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(54) **WARNING SYSTEM, METHOD OF CONTROLLING AND CONTROLLER**

(57) A warning system is provided, comprising: a warning signal source (12); a piezo-electric transducer (32) deformable by a user; a rechargeable battery (26), connected to receive an electric current generated due to deformation of the piezo-electric transducer (32) to charge the battery (26); and a controller (22) arranged to sense receipt of an electric current from the piezo-electric transducer (32), indicative of the presence of a user, and to trigger activation of the warning signal source (12).

In this way, the system is able to use the piezo-electric transducers (32) both as a source of electric current to charge the battery (26) and as a detector of the presence of a user for triggering activation of the warning signal source (12). A solar panel (30) may also be provided both to charge the battery (26) and to enable detection by the controller (22) of ambient light levels. Activation of the warning signal source (12) may be disabled by the controller (22) during higher ambient light levels.

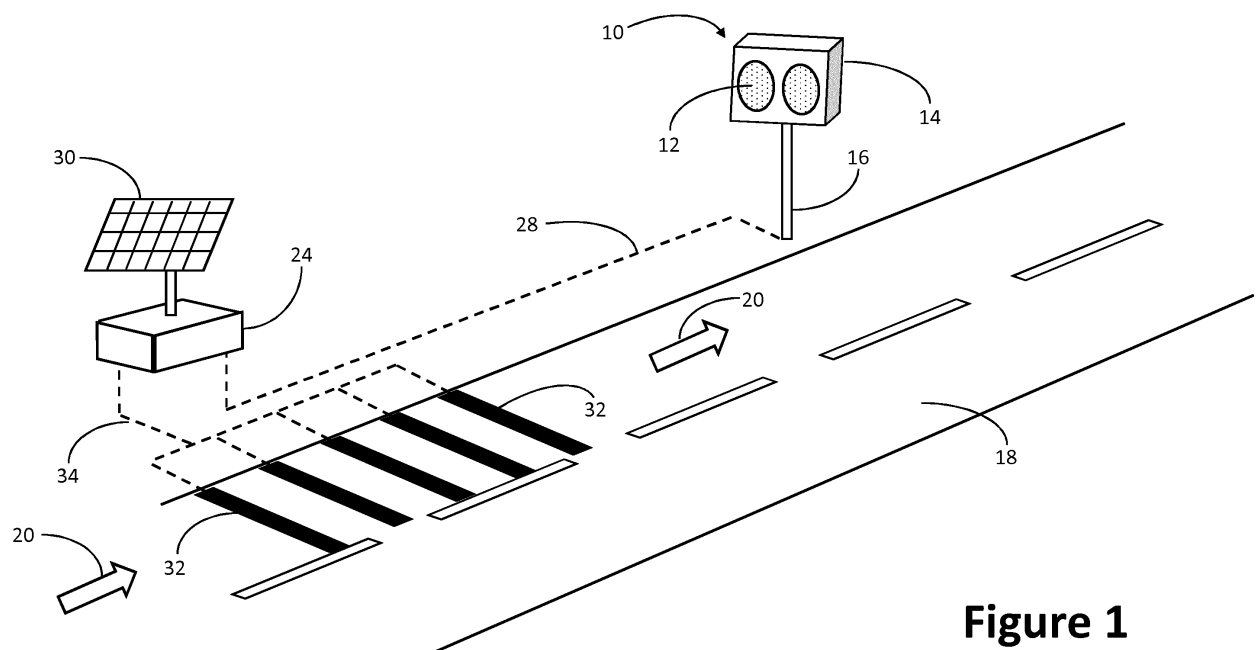


Figure 1

Description

Technical Field

[0001] The present disclosure relates to a warning system, a method of controlling a warning system and a controller for a warning system.

Background

[0002] It is known to provide warning lights for the benefit of road users approaching a potentially dangerous section of a road or other hazard. The lights may warn of danger to vehicle drivers or may warn drivers to be aware of other users of the road. For example, warning lights may be positioned ahead of a permanent or a temporary hazard such as a railway level-crossing, an entrance to a school, a sharp bend or sudden narrowing in the road or a damaged section of road awaiting repair or being repaired. Such warning lights may be connected to a permanent electricity supply or, in the absence of such a supply, to a solar panel and/or battery power supply.

[0003] Warning lights may be activated according to a timer, set to activate the warning lights during predetermined time periods such as the normally expected periods of entry or exit of pupils to or from a school, or they may operate all the time, for example at pedestrian road crossing points. Lights intended to operate only at night, for example general street lighting, may be activated in response to detection by an optical sensor of a reduced light level.

Summary

[0004] According to a first aspect disclosed herein, there is provided a warning system, comprising:

a warning signal source;
a piezo-electric transducer deformable by a user;
a rechargeable battery, connected to receive an electric current generated due to deformation of the piezo-electric transducer to charge the battery; and
a controller arranged to sense receipt of an electric current from the piezo-electric transducer, indicative of the presence of a user, and to trigger activation of the warning signal source.

[0005] A warning system according to this first aspect uses a piezo-electric transducer not only as a source of electric current for charging a battery intended to provide electrical power to operate the system, but also as a detector of the presence of a user intended to benefit from warning signals.

[0006] In an example, the piezo-electric transducer is embedded within a deformable material. For example the deformable material, in use, provides a raised surface profile as compared to a surrounding surface. This has

the benefit that the deformable material and the piezo-electric transducer embedded within may be exposed to a greater level of deformation by a passing user than if the profile of the material was not raised.

[0007] In an example, the warning system comprises a solar panel connected to supply an electric current to charge the battery, wherein the controller is arranged to measure an electric current received from the solar panel, indicative of an ambient light level, and to disable activation of the warning signal source if the measured electric current from the solar panel, and therefore the ambient light level, exceeds a predetermined threshold.

[0008] This option is particularly suited to use where a hazard is considered sufficiently visible during periods of higher ambient light level. During such periods, warning signals in addition to those warnings provided by any associated signs and the presence of the deformable material with embedded piezo-electric material, e.g. with a raised surface profile, may not be necessary. This provides an opportunity to save electrical energy and permit the battery to recharge more fully before the next period of reduced ambient light.

[0009] In an example, the controller is arranged to activate the warning signal source for a predetermined time period after sensing receipt of an electric current from the piezo-electric transducer. The time period may be set for example to be at least the expected time from first detection of the user to passing the hazard.

[0010] In an example, the deformable material and the piezo-electric transducer embedded therein are arranged to be deformable by wheels of a vehicle passing over the deformable material. For example, the deformable material comprises a "rumble-strip" attachable to or embeddable within the surface of a road.

[0011] In an example, the deformable material and the piezo-electric transducer embedded therein are arranged to be deformable by a person standing upon the deformable material.

[0012] In an example, the warning signal source comprises any selection of: one or more light sources; one or more sound sources; and one or more RF signal sources. Thus, the warning signals generated may be selected to be the signals most likely to be recognised by an approaching user. Signals visible directly to human uses include light signals and sound signals. However, in some applications, existing vehicle driver support and safety systems may be arranged to generate a local warning signal to the driver triggered by receipt of an RF warning signal by the system of the present invention. This may apply in particular to warning systems intended for application to railway applications providing warnings to train drivers.

[0013] In an example, the warning system is portable. For example, the different components of the system may be individually carried and placed in position. The different components may be interconnected using cables having connectors that may be removeably attached to corresponding sockets provided in the housings of the

individual components. This enables the components of the system to be transported and deployed for example from a van, for example, to warn of a temporary hazard and then, when no longer required, removed and re-used elsewhere.

[0014] According to a second aspect disclosed herein, there is provided a method for controlling a warning signal source using electrical energy supplied by a rechargeable battery, the battery being connected to receive an electric current, generated by a piezo-electric transducer when deformed by a user, for charging the battery, the method comprising activating the warning signal source upon sensing receipt of an electric current generated by the piezo-electric transducer, indicative of the presence of a user.

[0015] In an example of the method, the battery is connected to receive an electric current for charging the battery from a solar panel, the method comprising measuring an electric current received from the solar panel, indicative of an ambient light level, and disabling activation of the warning signal source if the measured electric current received from the solar panel, and therefore the ambient light level, exceeds a predetermined threshold.

[0016] In an example, the method comprises activating the warning signal source for a predetermined time period after sensing receipt of an electric current from the piezo-electric transducer.

[0017] According to a third aspect disclosed herein, there is provided a controller for a warning system, the warning system having a warning signal source controllable by the controller, the controller being arranged to receive electrical energy from a rechargeable battery connected to receive an electric current to charge the battery from a piezo-electric transducer deformable by a user, wherein the controller is arranged to sense an electric current received from the piezo-electric transducer indicative of the presence of a user and to activate the warning signal source.

[0018] In an example, the controller is arranged to measure an electric current received from a solar panel for charging the battery, the controller being arranged to disable activation of the warning signal source in the event that the measured electric current received from the solar panel, and hence a detected ambient light level, exceeds a predetermined threshold.

Brief Description of the Drawings

[0019] To assist understanding of the present disclosure and to show how embodiments may be put into effect, reference is made by way of example to the accompanying drawings in which:

Figure 1 shows schematically components of an example of a warning system deployed in a typical application according to the present disclosure;

Figure 2 shows schematically components of an ex-

ample of a warning system according to the present disclosure; and

Figure 3 shows a flow chart defining steps in an example process to be operated by a controller of the warning system of the present disclosure.

Detailed Description

[0020] A typical use of a warning system is, for example, to warn vehicle drivers that they are approaching a hazard on an unlit section of road, whether a permanent hazard or a temporary hazard. During daylight hours, the hazard may be clearly visible to vehicle drivers. However, it may be considered necessary to deploy a system of warning lights arranged to be illuminated at all times, during periods both of high and low ambient light levels, to ensure that the lights will always be visible, despite the varying hours of darkness or periods of low ambient light levels caused by poor weather conditions. The warning lights thereby consume electrical energy whether or not there are any vehicles approaching the hazard.

[0021] If the warning lights receive electrical energy from a battery, then regular replacement of the battery may be required. If a solar panel is provided to charge the battery, it may nevertheless fail to charge the battery during extended periods when ambient light levels are low. Such conditions are more likely to occur in remote mountain regions or other areas more likely to experience poor weather while being less likely to have access to a permanent electricity supply.

[0022] In an first embodiment, to be described below with reference to Figure 1 and to Figure 2, an example of a warning system based upon the use of warning lights is shown, being particularly suited to deployment in remote regions, or in any location without access to a permanent electricity supply.

[0023] Referring to Figure 1 and to Figure 2, the system of this example includes a warning light arrangement 10 comprising two light sources 12, each light source 12 comprising an array of light-emitting diodes (LEDs) or other low-power, long-life source of light tolerant of repeated on-off switching. The light sources 12 may emit yellow, red or other appropriate colour of light, either directly or via a colour filter. The light sources 12 are mounted within a weatherproof housing 14 supported by an upright pole 16. The warning light arrangement 10 may be deployed at an appropriate position beside (as in Figure 1) or above a road 18. In the example shown in Figure 1, vehicles are expected to drive on the left-hand side of the road 18 in the direction of travel shown by arrows 20. An equivalent arrangement may be provided where vehicles usually pass along the right-hand side of the road 18.

[0024] The system includes a controller 22, to be described further below, contained within a weatherproof controller housing 24 together with a rechargeable battery 26. The controller 22 is linked to the warning light

arrangement 10 by means of a cable 28 buried in the ground or otherwise laid beside the road 18. Alternatively, the controller may be linked to control the warning light arrangement 10 wirelessly or the controller may be installed within the same housing 14 as the light sources 12. The controller housing 24 has a solar panel 30 mounted upon it, in a fixed position, oriented to receive sunlight for the greatest possible average time per day. Electric current generated by the solar panel 30 is used to charge the battery 26.

[0025] The system also includes an arrangement of so-called "rumble-strips" 32 fixed upon or embedded within the road surface such that they present a raised profile to the wheels of vehicles passing over them in relation to the road surface. A driver of a vehicle, when passing over the rumble-strips 32, feels the effect of the wheels riding over the raised profile of each rumble-strip 32. The profile of each rumble-strip 32 may be designed such that vehicle drivers are deterred, by the severity of a "bump" experienced when passing over each rumble-strip 32, from passing over them at high speed or at more than a predetermined speed. A warning sign (not shown in Figure 1) may be provided beside or above the road 18 a predetermined distance in advance of the rumble-strips 32 to warn drivers that they are approaching the rumble-strips 32 and a reduced-speed hazardous area.

[0026] At least one and preferably each rumble-strip 32 may comprise a deformable section incorporating a piezo-electric element having electrodes attached or embedded within it. When the wheels of a vehicle pass over each of the rumble-strips 32, the piezo-electric element incorporated therein is deformed with the effect that a pulse of electric current is generated. The generated pulses of electric current are conducted through the respective electrodes and by means of connecting wires 34 to the controller 22 for the purpose of charging the battery 26. The piezo-electric elements supply electrical pulses to an optional Current Conditioning circuit 36 comprising electrical components, for example one or more capacitors or inductors to condition the received pulses of electric current, in particular to smooth the received pulses or to provide impedance matching with the battery 26 to enable a more efficient charging of the battery 26.

[0027] Besides receiving electric current from piezo-electric material incorporated within any of the rumble-strips 32 for the purpose of charging the battery 26, the controller 22 is arranged to sense a received pulse of electric current from a rumble-strip 32 to indicate that a vehicle is approaching. The controller is thereby arranged to respond to the detected presence of a vehicle by supplying an electric current to each of the light sources 12 in turn to cause them to flash alternately for a predetermined time period. The predetermined time period is set to a time period sufficiently long for the detected vehicle to pass the hazardous area of the road 18. On expiry of the time period from first detection of the vehicle, if another vehicle has not been detected in the meantime, the controller 22 is arranged to terminate the flashing of

the light sources 12, pending the detection of another vehicle, to avoid unnecessary consumption of electrical energy.

[0028] Besides receiving electric current from the solar panel 30 for charging the battery 26, the controller 22 is arranged to measure the level of electric current received from the solar panel 30 and to interpret the measured level as an indicator of the ambient light level. If the hazard being warned of is visible to approaching vehicle drivers during normal daylight, and if the presence of the rumble-strips 32 is a sufficient warning of the approaching hazard during daylight, the controller may be arranged to enable activation of the light sources 12 only in the event that the ambient light level is below a predetermined threshold. This provides a further opportunity to save electrical energy.

[0029] The controller 22 may implement a process, an example of which will now be described with reference to Figure 3, for the control of the warning light arrangement. The controller 22 may for example comprise a digital processor programmed to implement the process to be described or it may comprise a configurable logic device configured to implement the process to be described.

[0030] Referring to Figure 3, the process begins and at STEP 40 the controller 22 measures the electric current, if any, being received from the solar panel 30. If the measured electric current is below a predetermined threshold value, then the ambient light level is very low or it is night-time and the warning light is to be activated for any approaching vehicle. At STEP 42 the controller 22 determines whether an electric current has been received from one or more of the rumble-strips 32. If an electric current has been received from a rumble-strip 32, then a vehicle must have passed over the rumble-strip 32 and will be approaching the hazard. Therefore, at STEP 44, the controller 22 triggers a switch to energise the warning light sources 12 of the warning light arrangement 10 in a predetermined flashing sequence, to warn the approaching vehicle of the hazard. At the time of energising the light sources 12 the controller 22 begins a predetermined timeout process set to allow sufficient time for the vehicle to pass the warning light arrangement 10 and/or the hazard itself. If, at STEP 46 the timeout period expire, then at STEP 48 the controller 22 deactivates the warning light arrangement 10, terminating the supply of electric current to the light sources 12. Processing then returns to STEP 40.

[0031] If, at STEP 42, no electric current is received from a rumble-strip 32, then processing returns to STEP 40.

[0032] If, at STEP 40, the measured electric current received from the solar panel 30 exceeds the predetermined threshold, then there is sufficient electric current to charge the battery at STEP 50 and the ambient light level is determined as being sufficient not to require activation of the warning light arrangement 10.

[0033] If at STEP 42 an electric current is detected

coming from one of the rumble-strips 32, then besides triggering the activation of the warning light arrangement 10 at STEP 44, the received electric current is also supplied, after conditioning by the current conditioning circuit 36, to charge the battery at STEP 50.

[0034] Whereas this example implementation of the present invention has been described in the context of a road and road users driving vehicles, the method and equipment described above may be applied, with appropriate modification as would be apparent to a notional skilled person in this field, to other hazard situations. For example, the warning system may be deployed for use by pedestrians walking along a footpath and approaching a hazard, or to trains passing along a railway track wherein a section of the railway track is supported upon one or more piezo-electric transducers deformable by a train passing over that section of the track to generate an electric current.

[0035] In examples of the present invention described above, the different components have been shown as separately housed components. However, in alternative embodiments, the different components may be housed in other combinations to suit the intended application. For example, the controller 22, the battery 26 and the solar panel 30 may all be mounted within and on a single housing together with the warning light sources 12 so that only a single unit need to be deployed together with the piezo-electric transducers. Other combinations for housing and mounting the different components would be apparent to a person of ordinary skill in the relevant art, each falling within the intended scope of the present invention.

[0036] The warning system of the present invention may be arranged to be portable such that it may be deployed for use with temporary hazards, for example road works, road damage by other means, temporary obstacles in the road or slippery road conditions during cold weather. For example, the different components of the system may be individually carried and placed in position. The different components may be interconnected using cables having connectors that may be removeably attached to corresponding sockets provided in the housings of the individual components. This enables the components of the system to be transported and deployed for example from a van and then, when no longer required, removed and re-used elsewhere.

[0037] Warning signals may be generated by a warning signal source comprising any selection from: one or more light sources, one or more sound sources; one or more RF sources. Warning signals may be visible to an approaching user, audible to an approaching user or receivable by RF receiving equipment arranged to trigger a warning to a user on receipt of RF warning signals. The one or more RF signal sources may be arranged to transmit RF warning signals using signals in a frequency range having a short range of propagation in the atmosphere, for example in the frequency range of 30 to 300 GHz and, more particularly, in the 60 GHz band (57-71 GHz). The

frequency of warning signals is selected to ensure propagation over a distance sufficiently long to pass from an RF transmitter associated with the warning system to RF receiving equipment associated with an approaching user, but insufficiently long to be a source of interference to other RF systems.

[0038] It will be understood that the controller may be implemented using a processor or processing system or circuitry provided by a single chip or integrated circuit or plural chips or integrated circuits, optionally provided as a chipset, an application-specific integrated circuit (ASIC), field-programmable gate array (FPGA), digital signal processor (DSP), graphics processing units (GPUs), etc. The chip or chips may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry, which are configurable so as to operate in accordance with the exemplary embodiments. In this regard, the exemplary embodiments may be implemented at least in part by computer software stored in (non-transitory) memory and executable by the processor, or by hardware, or by a combination of tangibly stored software and hardware (and tangibly stored firmware).

[0039] Although at least some aspects of the embodiments described herein with reference to the drawings comprise computer processes performed in processing systems or processors, the invention also extends to computer programs, particularly computer programs on or in a carrier, adapted for putting the invention into practice. The program may be in the form of non-transitory source code, object code, a code intermediate source and object code such as in partially compiled form, or in any other non-transitory form suitable for use in the implementation of processes according to the invention. The carrier may be any entity or device capable of carrying the program. For example, the carrier may comprise a storage medium, such as a solid-state drive (SSD) or other semiconductor-based RAM; a ROM, for example a CD ROM or a semiconductor ROM; a magnetic recording medium, for example a floppy disk or hard disk; optical memory devices in general; etc.

[0040] The examples described herein are to be understood as illustrative examples of embodiments of the invention. Further embodiments and examples are envisaged. Any feature described in relation to any one example or embodiment may be used alone or in combination with other features. In addition, any feature described in relation to any one example or embodiment may also be used in combination with one or more features of any other of the examples or embodiments, or any combination of any other of the examples or embodiments. Furthermore, equivalents and modifications not described herein may also be employed within the scope of the invention, which is defined in the claims.

Claims**1.** A warning system, comprising:

a warning signal source (12);
 a piezo-electric transducer (32) deformable by a user;
 a rechargeable battery (26), connected to receive an electric current generated due to deformation of the piezo-electric transducer (32) to charge the battery (26); and
 a controller (22) arranged to sense receipt of an electric current from the piezo-electric transducer (32), indicative of the presence of a user, and to trigger activation of the warning signal source (12).

2. The warning system according to claim 1, wherein the piezo-electric transducer (32) is embedded within a deformable material (32).**3.** The warning system according to claim 2, wherein the deformable material (32), in use, provides a raised surface profile as compared to a surrounding surface.**4.** The warning system according to claim 2 or claim 3, wherein the deformable material (32) and the piezo-electric transducer (32) embedded therein are arranged to be deformable by wheels of a vehicle passing over the deformable material (32).**5.** The warning system according to claim 4, wherein the deformable material (32) comprises a "rumble-strip" attachable to or embeddable within the surface of a road (18).**6.** The warning system according to claim 2 or claim 3, wherein the deformable material (32) and the piezo-electric transducer (32) embedded therein are arranged to be deformable by a person standing upon the deformable material (32).**7.** The warning system according to any one of claims 1 to 6, comprising a solar panel (30) connected to supply an electric current to charge the battery (26), wherein the controller (22) is arranged to measure an electric current received from the solar panel (30), indicative of an ambient light level, and to disable activation of the warning signal source (12) if the measured electric current from the solar panel (30), and therefore the ambient light level, exceeds a predetermined threshold.**8.** The warning system according to any one of claims 1 to 7, wherein the controller (22) is arranged to activate the warning signal source (12) for a predetermined time period after sensing receipt of an electric

current from the piezo-electric transducer (32).

9. The warning system according to any one of claims 1 to 8, wherein the warning signal source (12) comprises any selection of: one or more light sources (12); one or more sound sources; and one or more RF signal sources.**10.** The warning system according to any one of claims 1 to 9, wherein the warning system is portable.**11.** A method for controlling a warning signal source (12) using electrical energy supplied by a rechargeable battery (26), the battery (26) being connected to receive an electric current, generated by a piezo-electric transducer (32) when deformed by a user, for charging the battery (26), the method comprising activating the warning signal source (12) upon sensing receipt of an electric current generated by the piezo-electric transducer (32), indicative of the presence of a user.**12.** The method according to claim 11, wherein the battery (26) is connected to receive an electric current for charging the battery (26) from a solar panel (30), the method comprising measuring an electric current received from the solar panel (30), indicative of an ambient light level, and disabling activation of the warning signal source (12) if the measured electric current received from the solar panel (30), and therefore the ambient light level, exceeds a predetermined threshold.**13.** The method according to claim 11 or claim 12, the method comprising activating the warning signal source (12) for a predetermined time period after sensing receipt of an electric current from the piezo-electric transducer (32).**14.** A controller (22) for a warning system, the warning system having a warning signal source (12) controllable by the controller (22), the controller (22) being arranged to receive electrical energy from a rechargeable battery (26) connected to receive an electric current to charge the battery (26) from a piezo-electric transducer (32) deformable by a user, wherein the controller (22) is arranged to sense an electric current received from the piezo-electric transducer (32) indicative of the presence of a user and to activate the warning signal source (12).**15.** The controller (22) according to claim 14, arranged to measure an electric current received from a solar panel (30) for charging the battery (26), the controller (22) being arranged to disable activation of the warning signal source (12) in the event that the measured electric current received from the solar panel (30), and hence a detected ambient light level, exceeds

a predetermined threshold.

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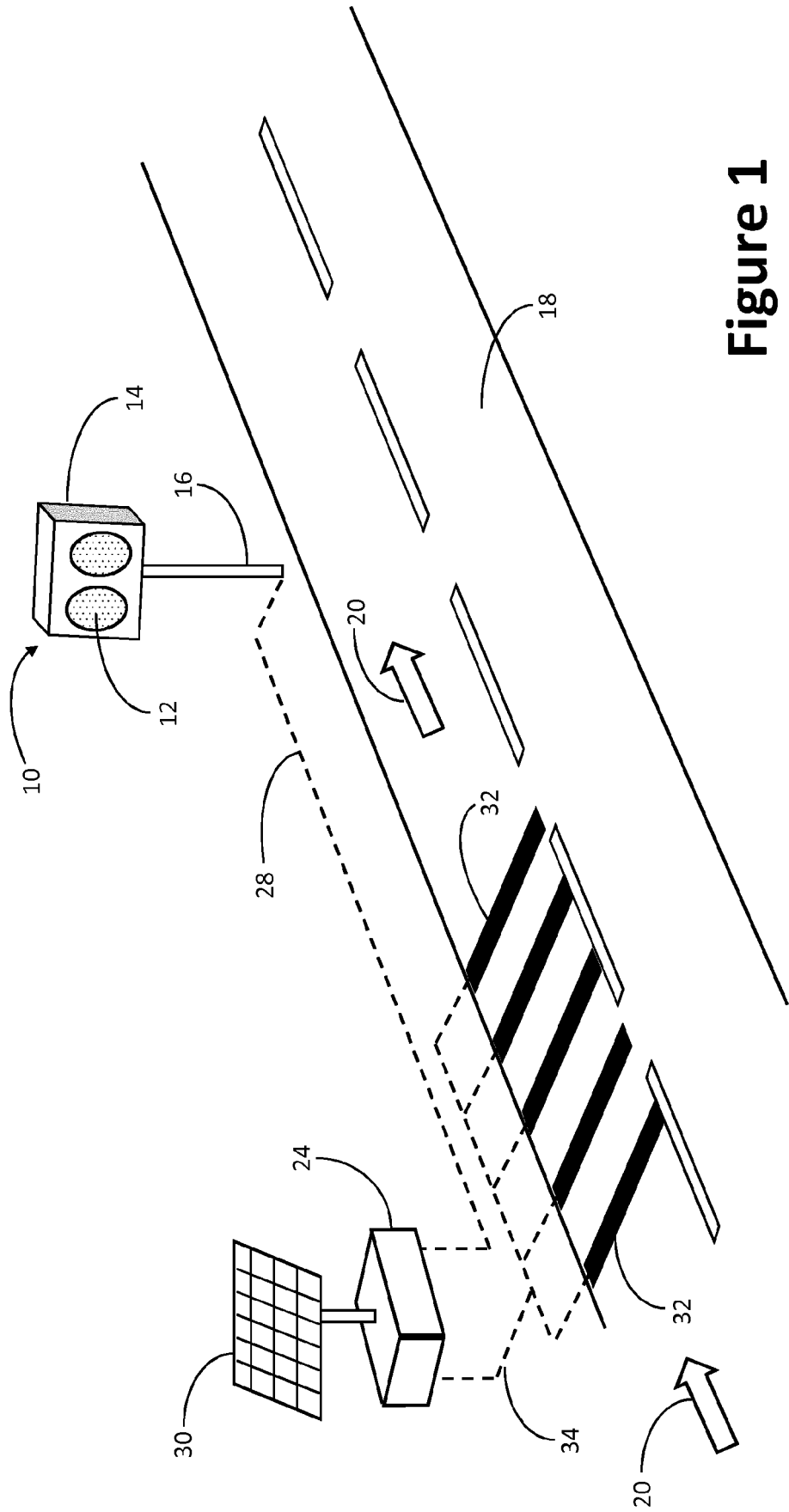


Figure 1

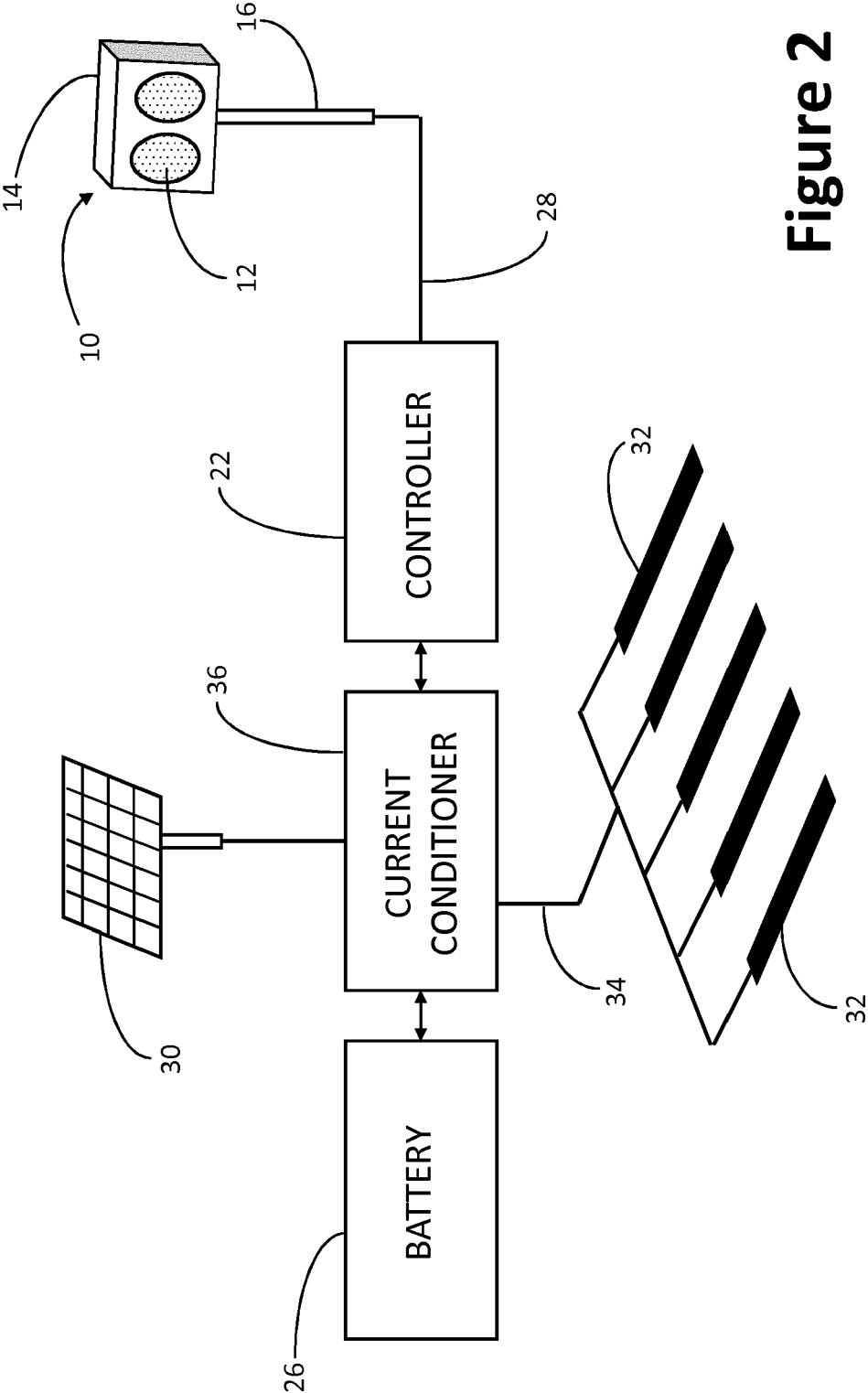
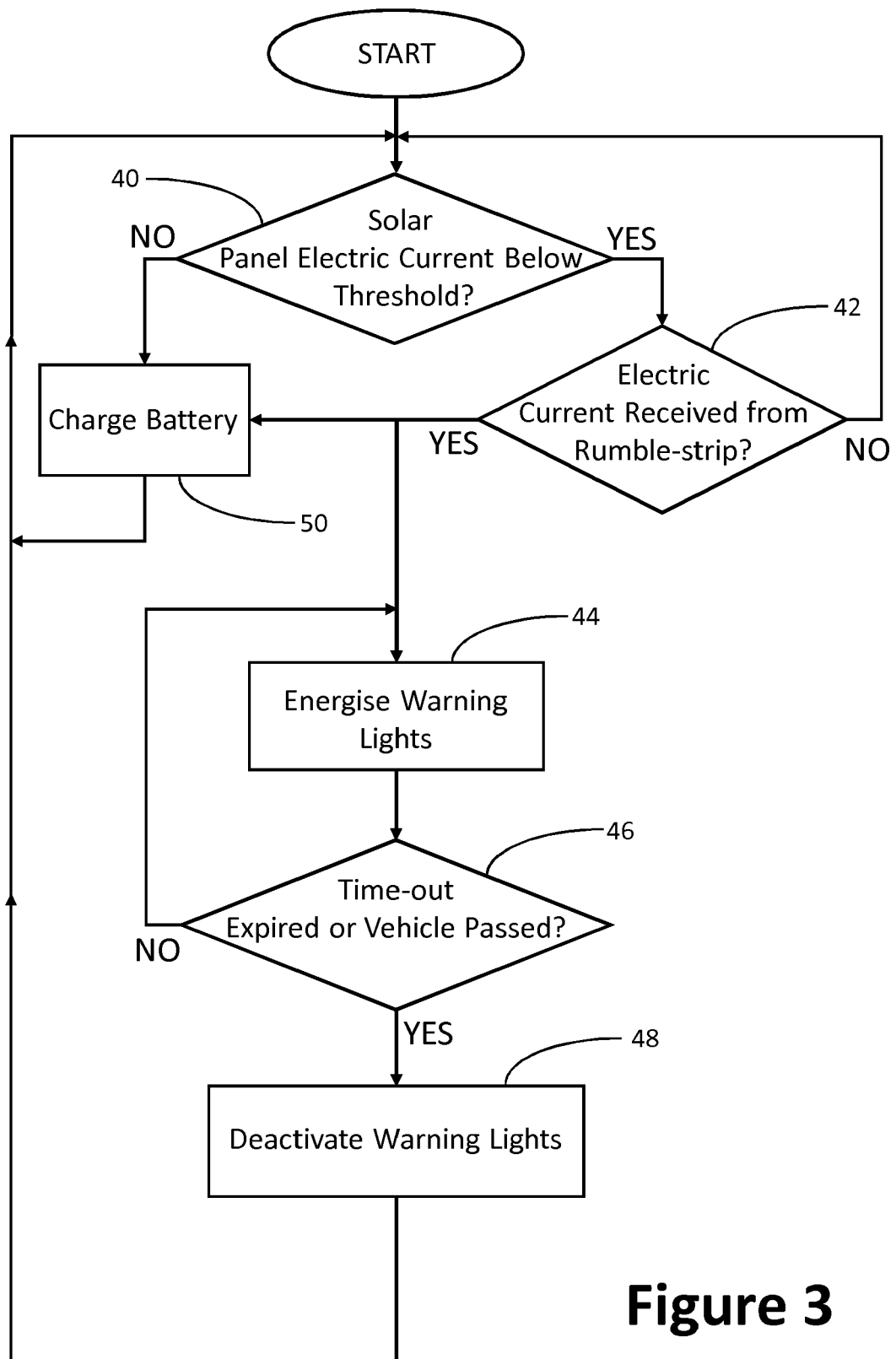


Figure 2

**Figure 3**



EUROPEAN SEARCH REPORT

 Application Number
 EP 17 19 2197

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 22 March 2018	Examiner Malagoli, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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