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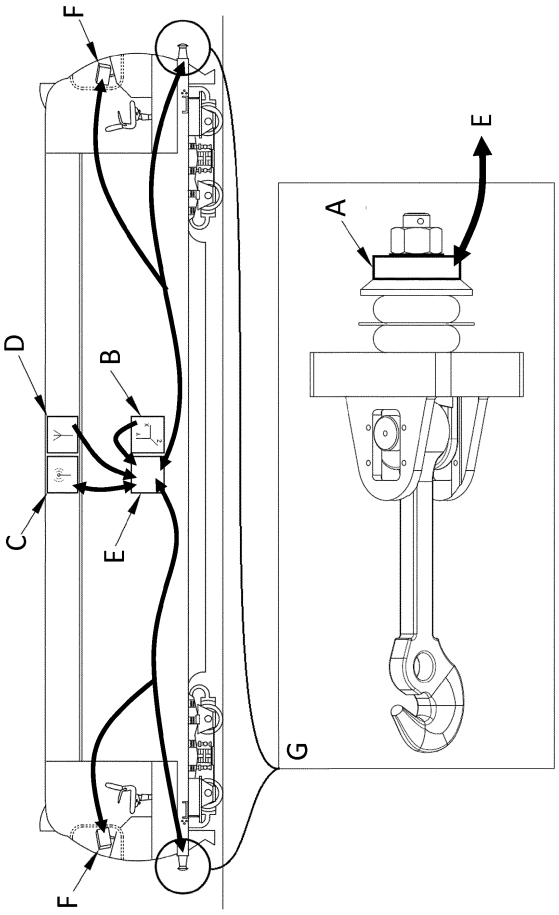
(54) AUTOMATIC DETECTION OF TRAIN DERAILMENT

(57) The invention has for object an automatic radio-electro-mechanical system for the detection of the derailment of one or more railway wagons towed by a locomotive, with an alarm signal in the cabin. The system involves the use of 2 electromechanical sensors (load cells) for detecting the tensile stress to the hook (one for each direction of travel of the locomotive), an accelerometer, a GPS module and a module that uses common GSM-R mobile telephone technology specific for railways (Global System for Mobile Communications - Railways). The electro-mechanical sensors are constituted by load cells of the type to bending, tension, or cut, equipped with strain gauges installed preferably according to the electrical diagram of a double full Wheatstone bridge in order to detect the stress at the locomotive traction hook. In the preferred embodiment, the accelerometer detects at least the acceleration on three axes. In the preferred embodiment, the GPS module detects the data according to the NMEA 0183 standard. In the preferred embodiment, the mobile phone module sends and receives data to and from remote via GSM-R commonly used by railways for air transmission and reception. The audio and visual alarm in the cabin is automatically launched by the software following the processing of the data related to the abnormal driving or when a derailment occurs. The system involves the use of an HMI (human machine interface) for the installation and operation of the software.



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Description

State Of The Art

[0001] The train derailment is the phenomenon that occurs when one or more prebuilt wheelset transverse constraint formed by the flange of wheel and the rail head shall lose; such an event can cause extensive damage to vehicles, to railway infrastructure, in particular to the track equipment, to the electric traction and to the signaling installations.

[0002] Today, modern locomotives, equipped with automatic adjustments for the running, have available extremely high powers that allow them to tow heavy convoys thus preventing the driver to realize, in a timely manner, the enhanced tensile strength, due to one or more wagons astray; the phenomenon of the derailment is not limited to a few hundreds of meters of damaged infrastructure (the space needed to safely shutdown the convoy after the perception of the derailment) but also continues to kilometers before the driver has perception and intervene with rapid braking.

[0003] It must also be considered the risk related to the prolongation of the derailment of a wagon progressing inadequately that increases the seriousness of the risk linked to the welfare of the people, the surroundings, and to rail traffic in general.

[0004] The idea of being able to quickly assess whether a cart is derailed is not new; already in the past years several systems have been studied to assess in real time the conditions of derailment of a train.

[0005] Among these, the most known is the detection of derailment through the pneumatic system of a railway vehicle said "EDT 101" of the German company KNOOR-BREMSE of Monaco; however, to date we are still not fully used to it for the need of having to install on all freight wagons these systems and this represents a major obstacle to their use, given the high number of wagons currently circulating in Italy and in Europe.

[0006] Furthermore, it is also known from document US 2008/195265 A1 a system to assess the train integrity, which comprises two or more bogie units that monitor critical parameters relating to the condition of bogie components and the rail track they are travelling on. In more detail, the bogie units monitor wheel and track factors by means of sensor installed on all carriages. The system of this document also allows monitoring compressive and tension stress in all wagon couplings along the entire length of the train, i.e., in the set of components of the American automatic hook of each wagon, by means of a simulation software.

[0007] In addition, an example of data transmission system by means of a dedicated technology specific for railways, i.e., Global System Communication - Railway (GSM-R) technology, is known from document AU 2014202937 A1.

Scope Of The Invention

[0008] Hence the idea of creating a system that does not need to be installed on all wagons, but simply on the locomotives only; in this way, it definitely solves the problem related to the number of vehicles to be equipped of instrumentation, since the number of locomotives is a small fraction of the total number of circulating railway vehicles; the system of the present invention can be used on all of the locomotives pulling hooks towing wagons cargo and/or passenger coaches.

[0009] The invention object of this application is composed of:

a) a load cell mounted to the hook of the locomotive to detect in a continuous manner the tensile stress,
b) an accelerometer able to recognize the different nature of the effort resulting from the derailment than the normal running condition specified on the route (acceleration, braking, uphill, downhill, curves),
c) a GPS module to geo-reference the convoy at the time of the derailment and calculate the speed of travel,
d) an appropriate software that evaluates with an HMI (human machine interface) if there are any anomalous tensile stresses due to the derailment of one or more wagons,
e) a module using GSM-R specific for railways (Global System for Mobile Communications - Railways) for the transmission of data remotely,
f) an audio and visual alarm in the cab for the driver.

[0010] In particular, the present invention relates to an automatic radio-electro-mechanical system for the detection of the derailment of one or more railway wagons towed by a locomotive, with an alarm signal in the cabin, comprising:

i) One load cell for each traction hook at the sole locomotive (A) for the measurement of the stresses within the traction hook,
ii) An accelerometer (B),
iii) A GPS module (C),
iv) A module that uses the GSM-R mobile telephone technology (D) specific for railways (Global System Communication - Railways) for the transmission of data remotely,
v) A HMI interface (F),
vi) Optical and acoustic alarm devices in the cabin.

[0011] The present invention also relates to said system, in which the measurement of traction stress takes place by means of load cells (A) provided with strain gauges installed in the cell preferably according to the wiring diagram of a double Wheatstone Bridge.

[0012] The present invention also relates to said system, in which the Wheatstone bridge is selected from one or more of whole Wheatstone Bridges, a half Wheatstone

bridge and a quarter of a Wheatstone bridge.

[0013] The present invention also relates to said system, wherein the strain gauges, are selected among the following types: traction and compression, bending, and cut.

[0014] The present invention also relates to said system that further comprises transmitting data from the sensors (i, ii, iii, iv) to the first processing apparatus (E), and the transmission from the first processing apparatus to the final processing apparatus (v) (F).

[0015] The present invention also relates to said system, in which the transmission of data from the first processing apparatus to the final processing of the apparatus preferably takes place by cable or by radio, preferably at a selected wavelength between micro wave, short wave, medium wave and long waves.

[0016] The present invention also relates to said system, wherein the first processing apparatus are amplifiers or conditioners of analog or digital signal and amplify the signal received from sensors.

[0017] The present invention also relates to said system, wherein the final processing apparatus running the dedicated software, that correlates the traction effort to the hook of the locomotive with the parameters detected by all the other sensors and verifies the condition of the train being misled, emitting, when necessary, a visual and acoustic alarm signal.

[0018] The objective to be achieved, with the invention of the present application, is that to warn the driver that the convoy is in abnormal running conditions or derailment, so as to minimize the damage to the convoy and to the infrastructure.

DETAILED DESCRITPION OF THE INVENTION

[0019] The invention object of the present application is a system composed by several electronic and electromechanics equipment belonging to three separate functional groups:

a) Measurement equipment (Fig. 1 and 2 - A - B - C - D),

b) Equipment of first processing and transmission of measurement data (Fig. 1 and 2 - E),

c) Equipment of final data processing and its registration with issuing of audible and visual alarm signal, at the recognition of the derailment with possible deployment in remote data (Fig. 1 and 2 - F).

[0020] Measurement equipment for the traction stress consists of an electro-mechanical sensor (traction, cut, or bend-type load cell - Fig. 1 and 2 - A) equipped of strain gauges, installed as an electrical scheme of a double Wheatstone bridge, or by half Wheatstone bridge or by a quarter of a Wheatstone bridge or by one or more complete Wheatstone bridge.

[0021] The apparatus for detection and measurement of the traction stress are preferably present in number of 2 units for each locomotive (one for each direction of travel).

[0022] The load cells (Fig. 1 and 2 - A) preferably will be mounted on the traction hook of the sole locomotive and they detect the value of the stress applied to the traction hook of the entire convoy.

[0023] The fastening of the load cell method is purely mechanical and is, preferably, for coupling along the traction rod (Fig. 2 - G).

[0024] The load cell, suitably powered from the locomotive battery or any other source of electrical energy, will release a value in mV directly proportional to the variation of stress to the hook; this voltage, amplified by a signal conditioner (analog or digital) will be sent to the equipment of first processing and transmission data preferably by cable or by radio (Fig. 1 and 2 - E).

[0025] In a preferred mode of realization, the load cell is of toroidal geometry and is mounted in the axis of the traction hook of the locomotive (Fig. 1 and 2 G - A).

[0026] The first processing and data transmission apparatus (Fig. 1 and 2 - E) communicates by wire or by radio with the final data processing equipment (Fig. 1 and 2 - F).

[0027] The accelerometer (Fig. 1 and 2 - B) detects accelerations of the locomotive, at least along the three Cartesian axes: X, Y and Z.

[0028] The GPS module (Fig. 1 and 2 - C) detects data related to geographic coordinates, preferably according to the NMEA 0183 protocol.

[0029] The mobile module (Fig. 1 and 2 - D), at the end of the journey, transmits by GSM-R all data recorded along the way.

[0030] All the installed sensors, in a preferred mode of realization, are electronically connected to a microprocessor for the first processing and subsequent transmission of data and, with the exception of the load cell, they are placed in a container, for example in PVC or metal equipped with connectors for cables and antennas required for the receipt and transmission of data (Fig. 1 and 2 A - B - C - D - E).

[0031] In this preferred mode of realization, the container Fig. 1 and 2 - E) has suitably shaped holes to allow the fixing of the panel connectors for the wiring of the cables coming from the sensors (Fig. 1 and 2 - A - B - C - D), and a USB panel connector to allow the electronic equipment be connected to a PC (Fig. 1 and 2 - F) for the data transmission operations and for the periodic maintenance of the system.

[0032] In this preferred mode of realization, the electronic equipment inside the container (Fig. 1 and 2 - E) include a suitable power supply capable of adequately transforming the voltage taken from the electrical system of the locomotive or from other power source for supplying the entire system.

[0033] The analog signal issued by the load cell is converted into a digital value (numeric value) and it is sent through a serial communication, via cable to the device of the final processing of the data, equipped with dedi-

cated software.

[0034] The final data processing equipment (Fig. 1 and 2 - F) consists of an HMI (human machine interface) where the dedicated software can process all data received from the sensors, their parameters, verify and record them.

[0035] The software, on the basis of the driving conditions, from the magnitude of the variation of the detected tensile stress to the hook, considering also the duration of the variation of the stress, and on the basis of the variation of acceleration and speed of the train, is able to detect anomalous stress trends at the locomotive hook and activate the alarm with light and sound signaling systems.

[0036] The software automatically creates an encrypted file for saving input data, process data and output data that remains available to the infrastructure manager and the train service manager in the event of subsequent investigations.

[0037] Once the train service is over, the software sends all data remotely, preferably by GSM-R specific for railways (Global System for Mobile Communications - Railways) or by a common mobile phone technology or any other protocol commonly today used for data transmission over the air.

Claims

1. Automatic radio-electro-mechanical system for the detection of the derailment of one or more railway wagons towed by a locomotive, comprising:

   - measurement equipment for the traction stress, comprising:

     an accelerometer (B) configured to detect acceleration of the locomotive along three cartesian axes;
     a GPS module (C) configured to detect data related to geographic coordinates;
     a mobile phone technology (D) configured to remotely transmit data;

   - first processing and data transmission apparatus configured to process and transmit measurement data and in signal communication by radio or by cable with the measurement equipment;
   - final data processing and registration equipment, placed in wire or radio communication with the first processing and data transmission apparatus, and configured to issue audible and visual alarm signal when a derailment is recognized, **characterized in that** the measurement equipment comprises a load cell mounted on the traction hook only of the locomotive (A), the load cell being configured to detect the value of the stress applied to the traction hook of the entire convoy.

2. The system according to claim 1, comprising one load cell for each traction hook of the locomotive only.

3. The system according to claim 1 or 2, wherein the load cell is of toroidal geometry and is mounted in the axis of the traction hook of the locomotive.

4. The system according to any claim 1 to 3, wherein the load cell is mechanically fastened to the traction hook.

5. The system according to any claim 1 to 4, wherein the load cell is configured to release an analogue signal relating to a voltage value directly proportional to the variation of stress to the hook, the load cell being configured to send said analogue signal to the first processing and data transmission apparatus which is configured to amplify said analogue signal.

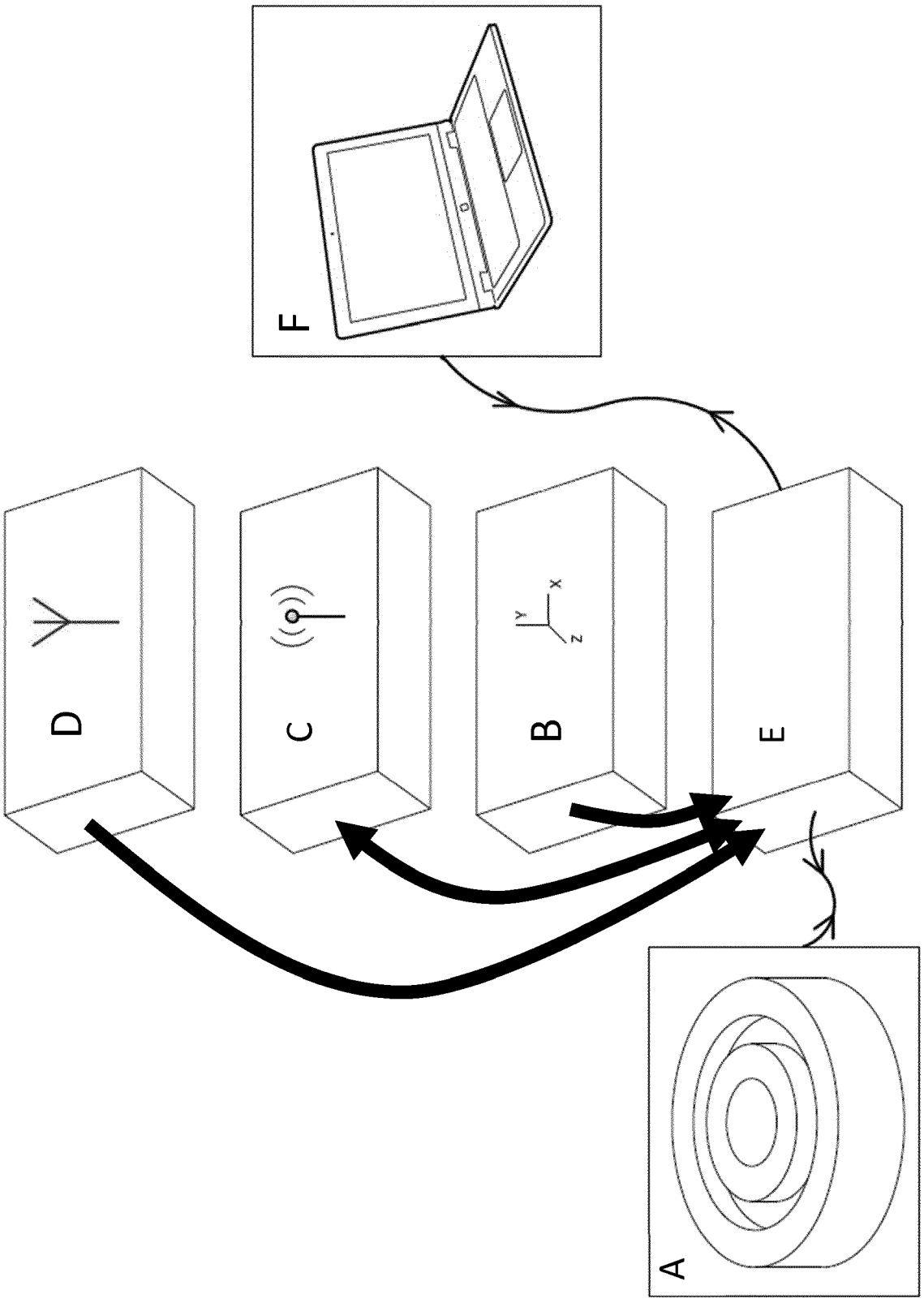
6. The system according to claim 5, wherein the analogue signal generated by the load cell is converted into a digital signal and sent through a serial communication via cable to the final data processing and registration equipment, which is equipped with a dedicated software.

7. The system according to any claim from 1 to 6, wherein the final data processing and registration equipment is configured to detect anomalous stress trends at the locomotive hook and activate the alarm with light and sound signaling systems ny means of the dedicated software on the basis of the variation magnitude of the detected tensile stress to the hook, the duration of the variation of the stress, the variation of acceleration and speed of the train.

8. The system according to claim 7, wherein the final data processing and registration equipment consists of a human machine interface configured to process, verify and record the signal generated by the lead cell.

9. The system according to any claim from 1 to 8, wherein the load cell is provided with strain gauges installed in the cell, wherein the strain gauges of the load cell are installed as an electrical scheme of one or more Wheatstone Bridge, the Wheatstone Bridge being selected between a double Wheatstone Bridge, a half Wheatstone Bridge, a quarter of Wheatstone Bridge, preferably the strain gauges being of one of the following types: traction and compression, bending, cut.

10. The system according to any claim from 1 to 9, comprising audio and visual alarm in the cab for the driver.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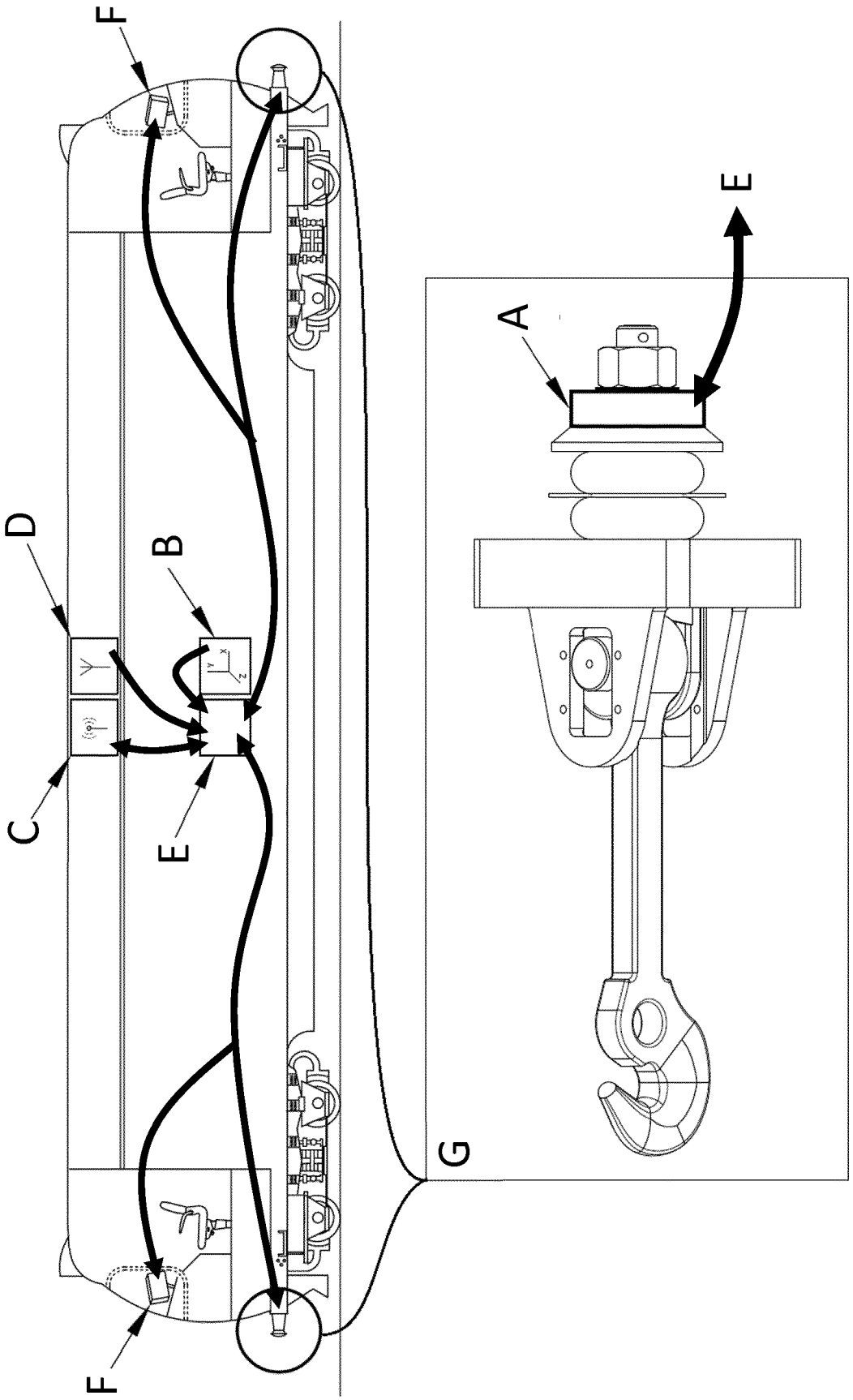
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Patent documents cited in the description

- US 2008195265 A1 **[0006]**
- AU 2014202937 A1 **[0007]**