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(72) Inventor(s):
Gary Andrew Walker
Ian Reddall
Peter Thomas Gray
Matthew Lees

(73) Proprietor(s):
Hastec Rail Limited
Unit 57 Station Lane Industrial Estate,
Old Whittington, Chesterfield, Derbyshire, S41 9QX,
United Kingdom

(74) Agent and/or Address for Service:
Mewburn Ellis LLP
Aurora Building, Counterslip, Bristol, BS1 6BX,
United Kingdom

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31 08 21

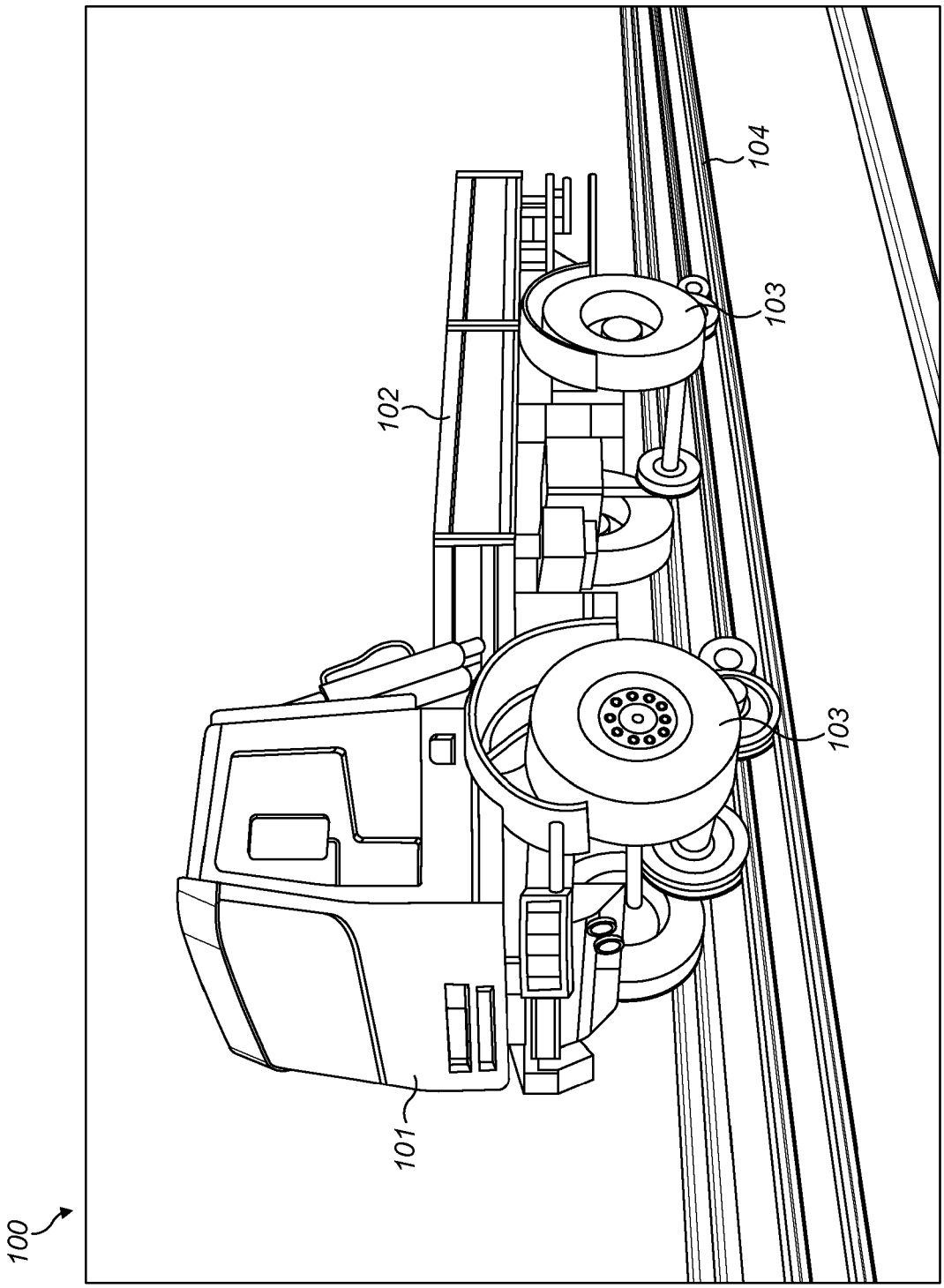

FIG. 1
(Prior Art)

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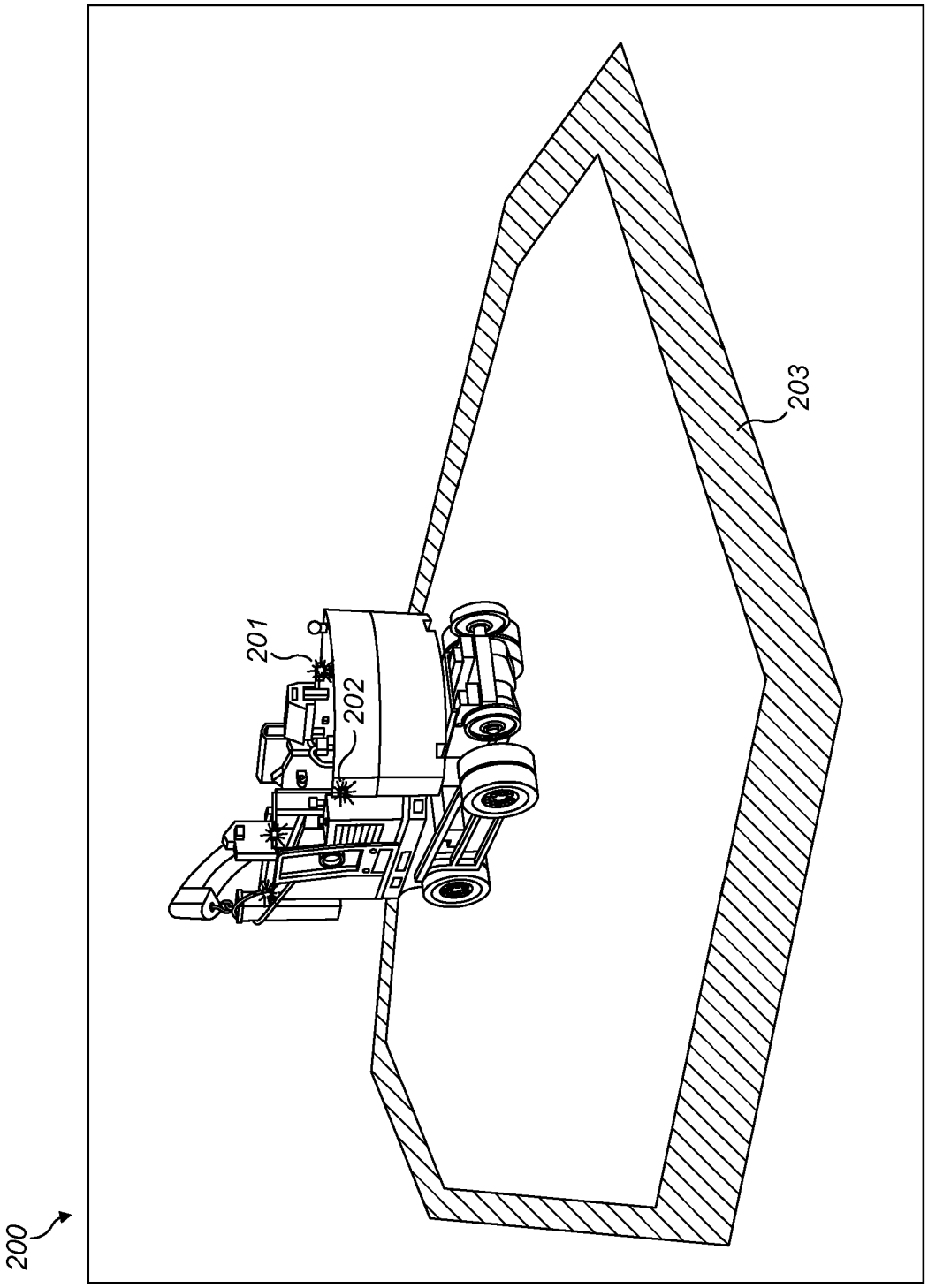

FIG. 2
(Prior Art)

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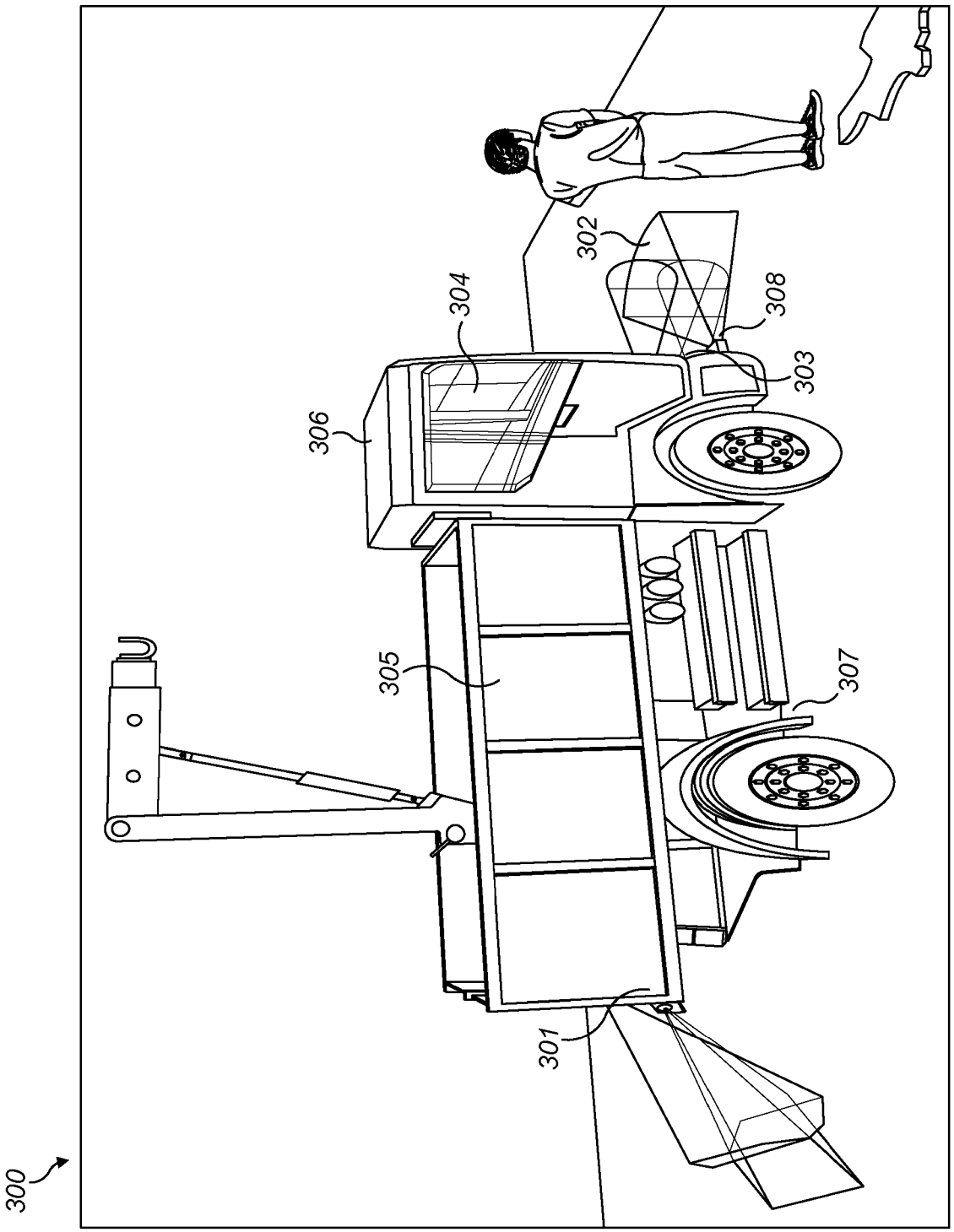

FIG. 3

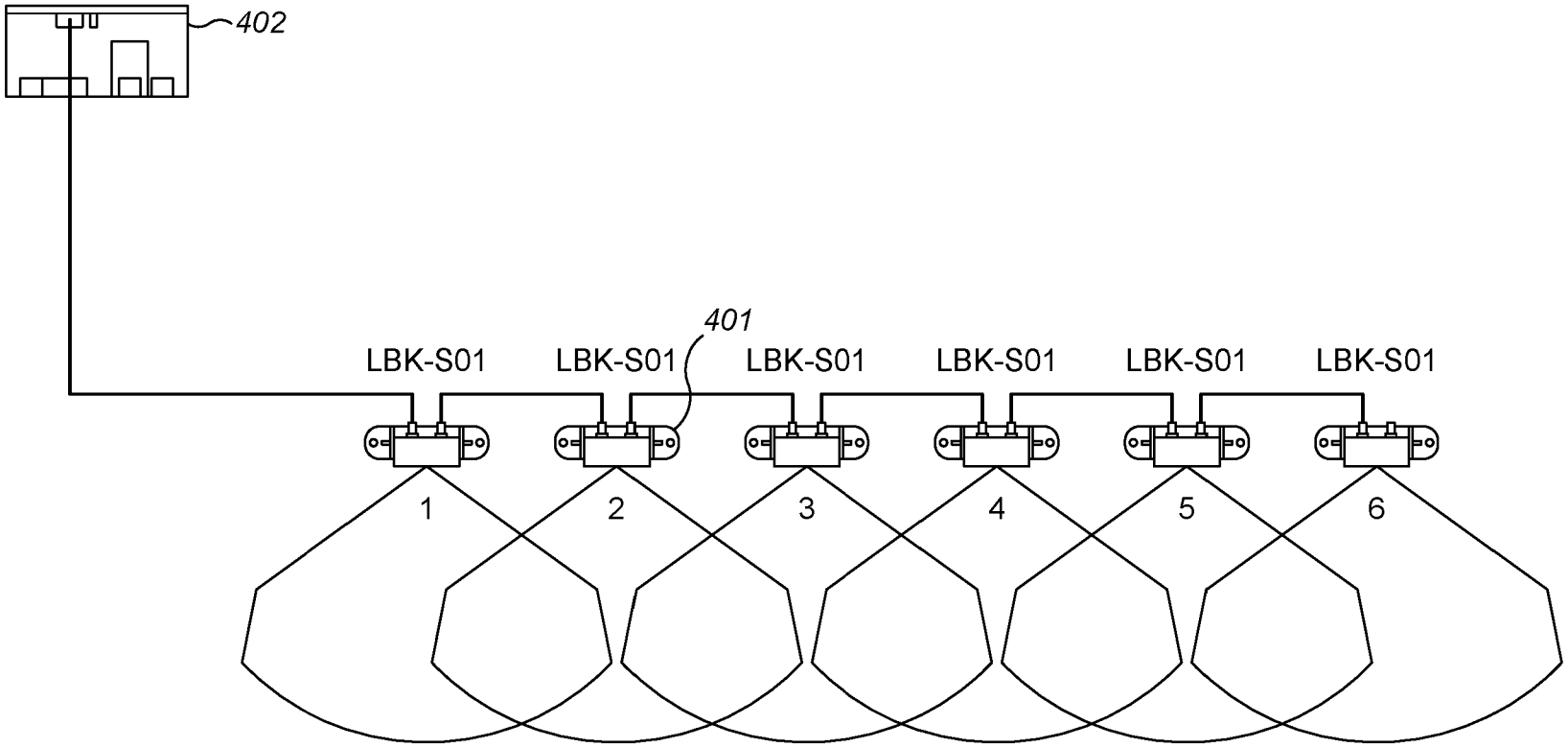

FIG. 4

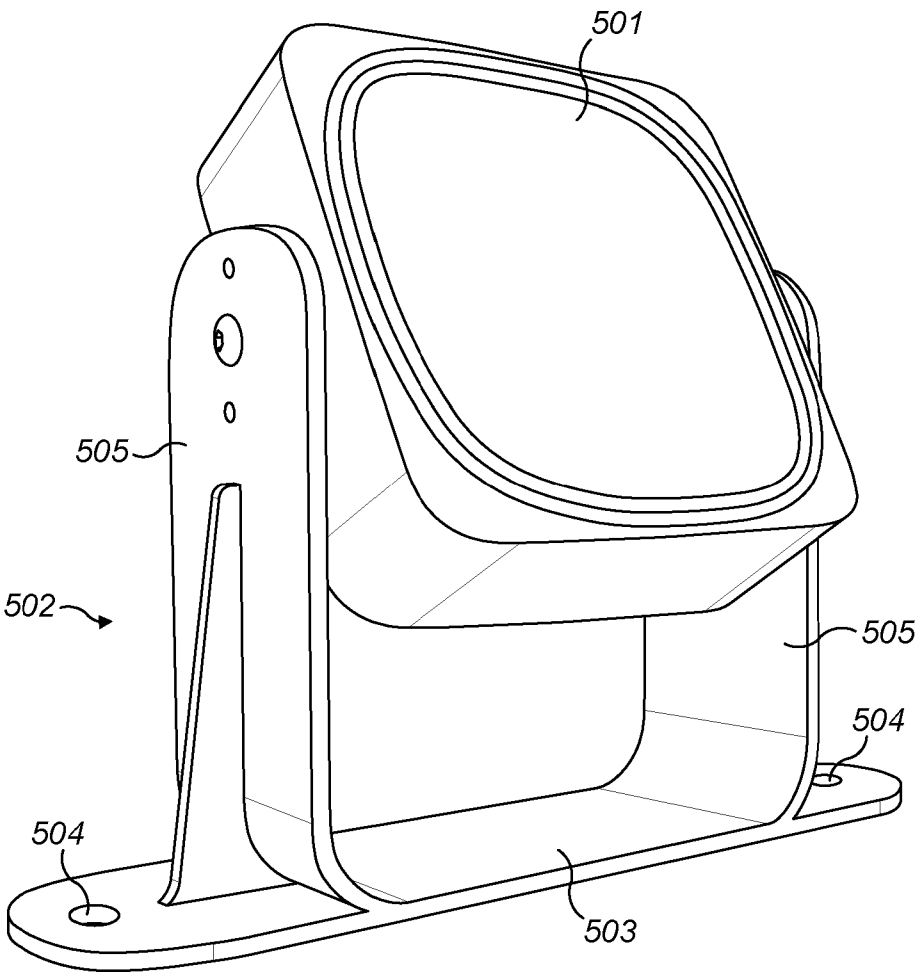

FIG. 5

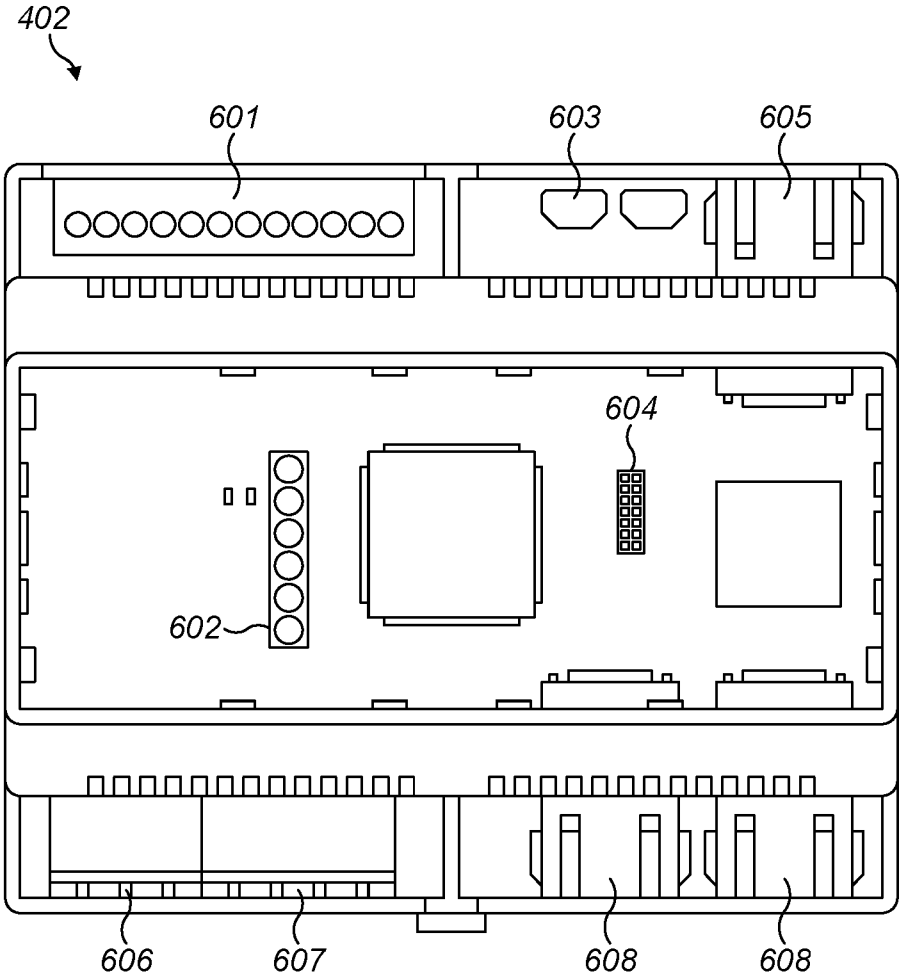

FIG. 6

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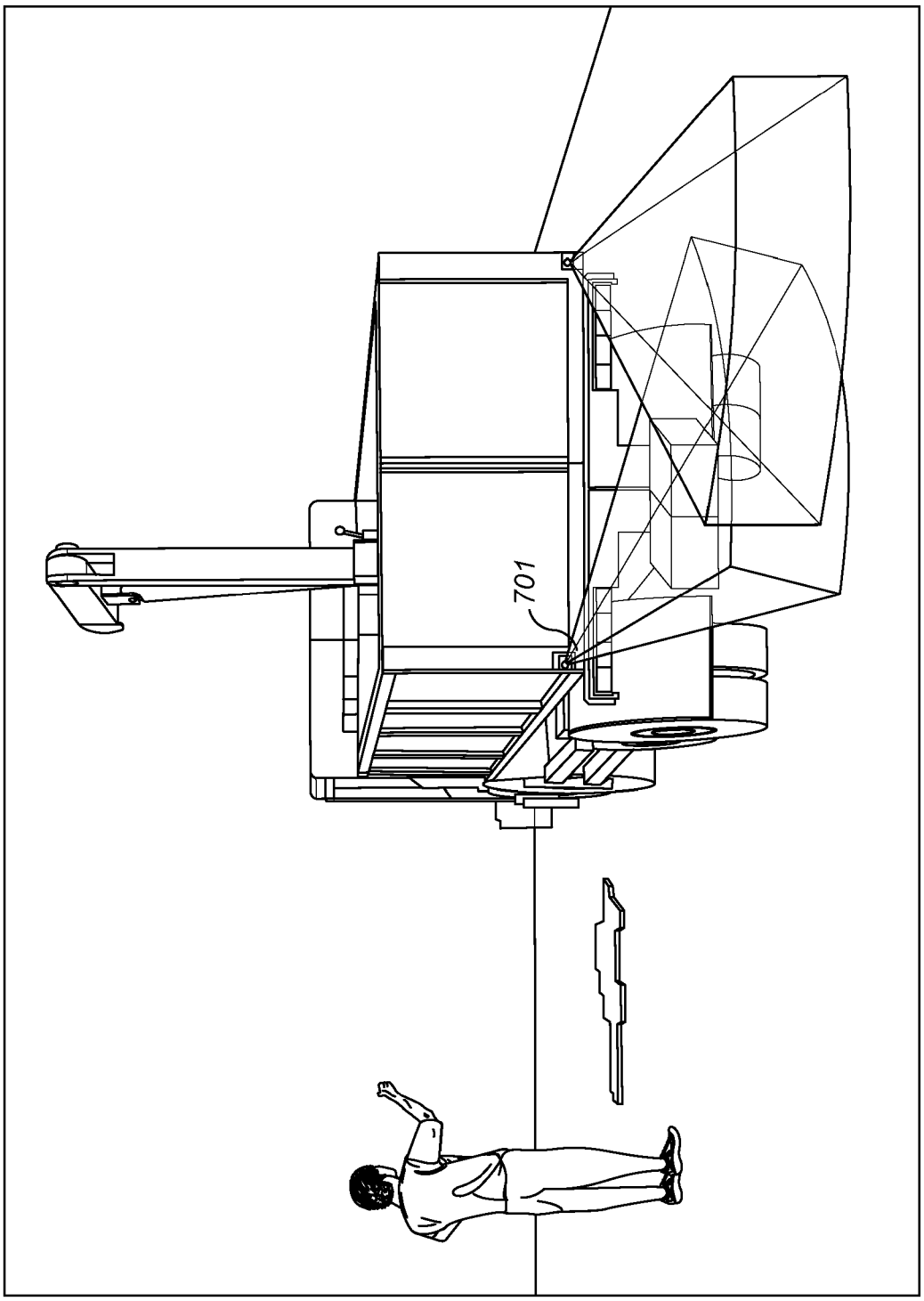

FIG. 7

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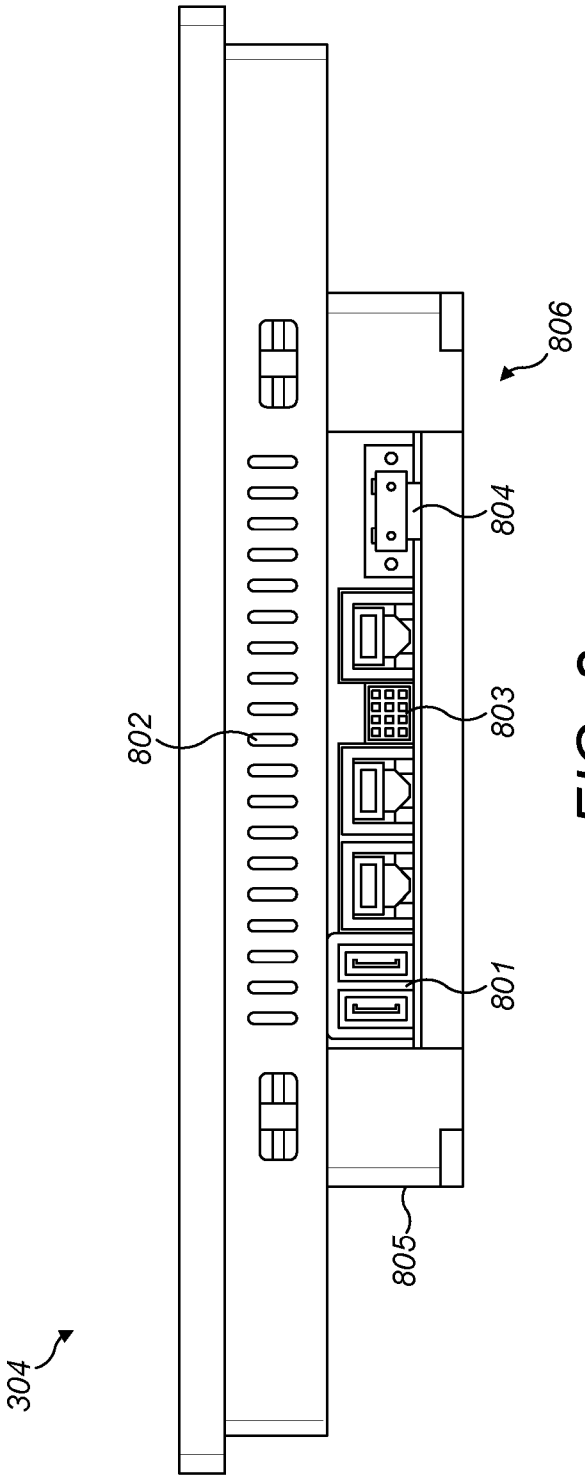

FIG. 8

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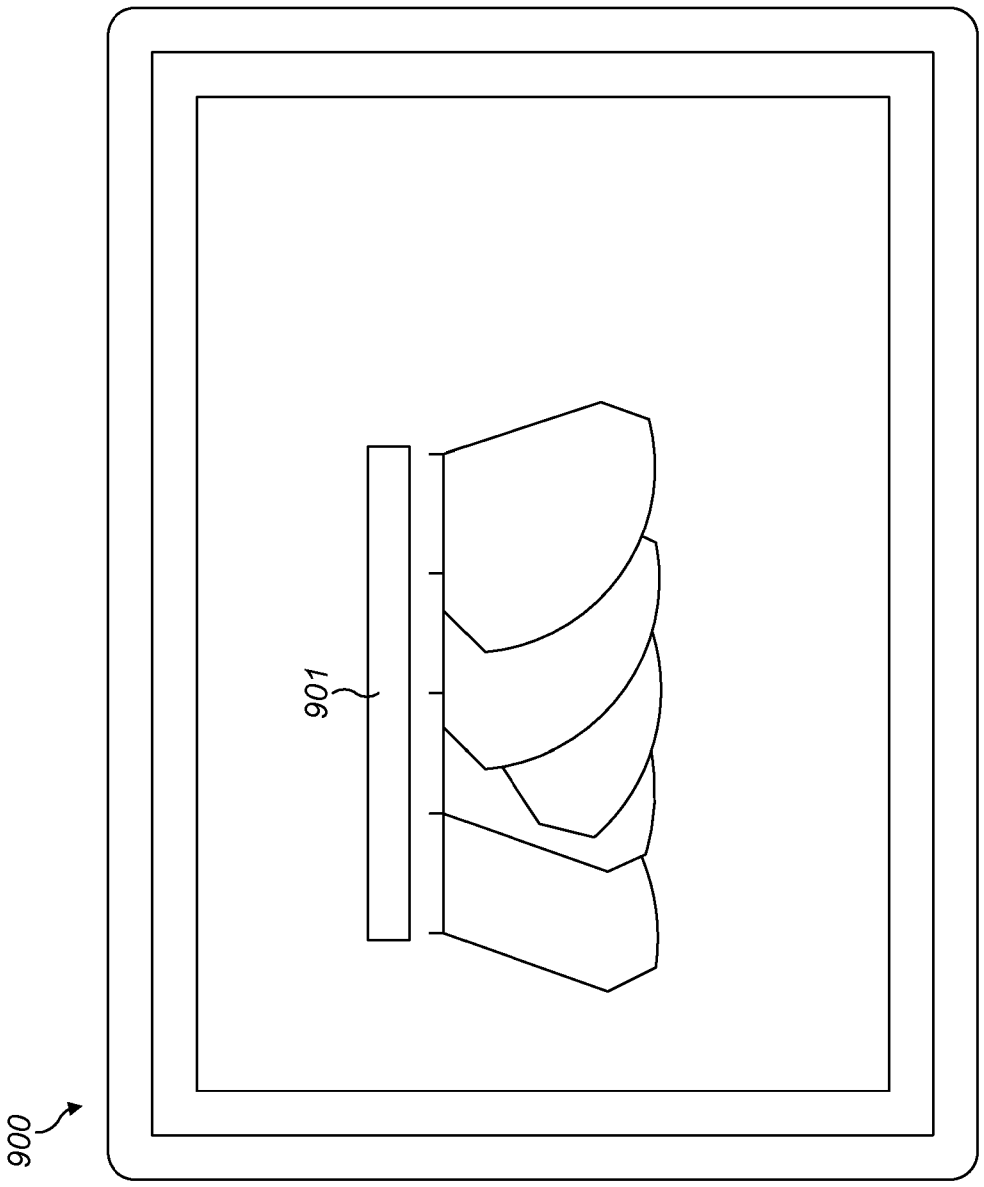

FIG. 9

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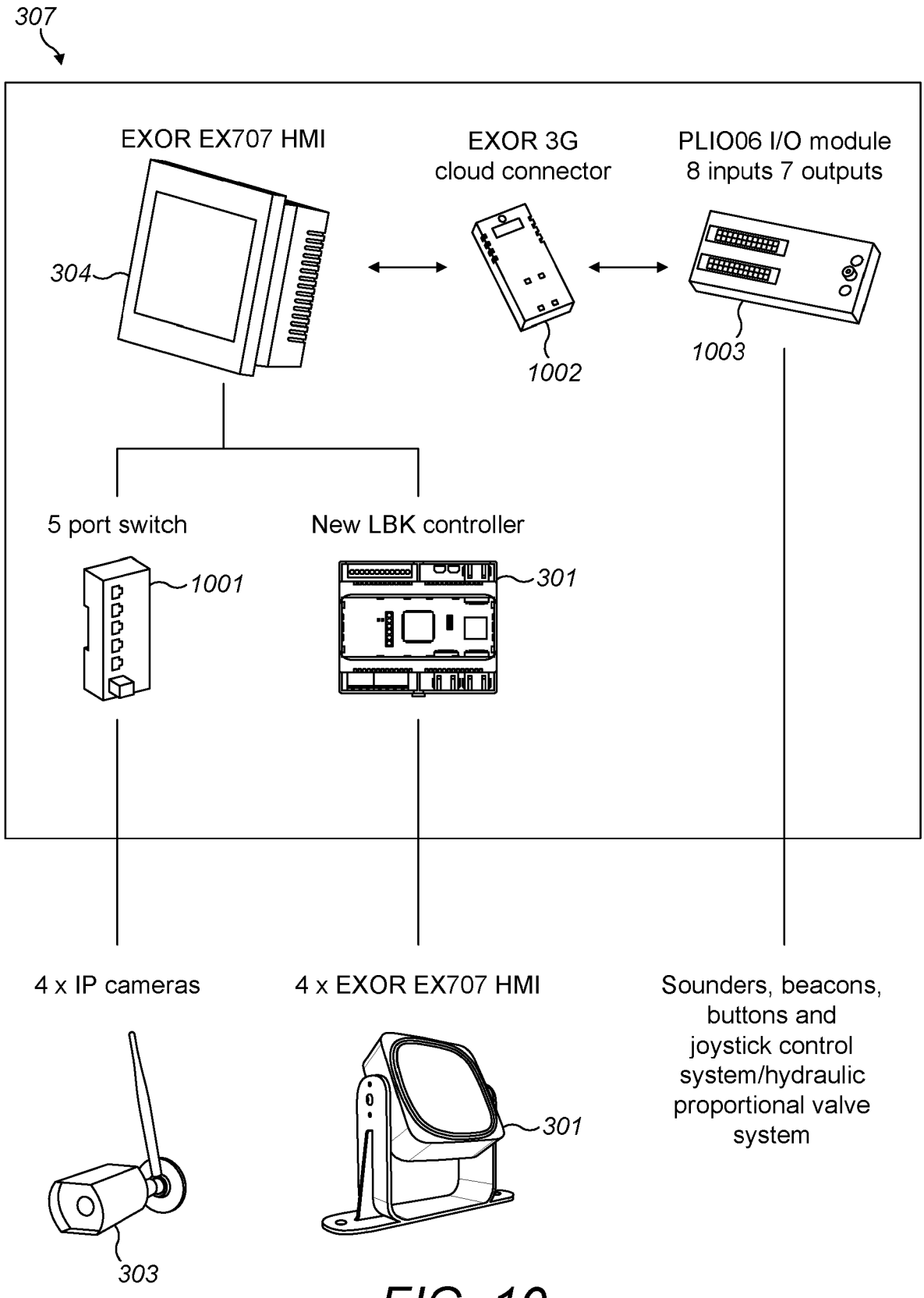

FIG. 10

ANTI-COLLISION APPARATUS FOR ON TRACK PLANT

Field of the Invention

[0001] The present invention relates to an anti-collision apparatus for on track plant, particularly although not exclusively for road rail vehicles.

Background of the Invention

[0002] Rail transport is a means of transferring goods and passengers on wheeled vehicles running on rails, which are located on tracks. Throughout its lifetime rail infrastructure has gone through significant changes and at this point in time requires regular maintenance and occasional renewal. Railway is often built in rural areas which can be difficult, if not impossible, to access by road vehicles. This poses an issue when maintenance or renewal is to be carried out as the necessary resources cannot be easily and safely transferred by traditional rail vehicles such as trains. In recent years the electrification of the railway has become a priority, which has increased the demand of resources to rural areas of the railway.

[0003] On track plant (OTP) is the term used for machinery designed to run on the railway. OTP includes rail mounted maintenance machines (RMMM), road rail vehicles (RRV), trailers and attachments. Road rail vehicles are capable of transporting the necessary workers, machinery and materials to rural areas of the railway for work to be completed. The vehicles are typically driven on roads as close as possible to the site and then access the rail for the final journey to the worksite.

[0004] Road rail vehicles can also be used to provide motive power for shunting, the process of sorting items or rolling stock into complete trains or the reverse.

[0005] Referring to Figure 1 herein, there is illustrated schematically one example of a known road rail vehicle 100, comprising a cabin 101, a trailer 102,

wheels 103 capable of driving the vehicle on the road or on the rail track. The road rail vehicle is shown in situ, on the rail track 104.

[0006] The driver of the vehicle sits in the cabin 101 and controls the vehicle by driving it either forwards or backwards along the track 104. Line closures are usually put in place closing the track to normal traffic when the vehicles are in operation. The vehicles can be insulated and not activate track signaling circuits, however, non-insulated vehicles are sometimes preferred as they are then detectable by train safety systems. The trailer 102 of the vehicle can vary depending on the purpose the vehicle is fulfilling.

[0007] In variations of the known road rail vehicle shown in Figure 1, the trailer may further comprise a personal carrier body which can be used to transport personnel from a possession access point to a possession worksite. In a second example, the trailer may further comprise a mobile elevating work platform which can be used to give workers access to overhead line equipment suspended at height above the rail tracks.

[0008] As rail vehicles are directionally guided by the tracks on which they run, they only have the ability to move forwards or move backwards along the tracks. A road rail vehicle has dramatically decreased maneuverability on the rail track as opposed to on the road. In additional to reduced maneuverability, the visibility of the driver is often obstructed by machinery carried on the trailer of the road rail vehicle.

[0009] Due to the limited visibility and reduced maneuverability accidents and incidents involving road rail vehicles are common and often result in damage to equipment and occasionally even human fatalities.

[0010] To avoid incidents, each road rail vehicle has its own exclusion zone. An exclusion zone is the area around a machine in which machine movements and operation could be undertaken that could cause accident, injury or death. Different machine types present different levels and types of risk to

persons entering the exclusion zones, examples of scenarios that may guide the requirement to adjust the minimum exclusion zone:

- Machine type – As the shape and profile of each machine type differs so too will the exclusion zone.
- Arcs of movement – 360 machines may present crushing risks to persons standing alongside the machine when in restricted spaces, whereas machines which do not rotate may only present risks to staff in the forward and reverse directions.
- Machine transit characteristics – machines which may need to be stabilised or fixed in one location to perform their work duties, for example 360 cranes with outriggers, may present a greater risk to workers standing on slung side of the machine and in the vicinity of the counterbalance weights.

[0011] One known method for reducing incidents is the use of exclusion zone lighting systems.

[0012] Referring to Figure 2 herein, there is illustrated schematically one example of a known exclusion zone lighting system 200 comprising a road rail vehicle 201, a plurality of line LEDs 202 and a visual indication of the road rail vehicle 201 exclusion zone 203.

[0013] In variations of these systems the LEDs producing the visual indication of the exclusion zone may comprise spot lights, arrow lights or any combination which may sufficiently depict the exclusion zone of the vehicle. The area around on track plant which is unsafe for workers to be in. This system informs workers in the vicinity of the plant the boundaries of the machines exclusion zone.

[0014] These systems may further comprises a plurality of cameras with an in-cab monitor increasing the visibility of the operator of the vehicle. The cameras

provide feedback to audible and visible alarms which simultaneous alert the machine operator and nearby workers to any intrusions of the exclusion zone.

[0015] When a breach has occurred, the operator of the vehicle must assess the breach and react appropriately, due to human reaction times these systems may not prevent an incident from occurring. Known exclusion zone systems can also cause unintended distraction to the operator and reduce efficiency.

[0016] Another known method of reducing the chances of incidents is the use of operator surveillance. Where one or a plurality of workers stand within the visible area of the vehicle operator, survey the area to ensure no obstructions and direct the vehicle forwards and backwards accordingly.

[0017] This method requires a plurality of workers which can be costly. The effectiveness of this method is restricted by the reaction time of both the workers providing the surveillance and the operator of the vehicle. It also requires constant attention from the workers for prolonged periods of time..

Summary of the Invention

[0018] According to a first aspect of the present invention, there is provided an on track plant (OTP) designed to run on a railway infrastructure for transferring goods and passengers, the OTP including an anti-collision and as claimed in Claim 1.

[0019] Other aspects are as set out in the claims herein.

Brief Description of the Drawings

[0020] For a better understanding of the invention and to show how the same may be carried into effect, there will now be described by way of example only, specific embodiments, methods and processes according to the present invention with reference to the accompanying drawings in which:

[0021] Figure 1 shows schematically the prior at road rail vehicle in situ.

[0022] Figure 2 shows schematically a prior art plant exclusion zone lighting system.

[0023] Figure 3 shows schematically a side view of the anti-collision apparatus on a road rail vehicle.

[0024] Figure 4 shows schematically the sensor system of the anti-collision apparatus.

[0025] Figure 5 shows schematically a radar sensor of the sensor system.

[0026] Figure 6 shows schematically a radar control unit of the sensor system.

[0027] Figure 7 shows schematically a rear view of the anti-collision apparatus on a road rail vehicle.

[0028] Figure 8 shows schematically the human machine interface of the anti-collision apparatus.

[0029] Figure 9 shows schematically the screen of the human machine interface.

[0030] Figure 10 shows schematically one example of the feedback loop for the brake system of the anti-collision apparatus.

Detailed Description of the Embodiments

[0031] There will now be described by way of example a specific mode contemplated by the inventors. In the following description numerous specific details are set forth in order to provide a thorough understanding. It will be apparent however, to one skilled in the art, that the present invention may be practiced without limitation to these specific details. In other instances, well known

methods and structures have not been described in detail so as not to unnecessarily obscure the description.

[0032] In the specification, like reference numerals used across different Figures denote like components.

[0033] In this specification the term "rail vehicle" is used to describe any type of vehicle which is suitable for use on a railway line. It includes road – rail vehicles.

[0034] In this specification, the term "road rail vehicle" includes all varieties of on track plant designed or adapted to run on railway tracks including but not limited to road - rail vehicles, Rail Mounted Maintenance Machines (RMMM), rail mounted trailers and rail mounted attachments. Such vehicles may be designed for road use and be adapted to run on rails, or may be designed exclusively for rail use.

[0035] Whilst the following embodiments refer to a road rail vehicle as an example, it will be understood by the skilled person that the embodiments may be fitted to any type of on track plant.

Overview of the Apparatus

[0036] Referring to Figure 3 herein there is illustrated schematically an anti-collision apparatus 300, suitable for reducing the chance of incidents involving road rail vehicles, specifically collisions between road rail vehicles, road rail vehicles and other objects, and road rail vehicles and workers.

[0037] The anti-collision apparatus 300 comprises a sensor system 301, a visible light exclusion zone 302, an IP camera system 303, a human machine interface 304, an audible alarm apparatus 305, a visual alarm apparatus 306 and a braking system 307.

[0038] The sensor system 301 is preferably wireless and operates 360 degrees around the vehicle monitoring the exclusion zone using motion and scenario analysis. The exclusion zone is defined as the area around the vehicle in which movements and operation are undertaken that could cause accident, injury or death.

[0039] A visible light exclusion zone 302 is created by a plurality of LEDs 308 built into the IP camera system 303. All apparatus is mounted on the road rail vehicle in such a way as to not inhibit the road rail vehicle from performing its function or impede or diminish the operator's visibility in all arcs of vision. All apparatus is preferably mounted on side of vehicle as to not strike the overhead line equipment.

[0040] The sensor system 301 and IP camera system 303 both send feedback to the human machine interface 304 situated within view of the operator of the road rail vehicle within the cabin. When a breach of the exclusion zone occurs the human machine interface 304 alerts the operator and shows the angle of entry of the breach, from the information communicated by both the sensor system and IP camera system. In addition to the alert on the HMI, audible and visual alarms are activated notifying those working nearby that the exclusion zone has been breached.

[0041] The video captured by the IP camera system has a data logging functionality to record breaches of the exclusion zone. The information logged includes:

- time and date of the breach
- angle of entry of the breach
- identification number of the road rail vehicle in use
- corresponding identity that caused the breach (if applicable)

[0042] The data is compiled through a programmable logic controller, then either stored on an SD card or sent via dongle connection to external storage. The information can be reviewed to improve protocol when working around road rail vehicles.

[0043] When a breach is detected the vehicle is automatically slowed to a stop by the brake system, removing the need for human intervention and the delay caused by human reaction time. The sensor and IP camera systems provide outputs that are connected to either the joystick control system or the hydraulic proportional valve system on the brakes. The machine is prevented from restarting during any breaches of the exclusion zone.

[0044] The anti-collision apparatus is activated when the ignition of the road rail vehicle is in the on position and can be used in all extremes of weather during both day and night time conditions, remaining functional in temperature extremes between -25 +40 degrees Celsius.

[0045] Referring to Figure 4 herein these is illustrated schematically the sensor system 301.

[0046] The sensor system 301 comprises a signal transmitter capable of receiving an electromagnetic or acoustic signal and a signal receiver for receiving an electromagnetic or acoustic signal. The sensor system is preferably wireless and operates at radiofrequency.

[0047] In the best mode embodiment, the sensor system comprises a plurality of radar sensors 401 and at least one radar control unit 402. The radar sensors are arranged around the vehicle to create a 360 degree around the vehicle with a range up to 10 meters. Perfect alignment between sensors is not required for the sensor system to function effectively. Sensors are installed around the road rail vehicle at specific heights and tilts depending on the area that needs to be covered.

[0048] Each individual sensor 401 can be programmed independently from the others within the sensor system to cover either a wide or narrow sensing field. Various configurations including irregular shapes and complex areas can be achieved using the position, tilt, and programmable radar sensing field of each individual sensor.

[0049] The sensor system further comprises a muting function, allowing operators to safely access parts of the exclusion zone according to production needs.

[0050] Referring to Figure 5 herein these is illustrated schematically a radar sensor 401 of the sensor system.

[0051] The radar sensor 401 comprises a sensor 501 which is held in position by a frame 502. The sensor 501 is preferably a frequency modulated continuous wave radar device which sends 24Ghz radio waves and recovers motion information by using known algorithms to analyse return signals reflected by both static and moving objects within the exclusion zone. Unlike traditional optoelectronic sensor the sensor 501 is immune to environmental disturbances such as smoke, dust, shavings, fluids and other debris, reducing false alarms and increases productivity. The frame 501 has a weighted base 503 with apertures 504 at either end of the weighted base, there are two arms 505 attached perpendicular to the base 503.

[0052] The apertures 504 are suitable for receiving means for attaching said frame 502 onto a road rail vehicle. The arms 505 comprise two ends, the first end is perpendicularly attached to the weighted base 503, at a second end are either side of the sensor 501 is adjustably attached to said arms such that the sensor can be titled back and forth to alter the position of the sensing field.

[0053] The sensor 501 comprises means for communicating the motion detection signal to the control unit, preferably said communication means comprises a CAN bus. Fault reporting and communication of diagnostic

information can also be sent to the control unit from the sensor via the communication means.

[0054] Referring to Figure 6 herein these is illustrated schematically a radar control unit 402.

[0055] The radar control unit 402 comprises an I/O connector 601, sensor status LEDs 602, a mirco-USB port 603, fieldbus status LEDs 604, an ethernet port 605, a power supply 606, a CAN bus connector 607 and two fieldbus ports 608.

[0056] The control unit 402 is capable of connecting up to 6 radar sensors 401 via the CAN bus connector 607. The configuration of sensitivity levels, safety functions, size of exclusion zone and the functionality of the controllers I/O port 601 can be configured through known software on a computer connected via the micro-USB port 603. Power is supplied to the controller by the power supply 606.

[0057] The controller has three dual-channel digital inputs and common reference potential for:

- muting
- machinery emergency
- machinery restart

[0058] The digital inputs can be configured through known software. The controller has two auxiliary relay outputs which can be configured to signal pre-alarm, fault, muting status. The controller has one dual-channel, force guided safety relay output for alarms and direct or indirect safety of the machine.

[0059] Referring to Figure 7 herein there is illustrated schematically a rear view of the anti-collision apparatus on a road rail vehicle.

[0060] The IP camera system comprises a plurality of motorised 360-degree IP cameras 701. LEDs 308 are built into the cameras 701 to create the visible light exclusion zone and facilitate clear video capture for identifying an unauthorised entries into the exclusion zone.

[0061] The visual exclusion zone is provided for the benefit of nearby workers and can be modified by the operator on the human machine interface depending on the area needed by the particular machine in use. The colour of the LEDs used in the lighting system is such that it does not interfere or be misinterpreted with any other light colour used on the railway. The light system automatically switches on / off at a set lux level (luminous flux per unit area) as dusk / dawn sets.

[0062] The IP cameras 701 are capable of being powered via both the 12 volts and 24 volts supplies on the road rail vehicle. The power may be supplied through a secure power supply or alternatively hardwired via a suitably fused link into the host vehicle electrical starter circuits or via direct battery link or an auxiliary supply which is not linked to the lighting, alert, interlocking, braking, safety, monitoring, control or communications supply circuits.

[0063] During a breach of the exclusion zone the audible alarm apparatus and visual alarm apparatus are activated by a signal sent from the human machine interface via the I/O connector. The audible alarm may comprise a plurality of sirens, horns and loudspeakers such that they are capable of achieving an audible alert of at least 118dB. The visual alarm apparatus may comprise a plurality of lights located around the road rail vehicle. The audible and visual alarm apparatus are mounted on the road rail vehicle such that they are capable of providing an effective alert. All alerts must be clearly identifiable and must not be confusable with other common host machine alerts or warnings.

[0064] The video captured by the IP camera system has a data logging functionality to record breaches of the exclusion zone. The information logged includes:

- time and date of the breach
- angle of entry of the breach
- identification number of the road rail vehicle in use
- corresponding identity that caused the breach (if applicable)

[0065] The data logged includes multiple entries from different angles and multiple entries by a single identity. The data from the IP cameras is compiled through known methods and can either be saved to an SD card and transmitted to an external server via a wireless connection automatically when a signal is available, either throughout operation or at the end of operation. Every entry into the exclusion zone will be logged, downloaded and sent to for analysis.

[0066] The IP camera system is also capable of providing video surveillance to capture all activities whilst the vehicles are in use on the work site. The video surveillance will be active when the exclusion zone is active. The video surveillance footage and breach data can be analysed in depth and used to improve protocol for working around OTP.

[0067] Referring to Figure 8 herein there is illustrated schematically the human machine interface 304 of the anti-collision apparatus.

[0068] The human machine interface comprises a plurality of USB ports 801, a plurality of ethernet ports 802, a serial port 803, means for receiving a power supply 804, means for receiving an SD card 805, a plurality of expansion slots for plugin modules 806.

[0069] The HMI comprises networking capabilities and a plurality of communication options to control the anti-collision apparatus and transfer data from the apparatus to an external device. The HMI comprises cloud secure connectivity with full network separation to allow for the secure transmission of

data. The human machine interface may further comprise internet of things edge device capabilities providing connectivity between disparate networks.

[0070] The two primary functions of the HMI are to control aspects of the anti-collision apparatus and to assist with the data logging functionality of the apparatus. All elements of the anti-collision apparatus are connected to the human machine interface through the various ports and slots provided by the HMI.

[0071] The IP camera system, the exclusion zone lighting system, and the sensor system are adjustable via the HMI to accommodate for different size exclusion zones around the road rail vehicle. Pre-set options calculated based on the machine type, arcs of movement and machine transit characteristics are configured into the apparatus. The HMI is complete with simple zone activations which allow the operator to choose the pre-set options. Allows configuration of sensitivity, safety functions as well as size of the exclusion zone.

[0072] Referring to Figure 9 herein there is illustrated schematically the screen 900 of the human machine interface.

[0073] The screen comprises a colour multitouch glass projected capacitive touchscreen 901.

[0074] The screen shows live video capture from the IP camera system so the operator can view 360 degrees around the road rail vehicle at all times. During a breach of the exclusion zone the operator will be notified with an alert shown on the screen. The screen does not provide unintended distraction to the machine operator during use other than when an alert is actioned.

[0075] Exclusion zones are calculated in advance, using the touchscreen, the operator can choose pre-set options to alter the anti-collision apparatus to accommodate the calculated requirements. As well as machine specific requirements of an exclusion zone there are also operational requirements such as extending the exclusion zone for lifting or towing activities and site-specific

requirements as a result of changes in the geography of Network Rail managed infrastructure such as cuttings, embankments, gradient, cant and obstacles. The machine operator may additionally configure the sensitivity and safety functions as well as size of the exclusion zone. Such changes must only be made in line with the appropriate safety protocols. The exclusion zone is only adjustable by the machine operator or a person with the appropriate permissions.

[0076] Referring to Figure 10 herein there is illustrated schematically one example of a feedback loop for the brake system 307.

[0077] The brake system comprises a sensor system 301 which sends feedback to the human machine interface 304. The system further comprises an IP camera system 303 which also sends feedback to the human machine interface 304 via a 5 port switch 1001. The human machine interface then sends feedback via a 3G cloud connector 1002 and I/O module 1003 to either the control system of the road rail vehicles joystick or the hydraulic proportional valve of the road rail vehicle.

[0078] The radar and IP camera systems provide outputs when a breach in the exclusion zone is detected which activates either the joystick control system or the hydraulic proportional valve system on the brakes and automatically slow the vehicle to a stop by the brake system. One of the factors which determines the size of the exclusions zone along the track is the stopping distance of the road rail vehicle in use. The machine is prevented from restarting during any breaches of the exclusion zone to prevent a release of the brakes.

Claims

1. An on track plant (OTP), rail mounted maintenance machine (RMMM) designed to run on rail tracks of a railway infrastructure for transferring goods and passengers, the RMMM including an anti-collision apparatus (300) comprising:

a radar transmitter for transmitting a radio frequency signal over a field of operation including an exclusion zone along the rail track;

a radar sensor for receiving a radio frequency signal;

wherein said radar transmitter sends out a radio frequency signal and said radar sensor receives a returned signal reflected from an object in the field of operation of said radar transmitter;

the RMMM (300) further comprising;

brake activation means (307) comprising one of the following:

one of more manually operable joystick controllers;

one or more hydraulic proportional valves;

a combination of one or more manually operable joystick controllers and one or more hydraulic proportional valves and;

wherein said brake activation means (307) is operable to automatically activate the brakes to slow the RMMM to a stop when being directionally guided by the rail track on which the RMMM is running and when said radar sensor receives the signal reflected from an object in the exclusion zone along the track.

2. The RMMM (300) as claimed in claim 1, further comprising;

a camera (303, 701);

wherein said camera (303, 701) monitors the field of operation of said signal transmitter.

3. The RMMM (300) as claimed in claim 2, wherein said camera (701) is motorised.

4. The RMMM (300) as claimed in claim 3, wherein said camera (701) further comprises;

a visible-light emitting element (308);

wherein said visible light is emitted in the direction of operation of said camera (701);

and wherein said emitted visible light illuminates the field of operation of said radar transmitter.

5. The RMMM (300) as claimed in claim 4, further comprising;

a data logger;

wherein said data logger is configured to record data selected from the set:

the time and date the object enters the field of operation of said radar transmitter;

the angle of entry of said object into said field of operation of said radar transmitter;

the identification number of the RMMM in use; and

wherein if the object is also an on track plant having a corresponding identity, the corresponding identity of said on track plant in the field of operation of said radar transmitter.

6. The RMMM (300) as claimed in claim 5, wherein said data logger is configured to record;

multiple entries into the field of operation of said radar transmitter by multiple objects; and

multiple entries into said field of operation by a single object.

7. The RMMM (300) as claimed in any one of the preceding claims, wherein said apparatus further comprises;

visual alert apparatus (306); and

audible alert apparatus (305);

wherein said visual alert apparatus (306) and said audible alert apparatus (305) are activated when said radar receiver receives the signal reflected from an object in the field of operation of said radar transmitter.

8. The RMMM (300) as claimed in any one of claims 2 to 6, further comprising;

a visual display monitor (304);

wherein said visual display monitor (304) shows the live video capture of said camera (701).

9. The RMMM (300) as claimed in any one of the preceding claims, wherein the field of operation of said radar transmitter is adjustable by a human operator.

10. The RMMM (300) as claimed in any one of the preceding claims, further comprising muting means for muting an area of the field of operation of said radar transmitter.

11. The RMMM (300) as claimed in claim 1, wherein said radar transmitter comprises;

a frequency modulated continuous wave radar device which sends 24Ghz radio waves; and

said radar sensor further comprises a signal analyser;

wherein said signal analyser recovers motion information by using known algorithms to analyse return signals reflected by both static and moving objects.

12. The RMMM of Claim 1, further comprising:

optionally a plurality of radar sensors positioned to receive the radar signal reflected back towards the radar sensors;

a human-machine interface (304) for interfacing between said at least one transmitter and a human operative;

an internet interface for sending and receiving data over an Internet;

an input/output module (1003) for sending and receiving data to and from devices selected from the set:

one or more sounders /claxons;

one or more beacons.