apparatus according to the invention in order to fulfil a mode of operation described herein may comprise a number of individual elements, components and units that differs from the number specified herein.

Drawings

Further advantages arise from the following description of drawings. An embodiment of the invention is represented in the drawings. The drawings, the description and the claims contain numerous features in combination. The person skilled in the art will expediently also consider the features individually and combine them into meaningful further combinations.

The drawings show in:

Fig. 1 an autonomous operating unit according to the invention with a vehicle apparatus according to the invention in a diagrammatic plan view,

Fig. 2 a detail of a schematic structure of the vehicle apparatus according to the invention,

Fig. 3 a detail of the schematic structure of the vehicle apparatus according to the invention of Fig. 2 and

Fig. 4 a detail of a schematic structure of an alternative embodiment of a vehicle apparatus according to the invention.

Description of the embodiments

Fig. 1 shows an autonomous operating device 12 according to the invention, which takes the form of an autonomous lawn mower, with a vehicle apparatus 10 according to the invention of the autonomous operating device 12. The autonomous operating device 12 is provided for machining a

work surface 14 in the form of an area of lawn. The autonomous operating device 12 is provided for automatically detecting and machining the work surface 14 by means of the vehicle apparatus 10. The vehicle apparatus 10 of the autonomous operating device 12 comprises a chassis 28 as well as four wheels 34 that are disposed on the chassis 28. Of the four wheels 34 only one is provided with a reference character. The vehicle apparatus 10 comprises a sensor unit 18 and an evaluation unit 20, which are connected to one another. The sensor unit 18 and the evaluation unit 20 are disposed in each case centrally in the chassis 28.

The vehicle apparatus 10 comprises nine light input elements 16, which are provided for receiving an electromagnetic radiation reflected by the work surface 14. Further numbers of light input element 16 that are deemed meaningful by a person skilled in the art are alternatively conceivable. The light input elements 16 are mounted on a surface of the chassis 28. In the present case the light input elements 16 are arranged distributed over the surface of the chassis 28. In relation to the sensor unit 18 the light input elements 16 are arranged in a plane, which is aligned substantially parallel to the work surface 14, over an angular range of substantially 250° on the surface of the chassis 28. Each of the light input elements 16 and the sensor unit 18 are arranged spaced by a distance in a range of between 10 cm and 20 cm. In this case, a precise length of the distance is defined by an arrangement of the respective light input element 16 on the surface of the chassis 28. Each of the distances is configured as a shortest connection along a surface of the chassis 28

between the respective light input element 16 and the sensor unit 18.

The sensor unit 18 is provided for detecting an electromagnetic radiation received by the light input elements 16. A respective viewing direction of the sensor unit 18 is defined by a position of the light input elements 16 on the surface of the chassis 28. In this case the viewing direction corresponds substantially to a direction of an electromagnetic radiation received by the light input elements 16. The viewing direction with a region of the work surface 14 covered by the chassis 28 forms an angle in a region of substantially 50° +/- 20°. Alternatively it is conceivable that the viewing direction is aligned substantially at right angles to the region of the work surface 14 that is covered by the chassis 28. It is further conceivable that the viewing direction is aligned substantially parallel to the region of the work surface 14 that is covered by the chassis 28, for example in order to detect obstacles situated in an area surrounding the chassis 28. In order to bridge the distance, by which a respective light input element 16 and the sensor unit 18 are spaced, the vehicle apparatus 10 comprises nine optical waveguides 22. Each of the optical waveguides 22 is provided for transmitting electromagnetic radiation between a respective one of the light input elements 16 and the sensor unit 18. In this case, a number of optical waveguides 22 corresponds to a number of light input elements 16. Alternatively it is conceivable that a number of optical waveguides 22 is greater than a number of light input elements 16.

The sensor unit 18 comprises nine sensor modules 36 (cf. Fig. 2). Each of the sensor modules 36 is associated with a respective one of the light input elements 16 and is provided for detecting electromagnetic radiation that is received by the respective light input element 16. Each of the sensor modules 36 comprises a receiver module 38 for detecting the electromagnetic radiation received by the respective light input element 16 and reflected by the work surface 14. Each of the sensor modules 36 of the sensor unit 18 moreover comprises an emitter module 24 for generating electromagnetic radiation. Each of the emitter modules 24 comprises a plurality of individual light sources 40 for generating electromagnetic radiation, wherein in Fig 3 for the sake of clarity only three of the light sources 40 are represented. The light sources 40 are configured in each case as an LED. Alternatively a number of light sources 40 that is deemed meaningful by a person skilled in the art is conceivable. In particular it is conceivable that each of the emitter modules 24 has precisely one light source 40. Each of the sensor modules 36 of the sensor unit 18 comprises a light-bundling element 26, which is provided for bundling electromagnetic radiation generated by the emitter module 24 for transmission by means of the optical waveguide 22 associated with the sensor module 36, in which the emitter module 24 is disposed. In this case the light-bundling element 26 is provided for bundling the electromagnetic radiation generated by the individual light sources 40 for transmission by means of the optical waveguide 22. It is alternatively conceivable that one light-bundling element is provided for bundling electromagnetic radiation

generated by a plurality of emitter modules for transmission by means of a common optical waveguide.

The sensor unit 18 is provided for emitting electromagnetic radiation generated by the emitter modules 24 onto the work surface 14. In this case the sensor unit 18 is provided for emitting electromagnetic radiation generated by the emitter modules 24 to the light input elements 16 by means of the optical waveguides 22. The light input elements 16 are formed integrally with light output elements and are provided for directing electromagnetic radiation onto the work surface 14. The optical waveguides 22 are provided for transmitting the electromagnetic radiation generated by the emitter modules 24 to the light input elements 16. The optical waveguides 22 are provided for substantially simultaneously transmitting electromagnetic radiation generated by the emitter modules 24 to the light input elements 16 and transmitting electromagnetic radiation reflected by the work surface 14 to the receiver modules 38. The sensor unit 18 is provided for detecting by means of the receiver modules 38 the electromagnetic radiation generated by the emitter modules 24 and reflected by the work surface 14.

Each of the sensor modules 36 of the sensor unit 18 comprises a beam splitter 42, which is provided for diverting the electromagnetic radiation reflected at the work surface 14 to the receiver module 38. The beam splitter 42 is moreover provided for diverting electromagnetic radiation generated by the respective emitter module 24 into the optical waveguide 22. Each of the sensor modules 36 comprises two internal optical

waveguides 44. A first of the internal optical waveguides 44 is provided for transmitting electromagnetic radiation from the emitter module 24 to the beam splitter 42. A second of the internal optical waveguides 44 is provided for transmitting electromagnetic radiation from the beam splitter 42 to the receiver module 38.

A development avoiding a beam splitter is alternatively conceivable (cf. Fig. 4). In this case the vehicle apparatus 10 comprises for each of the sensor modules 36 two optical waveguides 48, 50 for transmitting electromagnetic radiation between one of the light input elements 16 and one of the sensor modules 36. A first optical waveguide 48 is provided for transmitting an electromagnetic radiation generated by one of the emitter modules 24 to the light input element 16. A second optical waveguide 50 is provided for transmitting an electromagnetic radiation received by the light input element 16 for detection purposes to one of the receiver modules 38. For example it is conceivable that the second optical waveguides 50 are combined for transmitting an electromagnetic radiation received by the light input element 16 for detection purposes to a single common receiver module.

The receiver modules 38 are connected in each case to the evaluation unit 20. The evaluation unit 20 is provided for evaluating an electromagnetic radiation reflected at the work surface 14 and detected by the sensor unit 18. The evaluation unit 20 is moreover provided for determining a reflection behaviour of the work surface 14 in dependence upon an electromagnetic radiation detected by the sensor

unit 18. For this purpose the evaluation unit 20 evaluates an electromagnetic radiation detected by the sensor unit 18. The evaluation unit 20 is moreover provided for determining a work surface boundary of the work surface 14 in dependence upon an electromagnetic radiation detected by the sensor unit 18. The evaluation unit 20 calculates for a given pixel x, which symbolizes a given point of the work surface 14, for a respective wavelength μ a reflectance $p_{x(\mu)}$. For example the evaluation unit 20 by means of a reflectance $p_{x(red)}$ of a wavelength μ_{red} of red light and a reflectance $p_{x(NIR)}$ of a wavelength μ_{NIR} of a near-infrared radiation calculates a Normalized Difference Vegetation Index, NDVI. The NDVI of a respective pixel x arises according to the formula $NDVI_x = (p_{x(NIR)} - p_{x(red)}/(p_{x(NIR)} + p_{x(red)})$. Further evaluation options deemed meaningful by a person skilled in the art are alternatively conceivable.

The vehicle apparatus 10 comprises a control unit 52. The control unit 52 is provided for steering the chassis 28 in a direction of motion 46 in dependence upon an instruction received by the evaluation unit 20. The evaluation unit 20 is provided for communicating the direction of motion 46 to the control unit 52 in dependence upon the determined work surface boundary of the work surface 14.

The vehicle apparatus 10 comprises four further light input elements 30 and four further optical waveguides 32 for transmitting electromagnetic radiation between the sensor unit 18 and the further light input elements 30 (cf. Fig. 1). Two of the further light input elements 30', 30" are disposed in relation to the direction of motion 46 in a front region of the surface of the chassis 28. One of the

further light input elements 30‴ is disposed on an underside of the chassis 28 facing the work surface 14. One of the further light input elements 30⁗ is disposed on an upper side of the chassis 28 remote from the work surface 14. The evaluation unit 20 is provided for a function independent of work surface determination. In this case the evaluation unit 20 uses an electromagnetic radiation that is transmitted by means of the further optical waveguide 32 between a respective one of the further light input elements 30 and the sensor unit 18.

The evaluation unit 20 is provided for receiving signals of a remote control in dependence upon an electromagnetic radiation transmitted by the further optical waveguide 32′ between the further light input element 30′ and the sensor unit 18. The evaluation unit 20 is moreover provided for executing an instruction to the control unit 52 in dependence upon the received signals. For example, this makes it possible to realize a steering of the chassis 28 and/or a change of the direction of motion 46. A form of lighting might moreover be controllable by means of the signals. In this case the evaluation unit 20 controls one or more light sources of an emitter module, wherein the light source might emit a special wavelength of electromagnetic radiation, for example blue light. The electromagnetic radiation generated by the emitter module is transmitted by means of the further optical waveguide 32″ between the further light input element 30″ and the sensor unit 18 in order to illuminate the work surface 14.

The evaluation unit 20 is provided for calculating, in dependence upon an electromagnetic radiation transmitted by

the further optical waveguide 32‴ between the further light input element 30‴ and the sensor unit 18, a clearance of the chassis 28 from the work surface 14 that is aligned substantially at right angles to the work surface 14, for example for calculating a dip and/or a rise of the chassis 28 relative to the work surface 14. It is equally conceivable that the evaluation unit 20 is provided for issuing to the control unit 52, from a specific threshold value of the clearance on, an instruction to deactivate a functional component and/or an instruction to stop a movement of the chassis 28 in the direction of motion 46. The evaluation unit 20 is moreover provided for determining a precipitation parameter in dependence upon an electromagnetic radiation, which is transmitted by the further optical waveguide 32⁗ between the further light input element 30⁗ and the sensor unit 18 and the intensity of which varies as a function of a precipitation quantity. In this case the precipitation parameter takes the form of a volume of precipitation per unit area.

In a method of operating the vehicle apparatus 10 the sensor unit 18 emits electromagnetic radiation generated by the emitter modules 24 onto the work surface 14. This electromagnetic radiation generated by the emitter modules 24 is reflected by the work surface 14, received by the light input elements 16 and detected by the sensor unit 18 by means of the receiver modules 38. In dependence upon the electromagnetic radiation detected by the sensor unit 18 the evaluation unit 20 determines a work surface boundary of the work surface 14. The evaluation unit 20 moreover in dependence upon the determined work surface boundary of the work surface 14 issues instructions to the

control unit 52 in order to steer the chassis 28 within the work surface boundary of the work surface 14 in order to machine the work surface 14.

As an alternative to a development as described above, an electromagnetic radiation might be distributed to a plurality of optical waveguides in dependence upon a wavelength range, for example a wavelength μ_{red} of red light and a wavelength μ_{NIR} of a near-infrared radiation might be transmitted each in an independent optical waveguide. As a further possible application, an evaluation unit might be provided for identifying human skin in dependence upon an electromagnetic radiation detected by a sensor unit and, in the event of human skin being detected in a region of a functional component, for executing an emergency shutdown. Applications with regard to a two-hand solution are moreover conceivable, in which an evaluation unit determines whether an operator has positioned both hands correctly.

Claims

1. Vehicle apparatus of an autonomous operating device (12) at least for machining a work surface (14), in particular for an autonomous lawn mower, having at least one light input element (16) that is provided for receiving at least an electromagnetic radiation reflected by the work surface (14), having at least one sensor unit (18) at least for detecting an electromagnetic radiation received by the light input element (16), and having at least one evaluation unit (20) that is provided for evaluating at least an electromagnetic radiation reflected at the work surface (14) and detected by the sensor unit (18), **characterized in that** the light input element (16) and the sensor unit (18) are arranged spaced by a distance of more than 5 cm.

2. Vehicle apparatus according to claim 1, **characterized by** at least one optical waveguide (22) for transmitting electromagnetic radiation between the light input element (16) and the sensor unit (18).

3. Vehicle apparatus according to one of the preceding claims, **characterized in that** the sensor unit (18) comprises at least one emitter module (24) for generating electromagnetic radiation.

4. Vehicle apparatus according to claims 2 and 3, **characterized in that** the optical waveguide (22) is provided for transmitting the electromagnetic radiation

generated by the emitter module (24) to the light input element (16).

5. Vehicle apparatus at least according to claim 3, **characterized in that** the sensor unit (18) comprises at least one light-bundling element (26), which is provided for bundling electromagnetic radiation generated by at least one emitter module (24) for transmission by means of the optical waveguide (22).

6. Vehicle apparatus according to one of the preceding claims, **characterized in that** the light input element (16) is provided for being mounted at least in one operating state on at least one surface of a chassis (28).

7. Vehicle apparatus according to one of the preceding claims, **characterized by** at least one further light input element (30) and at least one further optical waveguide (32) for transmitting electromagnetic radiation between the sensor unit (18) and the further light input element (30).

8. Vehicle apparatus according to claim 7, **characterized in that** the evaluation unit (20) is provided for a function independent of work surface determination.

9. Autonomous operating device, in particular an autonomous lawn mower, with a vehicle apparatus (10) according to one of claims 1 to 8.

10. Method of operating at least one vehicle apparatus (10) according to one of claims 1 to 8.

11. Vehicle apparatus as hereinbefore described with reference to and as shown in the accompanying drawings.

12. Autonomous operating device as hereinbefore described with reference to and as shown in the accompanying drawings.

13. Method of operating at least one vehicle apparatus (10) according to one of claims 1 to 8, the method as hereinbefore described with reference to and as shown in the accompanying drawings.

Intellectual Property Office

Application No:	GB1403667.7	**Examiner:**	Mr David McWhirter
Claims searched:	1-13	**Date of search:**	3 September 2014

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-4 & 6-10	DE 102011053975 A1 (VORWERK CO INTERHOLDING) see English abstract and figures
X	1-4, 6 & 8-10	US 2003/070852 A1 (ANGOTT) see whole document, particularly figure 1, 4 & 5 and paragraphs 18-20 & 27
X	1-4, 6 & 8-10	US 5467273 A (FAIBISH ET AL.) see whole document, particularly figures 1 & 3 and column 3 lines 5-12 and column 4 lines 13-35
X	1-4, 6 & 8-10	EP 2236069 A2 (VORWERK CO INTERHOLDING) see English abstract and figures
A	None	WO 2009/077239 A1 (BOSCH)
A	None	US 2011/040409 A1 (BOSCH)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A01D; A47L; G05D

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI, TXTE, TXTG

Intellectual Property Office

International Classification:

Subclass	Subgroup	Valid From
A01D	0034/00	01/01/2006