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**(54) METHOD AND APPARATUS FOR DETERMINING THE OCCUPATION STATE OF THE CIRCUIT  
OF A DIRECT CURRENT TRACK CIRCUIT IN A RAILWAY LINE**

VERFAHREN UND VORRICHTUNG ZUR BESTIMMUNG DES BELEGUNGSZUSTANDES EINES  
GLEICHSTROM-GLEISSTROMKREISES EINER EISENBAHNSTRECKE

PROCEDE ET DISPOSITIF POUR DETECTER L'OCCUPATION D'UN CIRCUIT DE VOIE A  
COURANT CONTINU POUR UNE LIGNE FERROVIAIRE

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## Description

**[0001]** The present invention refers to a method and apparatus for determining the occupation state of the circuit of a direct current track circuit in a railway line.

**[0002]** In the railway industry language, a direct current track circuit is a section of a railway track of variable length (ranging from a few metres to several kilometres) electrically insulated from the adjacent track sections and having a low voltage applied on the set of two tracks. Application of voltage onto the electrified tracks occurs at an end of the track section, while a voltage detector is applied parallel at the end opposite to such power supply point. When there are no vehicles on that track section, the detector extracts a non-zero voltage given that the electrified tracks are not short-circuited by the presence of the train axes, while should any railway vehicle reach that track section it short-circuits the tracks with each other through its axes, and triggers current circulation on the axes causing the detection of an ideally zero-voltage on the detector.

**[0003]** Thus, such technology allows continuously generating information regarding the presence in a track section for vehicles (standstill or mobile), and used as it is for automating the control of a railway line.

**[0004]** The information received from the direct current track circuit is reliable if electrically insulated from the earth, or from an adjacent direct current track circuit. Furthermore, the measurement environment is extremely noisy - just imagine the traction noise of electric locomotives - and the measurement method must be practically immune to noise signals even of high levels. In addition in case there is no train in the circuit, the current supplied by the generator is not zero due to the dispersion resistance between the insulating joints, due to the dispersion resistance between the tracks (depending on the ballast for example).

**[0005]** Document US20060155433 proposes a method and a system for detecting a train on a direct current track circuit wherein an unambiguous code is added to the signal transmitted to the circuit. In particular, added to the voltage signal at the carrier frequency sent on the direct current track circuit is a preset number of information bits which - if identified in the reception step - signal the absence of the train in that direct current track circuit. It is obvious that in a noisy environment like the one described above even this system could fail to signal the correct information in that the added word could erroneously not be received. The object of the present invention is that of overcoming the abovementioned drawbacks and finding a reliable method for accurately detecting the signal for identifying the occupation state of a direct current track circuit.

**[0006]** The present invention proposes a method and an apparatus wherein in a direct current track circuit part of a railway line the low alternating voltage signal is modulated in amplitude and/or in phase with an unambiguous digital code word. Each circuit shall have its own unam-

biguous digital word.

**[0007]** Such encoding is currently used for encoding signals in mobile phones and it is substantially a technique for access, by several sources of information, to the same transmission channel, by using the same frequency band, which consists in associating - to the information transmitted by each of these sources - a code capable of identifying it in an unambiguous manner with respect to the rest and capable of allowing a receiver, to selectively extract information associated to each of them.

**[0008]** In such manner, verifying - in reception - the correlation between the received signal and the unambiguous digital word associated to that direct current track circuit, among all possible words, there will be no doubts as to whether the received signal is due to the absence of a train on the direct current track circuit in that the power of the detected signal shall be the maximum one.

**[0009]** An aspect of the present invention regards an apparatus for verifying the occupation state of a direct current track circuit in a railway line, having the characteristics of claim 1.

**[0010]** A further aspect of the present invention regards a method for verifying the occupation state of a direct current track circuit in a railway line, having the characteristics of claim 3.

**[0011]** Characteristics and advantages of the method and apparatus according to the present invention shall be more clear and apparent from the following exemplifying and non-limiting description of an embodiment provided with reference to the attached figure which represents a block diagram of the apparatus according to the present invention.

**[0012]** With reference to the abovementioned figure the apparatus according to the invention is applied on a direct current track circuit which essentially comprises a pair of tracks R made of parallel metal sections usually T-shaped, mounted transversely with respect to a bearing structure made up of crosspieces made of wood, steel or cement. Each direct current track circuit is separated from the adjacent one through electrically insulating joints G. In a railway line there is a plurality of adjacent direct current track circuits and insulated with respect to each other.

**[0013]** The apparatus according to the present invention for each direct current track circuit comprises a transmission block 2 capable of transmitting an alternating voltage signal, to which an unambiguous code word is associated, to the circuit. Such code word consists in providing a preset number of positive and negative half-waves of such alternating current according to a predetermined sequence. In particular, a so-called spread word S, for example made up of 16 chips, wherein each chip is equivalent to a sinusoidal cycle at the considered frequency, wherein the chip with value "1" provides for the sinusoidal cycle at the considered frequency with zero-phase, while the chip with value "0" provides for the sinusoidal cycle with phase 180°.

[0014] Advantageously, an unambiguous digital word of a specific direct current track circuit is orthogonal to the unambiguous code words of the adjacent direct current track circuits.

[0015] According to the present invention, the term "orthogonal" is used to indicate that the scalar product between two orthogonal words is zero.

[0016] Such voltage signal on which the code word is overlapped or associated is the traditional 50 Hz or 83.3 Hz voltage signal or other frequencies, which is used for detecting the passage of the train on that direct current track circuit.

[0017] Exploiting such property, the apparatus of the present invention further comprises a block 3 for extracting or detecting an ideally zero-voltage signal when the presence of the train closes the track electric circuit and a block 4 for processing such signal.

[0018] Under normal conditions (no train) such signal must contain the unambiguous word regarding its direct current track circuit alongside the noise associated thereto caused by the abovementioned phenomena.

[0019] The detected signal is sent to the processing block which comprises a microprocessor and at least one analogue/digital converter for such extracted signal. By carrying out the scalar product between such signal and the unambiguous word assigned to that specific direct current track circuit the presence of the correct unambiguous word may be verified and an energy value is obtained. If lower than a predetermined threshold value, such energy value causes the emission of an occupation signal which reveals the occupation state of the track.

## Claims

1. Apparatus for determining the occupation state of the circuit of a direct current track circuit in a railway line provided with a plurality of direct current track circuits adjacent to each other, such circuit comprising a pair of tracks (R) made up of parallel metal sections between which it is possible to apply an electric voltage, each direct current track circuit being separated from the adjacent one through electrically insulating joints (G), **characterised in that** it comprises a transmission block (2) capable of transmitting to the direct current track circuit an alternating current signal, associated to which is an unambiguous code word which consists in providing a preset number of positive and negative half-waves of such alternating current according to a predetermined sequence, at least one block (3) for detecting a current signal in such direct current track circuit of the line and at least one processing block (4) adapted to compare such predetermined unambiguous code word with the extracted signal, wherein such processing block carrying out the scalar product between such alternating signal and the unambiguous code word assigned to that specific direct current

track circuit obtaining an energy value which, if greater than a predetermined threshold value, determines the emission of an occupation signal which shows the occupation state of the track,

wherein the unambiguous code word associated to each direct current track circuit being orthogonal to the one associated to an adjacent circuit.

2. Apparatus according to claim 1, wherein the processing block comprises a microprocessor and at least one analogue/digital converter for such extracted signal.
3. Method for checking the occupation of a direct current track circuit of a railway line provided with a plurality of direct current track circuits adjacent to each other, each circuit comprising a pair of tracks (R) made up of parallel metal sections between which it is possible to apply an electric voltage, **characterised in that** it comprises the following steps:

- transmitting an alternating current signal on a direct current track circuit,
- associating an unambiguous code word to such signal providing a preset number of positive and negative half-waves of such alternating current according to a predetermined sequence, the unambiguous code word associated to each direct current track circuit being orthogonal to the one associated to an adjacent circuit,
- detecting an alternating current signal from the circuit,
- carrying out the scalar product between such alternating signal and the unambiguous code word assigned to that specific direct current track circuit, obtaining an energy value,
- comparing such calculated energy value with a predetermined threshold value,
- emitting an occupation signal which shows the occupation state of the track.

## Patentansprüche

1. Vorrichtung zur Bestimmung des Belegungszustands des Stromkreises eines Gleichstrom-Schienenstromkreises in einem Eisenbahngleis, der mit einer Vielzahl von zueinander benachbarten Gleichstrom-Schienenstromkreisen versehen ist, solch ein Stromkreis weist ein Paar Schienen (R) auf, das aus parallelen Metallabschnitten bestehen, zwischen denen es möglich ist eine elektrische Spannung anzulegen, jeder Gleichstrom-Schienenstromkreis ist von dem benachbarten durch elektrisch isolierende Verbindungen (G) getrennt, **dadurch gekennzeichnet, dass** die Vorrichtung aufweist einen Übertragungsblock (2), der in der Lage ist, an den Gleichstrom-

Schienenstromkreis ein Wechselstromsignal zu übertragen, dem ein eindeutiges Codewort zugeordnet ist, das darin besteht, eine vorgegebene Anzahl von positiven und negativen Halbwellen eines solchen Wechselstroms gemäß einer vorbestimmten Sequenz bereitzustellen, wenigstens einen Block (3) zum Erfassen eines Stromsignals in solch einem Gleichstrom-Schienenstromkreis des Gleises und wenigstens einen Steuerblock (4), der geeignet ist, ein solches vorgegebenes eindeutiges Codewort mit den extrahierten Signalen zu vergleichen, wobei ein solcher Steuerblock das Skalarprodukt zwischen solch einem wechselnden Signal und dem eindeutigen Codewort, mit welchem der spezifische Gleichstrom-Schienenstromkreis beaufschlagt wurde, ausführt, erhaltend einen Energiewert, welcher, wenn größer als ein vorbestimmter Schwellwert, die Aussendung eines Belegungssignals bestimmt, welches den Belegungszustand des Gleises anzeigt, wobei das eindeutige Codewort, das jedem Gleichstrom-Schienenstromkreis zugeordnet ist, orthogonal zu demjenigen ist, welches einem benachbarten Stromkreis zugeordnet ist.

2. Vorrichtung gemäß Anspruch 1, wobei der Steuerblock einen Mikroprozessor und wenigstens einen Analog/Digital-Wandler für ein solches extrahiertes Signal aufweist.

3. Verfahren zum Testen der Belegung eines Gleichstrom-Schienenstromkreises in einem Eisenbahngleis, der mit einer Vielzahl von zueinander benachbarten Gleichstrom-Schienenstromkreisen versehen ist, jeder Stromkreis weist ein Paar Schienen (R) auf, das aus parallelen Metallabschnitten bestehen, zwischen denen es möglich ist eine elektrische Spannung anzulegen, **dadurch gekennzeichnet, dass** das Verfahren die folgenden Schritte aufweist:

- Übertragen eines Wechselstromsignals auf einen Gleichstrom-Schienenstromkreis,
- Zuordnen eines eindeutigen Codewortes zu einem solchen Signal, das eine voreingestellte Anzahl von positiven und negativen Halbwellen eines solchen Wechselstroms gemäß einer vorbestimmten Sequenz bereitstellt, das eindeutige Codewort, das jedem Gleichstrom-Schienenstromkreis zugeordnet ist, ist orthogonal zu demjenigen, welches einem benachbarten Schaltkreis zugeordnet ist,
- Erfassen eines Wechselstromsignals des Stromkreises,
- Ausführen des Skalarprodukts zwischen solch einem wechselnden Signal und dem eindeutigen Codewort, mit welchem der spezifische Gleichstrom-Schienenstromkreis beaufschlagt wurde, erhaltend einen Energiewert,
- Vergleichen eines solchen berechneten Ener-

giewertes mit einem vordefinierten Schwellwert,  
- Aussenden eines Belegungssignals, welches den Belegungszustand eines Gleises anzeigt.

## Revendications

1. Dispositif permettant de déterminer l'état d'occupation de circuit d'un circuit de voie à courant continu d'une ligne de chemin de fer comportant une pluralité de circuits de voie à courant continu adjacents les uns aux autres, un tel circuit comprenant deux rails (R) constitués de sections métalliques parallèles entre lesquelles il est possible d'appliquer une tension électrique, chaque circuit de voie à courant continu étant séparé du circuit adjacent par des joints d'isolation électrique (G),

**caractérisé en ce qu'il** comprend un bloc de transmission (2) capable de transmettre au circuit de voie à courant continu un signal de courant alternatif, auquel est associé un mot de code sans équivoque qui consiste à fournir un nombre prédéfini de demi-ondes positives et négatives dudit courant alternatif selon une séquence prédéterminée, au moins un bloc (3) pour détecter un signal de courant dans ledit circuit de voie à courant continu de la ligne et au moins un bloc de traitement (4) conçu pour comparer ledit mot de code sans équivoque avec le signal extrait, dans lequel ledit bloc de traitement effectuant le produit scalaire entre ledit signal alternatif et le mot de code sans équivoque attribué à ce circuit de voie à courant continu spécifique obtenant une valeur énergétique qui, si elle est supérieure à une valeur de seuil prédéterminée, détermine l'émission d'un signal d'occupation qui indique l'état d'occupation de la voie, dans lequel le mot de code sans équivoque associé à chaque circuit de voie à courant continu est orthogonal par rapport à celui qui est associé à un circuit adjacent.

2. Dispositif selon la revendication 1, dans lequel le bloc de traitement comprend un microprocesseur et au moins un convertisseur analogique/numérique du signal extrait.

3. Procédé pour tester l'occupation d'un circuit de voie à courant continu d'une ligne de chemin de fer comportant une pluralité de circuits de voie à courant continu adjacents les uns aux autres, chaque circuit comprenant une paire de rails (R) constitués de sections métalliques parallèles entre lesquelles il est possible d'appliquer une tension électrique, **caractérisé en ce qu'il** comprend les étapes suivantes :

- la transmission d'un signal de courant alternatif sur un circuit de voie à courant continu,
- l'association d'un mot de code sans équivoque

avec ledit signal en fournissant un nombre prédéfini de demi-ondes positives et négatives du dit courant alternatif selon une séquence prédéterminée, le mot de code sans équivoque associé à chaque circuit de voie à courant continu étant orthogonal par rapport à celui qui est associé à un circuit adjacent, 5

- la détection d'un signal de courant alternatif provenant du circuit, 10
- la réalisation du produit scalaire entre ledit signal alternatif et le mot de code sans équivoque attribué à ce circuit de voie à courant continu spécifique, 15
- la comparaison de ladite valeur énergétique calculée avec une valeur de seuil prédéterminée, 20
- l'émission d'un signal d'occupation qui indique l'état d'occupation de la voie. 25

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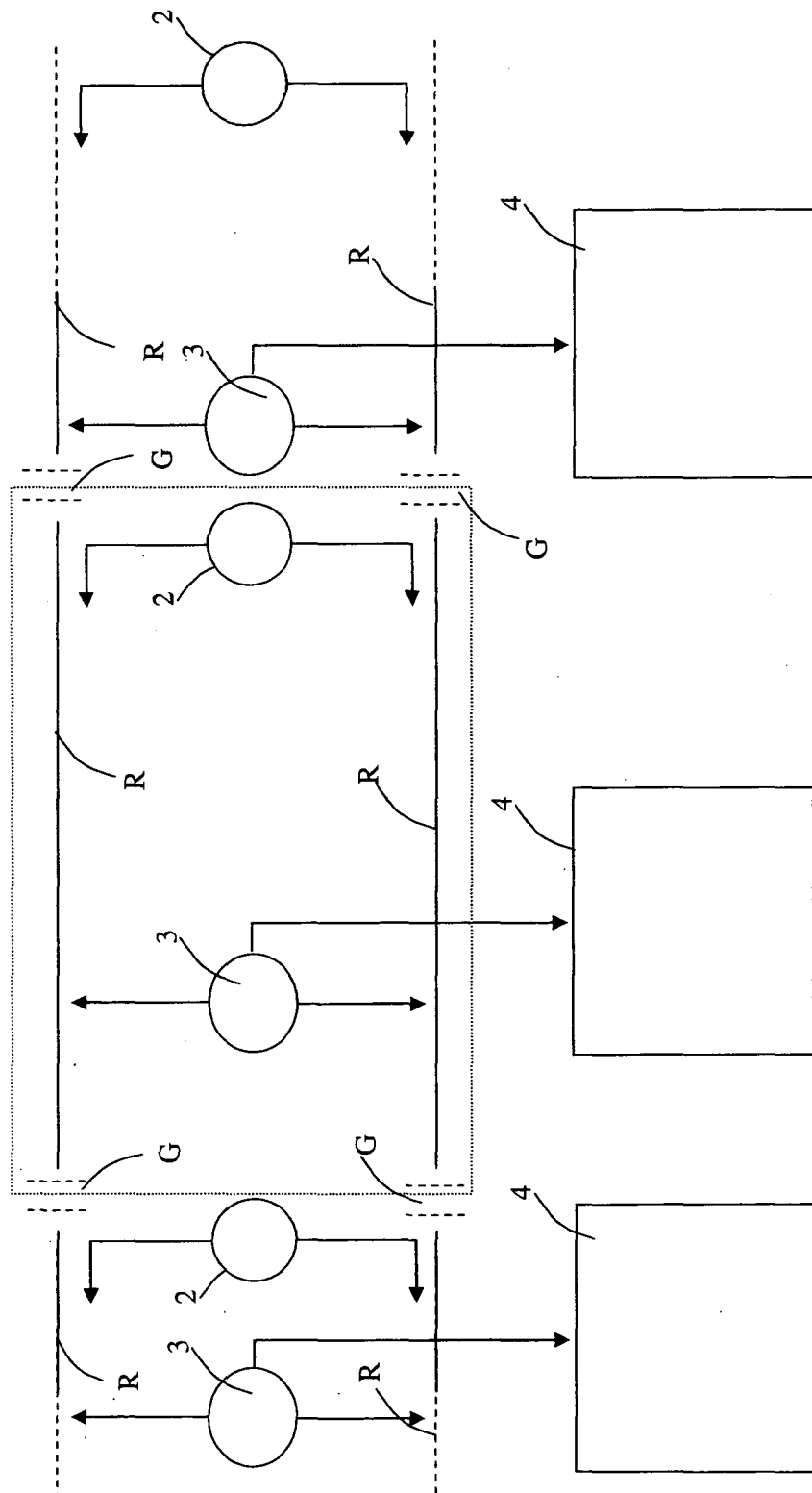


Fig. 1

**REFERENCES CITED IN THE DESCRIPTION**

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