

DEVICE AND METHOD FOR DETECTING THE PRESENCE OF AN OBJECT

The present invention relates to a device for detecting the presence of an object in a monitored zone, and in particular the use of such a device in order to detect an object falling onto a transport track.

In order to detect an object falling onto a transport track, for example, in an underground railway station, it is known to use a video camera which is positioned above the tracks. However, this solution is not completely satisfactory because it requires extensive and expensive installation and maintenance operations and does not function correctly if the viewing angle of the camera is obscured.

Another known solution is to provide a plurality of electroluminescent diodes along the transport track, for example, one diode every 25cm. The diodes emit beam rays, and it is possible to detect an interruption of the beam rays. That solution requires a large number of diodes and detectors which also involves extensive and expensive installation and maintenance operations.

An object of the invention is to provide a device for detecting the presence of an object in a detection zone, which does not have at least some of the above-mentioned disadvantages of the prior art.

To that end, the invention provides a device for detecting the presence of an object in a detection zone, characterised in that it comprises a transmission line, a generator which is connected to an input of the transmission line and which is able to generate an input signal, and a

receiver which is connected to an output of the transmission line and which is able to measure an output signal, the transmission line being able to radiate a radiated signal in the detection zone when the generator generates the input signal in such a manner that, if an object is present in the detection zone, the output signal comprises a first component owing to the propagation of the input signal along the transmission line and a second component owing to a phenomenon involving interaction between the radiated signal and the object, the detection device further comprising analysis means which are able to confirm the presence or absence of the second component in the output signal in order to detect the presence of an object in the detection zone. The detection of the object is preferably carried out in order to identify it.

The detection line constitutes a robust element which requires very little maintenance and which is easy to install.

Preferably, the analysis means are able to compare the output signal with a predetermined reference signal in order to detect the presence of an object.

Advantageously, the reference signal corresponds to an output signal which has been measured in the absence of any object in the detection zone and which is referred to as a calibration signal.

In this manner, a simple operation for differentiating between the output signal and the reference signal allows confirmation of the presence of the second component owing to the phenomenon involving interaction between the radiated signal and an object.

According to a specific embodiment, the analysis means comprise identification means which are able to detect characteristics of an object which is present in the detection zone and to compare those characteristics with reference characteristics in order to identify the object.

Preferably, the input signal comprises an ultra-wide frequency band pulse.

Such an input signal has a number of advantages. The first component of the output signal, owing to the propagation of the pulse along the transmission line, and the second component of the output signal, owing to an interaction phenomenon (for example, reflection) between the pulse and the object, are offset in terms of time, even in the case of a short distance between the transmission line and the object. That allows them readily to be distinguished. The first component can therefore serve as a starting point for a measuring time window which defines the range of the detection device. Furthermore, the radiated signal occupies a large bandwidth and, since the mean power emitted is limited, the spectral density is extremely weak. Thus, other neighbouring systems are prevented from being disrupted, or the system is prevented from being disrupted by narrow band systems. Furthermore, that bandwidth having a high frequency provides the overall response of the object to be detected within that entire frequency band, subsequently facilitating its identification.

According to a specific embodiment, the transmission line comprises at least one conductor and a reference plane. For example, the transmission line comprises a layer of dielectric material, a metal layer which covers a side of

the layer of dielectric material and a metal strip at the opposite side of the layer of dielectric material. For example, this can be a micro-tape line, strip-line or coplanar line.

Advantageously, the layer of dielectric material, the metal layer and the metal strip form a flexible strip.

A flexible strip of this type is particularly easy to install. For example, it can be stored in the form of a roll, then unrolled and fixed along the detection zone.

The invention also provides for use of a detection device according to the invention above, in order to detect an object falling onto a transport track.

The invention also provides for a method for detecting the presence of an object in a detection zone, characterised in that it comprises the steps involving:

- generating an input signal at an input of a transmission line,
- measuring an output signal at an output of the transmission line, the transmission line being able to radiate a radiated signal in the detection zone in such a manner that, if an object is present in the detection zone, the output signal comprises a first component owing to the propagation of the input signal along the transmission line and a second component owing to a phenomenon involving interaction between the radiated signal and the object,
- confirming the presence or absence of the second component in the output signal in order to detect the presence of an object in the detection zone.

Preferably, the method comprises the fact of analysing the output signal in order to detect characteristics of an object that is present in the detection zone, and comparing those characteristics with reference characteristics in order to identify the object.

The invention will be better understood, and other objects, details, features and advantages thereof will be appreciated more clearly, in the course of the following description of a specific embodiment of the invention, given purely by way of non-limiting example with reference to the appended drawings, in which:

- Figure 1 is a perspective view of a detection device according to an embodiment of the invention,
- Figure 2 is a view similar to Figure 1, in which an object to be detected is illustrated,
- Figure 3 is a perspective view of an underground railway station in which the device of Figure 1 is installed and
- Figure 4 is a time chart illustrating an example of an output signal of the device of Figure 1.

With reference to Figures 1 and 2, the detection device 1 comprises a transmission line 2. In the example illustrated, the transmission line 2 comprises a layer 3 of dielectric material of substantially rectangular shape, a metal layer 4 which covers one face of the layer 3 of dielectric material and a metal strip 5 which extends over the opposite face of the layer 3 of dielectric material, in a manner substantially parallel with and at the centre of the two long edges of the layer 3 of dielectric material. Those elements together form a flexible strip.

A generator 6 is connected to an input end of the transmission line 2 and is able to generate an input signal at the input end of the transmission line 2. A receiver (not illustrated) is connected to an output end of the transmission line 2 and is able to measure an output signal at the output end of the transmission line 2.

The detection device 1 serves to detect the presence of an object 14 in a detection zone adjacent to the transmission line 2. For that purpose, the detection device 1 also comprises analysis means (not illustrated) which are connected to the receiver and which are able to analyse the output signal in order to detect the presence of an object. The analysis means comprise, for example, a microprocessor or a device comprising an FPGA, on which a suitable program is executed. The microprocessor can be adjacent to the receiver, for example, it may be arranged in the same housing. Alternatively, the microprocessor can be located remote from the receiver, which transmits to it the output signal which is measured by a telecommunications network.

Figure 3 illustrates the detection device 1 which is provided in an underground railway station. The transmission line 2 is arranged at the edge 19 of the platform 7, over the entire length thereof. The detection device 1 allows the presence of an object, for example, a person 9, to be detected in a detection zone which is indicated by the curves 20. If a person falls from the platform 7 onto a transport track 8, as the arrow 10 indicates, it will thus be possible to take the appropriate steps in order to prevent or limit the risks of an accident.

The operation of the detection device 1 is as follows. In a periodic manner, the generator 6 generates an input

signal in the form of an ultra-wide frequency band pulse, that is to say, a pulse having a duration in the order of 1ns or less.

That pulse is propagated along the transmission line 2, as the propagated pulses 12 in Figures 1 and 2 illustrate. Furthermore, during that propagation action, two phenomena take place. Firstly, energy is dissipated by the Joule effect. Owing to the dissipated energy, the propagated pulses 12 are attenuated, for example, in the order of 1dB/10m at 3GHz. Secondly, energy is radiated, that is to say, emitted in the form of an electromagnetic wave along the line, as the radiated pulses 13 illustrate.

If an object 14, for example, a person 9, is present in the detection zone, the radiated energy is reflected by the object 14, in particular towards the transmission line 2, as the arrows 15 and 16 in Figures 2 and 3 illustrate.

In that case, the output signal comprises two components, as Figure 4 shows. A first component 17 is because of the propagation of the pulse on the transmission line 2, that is to say, directly from the input end to the output end. A second component 18 exists because of a phenomenon involving interference of the radiated pulse on the object 14, which is offset in terms of time by a value Δt , owing to the propagation time in accordance with the arrows 15 and 16. The interference phenomenon in question can be reflection on the conductive or dielectric walls of the object. Diffraction, in particular at the sharp edges of the object, can also bring about a significant contribution, depending on the type of object. At the highest frequencies, in the millimetric range, a third phenomenon referred to as diffusion of the electromagnetic

wave on the object can also often appear. The contribution of those various physical phenomena is a complex relationship involving the frequency, the conductive and dielectric characteristics of the object to be detected.... In a centimetric frequency band, that is to say, from 3 to 10GHz, the phenomena which mainly contribute to the second component 18 are reflection and diffraction. Even for a short distance between the object 14 and the transmission line 2, the offset value Δt will generally be greater than a few ns, for example, in the order of 8ns for a distance of 1.2m. The pulse generated by the generator 6 is an ultra-wide band pulse which is deformed only slightly during the propagation along the transmission line 2 which has a large pass-band. Thus, the first component 17 of the output signal is also an ultra-wide band pulse having a duration in the order of 1ns or less. The two components of the output signal can therefore readily be distinguished.

That allows the size of the detection zone to be limited by causing the offset value Δt to be less than a given threshold. For example, in the case of a transmission line 2 which is provided along a platform 7, as illustrated in Figure 3, it is possible to limit the size of the detection zone in order to detect objects falling onto the transport track 8 adjacent to the platform 7, and not onto the second track adjacent to the opposite platform, for which another detection device can be provided. Alternatively or in a complementary manner, the generators of two detection devices which are provided on two opposing platforms can generate pulses having different shapes in order to prevent one of the devices from disrupting the operation of the other, and vice versa.

By establishing the difference between the measured output signal and a predetermined reference signal, which is an output signal measured in the absence of any object in the detection zone, there is obtained a signal corresponding substantially to the second component 18 of the output signal. In a particularly simple embodiment, it is considered that an object is present in the detection zone if that signal has an amplitude greater than a given threshold.

In another more complex embodiment, processing is carried out in order to identify characteristics of the object 14 which is present in the detection zone. For example, the Prony method described in IEEE AP, Vol. 40, Issue 1, *High resolution radar target modeling using a modified Prony estimator*, is used in order to break down the second component 18 into n damped sinusoid curves and to establish n poles characteristic of the object 14. By comparing the n characteristic poles established with pieces of information contained in a library of known targets, it is possible to identify and classify the object 14. That allows, in particular in the event of an object falling onto a transport track 8, appropriate measures to be taken depending on the object 14.

Given that the generator 6 generates an input signal in the form of an ultra-wide frequency band pulse, the energy which is emitted in the form of an electromagnetic wave by the transmission line and which is illustrated by the radiated pulses 13 has a very high spectral content. Consequently, the object 14 generally complies with all of those frequencies/loads, in accordance with the phenomena of reflection and diffraction that are characteristic of its geometry and structure. Consequently, it provides in return

something which it is possible to refer to as a "global response" that is characteristic of that object in that entire frequency range. Owing to the richness of the information collected, that global response, which a narrow band radar would not provide, subsequently allows the object detected to be identified more readily.

Although the invention has been described with reference to a specific embodiment, it is quite evident that it is in no way limited thereto and that it comprises all the technical equivalents of the means described and combinations thereof if they fall within the scope of the invention.

CLAIMS

1. Device (1) for detecting the presence of an object (14, 9) in a detection zone in order to detect an object falling onto a transport track, in particular in an underground railway station, comprising a transmission line (2), a generator (6) which is connected to an input of the transmission line and which is able to generate an input signal, and a receiver which is connected to an output of the transmission line and which is able to measure an output signal, the transmission line being able to radiate a radiated signal (13, 15, 16) in the detection zone when the generator generates the input signal in such a manner that, if an object is present in the detection zone, the output signal comprises a first component (17) owing to the propagation of the input signal along the transmission line and a second component (18) owing to a phenomenon involving interaction between the radiated signal and the object, the detection device further comprising analysis means which are able to confirm the presence or absence of the second component in the output signal in order to detect the presence of an object in the detection zone, and which are able to compare that output signal with a predetermined reference signal in order to detect the presence of an object,

characterised in that the reference signal corresponds to an output signal which has been measured in the absence of any object in the detection zone and in that the transmission line is able to be provided at an edge of the underground railway platform over the entire length of the platform.

2. Device according to claim 1, characterised in that the analysis means comprise identification means which are

able to detect characteristics of an object which is present in the detection zone and to compare those characteristics with reference characteristics in order to identify the object.

3. Device according to either claim 1 or claim 2, characterised in that the input signal comprises an ultra-wide frequency band pulse.

4. Device according to any one of claims 1 to 3, characterised in that the transmission line comprises a layer (3) of dielectric material, a metal layer (4) which covers a side of the layer of dielectric material and a metal strip (5) at the opposite side of the layer of dielectric material.

5. Device according to claim 4, characterised in that the layer of dielectric material, the metal layer and the metal strip form a flexible strip.

6. Use of a detection device according to any one of claims 1 to 5 in order to detect an object falling onto a transport track (8).

7. Method for detecting the presence of an object (14, 9) in a detection zone, in order to detect an object falling onto a transport track, in particular in an underground railway station, comprising the steps involving:

- generating an input signal at an input of a transmission line (2) which is able to be provided along an edge of the underground railway platform over the entire length thereof,

- measuring an output signal at an output of the transmission line, the transmission line being able to

radiate a radiated signal (13, 15, 16) in the detection zone in such a manner that, if an object is present in the detection zone, the output signal comprises a first component (17) owing to the propagation of the input signal along the transmission line and a second component (18) owing to a phenomenon involving interaction between the radiated signal and the object,

confirming the presence or absence of the second component in the output signal in order to detect the presence of an object in the detection zone, characterised in that it comprises the step involving:

- comparing the output signal with a predetermined reference signal in order to detect the presence of an object, the reference signal corresponding to an output signal which has been measured in the absence of any object in the detection zone.

8. Method according to claim 7, comprising the fact of analysing the output signal in order to detect characteristics of an object which is present in the detection zone, and comparing those characteristics with reference characteristics in order to identify the object.

9. Platform of an underground railway station comprising an edge facing a transport track and a detection device according to any one of claims 1 to 5, whose transmission line (2) is provided over the entire length along the platform edge.