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(54) **BALISE FOR A RAILWAY TRACK**

BALISE FÜR EISENBAHNGLEISE

BALISE POUR UNE VOIE FERRÉE

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Description

TECHNICAL FIELD OF THE INVENTION AND BACKGROUND ART

[0001] The present invention relates to a balise to be arranged between two rails of a railway track to transmit data to antennas mounted beneath railway vehicles passing the balise, said balise comprising

- a conducting receiver loop configured to receive electric power by magnetic induction from a transmitter in said rail vehicle antennas when passing the balise,
- a transmitter configured to be powered by the electric power received by the receiver loop, and
- a conducting transmitter loop configured to be fed by said transmitter to transmit data to said railway vehicle antennas passing the balise.

[0002] Such a balise is known through FR 2 873 341 A1.

[0003] Accordingly, balises are distributed along railway tracks to send information from the track side to passing trains enabling safe control of the traffic on the railway tracks through use of this information by automatic supervising systems on board the trains (railway vehicles) moving on the railway tracks. Such an automatic supervising system is defined as an ATP (Automatic Train Protection) system, and it may for instance operate according to the European standard ERTMS (European Rail Traffic Management System). The link between the balise and an ATP antenna on the train is based on magnetic coupling, which means that the balise and said antenna constitute an air transformer whenever the antenna is located above or in direct vicinity of the balise. This link is bi-directional, and the down link from the transmitter on the railway vehicle transmits power to the balise by magnetic induction of the receiver loop of the balise, whereas the uplink transmits data to the ATP system on board the railway vehicle by the use of the transmitter loop of the balise through the balise transmitter powered by the electric power received by the receiver loop.

[0004] However, air transformers are characterized by low efficiency, and in known balises only a small fraction of the magnetic flux transmitted by the ATP antenna is absorbed by the receiver loop of the balise and the same low efficiency is true for said uplink. This means that the transmitter on board the railway vehicle has to generate an unproportionally strong magnetic field to power the transmitter of the balise properly, which results in heat problems in the transmitter due to high currents and by that losses therein. Furthermore, the receiver on board the railway vehicle is made very sensitive to be able to absorb the data transmitted from the balise, which makes said receiver susceptible to noise. This together means that the balise has to have a substantial size to maximise the magnetic flux passing through it, making it costly to manufacture. The size of balises known also constitutes a problem when work is to be carried out for maintenance of the railway tracks, such as on the bedding of the sleepers.

[0005] A possibility to reduce the size of a balise would be to arrange the receiver loop tuned to another frequency than the transmitter loop to run inside the transmitter loop. However, when the current runs in the transmitter loop it would then induce a current in the receiver loop. This induced current will have the same frequency as the current in the transmitter loop but it would be out of phase. This induced current in the receiver loop would generate a magnetic field that affects the field generated by the transmitter loop. The combined effect of this is a weakened field for the transmission of data from the balise to the ATP antenna by the transmitter loop of the balise. Thus, this way of reducing the size of the balise seems inappropriate.

SUMMARY OF THE INVENTION

[0006] The object of the present invention is to provide a balise of the type defined in the introduction being improved with respect to such balises already known by reducing the cross coupling between the transmitter loop and the receiver loop and by that addressing the size problem thereof mentioned above in a favourable way.

[0007] This object is according to the invention obtained by providing such a balise with the features listed in the characterizing part of appended patent claim 1.

[0008] Accordingly, the transmitter loop extends along the receiver loop making it possible to give the balise an attractive size, and this is enabled without suffering from the drawbacks of weakened transmission mentioned above by providing the transmitter loop at at least one location therealong with at least one extra turn, which encloses an area being a fraction of the area enclosed by the transmitter loop and is designed to have current flowing through the transmitter loop running through said extra turn while generating a magnetic field felt by the receiver loop being opposed to a magnetic field felt by receiver loop through the current running through the part of the transmitter loop not belonging to a said extra turn, said fraction being less than 5 %, said at least one extra turn being located closer to the receiver loop than the average distance of the transmitter loop to the receiver loop and the average distance of said at least one extra turn to the receiver loop being less than 0.5, of the average distance of the transmitter loop to the receiver loop. The current in the transmitter loop not belonging to the extra turn will generate a strong magnetic field inside the receiver loop, whereas the current in said extra turn will generate a weaker magnetic field due to the small size (area enclosed by) of the extra turn. From the receiver loops perspective, the magnetic field from the extra turn is opposed the magnetic field from the transmitter loop not belonging to such an extra turn, and since the dis-

tance from the extra turn to the receiver loop is short the opposing magnetic field will be comparatively strong. This means that the total field inside the receiver loop oscillating at the frequency to which the transmitter loop is tuned has been greatly reduced. This results in a great reduction of the induced current with the transmitter loop frequency in the receiver loop as well. This in turn means that the opposing field generated by the receiver loop has also been reduced addressing said problem of a weakened up-link transmission from the balise. This altogether means that the size of the balise may be reduced remarkably with respect to balises known without reducing the efficiency of the transmission of data therefrom to an ATP antenna on board a railway vehicle, at the same time as the magnetic flux transmitted by the transmitter on board the railway vehicle may be reduced, since a larger proportion thereof may be absorbed by the receiver loop of the balise and less power is needed for the transmitter of the balise.

[0009] US 2016/38 0678 A1 discloses a system for data collection using near-field magnetic induction having a transmitter coil with extra turns in the form of coils for reducing the cross coupling between the transmitter coil and a receiver coil. However, the extra turns in the form of coils have such a size that they would contribute substantially to the magnetic field "seen" by a receiver on a train when used for a balise which would result in a substantial influence upon the inductance value of the extra turns by the environment outside the shell of the balise. This environment may include debris onto and around the balise in the form of inter alia water, metal, magnetite and iron ore. The extra turns may therefor result in considerable fluctuations of the total inductance of the transmitter loop detrimental for the stability of the operation of a transmitter of a balise being built as a LC resonator with a frequency depending upon the value of L (the inductance) and C. Thus, a person with skill in the art will not have much help by knowing about this publication when trying to solve the problem to be solved by the present invention.

[0010] According to an embodiment of the invention the transmitter loop surrounds the receiver loop. Although it may be obtained that the transmitter loop extends along the receiver loop by having the receiver loop surround the transmitter loop or having these two loops overlapping, it is advantageous to let the transmitter loop surrounding the receiver loop.

[0011] Aaccording to another embodiment of the invention the average distance of said at least one extra turn to the receiver loop is less than 0.3 or less than 0.1 of the average distance of the transmitter loop to the receiver loop.

[0012] According to another embodiment of the invention the transmitter loop has at least one said extra turn at a plurality of locations along the extension of the transmitter loop. Such a distribution of extra turns along the transmitter loop and by that along the receiver loop may increase the efficiency of cancelling out the effect of the magnetic field generated by the current in the transmitter loop upon the operation of the receiver loop and by that also the influence of the receiver loop upon the operation of the transmitter loop. It may then be favourable to have each said extra turn enclosing an area being substantially equal to or equal to the area enclosed by the other said extra turn (-s) and also to have said extra turns arranged symmetrically or substantially symmetrically with respect to the receiver loop.

[0013] It is conceivable to have a transmitter loop provided with one said extra turn at at least one said location, but also to have the transmitter loop provided with a plurality of said extra turns at said at least one said location, and the choice of the number of extra turns at a given location will be made while considering other specific characteristics of the balise in question.

[0014] According to another embodiment of the invention said at least one extra turn at at least one said location is arranged outside the area enclosed by the receiver loop and extends so as to have a current flowing therethrough running in the same direction, clockwise or anticlockwise, as the current flowing at that moment through the part of the transmitter loop not belonging to a said extra turn. This will result in the generation of a said opposed magnetic field aimed at.

[0015] Another possibility to obtain this is to have said at least one said extra turn at at least one said location arranged within the area enclosed by the receiver loop and extending so as to have a current flowing therethrough running in an opposite direction, clockwise or anti-clockwise, to the current flowing at that moment through the part of the transmitter loop not belonging to a said extra turn.

[0016] According to another embodiment of the invention the transmitter loop and the receiver loop have a substantially rectangular or a rectangular extension, which may be favourable from the balise manufacturing point of view.

[0017] According to another embodiment of the invention at least one said location said at least one extra turn arranged within the area enclosed by the receiver loop is arranged at a corner of the rectangle along which the receiver loop extends. Such a location of the extra turn is favourable, since this extra turn will then have an increased influence upon the total magnetic field felt by the receiver loop since the extra turn and by that magnetic field generated thereby will be close to two parts of the receiver loop joined through said corner.

[0018] According to another embodiment of the invention the balise has an outer casing containing the receiver loop, the transmitter and the transmitter loop and having a width corresponding to a typical width of a sleeper supporting the rails of a railway track. It is evident that a size of a balise within the dimensions of a sleeper made possible through the present invention will facilitate work on a railway track close to said sleeper and also reduce the risk of damaging the balise when carrying out such work.

[0019] According to another embodiment of the inven-

tion the transmitter of the balise is configured to transmit data, such as currently maximum allowed speed and maximum allowed speed in a very near future, to an Automatic Train Protection system (ATP), such as the European Rail Traffic Management System (ERTMS), of railway vehicles passing the balise.

[0020] Further advantages as well as advantageous features of the invention will appear from the description following below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] With reference to the appended drawings below follows a specific description of embodiments of the invention cited as examples.

[0022] In the drawings:

Fig 1 shows how balises may be arranged on sleepers of a railway track,

Fig 2 shows a functional block diagram of a balise according to the present invention,

Fig 3 is a simplified view very schematically illustrating the principles of a balise according to a first embodiment of the invention, and

Figs 4 and 5 are views corresponding to Fig 3 of a balise according to a second and a third, respectively, embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0023] Fig 1 shows how two balises 1 may be arranged between two rails 15, 16 of a railway track 17 by being secured to sleepers 18 supporting the rails.

[0024] Fig 2 illustrates very schematically a functional block diagram for a balise 1 of the type to which the present invention relates. The balise has a conducting receiver loop configured to receive electric power by magnetic induction from a transmitter not shown in an antenna of a rail vehicle when passing the balise. The magnetic field generated by the latter antenna causes an AC current to run in the receiver loop 2 and this current is rectified, stored in an energy storing unit 3 and used to power a transmitter 4 belonging to the balise. The balise further comprises a conducting transmitter loop 5 configured to be fed by the transmitter 4 to transmit data to railway vehicle antennas passing the balise. It is shown how the balise also has a logic block 6 being no part of the present invention and including a controller 7 provided with a serial link input and an input from a default telegram 8 provided with a programming interface.

[0025] Fig 3 illustrates the general configuration of a balise according to a first embodiment of the invention and the principles of the present invention. The transmitter 4 is here symbolized by an impedance 9 and an AC-source 10 with a working frequency f_L in the order of 27 MHz. The transmitter feeds an inductive transmitter loop 5, which has been tuned to the frequency f_L of the transmitter. A receiver loop 2 is running inside the transmitter loop, and this has been tuned to another frequency f_H, which is the frequency of transmitters located on rail vehicles passing the balise. The magnetic field generated by such on-board ATP transmitters causes an AC current to run in the balises receiver loop 2 due to magnetic induction, and this current is rectified and used to power the transmitter 4.

[0026] The current I_t running in the transmitter loop 5 induces a current I_r in the receiver loop 2, which has the same frequency f_L as the current in the transmitter loop, but is out of phase. This induced current in the receiver loop generates a magnetic field that affects the field generated by the transmitter loop for transmitting data to the ATP antenna of a railway vehicle passing. The combined effect of this is a weakened up-link transmission would the balise not include the following feature of the present invention: the transmitter loop is provided with two extra turns 11, 12, which each encloses an area 13, 14 being a fraction of the area enclosed by the transmitter loop. Each such extra turn is located closer to the receiver loop 2 than the average distance of the transmitter loop to the receiver loop and is designed to have a current flowing through the transmitter loop running through said extra turn while generating a magnetic field felt by the receiver loop being opposed to the magnetic field felt by the receiver loop through the current running through the part of the transmitter loop not belonging to an extra turn. This is illustrated by the magnetic field H_T felt by the receiver loop through the current I_t running through the part of the transmitter loop not belonging to the extra turn and the magnetic field H_E generated by each extra turn. Conventionally, circles with a cross indicate a magnetic field going into the page and circles with a dot indicate a magnetic field coming out of the page. It is indicated that the current in the main transmitter loop 5 generates a strong magnetic field inside the receiver loop, whereas the current in the extra turns 11, 12 generate weaker fields, due to the small size of these turns, but the direction is the same as the main field. However, from the receiver loops perspective, the field from the extra turns is opposed the main field, and since the distance from the extra turns to the receiver loop is short - the opposing field is comparatively strong. This means that the total field inside the receiver loop 2, oscillating at the frequency f_L, has been considerably reduced. This results in that the induced current with the frequency f_L has been greatly reduced as well, which in turn means that the magnetic field generated by the receiver loop and opposing the field of the transmitter loop has also been reduced, which is the sought-after effect of the present invention.

[0027] Thus, it is by the present invention achieved that

the two loops, receiver loop and transmitter loop, have substantially no influence upon each other.

[0028] Another effect of the minimized coupling of the transmitter loop and the receiver loop has to do with impedance stability. The impedance 20 of the receiver loop emanating from electronic circuits in the receiver tends to vary with the amount of tele-powering flux passing through the receiver loop. Since the two loops 2, 5 are coupled (normally), this means that the total impedance in the transmitter loop varies with tele-powering flux also. This dependency is weakened when the coupling is minimized making the transmitter performance more stable.

[0029] The following test has been carried out for investigating the influence of extra turns in the transmitter loop according to the present invention upon the current induced in the receiver loop. A metal pattern was edged on the top side of an isolating laminate and a different pattern on the bottom side of the laminate. The patterns were joined to each other using metal vias. The combined effect is two conducting loops with an outer loop having two extra spirals in series. These spirals consist of three turns each. A simulation program did let a current run in the outer loop, calculated magnetic field inside the loop and calculated how much current was induced in the inner loop. At an arbitrary chosen point on the outer loop the current was calculated to be 16.2 mA. At an arbitrary chosen point on the inner loop the current was calculated to be 3.9 mA. Thus, dividing the two gives a ratio of 4.2. The two spirals were then shortened out (giving a traditional balise loop geometry). The calculation did then for the same point on the outer loop result in a current of 19.2 mA (the higher value is due to a lower impedance in the loop). At the same point on the inner loop the current was now 8.4 mA, which gives a ratio of 2.3. The two spirals were then replaced by small, traditional inductors of 400 nH each, which resulted in a calculated current in the outer loop of 16.2 mA and a current in the inner loop of 6.9 mA, which also gave a ratio of 2.3. These test reveals that the induced current in the inner loop is much lower compared to the current in the outer loop when introducing the extra turns according to the invention.

[0030] Figs 4 and 5 shows possible designs of a balise according to second and third embodiments of the invention. The embodiment shown in Fig 4 differs from that shown in Fig 3 by having extra turns 31-34 at four locations along the extension of the transmitter loop, whereas Fig 5 illustrates how extra turns 41-44 of the transmitter loop 5 may be arranged within the area enclosed by the receiver loop 2 at corners 45-48 of the rectangle along which the receiver loop extends. These extra turns 41-44 do then run so that the current flowing therethrough is running in an opposite direction, clockwise or anti-clockwise, to the current flowing at the same moment through the part of the transmitter loop not belonging to such an extra turn.

[0031] The invention is of course in no way restricted to the embodiments described above, since many possibilities for modifications thereof are likely to be obvious to one skilled in the art without having to deviate from the scope of the invention defined in the appended claims.

[0032] It is for instance within the scope of the invention to have one or more extra turns arranged at only one location along the extension of the receiver loop. Although not shown a plurality of said extra turns may be arranged at one and the same said location and a different number of extra turns may be arranged at different said locations.

Claims

1. A balise to be arranged between the two rails of a railway track to transmit data to antennas mounted beneath railway vehicles passing the balise, said balise comprising

   • a conducting receiver loop (2) configured to receive electric power by magnetic induction from a transmitter in said rail vehicle antennas when passing the balise,
   • a transmitter (4) configured to be powered by the electric power received by the receiver loop (2), and
   • a conducting transmitter loop (5) configured to be fed by said transmitter (4) to transmit data to said railway vehicle antennas passing the balise,
   wherein said transmitter loop (5) extends along the receiver loop (2),
   characterised in that
   the transmitter loop has at at least one location along the extension thereof at least one extra turn (11, 12, 31-34, 41-44), which encloses an area (13, 14) being a fraction of the area enclosed by the transmitter loop (5) and is designed to have a current (It) flowing through the transmitter loop running through said extra turn while generating a magnetic field (H_E) felt by the receiver loop (2) being opposed to a magnetic field (H_T) felt by the receiver loop through the current running through the part of the transmitter loop (5) not belonging to a said extra turn, that said fraction is less than 5 %, said at least one extra turn is located closer to the receiver loop (2) than the average distance of the transmitter loop to the receiver loop and that the average distance of said at least one extra turn (11, 12, 31-34, 41-44) to the receiver loop (2) is less than 0.5 of the average distance of the transmitter loop (5) to the receiver loop.

2. A balise according to claim 1, ***characterized*** **in that** the average distance of said at least one extra turn (11, 12, 31-34, 41-44) to the receiver loop (2) is less than 0.3 or less than 0.1 of the average distance of the transmitter loop (5) to the receiver loop.

3. A balise according to claim 1 or 2, **characterized in that** said transmitter loop (5) surrounds the receiver loop (2).

4. A balise according to any of the preceding claims, ***characterized*** **in that** the transmitter loop (5) has at least one said extra turn (11, 12, 31-34, 41-44) at a plurality of locations along the extension of the transmitter loop.

5. A balise according to claim 4, ***characterized*** **in that** each said extra turn (11, 12, 31-34, 41-44) encloses an area being substantially equal to or equal to the area enclosed by the other said extra turn(-s).

6. A balise according to claim 4 or 5, ***characterized*** **in that** said extra turns (11, 12, 31-34, 41-44) are arranged symmetrically or substantially symmetrically with respect to the receiver loop.

7. A balise according to any of the preceding claims, ***characterized*** **in that** the transmitter loop (5) has one said extra turn (11, 12, 31-34, 41-44) at at least one said location.

8. A balise according to any of the preceding claims, ***characterized*** **in that** the transmitter loop (5) has a plurality of said extra turns (11, 12, 31-34, 41-44) at said at least one said location.

9. A balise according to any of the preceding claims, ***characterized*** **in that** said at least one extra turn (11, 12, 31-34) at at least one said location is arranged outside the area enclosed by the receiver loop (2) and extends so as to have a current (It) flowing therethrough running in the same direction, clockwise or anti-clockwise, as the current flowing at that moment through the part of the transmitter loop (5) not belonging to a said extra turn.

10. A balise according to any of the preceding claims, ***characterized*** **in that** said at least one said extra turn (41-44) at at least one said location is arranged within the area enclosed by the receiver loop (2) and extends so as to have a current (It) flowing therethrough running in an opposite direction, clockwise or anti-clockwise, to the current flowing at that moment through the part of the transmitter loop (5) not belonging to a said extra turn.

11. A balise according to any of the preceding claims, ***characterized*** **in that** the transmitter loop (5) and the receiver loop (2) have a substantially rectangular or a rectangular extension.

12. A balise according to claims 10 and 11, ***characterized*** **in that** at at least one said location said at least one extra turn (41-44) arranged within the area enclosed by the receiver loop (2) is arranged at a corner (45-48) of the rectangle along which the receiver loop extends.

13. A balise according to any of the preceding claims, ***characterized*** **in that** it has an outer casing containing the receiver loop (2), the transmitter (4) and the transmitter loop (5) and having a width corresponding to a typical width of a sleeper supporting the rails of a railway track.

14. A balise according to any of the preceding claims, ***characterized*** **in that** the transmitter (4) of the balise is configured to transmit data, such as currently maximum allowed speed and maximum allowed speed in a very near future, to an Automatic Train Protection system (ATP), such as the European Rail Traffic Management System (ERTMS), of railway vehicles passing the balise.

15. A balise according to any of the preceding claims, **characterized in that** the extension of the transmitter loop (5) along the receiver loop (2) and said at least one extra turn (11, 12, 31-34, 41-44) are made to minimize the coupling of these two loops and by that increasing the impedance stability in the transmitter loop making the transmitter performance more stable.

Patentansprüche

1. Balise, die zwischen den beiden Schienen eines Eisenbahngleises anzuordnen ist, um Daten an Antennen zu senden, die unterhalb von Eisenbahnfahrzeugen montiert sind, die die Balise passieren, wobei die Balise Folgendes umfasst:

   • eine leitfähige Empfängerschleife (2), die dazu ausgestaltet ist, elektrische Energie durch magnetische Induktion von einem Sender in den Eisenbahnfahrzeugantennen beim Passieren der Balise zu empfangen,
   • einen Sender (4), der dazu ausgestaltet ist, durch die elektrische Energie, die durch die Empfängerschleife (2) empfangen wird, mit Energie versorgt zu werden, und
   • eine leitfähige Senderschleife (5), die dazu ausgestaltet ist, durch den Sender (4) gespeist zu werden, um Daten an die Eisenbahnfahrzeugantennen zu senden, die die Balise passieren,

   wobei die Senderschleife (5) sich entlang der Empfängerschleife (2) erstreckt,
   dadurch gekennzeichnet, dass die Senderschleife an mindestens einer Stelle entlang ihrer Erstreckung mindestens eine zusätzliche Windung (11, 12, 31-34, 41-44) aufweist, die einen

Bereich (13, 14) umschließt, der ein Teilbereich des durch die Senderschleife (5) umschlossenen Bereiches ist, und so gestaltet ist, dass ein durch die Senderschleife fließender Strom (I_t) die zusätzliche Windung durchläuft und währenddessen ein durch die Empfängerschleife (2) gefühltes Magnetfeld (H_E) erzeugt, das einem durch die Empfängerschleife gefühlten Magnetfeld (H_T) aufgrund des Stroms, der den Teil der Senderschleife (5) durchläuft, der nicht zu der zusätzlichen Windung gehört, entgegengesetzt ist, dass der Teilbereich weniger als 5 % beträgt, der Abstand der mindestens einen zusätzlichen Windung zu der Empfängerschleife (2) geringer als der mittlere Abstand der Senderschleife zu der Empfängerschleife ist und dass der mittlere Abstand der mindestens einen zusätzlichen Windung (11, 12, 31-34, 41-44) zu der Empfängerschleife (2) weniger als 0,5 des mittleren Abstandes der Senderschleife (5) zu der Empfängerschleife beträgt.

2. Balise nach Anspruch 1, **dadurch *gekennzeichnet*, dass** der mittlere Abstand der mindestens einen zusätzlichen Windung (11, 12, 31-34, 41-44) zu der Empfängerschleife (2) weniger als 0,3 oder weniger als 0,1 des mittleren Abstandes der Senderschleife (5) zu der Empfängerschleife beträgt.

3. Balise nach Anspruch 1 oder 2, **dadurch *gekennzeichnet*, dass** die Senderschleife (5) die Empfängerschleife (2) umgibt.

4. Balise nach einem der vorangehenden Ansprüche, **dadurch *gekennzeichnet*, dass** die Senderschleife (5) an einer Mehrzahl von Stellen entlang der Erstreckung der Senderschleife mindestens eine zusätzliche Windung (11, 12, 31-34, 41-44) aufweist.

5. Balise nach Anspruch 4, **dadurch *gekennzeichnet*, dass** jede zusätzliche Windung (11, 12, 31-34, 41-44) einen Bereich umschließt, der im Wesentlichen gleich dem oder gleich dem durch die andere(n) zusätzliche(n) Windung(en) umschlossenen Bereich ist.

6. Balise nach Anspruch 4 oder 5, **dadurch *gekennzeichnet*, dass** die zusätzlichen Windungen (11, 12, 31-34, 41-44) symmetrisch oder im Wesentlichen symmetrisch bezüglich der Empfängerschleife angeordnet sind.

7. Balise nach einem der vorangehenden Ansprüche, **dadurch *gekennzeichnet*, dass** die Senderschleife (5) eine zusätzliche Windung (11, 12, 31-34, 41-44) an mindestens einer Stelle aufweist.

8. Balise nach einem der vorangehenden Ansprüche, **dadurch *gekennzeichnet*, dass** die Senderschleife (5) eine Mehrzahl von zusätzlichen Windungen (11, 12, 31-34, 41-44) an der mindestens einen Stelle aufweist.

9. Balise nach einem der vorangehenden Ansprüche, **dadurch *gekennzeichnet*, dass** die mindestens eine zusätzliche Windung (11, 12, 31-34), die sich an mindestens einer Stelle befindet, außerhalb des durch die Empfängerschleife (2) umschlossenen Bereiches angeordnet ist und sich so erstreckt, dass ein durch sie hindurch fließender Strom (I_t) sich in der gleichen Richtung - im Uhrzeigersinn oder entgegen dem Uhrzeigersinn - bewegt wie der Strom, der gleichzeitig durch den Teil der Senderschleife (5) fließt, der nicht zu der zusätzlichen Windung gehört.

10. Balise nach einem der vorangehenden Ansprüche, **dadurch *gekennzeichnet*, dass** die mindestens eine zusätzliche Windung (41-44), die sich an mindestens einer Stelle befindet, innerhalb des durch die Empfängerschleife (2) umschlossenen Bereiches angeordnet ist und sich so erstreckt, dass ein durch sie hindurch fließender Strom (I_t) sich in einer Richtung - im Uhrzeigersinn oder entgegen dem Uhrzeigersinn - bewegt, die der Richtung des Stromes, der gleichzeitig durch den Teil der Senderschleife (5) fließt, der nicht zu der zusätzlichen Windung gehört, entgegengesetzt ist.

11. Balise nach einem der vorangehenden Ansprüche, **dadurch *gekennzeichnet*, dass** die Senderschleife (5) und die Empfängerschleife (2) eine im Wesentlichen rechtwinkelige oder eine rechtwinkelige Erstreckung aufweisen.

12. Balise nach den Ansprüchen 10 und 11, **dadurch *gekennzeichnet*, dass** an mindestens einer Stelle die mindestens eine zusätzliche Windung (41-44), die innerhalb des durch die Empfängerschleife (2) umschlossenen Bereiches angeordnet ist, an einer Ecke (45-48) des Rechteckes angeordnet ist, entlang dessen sich die Empfängerschleife erstreckt.

13. Balise nach einem der vorangehenden Ansprüche, **dadurch *gekennzeichnet*, dass** sie eine Außenhülle aufweist, die die Empfängerschleife (2), den Sender (4) und die Senderschleife (5) enthält und eine Breite aufweist, die einer typischen Breite einer Eisenbahnschwelle entspricht, die die Schienen eines Eisenbahngleises trägt.

14. Balise nach einem der vorangehenden Ansprüche, **dadurch *gekennzeichnet*, dass** der Sender (4) der Balise dazu ausgestaltet ist, Daten, wie beispielsweise die aktuell zulässige Höchstgeschwindigkeit und die in Kürze zulässige Höchstgeschwindigkeit,

von Eisenbahnfahrzeugen, die die Balise passieren, an ein System der Automatischen Zugsicherung (*Automatic Train Protection* -ATP), wie beispielsweise das Europäische Eisenbahnverkehrsleitsystem (*European Rail Traffic Management System* - ERTMS), zu senden.

15. Balise nach einem der vorangehenden Ansprüche, **dadurch *gekennzeichnet*, dass** die Erstreckung der Senderschleife (5) entlang der Empfängerschleife (2) und die mindestens eine zusätzliche Windung (11, 12, 31-34, 41-44) so sind, dass die Kopplung dieser beiden Schleifen minimiert und dadurch die Impedanzstabilität in der Senderschleife erhöht wird, was das Betriebsverhalten des Senders stabiler macht.

Revendications

1. Balise destinée à être agencée entre les deux rails d'une voie ferrée pour transmettre des données à des antennes montées sous des véhicules ferroviaires passant la balise, ladite balise comprenant

• une boucle de récepteur conductrice (2) configurée pour recevoir de la puissance électrique par induction magnétique depuis un émetteur dans lesdites antennes de véhicule ferroviaire lors du passage de la balise,
• un émetteur (4) configuré pour être mis en fonctionnement par la puissance électrique reçue par la boucle de récepteur (2), et
• une boucle d'émetteur conductrice (5) configurée pour être alimentée par ledit émetteur (4) afin de transmettre des données auxdites antennes de véhicule ferroviaire passant la balise, dans laquelle ladite boucle d'émetteur (5) s'étend le long de la boucle de récepteur (2),
caractérisée en ce que
la boucle d'émetteur à, au niveau d'au moins un emplacement le long de son extension, au moins une spire supplémentaire (11, 12, 31-34, 41-44), qui enferme une zone (13, 14) qui est une fraction de la zone renfermée par la boucle d'émetteur (5) et est conçue pour faire s'écouler un courant (It) circulant à travers la boucle d'émetteur à travers ladite spire supplémentaire tout en générant un champ magnétique (H_E) ressenti par la boucle de récepteur (2) qui s'oppose à un champ magnétique (H_T) ressenti par la boucle de récepteur à travers le courant circulant à travers la partie de la boucle d'émetteur (5) n'appartenant pas à une dite spire supplémentaire, **en ce que** ladite fraction est inférieure à 5 %, ladite au moins une spire supplémentaire est située plus près de la boucle de récepteur (2) que la distance moyenne de la boucle d'émetteur à la boucle de récepteur et **en ce que** la distance moyenne de ladite au moins une spire supplémentaire (11, 12, 31-34, 41-44) à la boucle de récepteur (2) est inférieure à 0,5 fois la distance moyenne de la boucle d'émetteur (5) à la boucle de récepteur.

2. Balise selon la revendication 1, ***caractérisée* en ce que** la distance moyenne de ladite au moins une spire supplémentaire (11, 12, 31-34, 41-44) à la boucle de récepteur (2) est inférieure à 0,3 ou inférieure à 0,1 fois la distance moyenne de la boucle d'émetteur (5) à la boucle de récepteur.

3. Balise selon la revendication 1 ou 2, **caractérisée en ce que** ladite boucle d'émetteur (5) entoure la boucle de récepteur (2) .

4. Balise selon l'une quelconque des revendications précédentes, ***caractérisée en* ce que** la boucle d'émetteur (5) a au moins une dite spire supplémentaire (11, 12, 31-34, 41-44) au niveau d'une pluralité d'emplacements le long de l'extension de la boucle d'émetteur.

5. Balise selon la revendication 4, ***caractérisée* en ce que** chaque dite spire supplémentaire (11, 12, 31-34, 41-44) renferme une zone qui est sensiblement égale ou égale à la zone renfermée par l'autre ou les autres dite(s) spire(s) supplémentaire(s) .

6. Balise selon la revendication 4 ou 5, ***caractérisée* en ce que** lesdites spires supplémentaires (11, 12, 31-34, 41-44) sont agencées symétriquement ou sensiblement symétriquement par rapport à la boucle de récepteur.

7. Balise selon l'une quelconque des revendications précédentes, ***caractérisée* en ce que** la boucle d'émetteur (5) a une dite spire supplémentaire (11, 12, 31-34, 41-44) au niveau d'au moins un dit emplacement.

8. Balise selon l'une quelconque des revendications précédentes, ***caractérisée* en ce que** la boucle d' émetteur (5) a une pluralité desdites spires supplémentaires (11, 12, 31-34, 41-44) au niveau dudit au moins un emplacement.

9. Balise selon l'une quelconque des revendications précédentes, ***caractérisée* en ce que** ladite au moins une spire supplémentaire (11, 12, 31-34) au niveau d'au moins un dit emplacement est agencée à l'extérieur de la zone renfermée par la boucle de récepteur (2) et s'étend de manière à ce qu'un courant (It) s'écoulant à travers elle circule dans le même sens, dans le sens des aiguilles d'une montre ou dans le sens inverse des aiguilles d'une montre, que

le courant s'écoulant à cet instant à travers la partie de la boucle d'émetteur (5) n'appartenant pas à une dite spire supplémentaire.

10. Balise selon l'une quelconque des revendications précédentes, ***caractérisée*** **en ce que** ladite au moins une dite spire supplémentaire (41- 44) au niveau d'au moins un dit emplacement est agencée au sein de la zone renfermée par la boucle de récepteur (2) et s'étend de manière à ce qu'un courant (It) s'écoulant à travers elle circule dans le sens opposé, dans le sens des aiguilles d'une montre ou dans le sens inverse des aiguilles d'une montre, à celui du courant s'écoulant à cet instant à travers la partie de la boucle d'émetteur (5) n'appartenant pas à une dite spire supplémentaire.

11. Balise selon l'une quelconque des revendications précédentes, ***caractérisée*** **en ce que** la boucle d'émetteur (5) et la boucle de récepteur (2) ont une extension sensiblement rectangulaire ou rectangulaire.

12. Balise selon les revendications 10 et 11, ***caractérisée*** **en ce qu'**au niveau d'au moins à un dit emplacement ladite au moins une spire supplémentaire (41-44) agencée au sein de la zone renfermée par la boucle de récepteur (2) est agencée au niveau d'un coin (45-48) du rectangle le long duquel s'étend la boucle de récepteur.

13. Balise selon l'une quelconque des revendications précédentes, ***caractérisée*** **en ce qu'**elle comporte une enveloppe extérieure contenant la boucle de récepteur (2), l'émetteur (4) et la boucle d'émetteur (5) et ayant une largeur correspondant à une largeur typique d'une traverse supportant les rails d'une voie ferrée.

14. Balise selon l'une quelconque des revendications précédentes, ***caractérisée*** **en ce que** l'émetteur (4) de la balise est configuré pour transmettre des données, telles qu'une vitesse permise actuellement maximale et une vitesse permise maximale dans un futur très proche, à un système de protection automatique de train (ATP), tel que le système européen de gestion de trafic ferroviaire (ERTMS), de véhicules ferroviaires passant la balise.

15. Balise selon l'une quelconque des revendications précédentes, **caractérisée en ce que** l'extension de la boucle d'émetteur (5) le long de la boucle de récepteur (2) et de ladite au moins une spire supplémentaire (11, 12, 31-34, 41-44) sont réalisées pour réduire au minimum le couplage de ces deux boucles et en augmentant ainsi la stabilité d'impédance dans la boucle d'émetteur rendant les performances de l'émetteur plus stables.

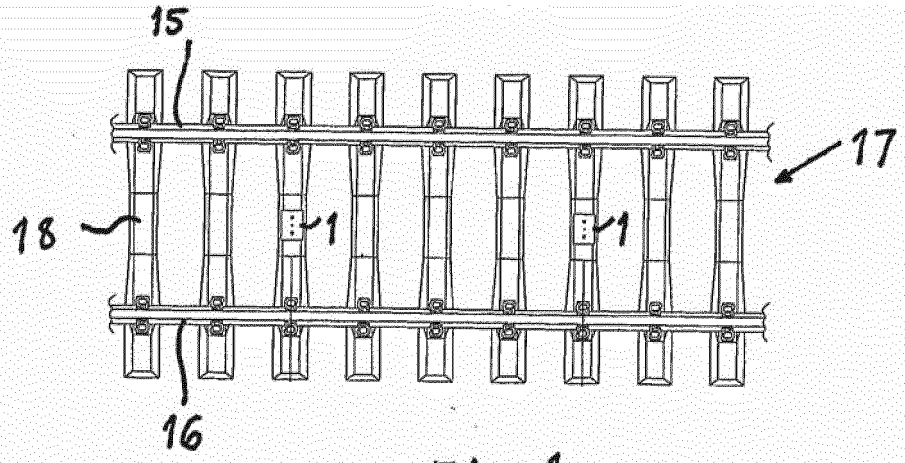

Fig 1

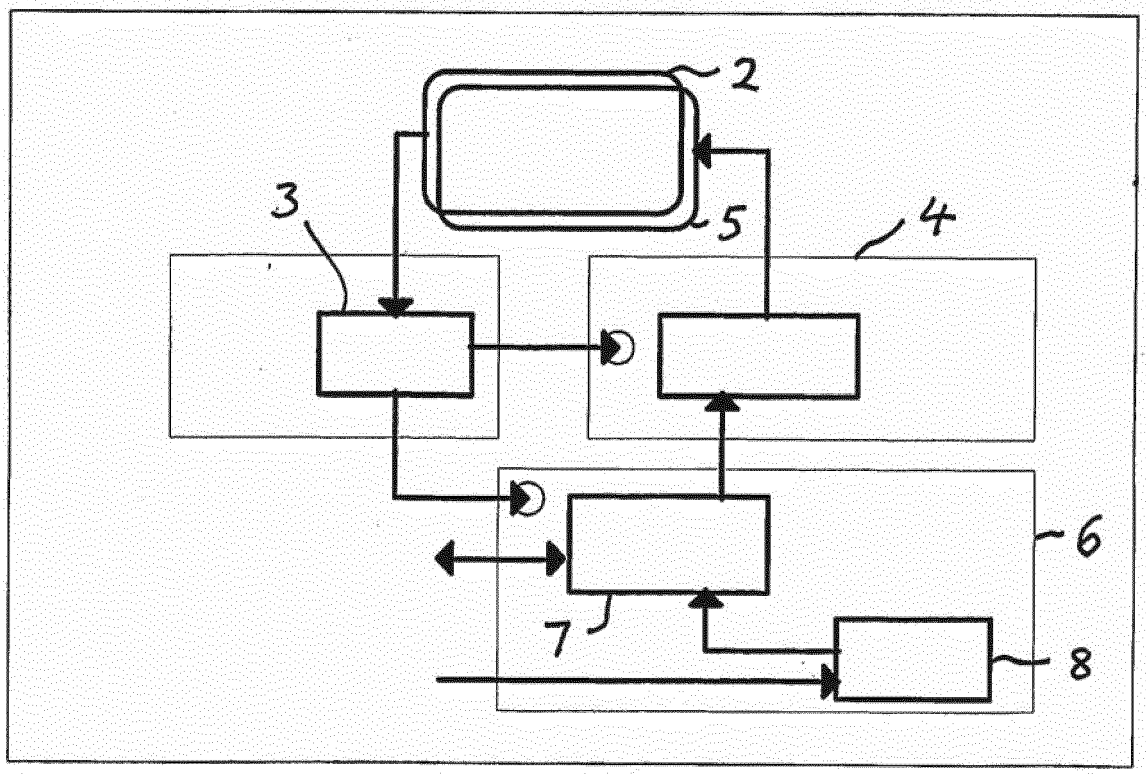

Fig 2

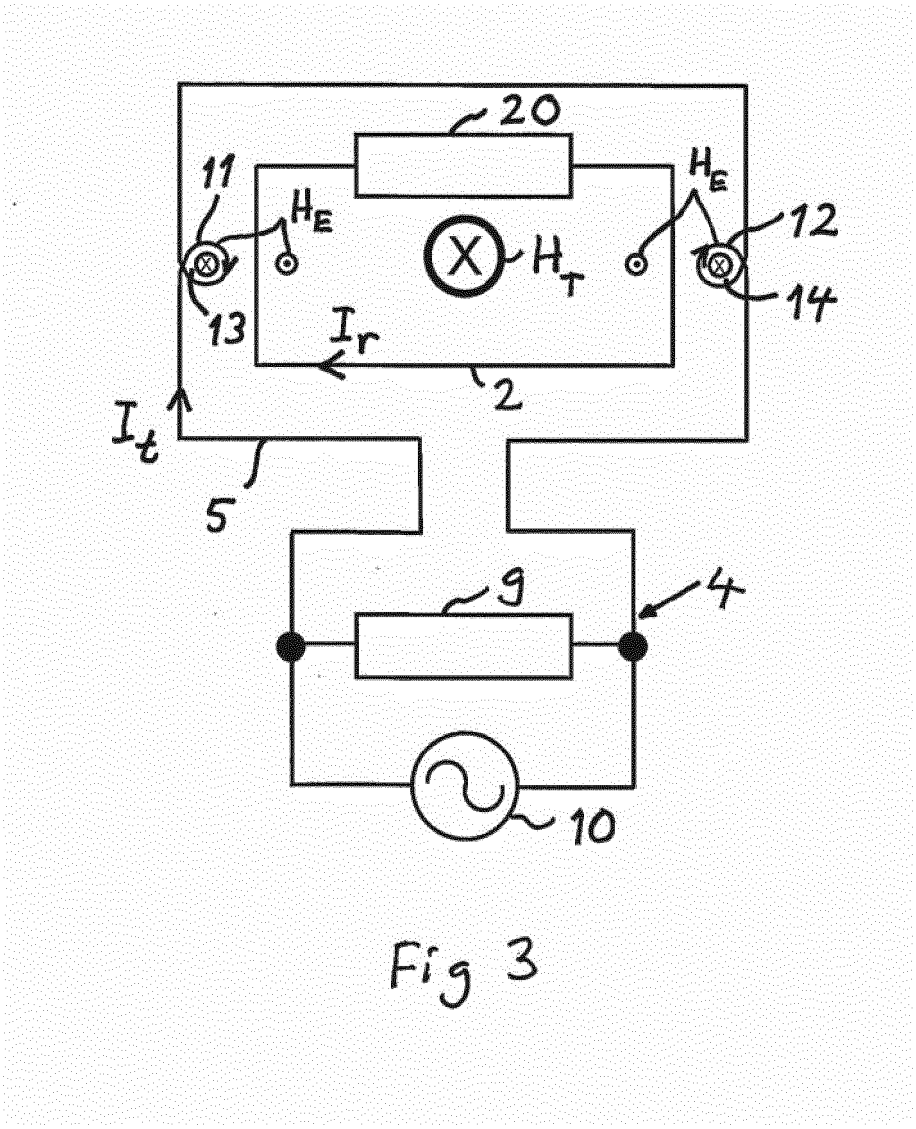

Fig 3

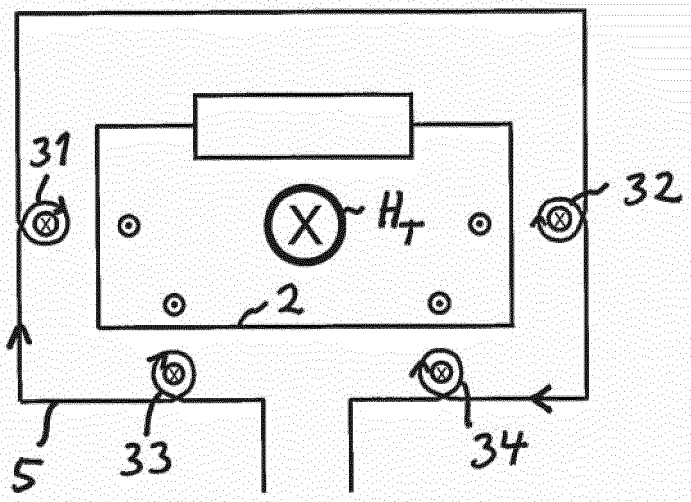

Fig 4

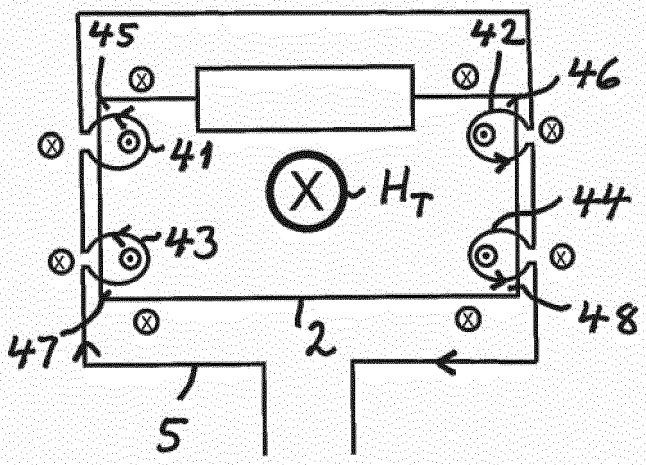

Fig 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- FR 2873341 A1 **[0002]**
- US 2016380678 A1 **[0009]**