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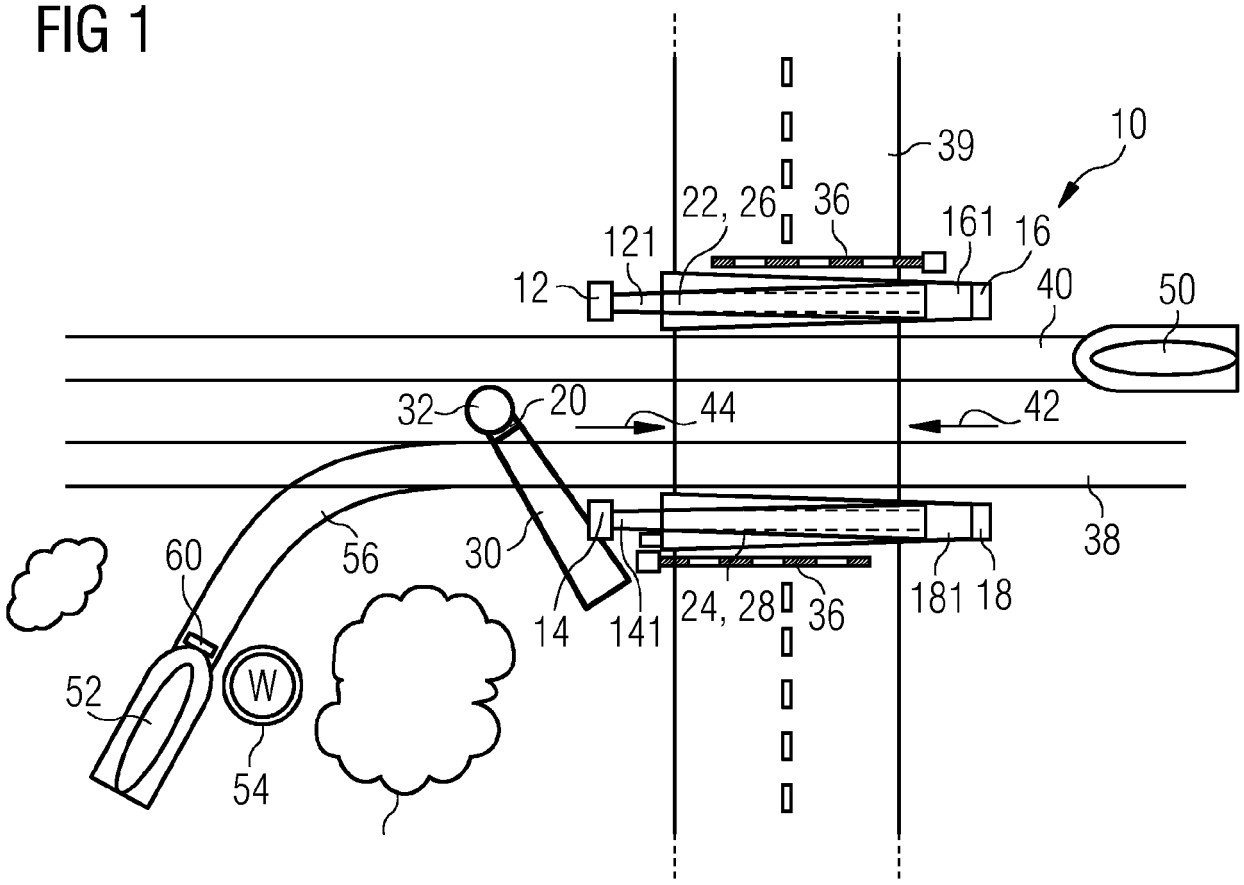
(54) TRESPASSING DETERRENCE FOR RAILWAYS

(57) An alarm system for deterring unauthorised access to a target area, as may be used, for example, at railway level crossings. An alarm output device arranged to direct an alarm output into the target area.

FIG 1



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Description

[0001] Level crossing abuse and trespassing onto railway lines continue to cause deaths and injuries. In the UK, several fatalities and many near misses are recorded on level crossings annually.

[0002] The present invention aims to provide improved warnings to users at level crossings, to deter the public from entering onto the railway particularly when a train is approaching, and to improve protection of workers on the line.

[0003] Recent amendments to regulations controlling the permitted loudness of audible signals carried on trains has reduced the permitted loudness of train horns such that they may not be reliably heard by a trespasser in time to provide adequate warning to leave the tracks.

[0004] Conventionally, "whistle boards", that is to say, fixed visible signs, are provided a certain distance ahead of a level crossing, and a train driver is required to sound the train's horn (audible warning device) as the train passes the whistle board. Conventionally, the loudness of the horn and the position of the whistle board, taking into account the speed of the train, meant that users at the level crossing were given appropriate warning of the approach of a train.

[0005] However, due to newer horn regulations reducing the maximum permitted loudness for the horn, it has been found that compliant horns, when sounded as a train passes the whistle board, do not provide adequate warning to users.

[0006] If the whistle board were moved closer to the level crossing so that a compliant horn may be clearly heard by a user, there would be insufficient time for a trespasser to react and reach a safe location before the train reaches the level crossing, unless all trains were to be required to slow down significantly on approach to every level crossing. Such a requirement would adversely affect the operational capability of the railway.

[0007] Some level crossings are provided with audible alarms, which sound a warning to indicate the approach of a train. Since such alarms are located at level crossings, they will be audible to users waiting at the crossing. The level crossing alarms will be triggered at appropriate times to warn of the approach of a train.

[0008] A recent decision by the UK rail network operator has introduced a Night Time Quiet Period (NTQP) (https://www.networkrail.co.uk/wp-content/uploads/2019/06/FAQs-for-Night-Time-Quiet-Period-NTQP.pdf) and forbids the sounding of train horns and level crossing alarms during a certain period at night, except in extenuating circumstances. The Night Time Quiet Period (NTQP) is currently 00:00-06:00, to prevent disruption to the local residents in the area. An earlier definition of the NTQP was from 23:00-07:00.

[0009] Although many level crossings are provided with light signals which indicate an approaching train, pedestrians are known to sometimes ignore light signals, and audible signals have been found to be more effective than light signals. The ban on audible alarms during the NTQP increases the risk of injury to users of level crossings as audible alarms will not usually be sounded during the NTQP.

[0010] The present invention therefore aims to provide a level crossing alarm which is effective and may be used during the NTQP. Other situations also arise on the railway where an effective audible alarm would be useful, but which should not disturb local residents. For example, protection of workers working on the line is important.

[0011] By providing an audible alarm suitable for installation at level crossings and suitable for protection of workers working on the line, but which does not disturb local residents, it may be possible to use such an alarm during the NTQP, and the alarm may be used during daytime also, to reduce noise perceived by local residents.

[0012] The present invention aims to provide audible alarms indicating an approach of a train, the audible signal emitted by such alarms being loud and/or distinctive enough that it is unlikely to be ignored, yet which generates minimal audible disruption to local residents.

[0013] The present invention accordingly provides apparatus as defined in the appended claims.

[0014] The above, and further, objects, characteristics and advantages of the present invention will become more apparent from the following description of certain embodiments thereof, given by way of examples only, with reference to the accompanying drawings, wherein:

Fig. 1 schematically represents a railway level crossing equipped with an alarm system according to the present invention;
Fig. 2 schematically represents a railway level crossing equipped with an alarm system according to the present invention; and
Fig. 3 schematically represents an authorised working area on a train track, equipped with alarms according to the present invention.

[0015] The present invention addresses the issue of pedestrians: workers, level-crossing users, trespassers, ignoring existing alarm arrangements to place themselves in danger. It also addresses regulatory limitations placed on use of audible alarms at night time.

[0016] The present invention addresses these issues by providing a directional output which is perceived by persons, or indeed by animals, present within a target area but which output is sufficiently directional that the output from the alarm system does not disturb persons nearby that are outside of the target area. In preferred embodiments, a directional horn, parametric device or speaker, such as those known as a Long Range Acoustic Device (LRAD), is used to produce an audible alarm output having a directional output audible signal which is loud and/or distinctive enough that it is unlikely to be ignored, yet is directional enough to generate only minimal sound to local residents. In other embodiments, the alarm

may also or alternatively produce a visual output, or an output of air currents, or other outputs, provided that each of such outputs is sufficiently directional as to provide minimal disturbance to persons outside of the target area. Suitable parametric devices include high-frequency amplifiers based on time variations in an electric parameter that converts input energy at the frequency of an alternating current into energy at an input signal frequency. Typically, devices based on time-variation of the reactance may be used.

[0017] Such alarms also find applications as safety warning alarms for workers on the line. Typically, alarms useful in such scenarios will be portable, being temporarily installed at a relevant work site only while work continues at that site.

[0018] Embodiments of the present invention may provide an audible alarm output of 134dB at 25m compared to 88dB as generated by a conventional horn as currently fitted to a Class 800 railway locomotive. An alarm output level of 120dB - 138dB was recommended in a recent accident investigation - https://assets.publishing.service.gov.uk/media/5fabd9c9e90e07
5c4965171e/R112020_201112_Margam.pdf

[0019] According to an aspect of the present invention, the alarm output generated is directional, and is constrained to be perceptible only within a target area, with very little alarm output being perceptible outside of the target area.

[0020] The directional horns, parametric devices or speakers currently available, and suitable for use in a system of the present invention, typically emit sound in a restricted direction, which is well controlled in azimuth and elevation. However, the distance travelled by the emitted sound is not well controlled. This characteristic may be addressed by directing the directional horns, parametric devices or speakers towards the ground, such that the directional horns, parametric devices or speakers do not significantly emit sound outside of a corresponding defined target area. Alternatively, a vertical or substantially vertical sound-absorbing surface, such as a wall or billboard, may be provided, to define a limit to the distance travelled by sound emitted by the directional horns, parametric devices or speakers of the present invention.

[0021] The described loudness of an audible alarm, for example, is only allowable due to the focussed, directional, nature of the alarm sound generated, meaning minimal disturbance to those outside the target area, even when a high volume alarm sound is generated. As mentioned above, while an alarm sound can be highly directional, restricted in extent in azimuth and elevation, specific arrangements may be required to restrict the distance over which the emitted sound can travel. Such arrangements may include directing a directional horn, parametric device or speaker at a downward angle, or directing the directional horn or speaker at a sound-absorbing surface.

[0022] The purpose of the alarm of the present invention is to alert persons within a target area to the approach of a train, and/or to encourage those persons to leave the target area. When activated, for example in response to a train approaching, the alarm emits a very loud and/or distinctive sound in a target area, such that persons within that target area are unlikely or unable to ignore the alarm, or to fail to notice it. Examples of suitable target areas include an area between a waiting area for pedestrians and/or vehicles beside a level crossing and the train tracks; an area in which workers are permitted to be working; a trackside location where trespassing is known to occur.

[0023] Preferably, the alarm of the present invention is so loud and/or distinctive within the target area that it cannot be ignored, even by workers using ear protectors. At level crossings and known trespassing locations, the alarm sound may be so loud that it causes discomfort to persons in the target area. Persons within the target area are thus encouraged to leave the target area.

[0024] At trespassing hotspots or at level crossings where misuse is frequent, certain embodiments of the present invention enable specifically targeting potential trespassers with a directed alarm output, rather than broadcasting an alarm output widely to a surrounding area. Targeted alarm output is employed, which does not disturb persons who are not in a target area, and such a targeted alarm can be used to have a greater effect on those within the target area. For example, stern spoken commands, instructions or siren sounds may be generated and directed to the target area using a focussed speaker system, parametric device or directional horn to deter persons within the target area.

[0025] Additionally, a camera system with computer vision and/or operated by a remote user may be used to steer and issue commands or alarm sounds to persons in the target area. The remote user, or an artificial intelligence feature of a computer vision system, may also inform appropriate authorities such as the police or railway signallers of possible trespassers, or obstructions such as animals or stationary vehicles on the line.

[0026] The directional horn or parametric devices in an embodiment of the present invention are preferably positioned for maximal effect with minimal disturbance to other persons nearby but outside of the target area and not in potential positions of danger. In certain embodiments, such directional horn or parametric devices may be activated to generate alarm sounds to persons in the target area by automated train-detection arrangements provided to detect the approach of a train at sufficient distance to enable an effective warning to be given to persons in the target area, such that they have time to move out of danger before the train arrives. Examples of such train-detection arrangements, known in themselves, include treadle-like trackside infrastructure, control centre systems, geo-location of trains, or similar; or manually. In any case, an arrangement may be provided for activating the alarm sounds manually, in parallel with any automated train detection equipment that may be provided. In the case of alarms at level crossings, the

alarm of the present invention may be activated by the level crossing itself in the case of automatic barrier level crossings, or, with similar effect, the alarm of the present invention could be triggered by the same systems used to activate current level crossing audible alarms, flashing lights and barriers.

[0027] Trackside use of highly directional alarm outputs such as described above may be found useful in deterring trespassers at level crossings and elsewhere.

[0028] An embodiment of the present invention may simply provide a railway level crossing warning device comprising an alarm system according to any preceding claim, arranged at a railway level crossing, such that the directional alarm output device is positioned to warn level crossing user(s) of an approaching train.

[0029] An embodiment of the invention is illustrated in Fig. 1. A level crossing 10 is equipped with a number of directional horn devices 12, 14, 16, 18, 20 arranged to provide directional sound to cover respective target areas 22, 24, 26, 28, 30. Such directional horn devices are known in themselves, examples being known as LRAD - Long-Range Acoustic Devices, as may be obtained for example from Genasys Corp. www.genasys.com. Parametric devices may be used as an alternative.

[0030] Directional horn device 20 operates in conjunction with a CCTV camera 32. A remote operator, or an artificial intelligence function, may receive images from the CCTV camera 32, and may detect the presence of persons in a position of danger, such as between barriers 36 and train tracks 38, 40, or attempting to walk around a barrier 36. In response to the detection of a person in a position of danger, the remote operator or the artificial intelligence function may direct the associated directional horn device 20 towards the detected person and direct a directional alarm sound towards that person. The alarm sound may be a siren sound or similar, or may be a spoken warning or instruction. Such spoken warning or instruction may be pre-recorded, or may be provided by a remote operator speaking into an associated microphone. One important use of being able to generate spoken words is to be able to provide instructions, as well as a warning. In an alternative embodiment, the present invention provides an alarm system that comprises not only the directional alarm output device but also a directional speaker adapted to generate spoken instructions. For example, when a person is detected in a position of danger, in addition to the "wall of sound" approach the directional speaker or the directional horn device 12, 14, 16, 18, if a directional speaker 12a, 14a, 16a, 18a is not present, can be used to initiate a conversation with the person. For example, in locations, such as level crossings or railway stations where there is a risk of a person committing suicide, the directional speaker or directional horn device may link to an organisation such as the Samaritans, or to a suicide helpline. In addition, station and signalling staff may speak to a person via the directional speaker or directional horn device without putting themselves into danger. This is illustrated further in Fig. 2 described below. In this embodiment, directional horn devices 16, 18 are located on a first side of a road 39, and may be used to warn of trains approaching the level crossing 10 in a corresponding first direction 42. Similarly, directional horn devices 12, 14 are located on a second side of the road 39, opposite to the first side, and these directional horn devices 12, 14 may be used to warn of trains approaching the level crossing 10 in a corresponding second direction 44, opposite to the first direction 42.

[0031] Fig. 2 schematically represents a railway level crossing equipped with an alarm system according to the present invention. Like numerals in Fig. 2 represent like features as in Fig. 1. In Fig. 2 each of the directional horn devices 12, 14, 16, 18 may be provided with a directional speaker 12a, 14a, 16a, 18a, such that each directional speaker is outside the target area of the level crossing 10. This arrangement causes a person to avoid the wall of sound created by the overlapping directional outputs and to be able to stand in a place of safety to speak with someone. In the situation shown in Fig. 2 where the directional speakers 12a, 14a, 16a, 18a are used to give a spoken warning, these may be directed into the target area or outside the target area. Typically for suicide prevention, the directional speakers 12a, 14a, 16a, 18a are directed outside of the target area or at the boundary of the target area. There is also the potential to use a directional speaker mounted and able to pivot (such as 20 on base 32 which is able to rotate and contains microphone and camera), allowing controller or artificial intelligence to "home" in on an individual and start a discussion, give commands or instructions.

[0032] In the illustrated example, a first train 50 is approaching the level crossing 10 in the first direction 42, while a second train 52 is approaching the level crossing 10 in the second direction 44.

[0033] Train 52 is shown as passing a whistle board 54. As mentioned elsewhere herein, a train driver must sound the train's audible warning device - horn - as the train 52 passes the whistle board 54. In the illustrated situation, there is no line-of-sight between the train 52 and the level crossing 10 at this point, due to a curve 56 in the track, and nearby vegetation 58. Conventionally, the sounding of the train horn as the train passes the whistle board 54 was regarded as sufficient warning of the train's approach to the level crossing 10. However, as discussed above, the recent restrictions on the loudness of train horns means that such a warning may no longer be effective. Moving the whistle board 54 nearer to level crossing 10 may result in the train horn being more audible at the level crossing, but the time taken for the train to reach the level crossing 10 after sounding its horn would be unacceptably short. In the position shown, train 52 activates the directional horn devices 12, 14 at level crossing 10, to warn anyone within the target areas 22, 24 of the approach of the train. As shown, and preferably, the positioning of the directional horn devices 12, 14 provide an indication of the direction of the train's approach. In an embodiment, a treadle device 60 may be

provided, which is activated by the passage of train 52 to activate the directional horn devices 12, 14. Other means for deducing the location of a train, known in themselves, may be used instead. Examples include GPS locations sent by a train control system, magnetic interference as detected by a trackside device, dead reckoning from a previous known location.

[0034] The directional horn devices 12, 14 may emit a siren sound, some other alarm sound, or a spoken command which may be heard within the target area 22, 24, but which is practically inaudible outside of those areas, due to the directional nature of the horns or speakers used for the directional horn devices 12, 14. In some embodiments, the target areas 22, 24 may extend over the tracks 38, 40, to provide an alarm to anyone who may be anywhere between the barriers 36. In order to prevent any type of access into the target area 22, 24, the directional horn devices 12, 14 16, 18 and directional speakers 12a, 14a, 16a, 18a of Fig. 2, may direct sound at the boundary of the target area 22, 24, such that this boundary is not crossed.

[0035] In a preferred embodiment, the loudness of the sound or the intensity of any other type of directional output provided by the alarm system of the present invention increases as the train gets closer to the level crossing 10. In Fig. 1, a train 50 is seen approaching level crossing 10 from the first direction 42. At the instant illustrated, train 50 is closer to the level crossing than train 52 is. The loudness or other intensity of the output from directional horn devices 16, 18 will, in such embodiments, be greater than the loudness or other intensity of the output from directional horn devices 12, 14. This is schematically represented by a larger projection 161, 181 of output from directional horn devices 16, 18, than corresponding projection 121, 141 of output from directional horn devices 12, 14.

[0036] In the illustrated embodiment, an alarm sound or other alarm output(s) will be perceptible in the target area 22, 24, 26, 28 from the second direction 44, indicating the approach of train 52, as yet not in view of a level crossing user, while simultaneously a more intense alarm sound or other output(s) will be perceptible in the target areas 22, 24, 26, 28 from the first direction 42, indicating the approach and imminent arrival of train 50. Once train 50 has passed the level crossing 10, the outputs from directional horn devices 16, 18 will cease, while outputs from directional horn devices 12, 14 will increase until train 52 has passed the level crossing 10.

[0037] In this way, preferred embodiments of the invention provide warnings of multiple train arrivals, and provide indication of the direction of approach of a train, with the increasing intensity of the alarm output indicating the approach of the corresponding train.

[0038] A CCTV unit 32 may be provided to detect trespassers. Directional horn device 20 is illustrated and is associated with the CCTV unit 32. The CCTV unit 32 and the associated directional horn device 20 may be operated by a remote human operator, or by an artificial intelligence function to direct an output 30 of directed sound, light, and/or air current, at trespassers to encourage them to move away from the tracks 38, 40. Detection may be automated or driven by a remote human user. Detection may involve image recognition on visible or infra-red image data collected by the CCTV unit 32. Alternatively, or in addition, radar may be used to detect persons or vehicles in a target area or nearby.

[0039] Embodiments of the alarm of the present invention located at automatic-barrier level crossings may be operated in response to the same methods used to activate the level crossing in response to the approach of a train: treadles, control signals in response to train location messages, human intervention by a signaller. In other embodiments, the level crossing may be user-operated, in which case a train detection arrangement will have to be provided to enable operation of the alarm of the present invention. Alarm systems of the present invention at user-operated level crossings may be active whenever a train is deemed to be approaching; or whenever a person or animal is detected nearby; or continuously, as the sound, light or air current outputs of the alarm of the present invention are sufficiently directional that they do not disturb persons nearby that are not in the target area.

[0040] In cases where an alarm output is produced in response to the detection of a person in a target area, or approaching the tracks 30, 40, an alarm output may be generated such that the intensity of the alarm output increases with increasing proximity of the person to the tracks. Filtering of detection may be used to adapt the alarm output according to whether the detected trespasser is a human trespasser, or is livestock or wildlife, such as cows, horses, deer.

[0041] In other embodiments of the present invention, highly directional alarm output devices, such as horns or speakers, may be used to provide warnings to authorised persons on or near the track: for example, maintenance workers repairing a track even though trains may be running. Although the workers may be authorised to work within a predetermined area, the present invention may be used to deter the workers from straying outside of the predetermined area. Straying outside of the predetermined area may be considered "trespassing" in the sense of moving into an area which they do not have permission to occupy.

[0042] In an example embodiment, such as illustrated in Fig. 3, a system includes a number of highly directional sound emitters 20, 80, 82, 84, 86, 88, 90 such as the horns and speakers described above, along a section of tracks 38, 40. An authorised working area 70 has been defined, and alarm systems according to the present invention have been established to protect workers who are working within the authorised working area 70.

[0043] Workers on the track 38 are likely to be concentrating on the job in hand, and a loud audible warning is an effective way of gaining their attention. In such cases, a device according to the present invention may be

placed trackside, to provide highly focussed and therefore much louder warning signal than would otherwise be permissible. Such warning signal can be heard above the noise of heavy machinery which the workers may be using, without generating unacceptable levels of noise outside of the target area, being the authorised working area 70.

[0044] As discussed above, the conventional directional sound emitters proposed for use in the present invention are capable of emitting sound in a direction which is tightly controlled in azimuth and elevation dimensions but is not controlled in the distance over which the sound may travel. If such a sound emitter is directed horizontally, an emitted sound may travel significantly beyond the target area, in a straight line, if there is no provision made to restrict the distance over which the emitted sound may travel. For this reason, and in embodiments of the present invention, provision may be made to limit the distance over which the emitted sound may travel. For example, such provision may comprise directing the sound emitter at a slight downward angle, so that the emitted sound is absorbed or at least dispersed by a ground surface at a far side of a target area; or a sound absorbent surface such as a wall or billboard may be intentionally placed at a side of the target area distant from the sound emitter, so as to absorb or at least disperse the sound emitted after it has traversed the target area.

[0045] Automation of the activation of an alarm system according to the present invention, such as use of a treadle-like device that triggers a temporarily or permanently placed alarm would provide not only protection but also reassurance to workers trackside as the system could be tested with heavy machinery active. Alternatively, or in addition, a human look-out would activate the alarm system, and the look-out could be sure that their warning would be heard by the workers.

[0046] Fixed alarms 84, 86 of the present invention, providing a highly directional sound into a target area may be used to alert workers to the fact that they are entering or leaving an authorised working area 70. Highly directional alarm emitters 84, 86 may be constantly active, providing an alarm sound output to respective target areas, to alert workers to the fact that they are entering or leaving authorised working area 70.

[0047] Other fixed alarms 80, 82 may be provided to alert workers that they have strayed outside of the authorised working area and into a position of danger. highly directional alarm emitters 80, 82 may be constantly active, providing an alarm sound output to respective target areas, to alert workers to the fact that they are in an area of danger, being on or near tracks 40 without a relevant authorisation. Track 40 may continue to carry trains even while work is performed on track 38, so it is very important that workers do not stray onto live track 40.

[0048] Yet other fixed alarms 88, 90 may be provided, covering the authorised working area, to warn the workers of an approaching train. Such alarms may be activated in response to the detection of an approaching train, such as by operation of a remote treadle by the train, GPS positioning data received from the train, control signals related to track interlocks, or from direct observation by a human observer.

[0049] A human observer 72 may be stationed to look out for approaching trains and to activate a suitable warning from an alarm system according to the present invention when a train is observed to be approaching, or in case of any other danger to the workers.

[0050] In certain embodiments, using known long-range acoustic devices, alarms of the present invention may enhance the ability of a human lookout to warn trackside workers by allowing near instantaneous warning over distances of 3km or more and with a loudness far greater than existing solutions such as a horn as conventionally used by a look-out. The human look-out may orient an alarm output device of the present invention towards a person in or nearing a position of danger.

[0051] An intended route of a train may be set by a signaller, and intended arrival times of the train may be used to send appropriate timing data to the static highly directional sound emitters 12-20; 80-90 to enable them to generate a timely alarm signal to warn of an approaching train. As discussed above, some of these sound emitters may be constantly active, regardless of whether a train is approaching. Other possible arrangements to detect an approaching train include conventional arrangements such as axle counters, or signals from a control room in response to a track section showing as "occupied". Appropriate signals may be generated and sent to the respective highly directional sound emitters 12-20; 80-90, to enable them to generate a timely warning of the approach of a train.

[0052] In some embodiments, where a train is expected on a track 40, the described detection or indication of an approaching train enables alarm sounds to be generated only for target areas relevant to a specific track 40 along which the train will travel. Hence, persons adjacent to or even on other nearby tracks 38 which the train will not use will therefore not be alerted unnecessarily.

[0053] The highly directional sound emitters 12-20; 80-90 may be standalone units or may be built into existing trackside infrastructure such as axle counters or level crossing barrier machines.

[0054] The highly directional sound emitters 12-20; 80-90 may be provided with detectors to detect the presence of persons within the respective target area. Such detectors may comprise an infra-red sensor, for example. Optionally, the highly-directional sound emitters 12-20; 80-90 may be arranged to generate their alarm sound only if a person is detected to be present within the target area and a train is approaching. In some arrangements, such as where focussed sound emitters are provided to deter trespassers, an alarm sound may be generated within the associated target area whenever a person is detected to be within the target area, regardless of whether a train is approaching.

[0055] In some embodiments of worker protection alarm systems according to the present invention, a CCTV system 32 may be provided, as described with reference to the embodiment of Fig. 1, and may be provided with an associated highly directional horn, parametric device or speaker 20, directed into a corresponding target area 30. The CCTV system 32 may be used to monitor the authorised working area 70. Workers within the authorised working area 70 may be identified in image data collected by the CCTV system, either by a human operator, or by an artificial intelligence function. The highly directional horn, parametric device or speaker 20 may then be directed at the detected worker, or at detected workers in turn if there are several, to provide an appropriate warning. The order of addressing such warnings to workers may preferably be according to the respective worker's proximity to an area of danger.

[0056] Certain specific situations may particularly benefit from application of the present invention, for example: worker protection arrangements could benefit from additional effective warning time to find a position of safety at night and at complex junctions with multiple train movements like at depots or at otherwise unprotected areas such as sidings or at locations with limited clearance such as in tunnels.

[0057] The very loud alarm enabled by the present invention means that workers using heavy machinery would be alerted of the approaching danger, despite background noise from machinery and the use of ear defenders. Preferably, alarm sounds from an alarm system according to an embodiment of the present invention could start relatively quietly and increase in loudness as a train approaches. Increasing loudness of the alarm sound would indicate increasing likeliness of being struck by a train, as time passes, and the train continues to approach the target area.

[0058] The highly directional alarm output devices as considered by the present invention provide output of such intensity and such directionality that they are effective to warn persons over a long distance. The directionality of the alarm output devices also ensures that minimal disruption is imposed upon persons nearby, but who are not in a position of danger. The loudness of alarm sounds that may be generated by the highly directional alarm output devices considered in the present invention enable the alarm to be clearly heard, even by workers operating machinery and wearing ear defenders.

[0059] Preferably, the highly directional horns, parametric devices or speakers used in this embodiment of the invention provide an easily recognisable alarm signature that will only be heard when a worker is in danger, allowing workers to be trained to have a clear procedure to follow upon hearing it. This may be regarded as a significant improvement over conventional warning devices such as a portable horn, since such conventional alarm sounds may be generic and may be misunderstood due to multiple uses and lack of directionality. The directionality and signature of the alarm sounds generated according to the present invention ensure that persons in danger are informed of the direction and severity of a situation more immediately than compared to conventional omnidirectional alarms, which may allow for increased chances of reaching a position of safety.

[0060] Such a trackside warning and protection system may use existing systems such as interlockings or control centre information to determine when and where to sound alarms. The directional alarm output devices used minimise disruption to persons outside of the target area, such as rail or crossing users not in danger and local residents living beyond the railway boundaries.

[0061] Alarm systems provided by the present invention would be able to be significantly louder than conventional alarms, as perceived by persons within the target area, yet significantly quieter than conventional alarms, as perceived by persons outside of the target area. The loudness of the alarm sound within the target area may increase to a level which causes discomfort to a person in the target area, as may be necessary in order to persuade that person to leave the target area and move away from the railway.

[0062] Fine-tuning of the focus of the highly directional horns, parametric devices or speakers 20, 80-90 may be performed during an alarm system setup phase, to allow to further minimise disruption to persons outside of the target area when the alarm of the present invention sounds. It is anticipated that such measures will enable the alarm system of the invention to be employed even at night during the NTQP and even allow a full alarm volume to be used within the target areas, as the sound of the alarm of the present invention is restricted to the target areas.

[0063] In certain embodiments, multiple alarm emitters (horn, speaker etc.) may be provided, directed to a same target area to increase the effective loudness of the alarm sound within that target area.

[0064] The highly directional horns, parametric devices or speakers 12-20, 80-90 employed by the illustrated embodiment provide sharply-defined target areas with a very loud alarm or deterrent sound. Other alarm outputs such as air currents, directed light, may be provided in addition to, or instead of, the described sound outputs in any of the described embodiments. As described above, a sound output may be sharply defined in azimuth and elevation directions, but not sharply defined in distance. Therefore, suitable arrangements may be provided to limit the distance over which an audible alarm output may travel. This may be by directing the emitted sounds at a downward angle, so that it is absorbed or dispersed after crossing the target area, or a sound absorbent or dispersive surface may be intentionally provided, at a far side of a target area, opposite the relevant highly directional horn, parametric devices or speaker, to absorb or at least disperse the highly directional sound once it has traversed the target area.

[0065] The alarm sound in the target area may be described as a "wall of sound", providing unpleasant con-

ditions for anyone in the target area, thereby deterring anyone from getting near to the tracks 38, 40 or approaching the barriers 36, for example a person intending to vault them or to walk around them, or leaving an authorised working area 70. This "wall of sound" is possible as the directionality of the sound emitted by each of the highly directional horns, parametric devices or speakers means that a sharp drop-off of sound occurs at the edge of each respective target area. Appropriate alignment of such target areas with the barriers 36 or the authorised working area 70 will allow the "wall of sound" to be created.

[0066] An optional feature of the alarm system of the invention reacts to the directional horn, parametric device or speaker, or other directional alarm output device being re-directed by an unauthorised person. For example, as a result of accidental damage, or an act of vandalism, an unauthorised person may interfere with a horn or speaker and re-orient it to emit sound away from the target area. Similar unauthorised interference may occur for other types of alarm emitter, such as light or air current sources. As a failsafe measure, the installed positioning of the alarm output device can be stored, for example in a memory carried within a casing of the alarm output device, along with position sensors. If deviation is found between a later-measured position and a stored position - for example, a change in angle relative to the x, y, z axes, or a change in GPS position, then the alarm output generation is inactivated for that alarm output device to avoid emitting loud sounds, or directed light, air current or other outputs outside of the target area. This would protect workers in positions of safety and persons nearby but not in a position of danger from being affected adversely by an alarm activation.

[0067] Trespass deterrent systems using the alarm system of the present invention may be placed at incident hotspots where repeated or simply previous incidents have occurred. These locations can thereby be protected in a specific manner befitting the causes of the previous incident and in a way that does not cause annoyance to persons nearby who are not in a position of danger, particularly at night. Trespasser deterrence may be activated using presence sensors such as infra-red detectors, such that the alarm of the present invention is sounded whenever a person is detected within the target area; alternatively, the alarm may be sounded whenever a train is known or predicted to be approaching; alternatively, the alarm may be sounded only when a person is detected within the target area and a train is known or predicted to be approaching. Such a trespasser deterrent systems resemble the level crossing deterrent alarm systems of the present invention, except that the level crossing deterrent alarm systems are typically activated whenever a train is approaching, while the trespasser deterrence system will more likely be activated in response to the detection of a person within the target area, or in response to the detection of a person within the target area while a train is approaching. Some trespasser deterrence alarms may be active constantly, as they provide little noise beyond the target area.

[0068] In some embodiments, several highly directional horns, parametric devices or speakers may be used, some with a more restricted directional output, to provide multiple "layers" of sound, increasing in loudness with increasing proximity to the tracks 38, 40 to deter trespassers from approaching the tracks, or to deter workers from straying outside of an authorised working area.

[0069] Equivalent arrangements to the "wall of sound" effect may be created with other means, for example with different media such as light, air currents or with different types of speakers. Vibration alerts may be also provided, by causing vibration of a nearby surface, which does not cause sufficient acoustic noise to disturb persons nearby but not in a position of danger. References herein to horns, speakers, sound generators of any kind may be replaced within the scope of the present invention by directional output devices of other types, such as generators of directional light, air currents, mechanical vibrations.

[0070] Preferably, the alarms as provided by the present invention are sufficiently directional that they are permitted for use during the Night Time Quiet Period.

[0071] The directional warnings generated according to the present invention reduce disturbance to persons nearby but not in danger, and allow for greater loudness of warnings, and targeted warnings directed at specific individuals in positions of danger.

[0072] While the present invention is described with reference to railways and trains, it could be applied to other vehicles and other situations, such as dispersal of persons, birds or animals present on a landing strip while an aircraft is approaching, dispersal of persons from other dangerous or sensitive areas.

[0073] The alarm systems of the invention may be solar powered, with battery power storage, in remote locations. When used with a powered level crossing of any description, the alarm system of the present invention may derive power from the same source used to power the level crossing.

[0074] Certain embodiments of the present invention may be linked to interlocking devices - for example, where there are points between a train's current location and an alarm system of the present invention, the state of the points may be taken into account by an interlocking system, so that an alarm system of the present invention is only activated if an approaching train is directed by the points on to the corresponding section of track.

[0075] In certain embodiments, such as trespasser prevention arrangements, a louder sound may be projected to be heard by persons of height 1.2m - 2.1m than for persons below 1.2m in height.

[0076] The target areas described could cover the tracks 38, 40, to repel trespassers who have reached the tracks. The directionality of the alarm output means that passengers on nearby or passing trains need not be affected by the alarm system of the present invention, even

if the target area covers tracks on which their train is travelling.

[0077] The target area described in any of the embodiments referenced herein may in fact be regarded as a target volume, with the output of the alarm system of the invention being directed to fill a volume extending from a floor level of the target area up to head height, for example two metres above ground level.

Claims

1. An alarm system for deterring unauthorised access to a target area of a railway, comprising a directional alarm output device arranged to direct an alarm output into the target area, or at the boundary of the target area, and to direct no alarm output outside of the target area or away from the boundary of the target area, wherein the directional alarm output comprises a sound generator arranged to generate spoken instructions or warning.

2. An alarm system as claimed in claim 1, wherein the sound generator is a directional horn device or parametric device, and wherein the alarm system further comprises a directional speaker arranged to generate the spoken instructions or warning.

3. An alarm system as claimed in claim 2, wherein the directional speaker is arranged to generate spoken instructions or warning into the target area, at the boundary of the target area or outside the target area.

4. An alarm system as claimed in claim 2 or 3, wherein the directional speaker comprises a microphone to enable two-way communication.

5. An alarm system according to any preceding claim, further comprising a sensor for detecting the presence of a person, and for generating a directional alarm output into the target area in response to the detection of a person within the target area.

6. An alarm system according to claim 5, wherein a steerable alarm output device (20) is provided in association with the sensor (32) whereby a directional alarm output (30) may be directed at a detected person, the target area associated with the steerable alarm output device (20) being defined according to a direction in which the steerable alarm output device (20) is currently directed.

7. An alarm system according to claim 5 or claim 6, wherein the sensor is an image sensor.

8. An alarm system according to any preceding claim, wherein the directional alarm output device is provided with a means for detection of a change in position or a change in orientation of the directional alarm output device; and arranged to inactivate a directional alarm output device in response to a corresponding detection of a change in location or a change in orientation.

9. A railway level crossing warning device comprising an alarm system according to any preceding claim, arranged at a railway level crossing (10), such that the directional alarm output device is positioned to warn level crossing user(s) of an approaching train.

10. A trespassing deterrent system for deterring trespassing onto railway lines comprising an alarm system according to any preceding claim.

11. A trespassing deterrent system according to claim 10, located at a level crossing (10) and comprising two alarm systems (12, 14; 16, 18) according to any of claims 1-13, each arranged to direct an alarm output into a target area located between railway tracks (38, 40) and a respective level crossing barrier (36).

12. A trespassing deterrent system according to any of claims 10 or 11, wherein directional alarm output devices (12, 14, 16, 18) are arranged and activated to indicate a direction of approach of an approaching train.

13. A trespassing deterrent system according to claim 12 wherein the alarm output devices generate an alarm output which increases with proximity of an approaching train, or which increases with proximity to the railway lines.

14. A trespassing deterrent system according to claim 10, wherein the alarm systems are arranged to be activated by a human look-out in response to an observation of an approaching train by the human look-out.

FIG 1

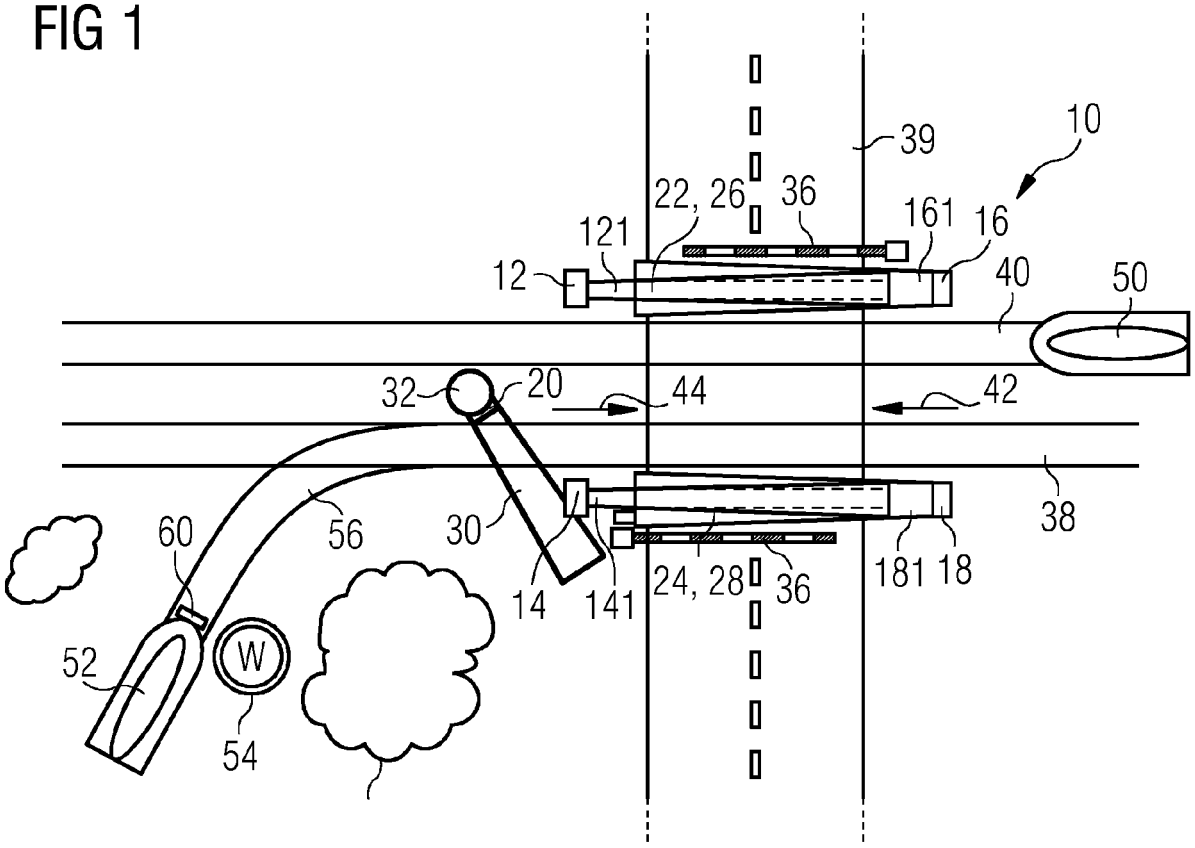
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FIG 2

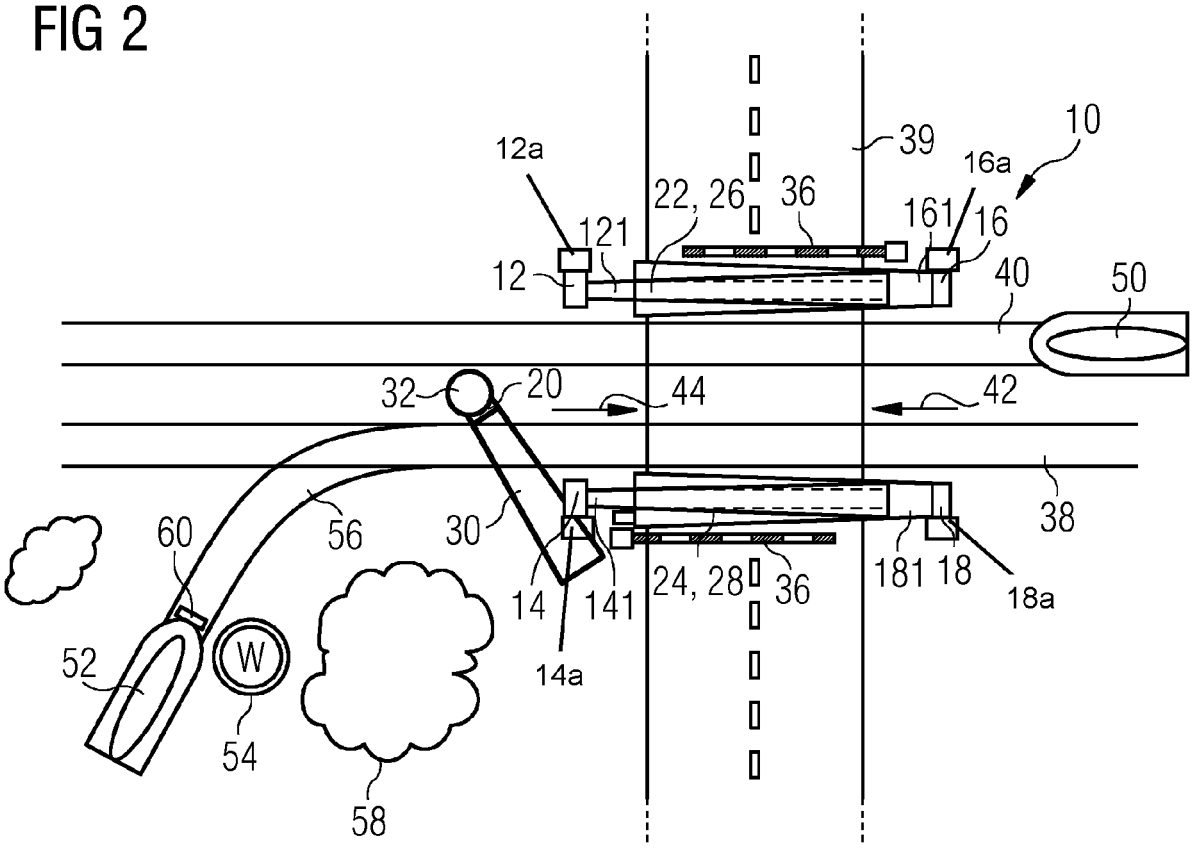
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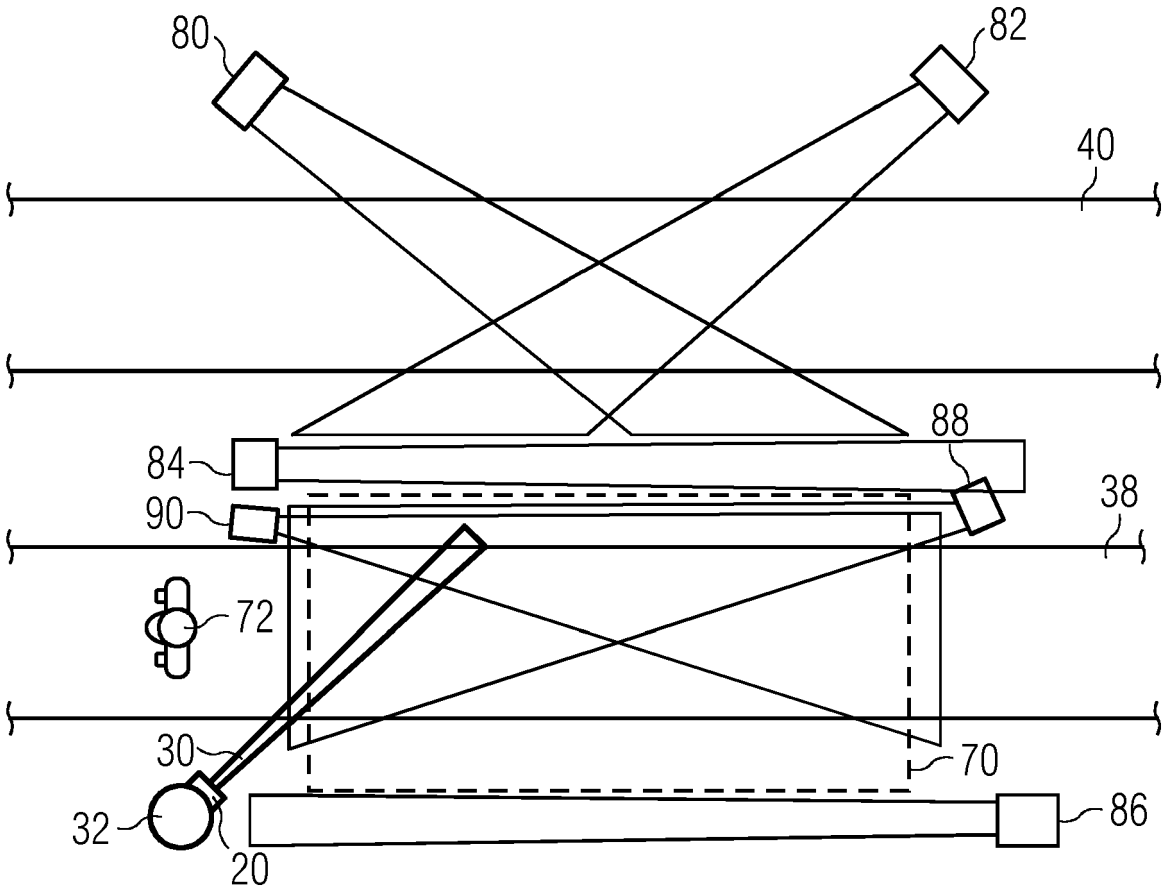
FIG 3



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EUROPEAN SEARCH REPORT

Application Number
EP 22 19 1656

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 January 2023	Robinson, Victoria

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