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(71) Applicant: **Bombardier Transportation GmbH**
10785 Berlin (DE)

(72) Inventor: **Rehn, Anders**
SE-181 56 Lidingö (SE)

(74) Representative: **Bjerkéns Patentbyrå KB (Gävle)**
Box 1274
801 37 Gävle (SE)

(54) BALISE FOR A RAILWAY TRACK

(57) A balise to be arranged between the two rails of a railway track has a transmitter loop (5) surrounding a receiver loop (2). The transmitter loop has at at least one location along the extension thereof at least one extra turn (11, 12), which encloses an area being a fraction of the area enclosed by the transmitter loop and is designed to have a current (I_t) flowing through the transmitter loop running through the extra turn while generating a magnetic field felt by the receiver loop being opposed to a magnetic field felt by the receiver loop through the current running through the part of the transmitter loop not belonging to a said extra turn (11, 12).

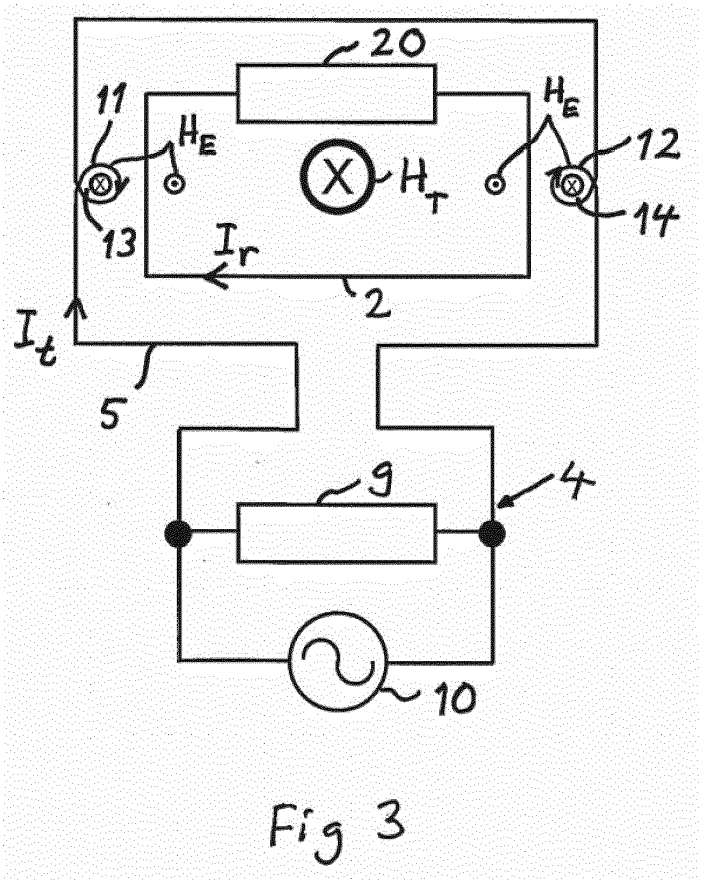

Fig 3

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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] 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.

[0003] 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.

[0004] 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

[0005] 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 addressing the size problem thereof mentioned above in a favourable way.

[0006] 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.

[0007] 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. 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 distance 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.

[0008] 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.

[0009] According to another embodiment of the invention said fraction is less than 20 %, less than 10 % or less than 5 %. This means that the magnetic field generated by such an extra turn will be considerably weaker than the field generated by the rest of the transmitter loop, but the effect of this magnetic field will be considerable thanks to the short distance between the extra turn and the receiver loop, and according to another embodiment of the invention said at least one extra turn is 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 is less than 1, less than 0.5, less than 0.3 or less than 0.1 of the average distance of the transmitter loop to the receiver loop.

[0010] 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.

[0011] 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.

[0012] 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 anti-clockwise, 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.

[0013] 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.

[0014] 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.

[0015] 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.

[0016] 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.

[0017] According to another embodiment of the invention 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.

[0018] Further advantages as well as advantageous features of the invention will appear from the description following below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] With reference to the appended drawings below follows a specific description of embodiments of the invention cited as examples.

[0020] 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

[0021] 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.

[0022] 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.

[0023] 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.

[0024] The current It 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 preferably 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 It 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.

[0025] Thus, it is by the present invention achieved that the two loops, receiver loop and transmitter loop, have substantially no influence upon each other.

[0026] 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.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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,

   characterized **in that** said transmitter loop (5) extends along the receiver loop (2), and 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.

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

3. A balise according to claim 1 or 2, ***characterized*** **in that** said fraction is less than 20 %, less than 10 % or less than 5 %.

4. A balise according to any of the preceding claims, ***characterized*** **in that** 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 1, less than 0.5, less than 0.3 or less than 0.1 of the average distance of the transmitter loop (5) to the receiver loop.

5. 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.

6. A balise according to claim 5, ***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).

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

8. 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.

9. 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.

10. 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.

11. 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.

12. 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.

13. A balise according to claims 11 and 12, ***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.

14. 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.

15. 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.

16. 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.

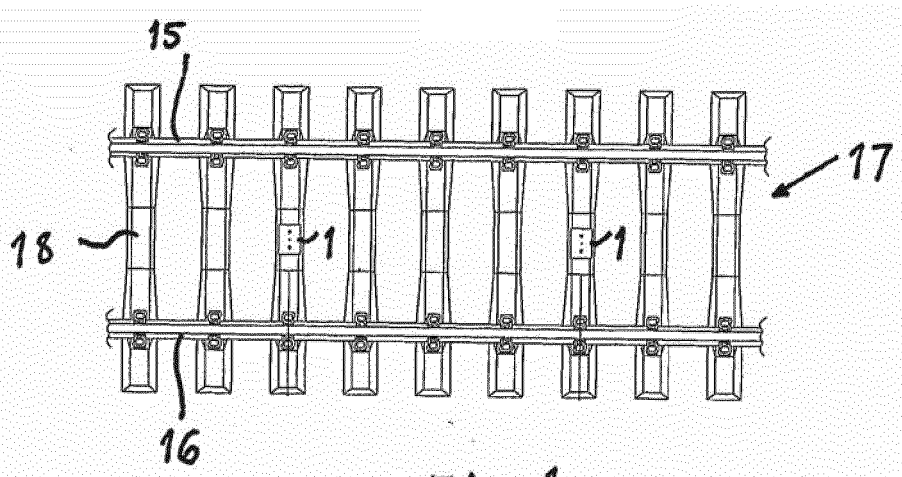

Fig 1

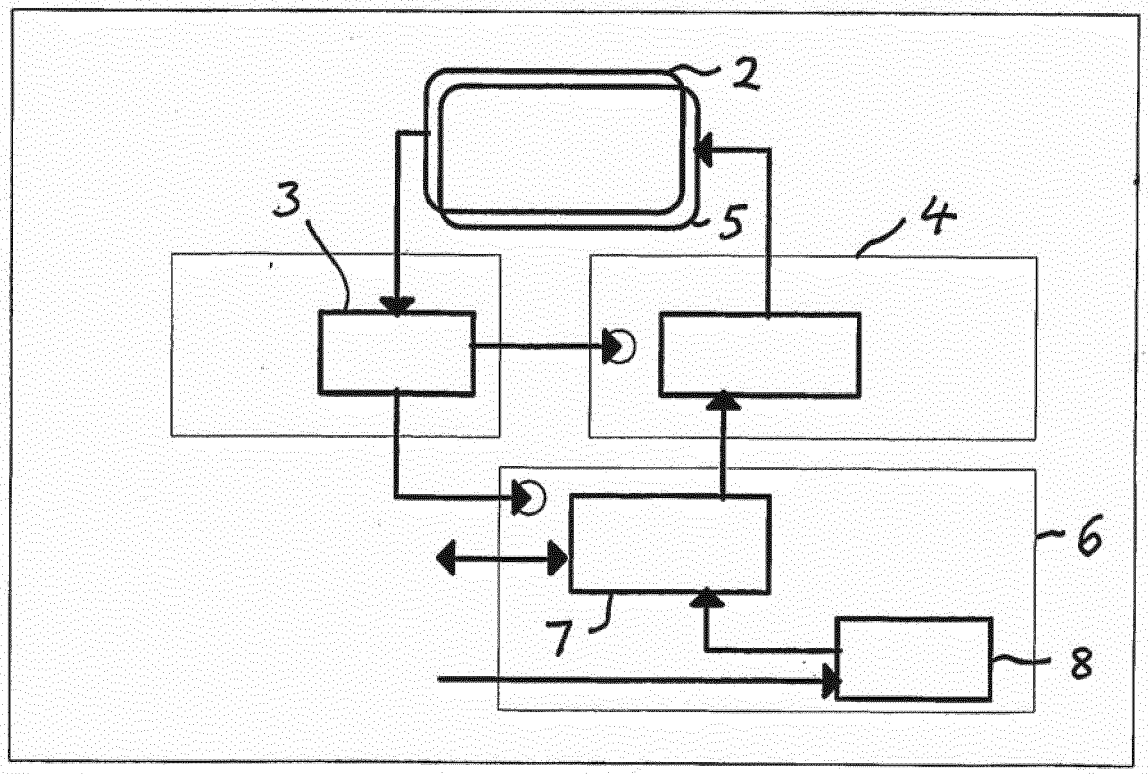

Fig 2

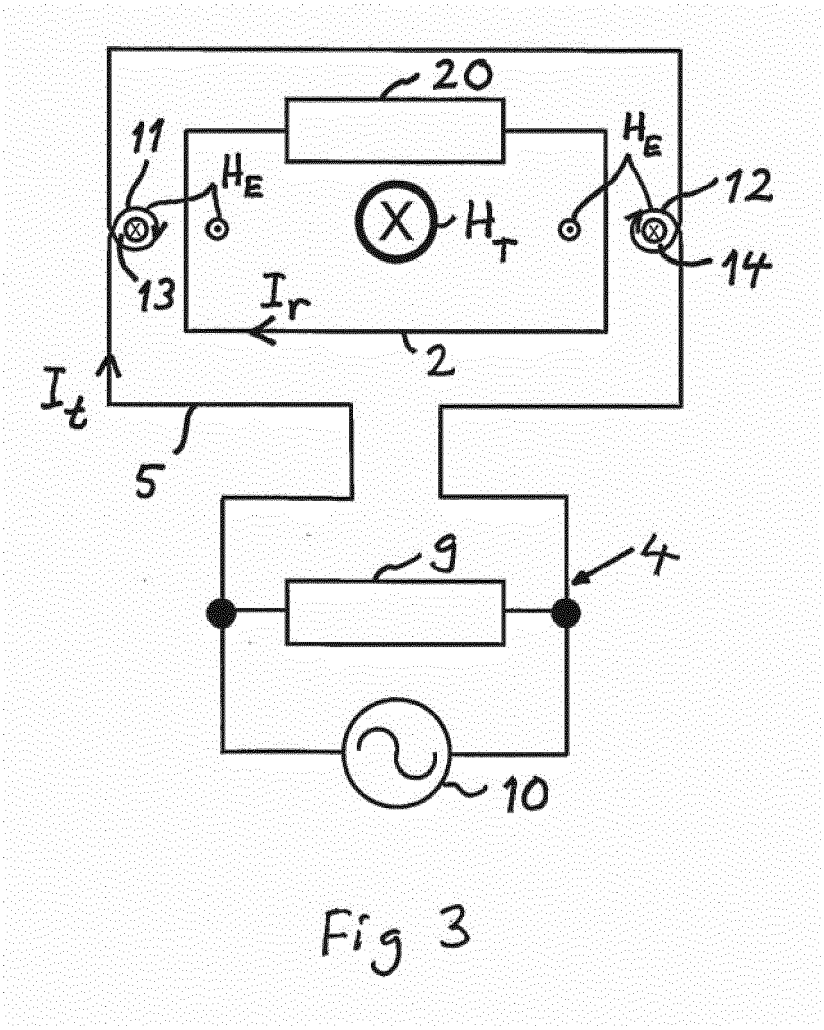

Fig 3

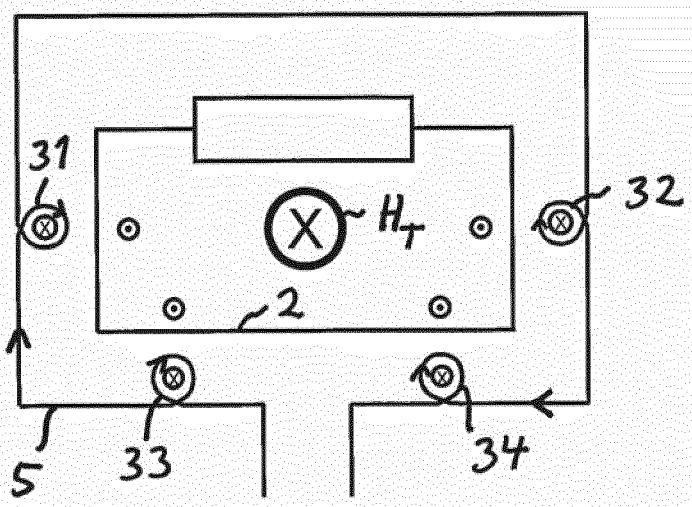

Fig 4

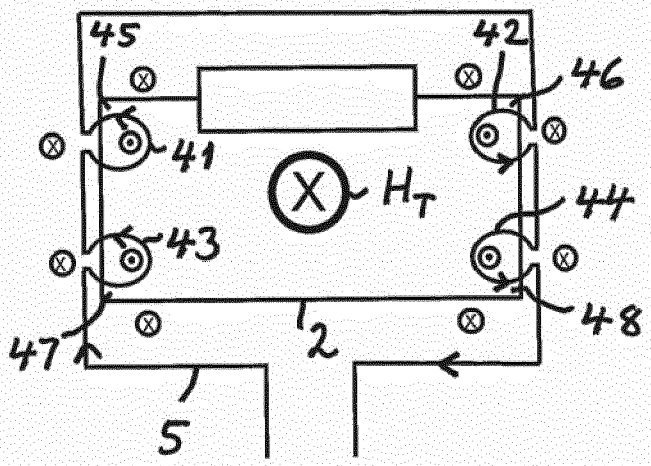

Fig 5

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EUROPEAN SEARCH REPORT

Application Number
EP 17 17 2467

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	FR 2 873 341 A1 (SIEMENS TRANSP SYSTEMS SOC PAR [FR]) 27 January 2006 (2006-01-27) * abstract; figures 2,11 * * page 1, line 1 - page 2, line 25 * * page 11, line 6 - page 12, line 27 *	1-16	INV. B61L3/12
Y	US 2016/380678 A1 (MCMANUS DAVID F [US] ET AL) 29 December 2016 (2016-12-29) * figures 8, 10,11,12, 13, 14 * * paragraphs [0020], [0021], [0032] * * paragraphs [0099] - [0125] *	1-16	
Y	DE 103 38 311 B3 (SIEMENS AG [DE]) 10 February 2005 (2005-02-10) * the whole document *	1-16	

TECHNICAL FIELDS SEARCHED (IPC)

B61L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 November 2017	Robinson, Victoria

CATEGORY OF CITED DOCUMENTS

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20-11-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 2873341 A1	27-01-2006	NONE	
US 2016380678 A1	29-12-2016	NONE	
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