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(72) Inventors:
• **Van der Schrieck, Maarten Pim**
2106 EH HEEMSTEDE (NL)
• **Kranenburg, Wichert Jan**
2582 XL THE HAGUE (NL)

(74) Representative: **Arnold & Siedsma**
Bezuidenhoutseweg 57
2594 AC The Hague (NL)

(71) Applicant: **BUILD CONNECTED B.V.**
2582 XL The Hague (NL)

(54) **METHOD AND DEVICE FOR DETERMINING A DIRECTION OF MOTION OF A WHEEL OF A PASSING TRAIN ON A RAIL TRACK**

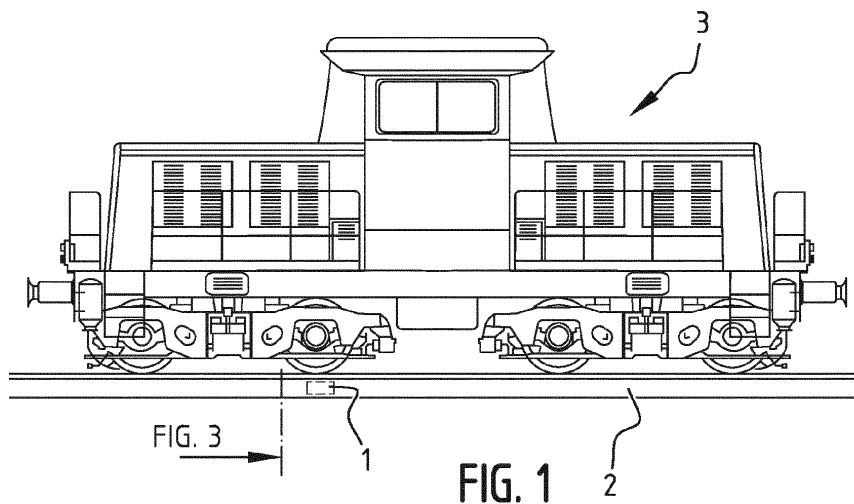
(57) Method for determining a direction of motion of a wheel of a passing train on a rail track, the method comprising:

- sensing, in at least a first and a second direction different from the first direction, a change in a magnetic field value caused by stress exerted on the rail via the wheel of the passing train, wherein the magnetic field value is indicative for a change in a flux density of a magnetic field originating from the rail track, wherein the sensing comprises
- obtaining a first signal associated with the wheel com-

prising a first plurality of the magnetic field values for the first direction for respective times from the magnetic field sensor, and

- obtaining a second signal associated with the wheel comprising a second plurality of the magnetic field values for the second direction for respective times from the magnetic field sensor; and

- determining the direction of motion of the passing wheel on the basis of the obtained first signal and second signal.



Description

[0001] The present patent disclosure concerns a method and device for determining a direction of motion of a wheel of a passing train on a rail track.

[0002] In many applications concerning rail tracks, such as in rail transport with trains, it is beneficial to obtain information on the whereabouts of train vehicles. Many marshalling yards, especially those without electrified systems, lack safety systems.

[0003] Detection of wheels on a rail track using e.g. a Hall effect device is shown for instance in US 4,524,932 A. Here the Hall effect device is to be placed in a pole-to-pole hole drilled through a permanent magnet to create a magnetic flux null in order to avoid saturating the Hall element. The detector is configured to detect the passing of railroad car wheels along the track by the change in the flux level from the permanent magnet. With this single apparatus, it is impossible to detect in which direction a passing train is going.

[0004] Patent documents US 2007/0001059 A1 and WO 2017/045888 A1 are examples of where multiple sensors are used to determine a direction and speed of train vehicles.

[0005] WO2021/004800 in the name of the current applicant concerns a device for detecting a wheel on a rail track, wherein a motion direction of the wheel is determined based on the detection of the influence on the magnetic field generated by magnets by a passing train wheel. In order to detect this influence on the magnetic field, the permanent magnets in the device are held at a position at the inner side of the rail track and near the head of the rail track such that the rim of a train wheel passes near the permanent magnets of the device.

[0006] It is an object among objects of the present patent disclosure to improve the detection of a direction of motion of train wheels on a rail track.

[0007] This object, amongst other objects, is met by a method according to claim 1. More specifically, this is met by a method for determining a direction of motion of a wheel of a passing train on a rail track, the method comprising:

- sensing, in at least a first and a second direction different from the first direction, a change in a magnetic field value caused by stress exerted on the rail via the wheel of the passing train, wherein the magnetic field value is indicative for a change in a flux density of a magnetic field originating from the rail track, wherein the sensing comprises
 - obtaining a first signal associated with the wheel comprising a first plurality of the magnetic field values for the first direction for respective times from the magnetic field sensor, and
 - obtaining a second signal associated with the wheel comprising a second plurality of the magnetic field values for the second direction for re-

spective times from the magnetic field sensor; and

- determining the direction of motion of the passing wheel on the basis of the obtained first signal and second signal.

[0008] When a train or other typically heavy rail vehicle passes by, a magnetic field is induced by the force introduced onto the rail, which is typically manufactured from a ferromagnetic material, e.g. steel. This effect is known as the Villari effect or the inverse magnetostrictive effect. This effect can be described as the change of the magnetic susceptibility of a material when subjected to a mechanical stress. By sensing, i.e. measuring, the change in magnetic field value caused by stress exerted on the rail via the wheel of the passing train, an accurate determination of the direction of motion of the passing wheel is made possible. At the same time, the location of sensing is less dependent on the relative position of the passing wheel, which relative position is more relevant if the influence of the motion of the wheel itself on the magnetic field is measured.

[0009] Typically, the rail track comprises two rails each having a head, a neck and a base, also referred to as a head, web or foot, respectively.

[0010] The current method relies on detecting any change in a magnetic field value caused by stress exerted on the rail via the wheel of the passing train. It was found that any such changes can be sensed reliably in the neck of the rail. The location of sensing, in particular the magnetic flux sensor, is thus less dependent on the location of any passing wheel, as opposed to a change due to the shunting effect of a passing wheel as disclosed in opposed referred to publication WO2021/004800. Preferably, the sensing is thus performed at the neck of the rail track. More preferably, the sensing is performed at a location closer to the base than to the head. Sensing can thus take place at a lower location, that is closer to the base than to the head. A reliable method is thus obtained, as by locating a device lower on the rail track, any such device is less likely to be damaged by a passing train or other equipment.

[0011] According to a preferred embodiment, the sensing comprises sensing at a location adjacent the neck, specifically for detecting the change in the magnetic field value in the neck caused by stress exerted on the rail via the wheel of the passing train. This allows a compact configuration of the device, while still allowing reliable measurement of the changes in the magnetic field value. Preferably, the method comprises sensing at a location directly adjacent the neck. More preferably, the sensor in a device is then located at, or at least near, the neck.

[0012] Preferably, the device, for instance a housing thereof, extends adjacently the neck of the rail. The sensor is then preferably located at a lateral location in said housing, such that said sensor, in coupled state of the device, extends at or near the neck. Any influence of dirt

or other changing environmental parameters between the device and the object to be measured, i.e. the neck, on the measured values is thus limited.

[0013] According to a further preferred embodiment, the sensing comprising sensing using a sensor at a lateral outside location on the rail track. Also in this location, any changes due to Villari effect can be measured reliably. This further reduces exposure of any device to passing trains or other equipment, while this also has advantages in terms of broadcasting range of any wireless transmitter as opposed to a location laterally inwardly on a rail, seen with respect to the other rail.

[0014] In general, the skilled person will understand, after reading the present disclosure, that the above aspect, embodiments and teachings of this disclosure can be applied to other fields outside of rail vehicles, wherein a direction of movement can be determined of an object moving on any longitudinal carrier onto which a load is applied by this object which influences the magnetic susceptibility of the carrier.

[0015] An advantage of relying on the changes due to the Villari effect is further that the range of influence is relatively large, for instance when compared to relying solely on the shunting effect of the wheel. As such, a more reliable determination is possible. According to a further preferred embodiment, the step of sensing thus comprises:

- a. sensing using a first sampling rate;
- b. determining, on the basis of the sensed magnetic field values sampled at the first sampling rate, whether a wheel is approaching and;
- c. following the detection of an approaching wheel, sensing using a second sampling rate which is higher than the first sampling rate,

wherein the determination of the direction of motion of the passing wheel is based on the sensed magnetic field values sampled at the second sampling rate.

[0016] During a rest state, the sampling rate can be kept relatively low, which saves power. When an approaching wheel is detected, for instance by registering a change in magnetic field values, the sampling rate is increased, which then allows an accurate determination of the direction of motion. Preferably, the first sampling rate is so low that determining a direction of motion from the sampled magnetic field values is not possible. The first sampling rate may for instance be in the range of 50 - 100 Hz, while the second sampling rate is preferably at least 2 times, more preferably at least 10 times higher than the first sampling rate. The second sampling rate is preferably between 300 - 600 Hz.

[0017] According to a preferred embodiment, the first and second direction are orthogonal with respect to each other. Preferably, the first direction is substantially horizontal and more preferably the first direction is at least substantially in the longitudinal direction of the rail track. The second direction is preferably also substantially hor-

izontal and more preferably extends lateral outwardly, preferably at least substantially perpendicular to the surface of the neck.

[0018] For determining the direction of motion, the first and second signals, each comprising a plurality of datapoints for the magnetic values over time, are analysed. By determining the direction of motion on the basis of a time dependent signal, as opposed to for instance a single measurement or a thresholding technique, an accurate determination of the direction of motion is made possible.

[0019] Additionally or alternatively, the first signal may be used to detect the presence of a wheel, while the second signal may be used to determine the direction of the wheel. This embodiment is particularly beneficial since the change in one of the sensing directions may be larger than the other.

[0020] It is preferred to analyse the second signal comprising a plurality of magnetic field values to determine the direction of motion of the wheel by estimating a peak position in the first signal comprising a plurality of magnetic field values, the peak position indicating a moment in time when the wheel is substantially above the device; determine a sign of a first derivative of the second signal near the estimated peak position; when the determined sign of the first derivative is positive, determining the direction of motion of the wheel to be in a first direction along the rail track; and when the determined sign of the first derivative is negative, determining the direction of motion of the wheel to be in a second direction along the rail track.

[0021] As mentioned, it is preferred to determine the direction using first and second signals, each representing changes in magnetic field values in two different, preferably orthogonal, directions.

[0022] It may however also be possible to sense only in one direction, and to obtain only a single signal on the basis of which the direction of motion is determined. In such an embodiment, a direction of motion of a wheel passing the device is obtained by comparing the plurality of magnetic field values in the signal with a base line magnetic field value sensed by the magnetic field sensor when no wheel is present to detect a relative increase and subsequent decrease, or a relative decrease and subsequent increase of the signal compared to the base line magnetic field value. The relative increase and decrease are preferably substantial, wherein substantial may for instance indicate that the relative increase and decrease are at least twice the noise level of the signal. That the relative increase and decrease are substantial may additionally or alternatively indicate that the relative increase and decrease are at least twice the combined value of sensor noise, remanent magnetic fields of the passing vehicle/wheels and disturbance of the earth magnetic field.

[0023] In another embodiment, the comparing comprises detecting whether at a first point in time one of the plurality of magnetic field values in the signal is larger

than the base line magnetic field value and at a second point in time after the first point in time another one of the plurality of magnetic field values in the signal is smaller than the base line magnetic field value in order to determine that the wheel passing the device has a first direction of motion; and detecting whether at a first point in time one of the plurality of magnetic field values in the signal is smaller than the base line magnetic field value and at a second point in time after the first point in time another one of the plurality of magnetic field values in the signal is larger than the base line magnetic field value in order to determine that the wheel passing the device has a second direction of motion different from the first direction of motion. This provides a robust way of determining the direction of motion.

[0024] In yet another embodiment, wherein the comparing comprises detecting whether a first difference between a first value of the plurality of magnetic field values in the signal and the base line magnetic field value is larger than a first threshold value above the base line magnetic field value or lower than a second threshold value below the base line magnetic field value; when the first difference is larger than the first threshold value, detecting whether a second difference between a second value of the plurality of magnetic field values in the signal and the base line magnetic field value is lower than a third threshold value, the second value corresponding to a later point in time than the first value, in order to determine that the wheel passing the device has a first direction of motion; and when the first difference is smaller than the second threshold value, detecting whether a second difference between a second value of the plurality of magnetic field values and the base line magnetic field value is larger than a fourth threshold value, the second value corresponding to a later point in time than the first value in order to determine that the wheel passing the device has a second direction of motion different from the first direction of motion. This embodiment provides an especially robust way of determining the direction of motion of the wheel passing the device on the basis of detection in one direction only.

[0025] The method is also suitable to more generally detect the presence of a wheel with a higher accuracy than in the prior art. It is not required to also measure the direction of motion of the passing wheel. Thus, according to another aspect, instead of analysing the signal obtained from the plurality of magnetic field values such that a direction of motion of a wheel passing the device is obtained, the plurality of magnetic field values may be analysed such that at least the presence of a wheel passing the device is obtained. It is also in general possible to measure, with an increased accuracy, the speed of the passing wheel by analysing the plurality of magnetic field values. It will be understood that the described (preferred) embodiments above and below concern embodiments of any of the possible aspects described herein.

[0026] According to a preferred embodiment, sensing is performed with a Hall effect sensor.

[0027] A preferred embodiment further comprises the step of applying a bias magnetic field to the rail track, in particular a neck of the rail track, using one or more magnets. The method then preferably comprises the step of magnetizing the neck of the rail track. This improves the reliability of the measurements, in particular increases the signal-to-noise ratio, and thus the determination of the direction of motion. Preferably, the pole direction is substantially directed towards a lateral side of the rail track.

[0028] To reduce power usage, the magnets preferably comprise permanent magnets. This requires less power, for instance compared to the use of coils, and allows the device to operate wirelessly over long times, in the order of at least one year up to even six or more years.

[0029] Preferably, the bias magnetic field is applied using a first and a second magnet, wherein the first magnet is oriented with a first pole orientation, wherein the second magnet is oriented with a second pole orientation, wherein the first and second pole orientation are preferably opposite each other. Preferably, the first pole direction is substantially directed towards a lateral side of the rail track. Preferably, the step of sensing comprises sensing at a location between the at least two magnets. A substantially uniform magnetic field is then preferably provided in the rail, at the location where the Villari effect occurs, specifically in the neck of the rail. The step of applying a bias magnetic field to the rail thus preferably comprises providing a substantially uniform magnetic field in at least a part of the neck of the rail, wherein the step of sensing preferably comprises sensing changes in said magnetic field caused by stress exerted on the rail.

[0030] Alternatively, the first and second magnets are positioned such that magnetic pole directions of the first and second magnets are substantially parallel.

[0031] According to a further aspect, a device is provided for determining a direction of motion of a wheel of a passing train on a rail track, which is arranged to perform the method as described above. Preferably, the device is configured to be placed on the rail track, the device comprising:

- a magnetic field sensor configured for sensing, in at least a first and a second direction different from the first direction, a change in a magnetic field value indicative for a change in a flux density of a magnetic field originating from the rail track caused by stress exerted on the rail via the wheel of the passing train; and
- at least one processor in communication with the magnetic field sensor, wherein the at least one processor is configured to:
 - obtain a first signal associated with the wheel comprising a first plurality of the magnetic field values for the first direction for respective times from the magnetic field sensor;

- obtain a second signal associated with the wheel comprising a second plurality of the magnetic field values for the second direction for respective times from magnetic field; and to
- determine the direction of motion of the passing wheel on the basis of the obtained first and second pluralities of magnetic field values such that a direction of motion of a wheel passing the device is obtained.

[0032] Preferably, the magnetic field sensor is a Hall effect sensor. In an embodiment, the magnetic field sensor is configured to sense the flux density or change in the flux density in a range of -50 to +50 gauss. The magnetic sensitivity of the magnetic field sensor is preferably smaller than 10 mgauss, more preferably smaller than 5 mgauss, for instance 1, 1.5 or 2 mgauss.

[0033] In an embodiment of any of the above aspects/embodiments, the device comprises a single magnetic field sensor. Especially in combination with two, preferably permanent, magnets as described above, the use of the single magnetic field sensor is beneficial as it reduces the number of electronic components and power consumption of the device, elongating the battery life time.

[0034] A preferred embodiment further comprises one or more magnets, preferably permanent magnets, for applying a bias magnetic field to a neck of the rail track, as described above. Preferably, the bias magnetic field is applied using a first and a second magnet, wherein the first magnet is oriented with a first pole orientation, wherein the second magnet is oriented with a second pole orientation, wherein the first and second pole orientation or opposite each other, wherein the first pole direction is substantially directed towards a lateral side of the rail track.

[0035] In an embodiment, the magnetic field provided by the at least one magnet is substantially larger (e.g. at least 2x or at least 10x larger) than the average magnetic field of Earth. Preferably, at the position of the magnetic field sensor, the at least one magnet provides a flux density of at least 1.5 gauss. It is preferred that the at least one magnets has a remanence of at least 5000 gauss, preferably at least 8000 gauss, more preferred at least 12000 gauss.

[0036] According to a preferred embodiment, the device comprises a housing having a connecting side wall for laterally coupling the device to the rail track, wherein the magnetic field sensor is located at, or at least near, the connecting side wall for sensing at a location adjacent, preferably directly adjacent, the neck for detecting the change in the magnetic field value in the neck caused by stress exerted on the rail via the wheel of the passing train.

[0037] According to a preferred embodiment, the device has a width, seen in a lateral direction of the rail track, which is smaller than 40 mm, preferably smaller than 25 mm. As such, the device preferably does not

extend, in the lateral direction, beyond the head of the respective rail.

[0038] In an embodiment of any of the above aspects/embodiments, the device comprises a network interface for transmitting the obtained direction of motion of the wheel, wherein preferably the network interface is a wireless network interface. The use of a wireless interface is especially beneficial since at many parts of a rail network it is often too costly to provide a network of power and communication lines. It is preferred that the wireless interface is configured to use a low power, long range network such as the LoRa network or a GSM network. A further benefit of the device is that no raw data has to be sent over the network; the device performs the analysis of the data internally with the processor. This allows for a limited amount of data to be transmitted, which also increases battery lifetime.

[0039] In a further embodiment, the device comprises energy storage means for providing electric power to the device. Also, portable energy providing means such as a solar cell may be provided.

[0040] According to a further aspect, a rail track is provided with a device as described above.

[0041] The accompanying drawings are used to illustrate presently preferred non-limiting exemplary embodiments of the method and device of the present disclosure. The above and other advantages of the features and objects of the disclosure will become more apparent and the aspects and embodiments will be better understood from the following detailed description when read in conjunction with the accompanying drawings, in which:

- Fig. 1 is a schematic side view of an embodiment of the device according to the present disclosure positioned on a lateral side of a rail carrying a rail vehicle;
- Fig. 2 is a schematic view in perspective of an embodiment of the device according to the present disclosure;
- Fig. 3 is a side and partial section view in a longitudinal direction of the rail as indicated in Fig. 1;
- Figs. 4 and 5 show plots of the measured magnetic field flux density as a function of time and in three directions for a train moving forward and backward, respectively;
- Fig. 6 is a scheme of a part of the device housing electronics according to an embodiment of the present disclosure; and

[0042] As shown in Fig. 1, a device 1 for detecting a direction of motion of a wheel on a rail track is placed on an outer lateral side of a rail 2 over which a locomotive 3 is passing. The locomotive 3 is an example of a rail vehicle. The direction of motion of the locomotive 3 (and thus its wheels) in these figures is indicated as forward when the locomotive is moving from the right towards the left, and backward when the locomotive 3 is moving towards the right.

[0043] With reference to figure 3, a rail track comprises

two rails 2 each having a head 21, a neck 22 and a base 23, also referred to as a head 21, web 22 or foot 23, respectively. The device 1 is configured to be placed on or near a lateral side 22a of the rail track 2, in particular on the neck 22 thereof. The device 1 comprises in this embodiment a first magnet 12 and a second magnet 14 (see Fig. 2). These magnets 12 and 14 are for providing a magnetic field on the one hand and for connecting the device 1 to the rail 2 on the other hand. The pole directions of the magnets 12 and 14 are substantially directed towards, i.e. perpendicular to, the lateral side 22a of the rail 2. The orientation of the poles of the magnets 12 and 14 are anti-parallel in this example, as indicated in figure 2. The magnets 12 and 14 are arranged to magnetize, i.e. provide a bias magnetic field to the rail track, in particular a neck 22 of the rail 2, in particular in a lower range thereof.

[0044] The device 1 further comprises a magnetic field sensor 18 for sensing a magnetic field value indicative for a flux density, or a change in the flux density, of the provided magnetic field. The sensor 18 is placed in housing 16, which contains the electronic parts of the device 1, preferably in a waterproof manner. The housing 16 has sidewalls 161a, b, of which sidewall 161a is arranged to connect or couple to the rail 2. The magnets 12, 14 may assist in coupling the device 1 to the rail 2.

[0045] The housing 16 further comprises top wall 162a, bottom wall 162b and end walls (not shown in figure 3). As shown in figure 3, the sensor 18 is located close, in this example adjacent the connecting side wall 161a, such that the sensor 18 extends adjacently the neck 22.

[0046] Locating the sensor 18 close to neck 22 allows an efficient measurement of any changes in a magnetic field value caused by stress (see arrow G) exerted on the rail 2 via the wheel 4 of the passing train. When a train 3 or other typically heavy rail vehicle passes by, a magnetic field is induced by the force introduced onto the rail 2. This effect is known as the Villari effect or the inverse magnetostrictive effect. The sensor 18 is arranged to measure any changes in three directions, generally in X, Y and Z direction.

[0047] By locating the sensor 18 close to the neck 22, a compact configuration in width (Z) direction is obtained. The width of the housing 16 is smaller than 25 mm, such that the housing 16 does not protrude, in the width direction, from the width of the head 21 (see line B).

[0048] Furthermore, the Villari effect can also be measured efficiently in the bottom region of the neck 22. The device 1 can thus be placed relatively low on the rail 2. That is, the device 1 is located near base 23 of the rail 2, i.e. closer to the base 23 than to the head 21. The chance of any damage due to passing trains or other equipment is thus reduced.

[0049] It is further not required to measure below a flange 5 of a wheel 4. As such, the device 1 can be placed on an outer lateral side of a rail 2. This increases the range of the wireless interface 48 (see figure 6 and further below) of the device 1.

[0050] It is preferred that respective first and second pluralities of the magnetic field values are obtained for respective times from the magnetic field sensor 18 for each respective first and second sensing direction.

5 Thereafter, the obtained first plurality of magnetic field values are analysed by detecting whether the magnetic field values peaks above a threshold value indicating the presence of a wheel on the rail track passing the device. For example, the first plurality of magnetic field values is the "Bx" signal in Figs. 4 and 5, i.e. the signal measured in the X-direction which is substantially parallel to the longitudinal direction of the rail 2. The second sensing direction is in this example in the Z-direction, i.e. substantially perpendicular to the first direction X in the horizontal plane and substantially perpendicular to the surface 22a of the neck 22. The plurality of magnetic field values sensed in the second direction Z is the signal "Bz" in Figs. 4 and 5.

[0051] When presence of a wheel is detected in the first signal Bx, the second plurality of magnetic field values of the second signal Bz is analysed to determine the direction of motion of the wheel.

[0052] This analysis of the second plurality of magnetic field values of the second signal Bz to determine the direction of motion of the wheel may be done by estimating a peak position 76, 86 in the first plurality of magnetic field values (Bx), the peak position 76, 86 indicating a moment in time when the wheel 4 is substantially above the device 1. Thereafter, a sign of a first derivative of the second plurality of magnetic field values (Bz) near the estimated peak position 76, 86 is determined. When the determined sign of the first derivative is positive (situation of Fig. 5 as seen in signal Bz between the decrease 80 and the increase 82), the direction of motion of the wheel to be in a backward direction along the rail track is determined. When the determined sign of the first derivative is negative (situation of Fig. 4 as seen in signal Bz between the increase 70 and the decrease 72), the direction of motion of the wheel is determined to be in the forward direction along the rail track 2.

[0053] Although this is a resource efficient and practical way of determining the direction of motion, it will be apparent to the skilled person that various other ways of determining the increase/decrease or decrease/increase of the measured signal.

[0054] Figure 6 shows a schematic overview of the device 1. The device 1 further comprises at least one processor 40 in communication with the magnetic field sensor 18. In addition, the device 1 may comprise a battery 44, which is an example of power storage means, an acceleration sensor 42, which is an example of a motion sensor, and a wireless interface 48. Although the device 1 could alternatively or additionally comprise a wired interface, a wireless interface is preferred due to the ease of implementation. The wireless interface 48 preferably connects via a LoRa network or a GSM network. The device 1 in addition comprises a storage unit 46, configured to store instructions for the processor 40 to execute.

These instructions may take the form of firmware.

[0055] A person of skill in the art would readily recognize that steps of various above-described methods can be performed by programmed computers. Herein, some embodiments are also intended to cover program storage devices, e.g., digital data storage media, which are machine or computer readable and encode machine-executable or computer-executable programs of instructions, wherein said instructions perform some or all of the steps of said above-described methods. The program storage devices may be, e.g., digital memories, magnetic storage media such as a magnetic disks and magnetic tapes, hard drives, or optically readable digital data storage media. The embodiments are also intended to cover computers programmed to perform said steps of the above-described methods.

[0056] The functions of the various elements shown in the figures, including any functional blocks labelled as "units", "processors" or "modules", may be provided through the use of dedicated hardware as well as hardware capable of executing software such as firmware in association with appropriate software. When provided by a processor, the functions may be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which may be shared. Moreover, explicit use of the term "unit", "processor" or "controller" should not be construed to refer exclusively to hardware capable of executing software, and may implicitly include, without limitation, digital signal processor (DSP) hardware, network processor, application specific integrated circuit (ASIC), field programmable gate array (FPGA), read only memory (ROM) for storing software, random access memory (RAM), and non volatile storage. Other hardware, conventional and/or custom, may also be included. Similarly, any switches shown in the FIGS. are conceptual only. Their function may be carried out through the operation of program logic, through dedicated logic, through the interaction of program control and dedicated logic, or even manually, the particular technique being selectable by the implementer as more specifically understood from the context.

[0057] It should be appreciated by those skilled in the art that any block diagrams herein represent conceptual views of illustrative circuitry embodying the principles of the invention. Similarly, it will be appreciated that any flow charts, flow diagrams, state transition diagrams, pseudo code, and the like represent various processes which may be substantially represented in computer readable medium and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

Claims

1. Method for determining a direction of motion of a wheel of a passing train on a rail track, the method comprising:

- sensing, in at least a first and a second direction different from the first direction, a change in a magnetic field value caused by stress exerted on the rail via the wheel of the passing train, wherein the magnetic field value is indicative for a change in a flux density of a magnetic field originating from the rail track, wherein the sensing comprises

- obtaining a first signal associated with the wheel comprising a first plurality of the magnetic field values for the first direction for respective times from the magnetic field sensor, and

- obtaining a second signal associated with the wheel comprising a second plurality of the magnetic field values for the second direction for respective times from the magnetic field sensor; and

- determining the direction of motion of the passing wheel on the basis of the obtained first signal and second signal.

2. Method according to claim 1, wherein the rail track comprises a head, a neck and a base, wherein the sensing is performed at the neck of the rail track at a location closer to the base than to the head.

3. Method according to claim 1 or 2, wherein the rail track comprises a head, a neck and a base, wherein the sensing comprises sensing using a sensor at a location directly adjacent the neck for detecting the change in the magnetic field value in the neck caused by stress exerted on the rail via the wheel of the passing train.

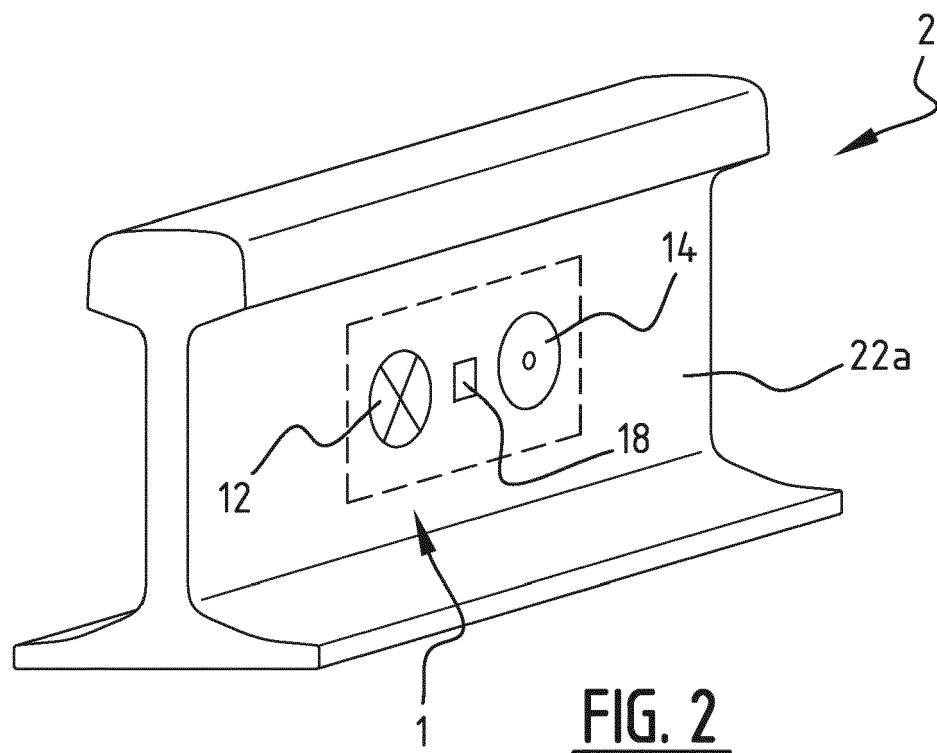
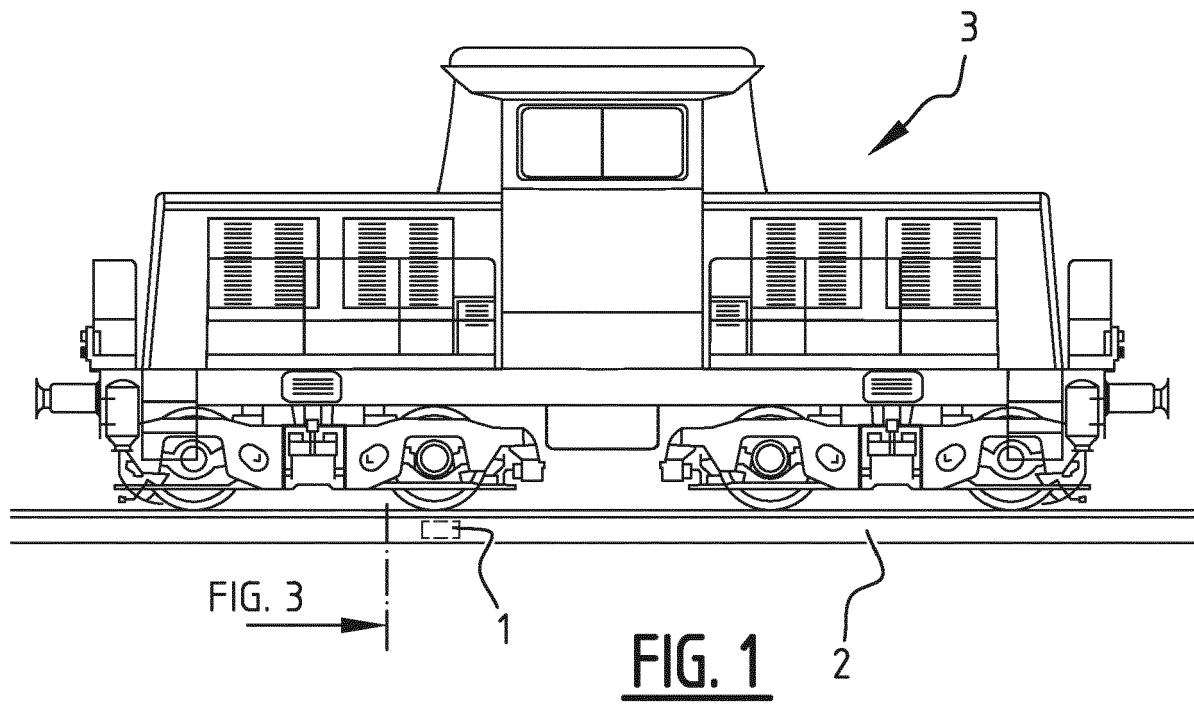
4. Method according to claim 1, 2 or 3, wherein the rail track comprises a head, a neck and a base, wherein the sensing comprises sensing using a sensor at a lateral outside location on the rail track.

5. Method according to any one of the preceding claims, wherein the step of sensing comprises:

- a. sensing using a first sampling rate;
- b. determining, on the basis of the sensed magnetic field values sampled at the first sampling rate, whether a wheel is approaching and;
- c. following the detection of an approaching wheel, sensing using a second sampling rate which is higher than the first sampling rate,

wherein the determination of the direction of motion of the passing wheel is based on the sensed magnetic field values sampled at the second sampling rate.

6. Method according to any one of the preceding claims, wherein the first and second direction are orthogonal with respect to each other.
7. Method according to any one of the preceding claims, further comprising the step of applying a bias magnetic field to the rail track, in particular a neck of the rail track, using one or more magnets, preferably permanent magnets.
8. Method according to claim 7, wherein the bias magnetic field is applied using a first and a second magnet, wherein the first magnet is oriented with a first pole orientation, wherein the second magnet is oriented with a second pole orientation, wherein the first and second pole orientation are opposite each other, wherein the first pole direction is substantially directed towards a lateral side of the rail track.
9. Device for determining a direction of motion of a wheel of a passing train on a rail track, the device being configured to be placed on the rail track, the device comprising:
- a magnetic field sensor configured for sensing, in at least a first and a second direction different from the first direction, a change in a magnetic field value indicative for a change in a flux density of a magnetic field originating from the rail track caused by stress exerted on the rail via the wheel of the passing train; and
 - at least one processor in communication with the magnetic field sensor, wherein the at least one processor is configured to:
 - obtain a first signal associated with the wheel comprising a first plurality of the magnetic field values for the first direction for respective times from the magnetic field sensor;
 - obtain a second signal associated with the wheel comprising a second plurality of the magnetic field values for the second direction for respective times from magnetic field; and to
 - determine the direction of motion of the passing wheel on the basis of the obtained first and second pluralities of magnetic field values such that a direction of motion of a wheel passing the device is obtained.
10. Device according to claim 9, wherein the magnetic field sensor is a Hall effect sensor.
11. Device according to any one of claims 9-10, further comprising one or more magnets, preferably permanent magnets, for applying a bias magnetic field to a neck of the rail track.
12. Device according to the previous claim, wherein the bias magnetic field is applied using a first and a second magnet, wherein the first magnet is oriented with a first pole orientation, wherein the second magnet is oriented with a second pole orientation, wherein the first and second pole orientation are opposite each other, wherein the first pole direction is substantially directed towards a lateral side of the rail track.
13. Device according to any of the preceding claims, wherein the device comprises a housing having a connecting side wall for laterally coupling the device to the rail track, wherein the magnetic field sensor is located at, or at least near, the connecting side wall for sensing at a location directly adjacent the neck for detecting the change in the magnetic field value in the neck caused by stress exerted on the rail via the wheel of the passing train.
14. Device according to any of the preceding claims, wherein the device has a width, seen in a lateral direction of the rail track, which is smaller than 25 mm.
15. Rail track provided with a device according to any of the preceding claims, wherein the rail track comprises a head, a neck and a base, wherein the magnetic field sensor extends adjacently the neck of the rail track at a location closer to the base than to the head, wherein the device is located at a lateral outside location on the rail track.



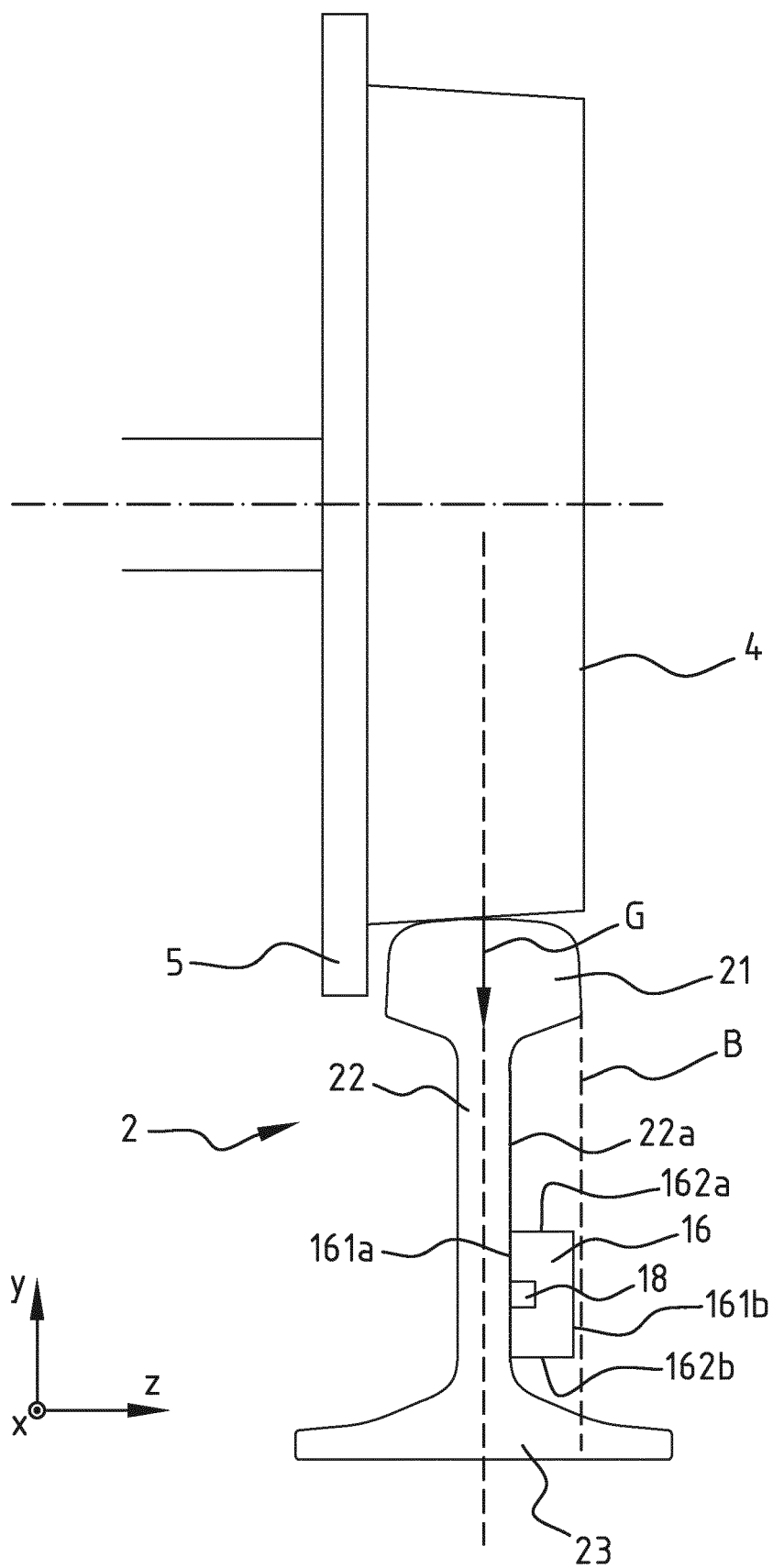


FIG. 3

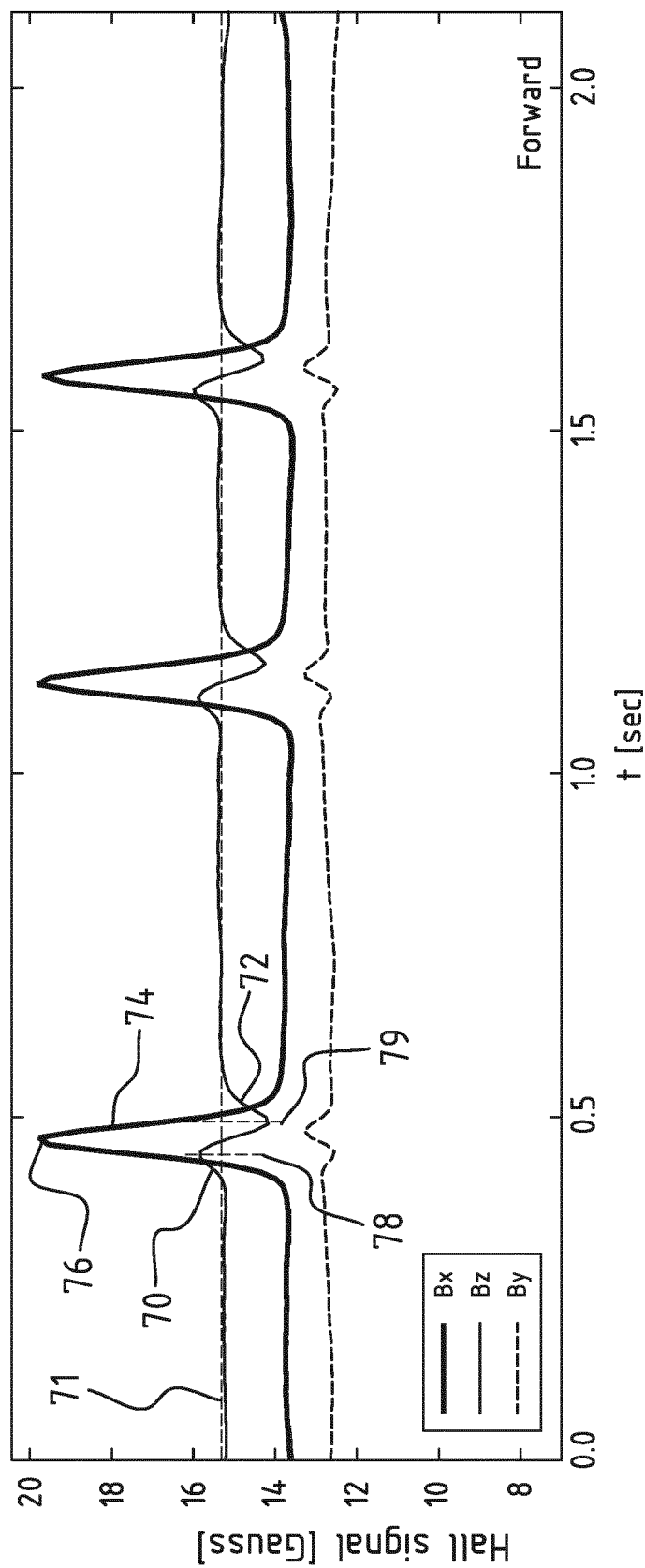


FIG. 4

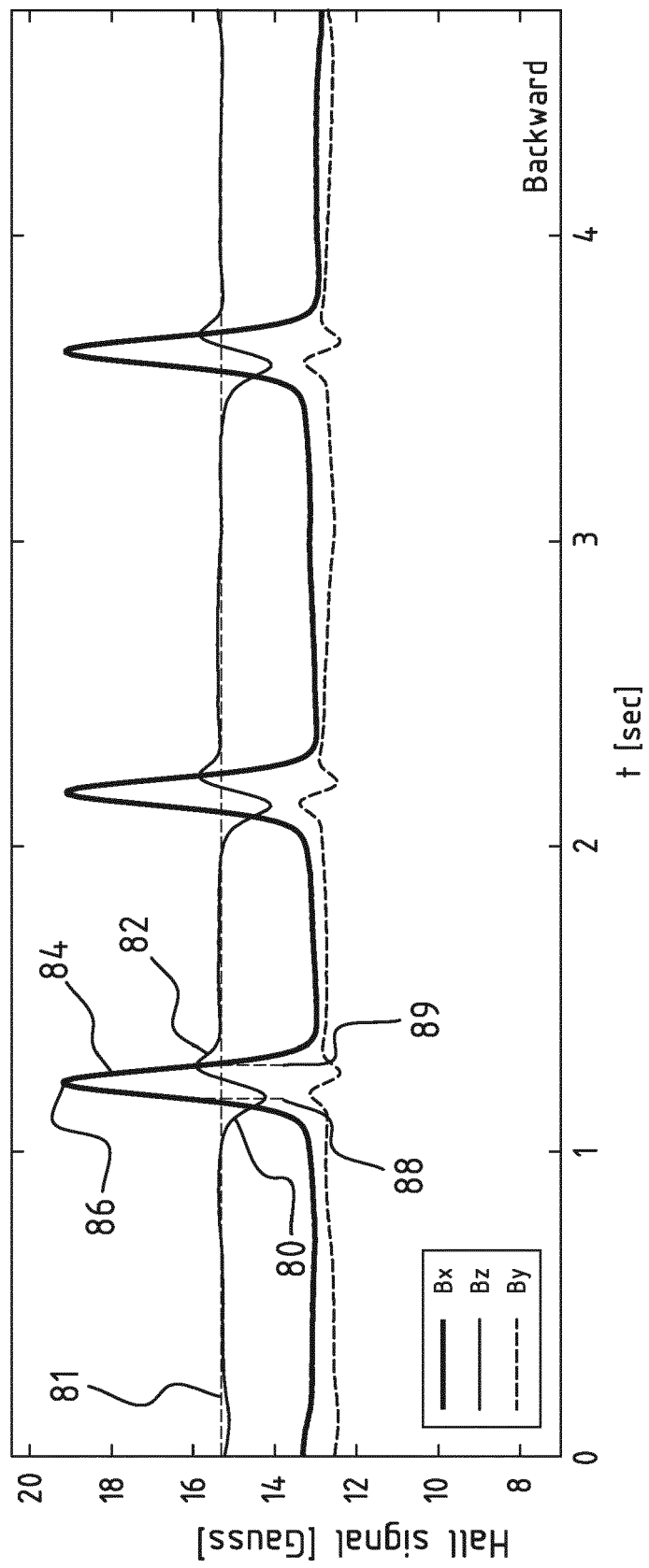
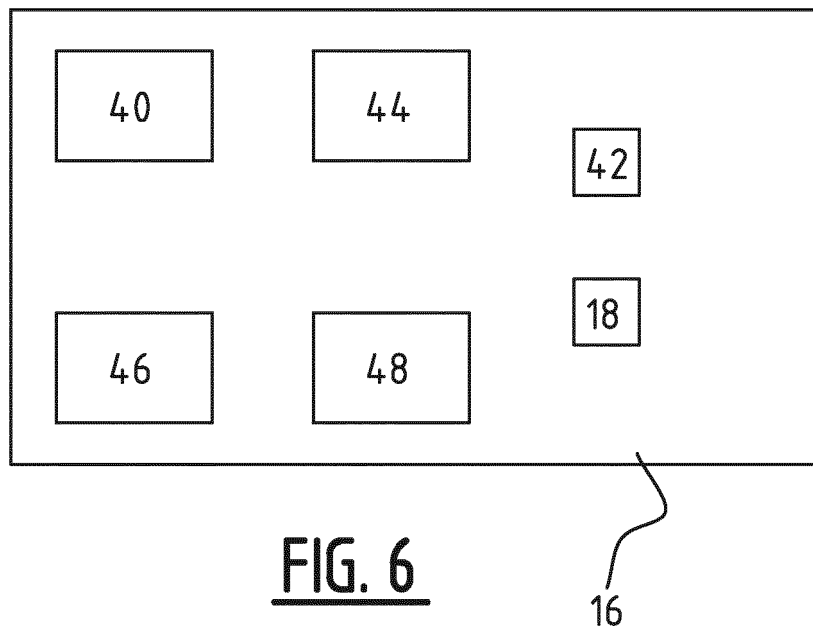


FIG. 5





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