

United States Patent

[11] 3,581,084

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| [32] | Priority | Nov. 10, 1967 |
| [33] | | Japan |
| [31] | | 42/71965 |

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| [56] | References Cited | | |
| | UNITED STATES PATENTS | | |
| 2,558,563 | 6/1951 | Janssen | 246/251(UX) |
| 2,755,384 | 7/1956 | Pierson et al. | 331/116 |
| 2,906,865 | 9/1959 | Jefferson | 246/251 |
| 2,966,582 | 12/1960 | Wachtel | 246/249 |
| 3,086,109 | 4/1963 | Kaehms | 246/249 |
| 3,469,116 | 9/1969 | Parkinson | 310/8.7 |

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- [54] **PIEZOELECTRIC WHEEL-AXLE DETECTOR**
13 Claims, 10 Drawing Figs.
- [52] **U.S. Cl.**..... 246/249,
246/248, 310/8.7, 324/70
- [51] **Int. Cl.**..... B611 13/04
- [50] **Field of Search**..... 246/246,
249, 169.5, 251; 310/8.1, 8.7; 331/116, 139, 155

ABSTRACT: A wheel-axle detector for wheeled vehicles following a track having rails with an I-shaped cross section forming a continuous imperforate web with an opposed overhanging head and foot. A piezoelectric element holder containing a piezoelectric element is inserted directly between the head and the foot of the rail such that a portion of the vehicle wheel load borne on the rail is imparted to the element. A detecting circuit is provided to receive and detect the electrical output of the piezoelectric element.

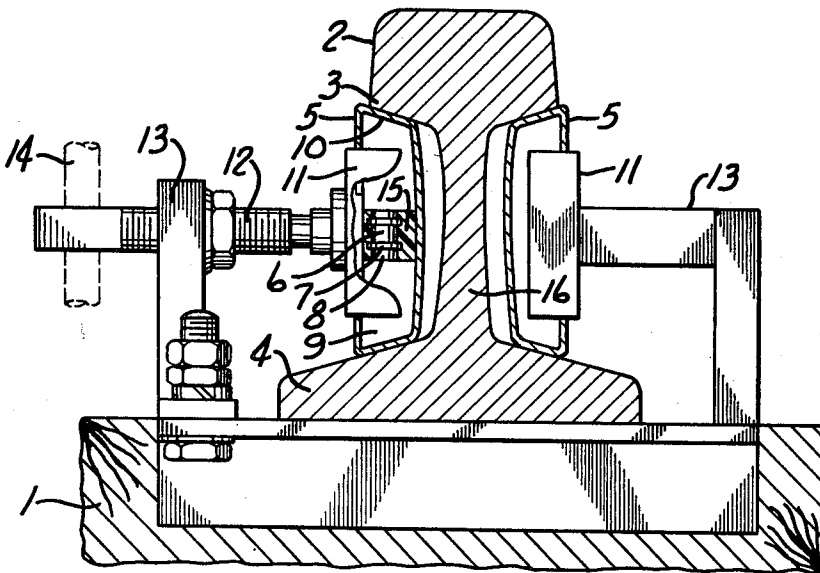


Fig. 1

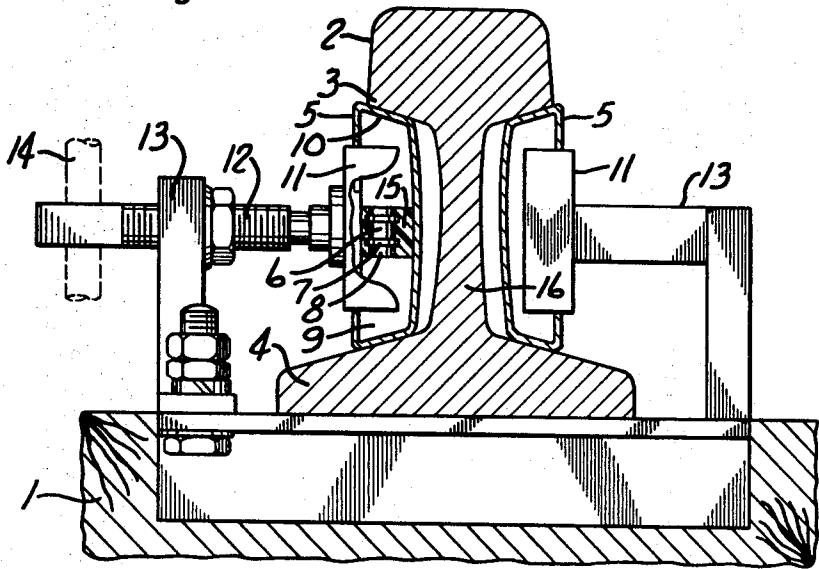


Fig. 2(1)

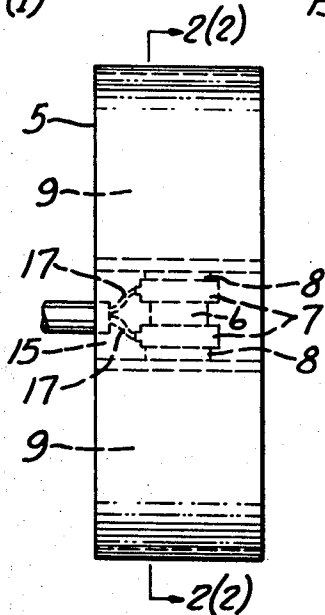
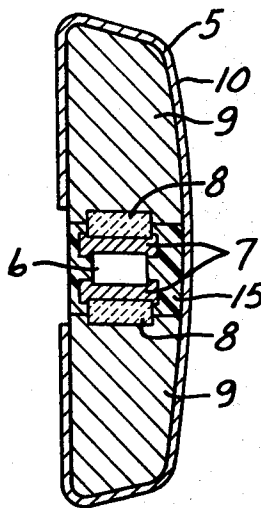
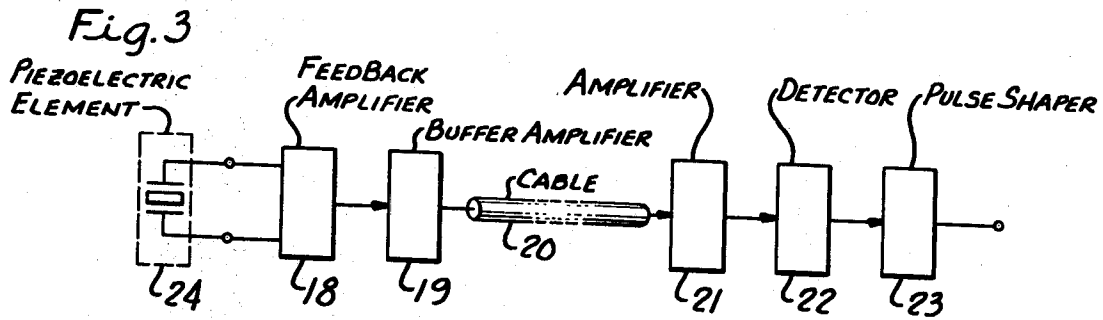
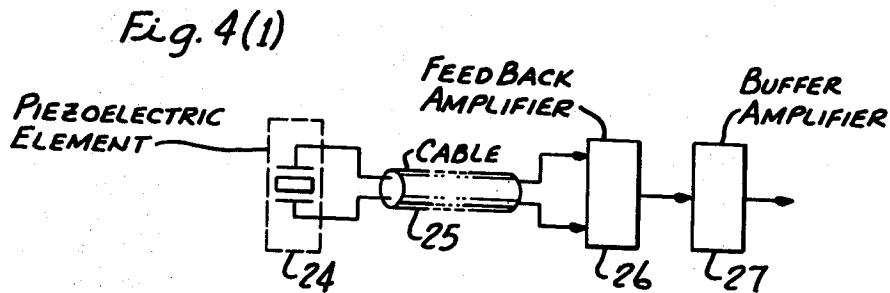
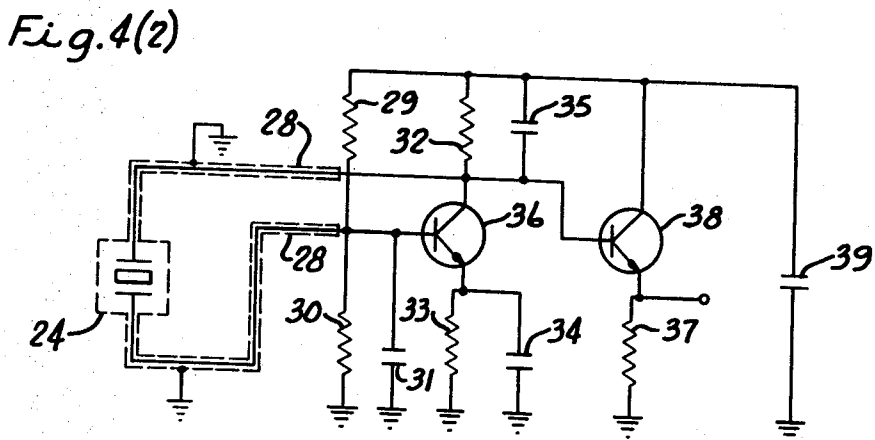


Fig. 2(2)



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Fig. 5(1)

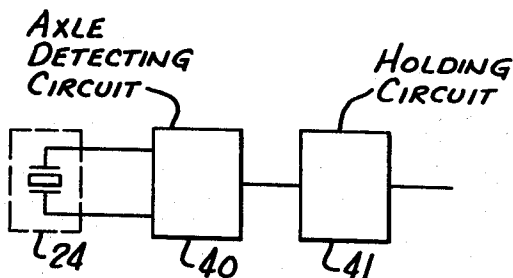


Fig. 5(2)

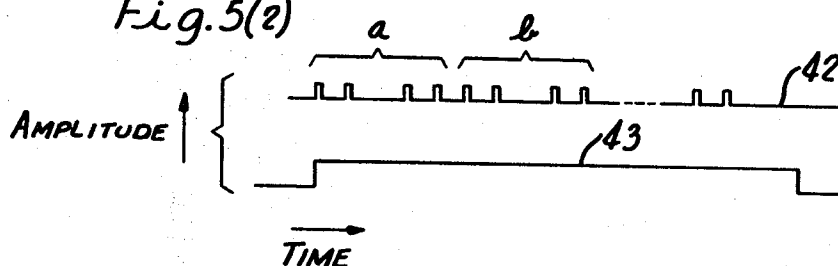


Fig. 6(1)

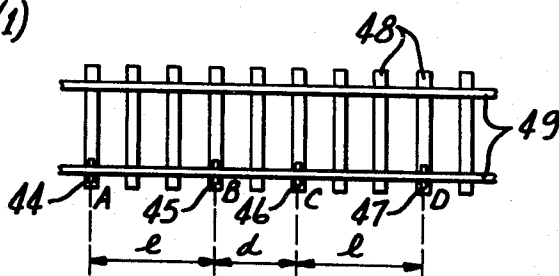
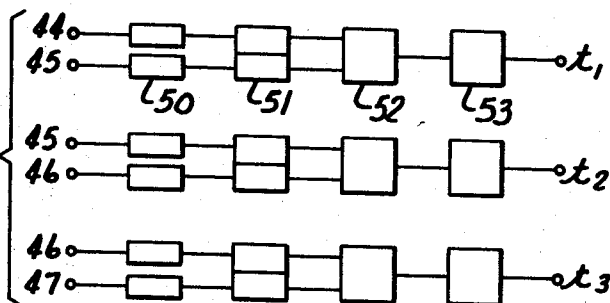


Fig. 6(2)



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PIEZOELECTRIC WHEEL-AXLE DETECTOR

This invention relates to a detector of wheel-axes of railroad cars which utilizes a piezoelectric element.

More particularly, this invention relates to a wheel-axle detector which is characterized in that on the outside of the electrode placed on each end of a piezoelectric element a coupler is provided with an insulating plate having a spring constant equal to or greater than that of the piezoelectric element interposed between the coupler and the piezoelectric element. These couplers are connected together on one side to form a holder for the piezoelectric element by means of a coupling plate, and this piezoelectric element holder is inserted between the lower surface of the rail head and the upper surface of the rail which is resting foot of the rail upon a tie. An oscillating circuit is formed by combining this piezoelectric element for wheel-axle detection with a feedback amplifier, thereby providing a wheel-axle detecting circuit on its output side.

The device of this invention has the following advantages.

1. It is made possible to detect accurately and without fail the passage of a wheel-axle of a rail vehicle running on a rail at a given point.
2. It is not necessary to insulate the rail when using it as part of the train detector, as is necessary when a track circuit is used.
3. It can easily be made a fail-safe mechanism, which can detect the passage of a wheel-axle irrespective of the speed of the vehicle.
4. Since this device is designed within the structural limits of railroads, it can be installed on any rail where desired.
5. It is very simple and easy to install and to detach this device, since it need only to be inserted between the under surface of the rail head and the upper surface of the rail foot.
6. It makes it possible to externally measure the speed of the vehicle by means of a simple device.
7. It makes it possible externally to measure the acceleration rate of the vehicle movement by means of a simple device.

Embodiments of this invention will be explained, making reference to the appended drawings.

FIG. 1 shows the principle of this invention.

FIG. 2 (1), (2) show a construction according to this invention.

FIG. 3 is a block diagram showing with a wheel-axle detector with a fail-safe mechanism, using the piezoelectric element shown in FIG. 2 as an oscillating element and adding thereto an electric circuit of a feedback amplifier and others.

FIG. 4 (1), (2) are schematic diagrams illustrating an example of the wheel-axle detector having the fail-safe mechanism shown in FIG. 3.

FIG. 5 (1), (2) are a block diagram and associated output signal respectively which illustrate a train detector made by utilizing the wheel-axle detector described with reference to FIG. 1, FIG. 2 and FIG. 3.

FIG. 6 (1), (2) are diagrammatic sketches illustrating an acceleration measuring device utilizing the wheel-axle detector explained with reference to FIG. 1 and FIG. 3.

The invention will be explained in detail with reference to the drawings.

Two piezoelectric element holders are shown in FIG. 1, one on each side of a rail 2. FIG. 2 shows the construction of the holder for a piezoelectric element. In more detail, the piezoelectric element holder 5 containing the piezoelectric element 6 is inserted between the under surface of the rail-head 3 and the upper surface of the rail-foot 4 of the rail 2 located upon a tie 1. The piezoelectric element holder 5 is fixed in position by means of a threaded bolt 12 screwed through the metal fixture 13 with a holder piece 11. A handle 14 is put through the threaded bolt 12.

In the piezoelectric element holder 5 are provided electrodes 7 on the upper and the lower end of the piezoelectric element 6 made of lead zirconate titanate ceramic or the like.

Silver electrodes are formed by baking them on the surfaces of the piezoelectric element 6 which contact the electrodes 7.

On the outside of each electrode 7 is provided a couplers 9, 9 made of iron or the like with an insulating plate 8 having a spring constant equal to or greater than that of the piezoelectric element 6 placed in between. These upper and lower couplers 9, 9 are coupled together on one side by means of a coupling plate 10 made of a steel plate. For the insulating plate 8, for example, nonpolarized lead zirconate titanate or alumina ceramic or the like may be used. The space between the couplers 9, 9 is filled with an insulating material 15 such as synthetic resin, silicone rubber, rubber, etc. to make it a waterproof construction. A material elastic enough to withstand a considerable distortion should be used for this insulating material 15. The electrodes 7 are made of brass plated with silver, and lead wires 17 are connected thereto.

The operation of the device shown in FIG. 1 will be explained. When a wheel-axle of a car travelling on the rail comes to that part of the rail 2 where the piezoelectric element holder 5 is installed, the weight of the car is applied to the head of the rail 2 via the wheel. Most of the load applied to the rail head is supported by the web 16 of the rail, but part of the load is applied also to the piezoelectric element holder 5 inserted between the under surface 3 of the rail head and the upper surface 4 of the rail foot.

The detector of this invention utilizes the deformation in the section of the rail due to both the vertical contraction of the web of the rail and the transversal warping of the rail caused by the contact between the rail head and the tapered tread of the vehicle wheel.

This warping of the rail-web applies a vertical load to the piezoelectric element holder 5 interposed between the under surface 3 of the rail head and the foot 4 of the rail. This load is applied to the piezoelectric element 6 via the couplers 9, insulating plates 8 and electrodes 7 and generates piezoelectricity in the piezoelectric element 6. This piezoelectricity is taken out from the electrodes 7, 7 by the lead wires 17 to indicate the presence of a wheel axle of a car moving over that portion of the rail 2 where the piezoelectric element holder 5 is placed.

When a wheel travels on a rail, the weight of the wheel produces a longitudinal bending of the rail before and after the contact point of the wheel and the rail. If the piezoelectric element holder is placed on the rail between two ties, therefore, it may be influenced by this longitudinal bending and may generate larger errors in detecting the position of a wheel-axle. In the case of the detector of this invention, however, the piezoelectric element holder 5 is interposed between the under surface 3 of the head of the rail 2 and the upper surface of the rail foot 4 and is furthermore located right above a tie 1 of rails, so that it is scarcely influenced by the longitudinal bending of the rail even if a wheel of the car travelling on the rail approaches the position of the piezoelectric element holder 5 and the detector is not yet actuated. The detector is actuated only when a wheel axle comes very near to the position of the piezoelectric element holder 5, so that the detection of wheel axles can be effected very accurately.

The piezoelectric element holder 5 has insulating plates 8 of a spring constant equal to or greater than that of the piezoelectric element 6 interposed between the upper and lower electrodes 7, 7 of the piezoelectric element 6 and the couplers 9, 9 respectively. As a result, the displacement of the under surface 3 of the head of the rail is effectively transmitted to the piezoelectric element 6 via the couplers 9, insulating plates 8 and electrodes 7, and generates piezoelectricity in the piezoelectric element 6.

If the insulating plates 8 are soft and have a spring constant smaller than that of the piezoelectric element 6, then the load upon the rail head will not effectively act upon the piezoelectric element 6, and a wheel axle coming upon the rail 2 where the piezoelectric element holder 5 is placed may not be detected effectively.

The detector of this invention utilizes the contraction of the rail, especially of its web, and transversal bending due to the taper of the wheel to apply a load to the piezoelectric element holder 5. However, if this piezoelectric element holder is installed only on one side of the rail 2, the load applied to the inside and outside parts of the rail head may become uneven due to the rolling of the travelling car or due to other causes. For example, when a wheel axle comes upon the rail 2 where a piezoelectric element holder 5 is located, the load applied via the rail may become less than a prescribed value. In such a case, it may become impossible to detect effectively a wheel axle coming upon the rail where the piezoelectric element holder is located. The dependability of this device can therefore be enhanced by providing piezoelectric element holders on both sides of the rail web and adding the output voltages of these piezoelectric element holders.

FIG. 3 is a diagram illustrating a wheel axle detector of a fail-safe mechanism using the piezoelectric elements described with reference to FIG. 1 and FIG. 2 as an oscillator element and combining it with a feedback amplifier and other electric circuits. An oscillator circuit is formed by connecting a feedback amplifier 18 to the electrodes on both sides of the piezoelectric element 17 interposed between the under surface of the rail head and the upper surface of the rail foot. A transmission line 20 is connected to the feedback amplifier 18 via a buffer amplifier 19, and an amplifier 21 and detector 22 are connected to the transmission line 20, a pulse shaping circuit 23 being connected to the output side of this detector.

The operation of the device of this invention as shown in FIG. 3 will be explained. A piezoelectric element 17 as a detecting element is interposed between the under surface of the rail head and the upper surface of the rail foot, so that the weight of a car passing it on the rail may indirectly act on the piezoelectric element 17.

The electrodes on both sides of the piezoelectric element 17 are electrically connected to the feedback amplifier 18, so that the oscillator circuit consisting of the piezoelectric element 17 and the feedback amplifier 18 produces an oscillation at the natural oscillation frequency of the piezoelectric element 17 and this output signal is sent, via the buffer amplifier 19 and transmission line 20, to the amplifier 21, detector 22 and pulse shaping circuit 23.

The signal amplified by the amplifier 21 is detected by the detector 22 and becomes an envelope as the output of the oscillator circuit. In the normal condition it is a constant direct current, but, when a car travels on the rail at the point where the detection element is installed, the weight of the car applies pressure for an instant to the piezoelectric element 17 as a detecting element, so that the value Q of the piezoelectric element comes down and the oscillation is stopped instantaneously. This instantaneous stopping of oscillation makes the DC voltage at the output of the detector 22 zero for an instant. The axle position detection signal is detected by detecting this voltage change by means of the pulse shaping circuit 23 (hereinafter this condition will be referred to as the condition "1") and thus the passage of a car is detected.

In case the piezoelectric element 17 becomes out of order for a physical, chemical or other reason and loses its ability as a piezoelectric element, the oscillator circuit consisting of the piezoelectric element and the feedback amplifier stops functioning and remains in that condition. In consequence, the feedback amplifier 18 does not send out a signal, and the output signal from the amplifier 21 and detector 22 comes to a stop. The output signal of the pulse shaping circuit 23, therefore, remains in the condition of "1." A fault in the feedback amplifier and other circuitry can also be detected in the same manner.

As mentioned above, both the axle detection signal and the fault detection signal are obtained by the suspension of oscillation. The former is, however, obtained by suspension for a short time, while the latter is obtained by a continuous stopping. There is a big difference of time durations between these two, so that they can definitely be differentiated by measuring their time durations.

The device of this invention detects the passage of a car by an instantaneous suspension of oscillation from an oscillator circuit consisting of a piezoelectric element 17 and a feedback amplifier 18. It can detect a fault in the piezoelectric element 17 and other circuitry by a continuous suspension of the oscillation. It is, therefore, possible to detect a fault without using any special circuit. As a result, the device is of a simple construction and can be made a fail-safe structure, so that the device has a high dependability. Furthermore, since the passage of a wheel is detected by the instantaneous suspension of the oscillation of an oscillator circuit, the passage of a car can be detected irrespective of the speed of the travelling car.

An example of the oscillator circuit which plays an important part in the wheel axle detector of the fail-safe structure explained with reference to FIG. 3 will be explained.

FIG. 4 (1) is a block diagram of the oscillator circuit of the wheel axle detector of the fail-safe structure. FIG. 4 (2) is a detailed circuit diagram for FIG. 4 (1).

The electrodes on both sides of the piezoelectric element 24 employed as a detection element are electrically connected to the transmission line 25, and the other end of the transmission line 25 is connected to the feedback amplifier 26, so that the oscillator circuit consisting of the piezoelectric element 24, transmission line 25 and feedback amplifier 26 produces oscillations at the natural oscillation frequency of the piezoelectric element 24 and its output signal is sent to a buffer amplifier. The amplifier, detector and pulse shaping circuit shown in FIG. 3 are connected to circuits subsequent to the buffer amplifier, and the output signal coming out of the buffer amplifier is processed by each circuit and becomes an axle position signal. FIG. 4 (2) is a detailed circuit diagram for FIG. 4 (1). In the figure, 24 denotes the piezoelectric element, 28, 28 coaxial cords, 29, 30, 32, 33 and 37 fixed resistances for biasing the transistors, 36 the transistor for oscillation, 38 the transistor for buffer, 34 the condenser for bypassing, 31 and 35 the condensers for oscillation, and 39 the electric power supply source.

If, when connecting the feedback amplifier to the electrodes on both sides of the piezoelectric element via the transmission line, the capacitance between the signal line and the shielded wire is equivalently inserted in parallel with the piezoelectric element, then the Q of the piezoelectric element will be apparently reduced and may cause the stopping of the oscillation.

In order to avoid such a suspension of oscillation, it is necessary to eliminate the transmission line, such as the coaxial cord, and to install the piezoelectric element and the feedback amplifier near to each other by some suitable means. In the instance where the piezoelectric element 24 is inserted between the base of a transistor and the collector as in this example, the capacitance between the shield wire and the signal line is all included in the condensers for oscillation 31 and 35, and does not have any effect on the piezoelectric element 24. The capacitance in parallel with the piezoelectric element in this case becomes only the very small line capacity of the two signal line wires and does not cause the stopping of oscillation.

The piezoelectric element and the electrical system units have been able to be separated from each other by the use of an oscillator circuit interposed between the base and collector. This makes it possible to install the units of the electrical system at a location considerably distant from the rail.

An example of a train detector which illustrates an application of the wheel axle detector of this invention is shown in FIG. 5 (1), (2).

This is an application of the wheel axle detector which has been explained in detail with reference to FIG. 1, FIG. 2, FIG. 3 and FIG. 4. It detects the passage of a train by detecting the passage of axle wheels of cars travelling on rails and converting its outputs into a single pulse signal by applying them to an electric circuit which hold them for a fixed length of time. Its object is to detect accurately trains travelling on rails.

With reference to FIG. 5, an example of the train detector will be explained.

A piezoelectric element holder containing a piezoelectric element 24 is interposed between the under surface of the rail head and the upper surface of the rail foot, and its output terminals are connected to an axle detection circuit 40. When a train travels on the rail on which this piezoelectric element is installed, signal 42 is obtained as the output signal of the axle detection circuit 40. This output signal 42 is fed to a holding circuit 41. Each of a and b of FIG. 5 (2) represents the number of axles of one car. As the holding circuit 41 has the function of holding an amplitude for a certain length of time, a single pulse output signal such as 43 is obtained on the output side of the holding circuit 41, the passage of one train being thus detected. This certain length of time is a time determined by the maximum distance between axles of the car and the minimum speed of the train. If the certain length of time is represented by t (sec.), maximum distance between axles by L (m) and the minimum speed of the train by V [km/H], then

$$t \text{ (sec.)} > \frac{L(m) \times 3,600 \text{ (sec.)}}{V \times 10^3(m)} \quad (1)$$

Thus the range of the time t is represented by formula (1). The maximum holding period may be limited to such a degree that it will not interfere with time intervals between travelling trains and the processing of the output signal.

If the above-described train detector is used, it is necessary merely to insert the piezoelectric element holder containing a piezoelectric element between the under surface of the rail head and he upper surface of the rail foot, so that it is exceedingly easy to attach and detach the device. It has a wide scope of applications, such as the detection of an approaching train when repairing railroad tracks.

An example of a device making use of the wheel axle detector of this invention for the detection of the acceleration of a travelling car is shown in FIG. 6 (1), (2).

This is an application of the wheel axle detector explained in detail with reference to FIG. 1, FIG. 2, FIG. 3 and FIG. 4. Piezoelectric element holders containing piezoelectric elements are interposed between the under surface of the rail-head and the upper surface of the rail-foot at three or more points of the rail located upon ties. The passage of wheel axles of a car travelling on the rail is detected at these three or more points, while the time for travelling the distance between two points of these three or more points is detected. The acceleration rate of the travelling speed is thus measured. Its object is to detect the acceleration rate of a car travelling on a rail from outside by a simple means.

An example of the car speed acceleration rate detector will be explained with reference to FIG. 6. Piezoelectric element holders 44, 45, 46 and 47 containing piezoelectric elements are installed between the under surface of rail-head and the upper surface of rail-foot at the four points A, B, C and D of the rail upon railroad ties 48. A wheel axle detection circuit 50 is connected to the output terminal connected to the electrodes of each piezoelectric element. A flip-flop 51 is connected to the output terminal of each wheel-axle detection circuit 50, and the output side of this flip-flop 51 is connected to a start-stop oscillator 52, and a counter 53 is connected to the output side of this start-stop oscillator 52.

The operation of this device according to this invention will be explained. When the wheel axles of a car travelling on the rail pass the points A, B, C and D where the piezoelectric element holders 44, 45, 46 and 47 are installed respectively, the weight of the car is applied to the rail via the wheel axles and are applied to the piezoelectric element holders installed on the rail. Since voltages are being induced in the piezoelectric elements, the passage of the wheel axles at the four points, A, B, C and D, is thus detected.

The signal from point A detecting the passage of wheel axles is led, via the axle detection circuit 50, to the flip-flop 51 and then to the start-stop oscillator 52 which then begins sending out pulse signals. These pulses are counted by the counter 53. When the passage of the car is detected at point B, the signal from point B is led to the wheel axle detection circuit 50, flip-

flop 51 and the start-stop oscillator 52, and stops the signal pulses sent by the start-stop oscillator 52. Then, using the number of pulses counted by the counter 53, the time t_1 required for an wheel-axle to travel the distance between point A and point B is determined. The average speed of the car travelling from point A to point B on the rail can then be obtained by dividing the distance l between point A and point B by the time t_1 .

The lengths of time required for travelling the distance L between the two points, C and D, and distance D between the two points, B and C, $-t_2$ and t_3 respectively—are measured in the same manner. The acceleration rate α can be obtained by dividing the difference between the average speeds between A and B and C and D by the time required for a wheel axle to travel the distance between the middle point between A and B and the middle point between C and D.

$$\alpha = \frac{\frac{l}{t_2} - \frac{l}{t_1}}{t_3 + \frac{t_1}{2} + \frac{t_2}{2}} \quad (2)$$

In this instance, D shall be selected to be approximately zero less than or equal to D less than or equal to L , wherein L may be selected in a range of one to two meters. The travelling time t_3 is made smaller than t_1 or t_2 in this circumstance.

The formula for the accelerations is obtained as follows by the reduction of formula (II).

$$\alpha = \frac{2l(t_1 - t_2)}{t_1 t_2 (t_1 + t_2)}$$

As already stated, this device is very simple because piezoelectric element holders are interposed between the under surface of the rail-head and the upper surface of the rail-foot. It also makes it possible to measure the travelling speed of cars and trains by measuring the time for a wheel axle to pass two points on the rail.

The present invention has been explained in detail. As advantages common to its embodiments, it may be pointed out as follows: There are systems in which the passage of a body is detected by having it pass between a light source and a photo detector. Compared with such photoelectric systems, the device of this invention employs as a signal source a piezoelectric element which generates electricity by itself, so that the device is of a very simple construction, seldom becomes out of order and is less expensive.

Furthermore, it is exceedingly simple to install and remove the device because it is necessary only to insert the unit between the under surface of a rail-head and the upper surface of the rail-foot. Moreover, this device is designed so as not to interfere with the construction limits of a railroad, so that it can be installed on any desired tie. Neither is it necessary to insulate the rail when installing it, as is the case with track circuits.

We claim:

1. A wheel-axle detector for wheeled vehicles following a track having rails with an I-shaped cross section forming a continuous imperforate web with an opposed overhanging head and foot, comprising a piezoelectric element holder containing a piezoelectric element and having top and bottom load bearing surface means to impart pressure to said element when said surface means are compressed toward each other, means to interpose said holder directly between the head and foot of a rail of a track with said top and bottom surface means engaging the opposed rail head and foot surfaces to impart a portion of the vehicle wheel load to be borne on said rail to said element, and detecting circuit means electrically connected to said element to receive and detect the output of said element.

2. The wheel-axle detector of claim 1 wherein the rails are laid upon ties and said holder is positioned over a tie.

3. The wheel-axle detector of claim 1 wherein said piezoelectric element is lead zirconate titanate ceramic.

4. The wheel-axle detector as claimed in claim 1 wherein said piezoelectric element holder includes at least one insulating plate mechanically conducting a portion of the vehicle load to said piezoelectric element and electrically insulating said element, said insulating plate having a spring constant at least equal to that of said element.

5. The wheel-axle detector of claim 4 wherein said insulating plates are nonelectrically polarized lead zirconate titanate ceramic.

6. The wheel-axle detector of claim 4 characterized by a pair of couplers having two of said insulating plates holding said element disposed therebetween, and a flexible coupling plate connecting said couplers.

7. The wheel-axle detector of claim 1 wherein a second piezoelectric element holder containing a second piezoelectric element and said first holder with said first element are positioned directly opposite each other between the head and foot on opposite sides of the same rail, their piezoelectric outputs being additively combined to produce said output signal.

8. The wheel-axle detector of claim 1 wherein said detecting circuit means includes an oscillator circuit which incorporates said piezoelectric element as a crystal in its tuned circuit.

9. The wheel-axle detector of claim 8 wherein said oscillator circuit includes a transistor, said piezoelectric element remotely connected through a transmission line between the base and collector of said transistor.

10. The wheel-axle detector of claim 9 wherein individually shielded signal wires are employed as said transmission line.

11. The wheel-axle detector of claim 1 wherein said detect-

ing circuit means includes a holding circuit responsive to each output signal of said element to emit a second signal having a duration of predetermined magnitude greater than the time it takes a vehicle to be detected travelling on said track at minimum velocity to travel a distance equal to the maximum distance between adjacent axles of said vehicle but less than the time interval between succeeding vehicles to be detected.

12. The wheel-axle detector of claim 1 characterized by at least two more of said piezoelectric elements positioned in the same manner as the first at different points along said track and at predetermined distances from said first element and each other, said detecting circuit means connected to receive and operable to independently detect the respective output signals of said element and including an acceleration detection circuit responsive to said independently detected output signals to detect the acceleration of the vehicle being detected.

13. The wheel-axle detector of claim 1 characterized by a second piezoelectric element positioned in relation to said track in the same manner as said first element to produce a piezoelectric output for each passing vehicle wheel, said second element positioned at a predetermined distance along said track from said first element, said detecting circuit means connected to receive and operable to independently detect the respective output signals of said elements and including a velocity detection circuit response to said independently detected output signals to detect the time required for a vehicle to travel said predetermined distance between said elements.

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