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(54) **A DEVICE FOR WIRELESSLY RECEIVING ELECTRIC ENERGY**

(57) A device for wirelessly receiving electric energy to be transferred from a source (2) of alternating current by electromagnetic coupling through a conducting transmitter loop (3) has a conducting receiver loop (4) in which a current is induced and a capacitor (5) connected into the receiver loop and charged with electric energy

through the current induced in the receiver loop. A rectifying member (10) is connected into the receiver loop at a second location (11) spaced with respect to a first location (8) for connection of the capacitor and configured to allow a rectified portion of the current induced in the receiver loop to only flow in one direction therethrough.

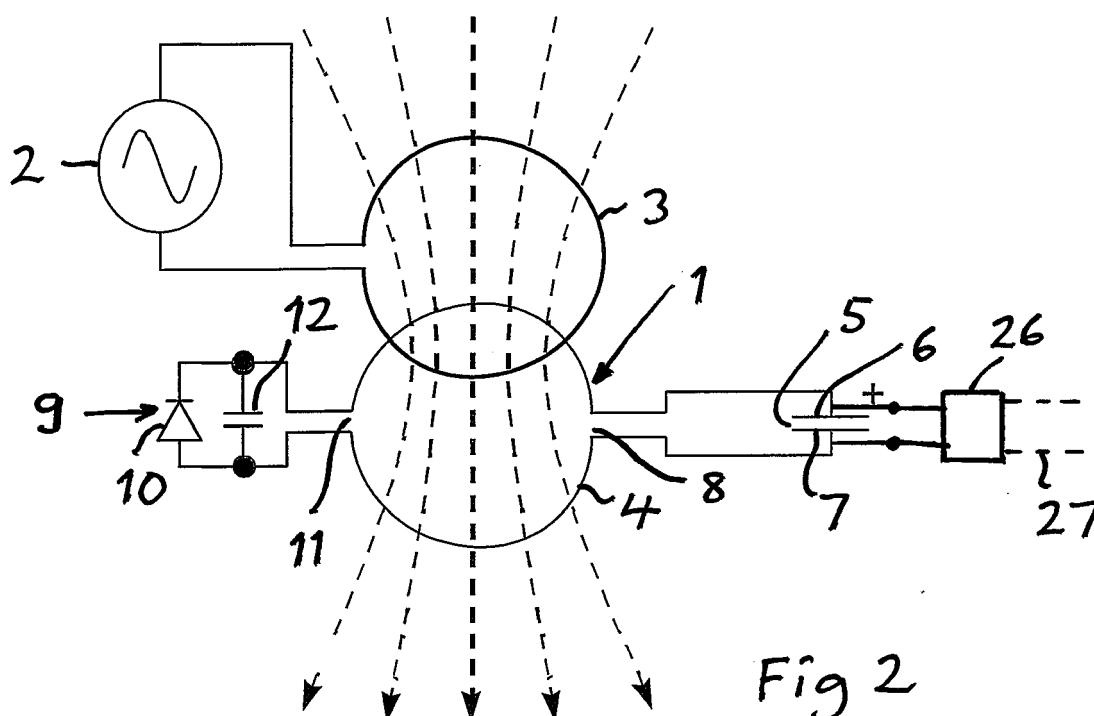


Fig 2

Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to a device for wirelessly receiving electric energy to be transferred from a source of alternating current by electromagnetic coupling through a conducting transmitter loop connected to this source, said device comprising at least one conducting receiver loop configured to receive electric energy from a said source in the form of current induced therein through electromagnetic coupling when placed close to a said conducting transmitter loop, at least one capacitor connected into said receiver loop for being charged with electric energy through said current induced in the receiver loop, an arrangement configured to allow a portion of the current induced in said receiver loop to only reach one pole of the capacitor for charging the capacitor and not flow in opposite direction and discharge the capacitor, and a capacitance connected to the receiver loop to tune this to a determined frequency.

[0002] Such a device may be used in any type of equipment to be wirelessly fed with electric energy, i.e. be energized by so called tele-powering. Such an equipment in the form of a balise to be arranged between two rails of a railway track to transmit data through antennas mounted beneath railway vehicles passing the balise is only one example of this type of equipment.

[0003] The particular application of the invention in a balise will hereinafter be discussed for illuminating the invention and the problems to be solved thereby without for that sake restricting the invention thereto.

[0004] Balises are used by railways to send information from the track side to passing trains. There are many ways to do this, and one method for this is to be found in the standard ERTMS, European Rail Traffic Management System. The balise link is based on electromagnetic coupling, that is, the balise on the ground and the ATP (Automatic Train Protection) antenna on the train constitute an air transformer whenever the antenna is located above (or in the direct vicinity of) the balise. The link is bi-directional and the frequencies used are radio short wave. The downlink is used to transmit power to the balise, which is accordingly received by the device defined in the introduction. The uplink is used to transmit data to the train, and the transmitter of such an uplink is powered by the electric energy received by said device. AU 2013206087 B2 is a document disclosing tele-powering of a balise in general.

[0005] Since the contact distance between a standard-size balise on the ground and the ATP antenna on the train is about 1 m, it means that the contact duration is highly speed dependent. Modern trains can travel at 100 m/s, which means that it takes 10 ms to move 1 m. This means that the time allowed for the balise to be tele-powered by the train and for the balise to send its ATP telegram comes to about 10 ms. This is a technical challenge. The railway track companies would like to have

smaller balises and at the same time allow higher train speeds on their tracks, which means that the contact time for said tele-powering will be shrinking to levels requiring improvements in balise efficiency for meeting these demands.

BACKGROUND ART

[0006] Fig. 1 illustrates schematically the structure of a known device of the type defined in the introduction as used in a balise. 100 illustrates a source of alternating current arranged on board a rail vehicle. This source generates an alternating current in a conducting transmitter loop 101 on board the vehicle. When this transmitter loop 101 passes over a conducting receiver loop 102 in a said balise the alternating current in the transmitter loop 101 will through electromagnetic coupling generate a current in the receiver loop. The transmitter loop 101 and the receiver loop 102 have not to have the same shape and size for obtaining this. The current induced in the receiver loop 102 is rectified by the use of a bridge of diodes 103-106, which forms an arrangement configured to allow a rectified portion of the current induced in the receiver loop to only reach one pole of a capacitor 107 connected into the receiver loop for being charged with electric energy through the current induced in the receiver loop. The charge (DC voltage) across the capacitor 107 may then be used for powering other electrical devices, such as a microprocessor. Furthermore, a capacitance in the form of a capacitor 108 is connected to the receiver loop to tune this to the frequency of transmitters of rail vehicles passing the balise.

[0007] Once the tele-powering is started by electromagnetic coupling the time it takes to charge the capacitor 107 to a determined voltage level decides the point of time at which a transmitter in the balise may send its ATP telegram to the antennas of the rail vehicles passing. This does then also decide at which speed a train may pass the balise and still receive a said telegram with important information therefrom. Accordingly, it is a desire to be able to shorten the charging time of said capacitor for enabling higher train speeds and/or smaller balises with respect to balises provided with a known device shown in Fig. 1.

SUMMARY OF THE INVENTION

[0008] The object of the present invention is to provide a device of the type defined in the introduction being improved with respect to such devices already known by addressing the problems thereof discussed above.

[0009] This object is according to the invention obtained by providing such a device with the features listed in the characterizing part of appended patent claim 1.

[0010] Accordingly, said capacitor is connected into the receiver loop by having opposite poles thereof directly connected to the receiver loop at a first location therealong, and the arrangement comprises at least one rec-

tifying member, such as a rectifying diode, connected into the receiver loop at a second location therealong spaced with respect to the first location and configured to allow a rectified portion of the current induced in the receiver loop to only flow in one direction therethrough. Furthermore, the capacitance for said tuning is connected into the receiver loop at said second location.

[0011] The voltage across said capacitor will be higher than in the known device in which it will be a voltage drop across each diode, since the diode bridge has been replaced by said rectifying member connected into the receiver loop. This means that the time it will take to charge the capacitor to a predetermined level will be shortened, so that in the case of the device used in a balise a transmitter in the balise powered by the capacitor will earlier be able to send a message to the train passing allowing this to pass the balise with a higher speed than a balise provided with a known device. Thus, the critical wake up time of the balise will be shortened by a device according to the invention.

[0012] According to an embodiment of the invention said first and second locations are at opposite positions along said receiver loop, which means that the rectifying member and the tuning capacitance are arranged in one side of the receiver loop and the capacitor to be charged on the opposite side, which keeps the receiver device balanced and less sensitive to stray capacitances than an unbalanced receiver device.

[0013] According to another embodiment of the invention said tuning capacitance is connected in parallel to said rectifying member, and the rectifying member is according to another embodiment preferably a rectifying diode. The tuning capacitance may then be formed by the inherent capacitance of the diode or be provided by a capacitor connected in parallel to the diode.

[0014] According to another embodiment of the invention the general shape and size of the receiver loop defined by receiver loop portions between said first and second locations are substantially identical to the shape and size of a said conducting transmitter loop from which the receiver loop is configured to receive electric energy, which may increase the efficiency of the tele-powering by electromagnetic coupling, and it is then advantageous that the general shape of the receiver loop is symmetrical with rectifying member and capacitor to be charged on opposite sides.

[0015] According to another embodiment of the invention the device comprises a plurality of said conducting receiver loops superimposed and a rectifying member connected into an individual receiver loop is configured to allow current induced in that receiver loop to only flow in the opposite direction therethrough with respect to what a rectifying member in a neighbouring receiver loop is configured to allow. This means that every second receiver loop will be active and charging the capacitor in question during a half period of the alternating current of a said source, and that the neighbouring receiver loops will be active in that sense during the other half period of

the alternating current, so that the capacitors are charged all the time and a DC source formed by said capacitors will be more efficient than in the case of only one receiver loop, since losses with respect to the utility power will be lower than for a device having only one receiver loop. Furthermore, the currents in adjacent receiver loops will be out of phase, which means that harmonics in the currents induced will also be out of phase and they will counteract each other. This means that harmonics in the induced currents are greatly reduced, which is a very desirable property.

[0016] According to another embodiment of the invention all said at least one capacitor of the receiver loops are interconnected to together form an assembly storing electric energy, which accordingly results in an efficient DC source to be used by equipment in which the device according to the invention is integrated.

[0017] According to another embodiment of the invention said interconnected capacitors are connected in parallel to each other.

[0018] According to another embodiment of the invention said interconnected capacitors are connected in series to provide a voltage of said assembly formed by an addition of the voltages across all said capacitors. The way of interconnecting said capacitors chosen will be dependent upon the type of load to be connected thereto. A series connection may be selected when there is a need to generate high voltages, and a parallel connection when high currents are of more importance.

[0019] According to another embodiment of the invention the number of receiver loops is even, which results in an optimum of the reduction of harmonics created in the device.

[0020] The invention also relates to a balise according to the preamble of the appended claim directed thereto and which comprises a device according to the present invention for wirelessly receiving electric energy from a transmitter in a rail vehicle antenna. The advantages of providing a balise with a device according to the present invention appear clearly from the above discussion of the device according to the invention and embodiments thereof.

[0021] Further advantages and advantageous features of the invention will appear from the description following below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] With reference to the appended drawings, below follows a specific description of embodiments of the invention cited as examples.

[0023] In the drawings:

Fig. 1 is a simplified view very schematically illustrating the structure of a known device of the type to which the present invention belongs,

Fig. 2-4 are views corresponding to Fig. 1 of devices

according to a first, second and third, respectively, embodiment of the invention, and

Fig. 5 is a graph showing the DC voltage across the capacitor charged versus time obtained by electromagnetic coupling for the devices shown in Fig. 1, 2 and 3.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0024] A device 1 for wirelessly receiving electric energy to be transferred from a source 2 of alternating current by electromagnetic coupling through a conducting transmitter loop 3 is shown in Fig. 2. This device has a conducting receiver loop 4 configured to receive electric energy from said source 2 in the form of current induced therein through electromagnetic coupling when placed close to said conducting transmitter loop 3. A capacitor 5 is connected into the receiver loop by having opposite poles 6, 7 thereof directly connected to the receiver loop at a first location 8 therealong. An arrangement 9 configured to allow a rectified portion of current induced in the receiver loop to only reach one pole 6 of the capacitor 5 for charging the capacitor and not flow in opposite direction, which would discharge the capacitor, is formed by a diode 10. This diode is connected into the receiver loop at a second location 11 therealong spaced with respect to the first location. A capacitance in the form of a capacitor 12 is connected into the receiver loop in parallel with the diode 10 at said second location for tuning the receiver loop to a determined frequency.

[0025] The diode bridge in the known device shown in Fig. 1 has here been replaced by a single diode 10. This means that the voltage across the charged capacitor will be higher, since for instance in case of voltage thereacross of 4 V the voltage across the capacitor of the device in Fig. 1 would only be approximately 3 V owing to a voltage drop in the order of 0.2-0.5 V across each diode. This higher voltage shortens the charging time needed for reaching a predetermined voltage level, such as 3 V, of the capacitor for enabling this to be used as a source for powering for instance a microprocessor. However, charging of a capacitor will only take place every second half period of the induced current, which lengthens the charging time. By moving the diode 10 and the tuning capacitor 12 to an opposite side of the receiver loop 4, the receiver device will be kept balanced and less sensitive to stray capacitances. Furthermore, the removal of the diode bridge means that for a determined size of the device the receiver loop 4 may be made larger resulting in a more efficient transfer of energy and data while interacting with the transmitter loop 3, or the device may be made smaller without for that sake making the receiver loop smaller. Thus, in the case of a balise provided with said device the balise may be made smaller and the capacity thereof still be maintained with respect to transfer efficiency and improved with respect to starting time of

said data transfer.

[0026] A device according to a second embodiment of the invention is shown in Fig. 3. This device has two conducting receiver loops 20, 21 superimposed. A diode 22, 23 connected into an individual receiver loop is configured to allow current induced in that receiver loop to only flow in the opposite direction therethrough with respect to what a diode in the other receiver loop is configured to allow. This means that each receiver loop will be active during "its" half-period. The capacitors 24, 25 of the two receiver loops are interconnected and connected in parallel. Thus, charging goes on all the time, not just every second half-period, so that a more efficient DC source than the one in the embodiment shown in Fig. 2 is created. This receiving device is also balanced. As mentioned above the currents induced in the receiver loops are always out of phase, so that harmonics will also be out of phase and they will counteract each other and by that greatly reduced.

[0027] Fig. 4 illustrates a device according to a third embodiment of the invention differing from that shown in Fig. 3 by having the capacitors 24, 25 connected in series which means that the voltage obtainable across the DC-source obtained through the two capacitors will be doubled with respect to that in the embodiment shown in Fig. 3. Which type of interconnection of the capacitors, in parallel or in series, is selected can be based on the need to generate high voltages or high currents.

[0028] As example of a load which may be powered by the DC voltage of the capacitor/capacitors charged a transmitter 26 and a conducting transmitter loop 27 for transmission of data in the case of having the receiving device included in a balise are indicated in Figs 2-4.

[0029] The graph of Fig. 5 illustrates the DC voltage U across the DC source formed by the capacitor (capacitors in Fig. 3) charged versus time t for the three designs shown in Fig. 1, Fig. 2 and Fig. 3. It appears clearly that the charging-up process will be slower and the obtainable voltage will be lower for the known device shown in Fig. 1(a), whereas the devices shown in Fig. 2(b) and Fig. 3 (c) perform similarly with respect to charging-up time and voltage obtainable. If we assume that a DC voltage of 2.9 V is needed for starting a microprocessor powered by this voltage source the time needed for this will for the device shown in Fig. 1 be t_1 and for the devices shown in Fig. 2 and 3 t_2 being approximately half as long. This means for the case of having such a device in a balise a possibility to allow considerably higher train speeds and still ensuring a proper transfer of electric energy and messages between a train and the balise.

[0030] 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.

[0031] Although not shown in the figures, it is pointed out that each receiver loop may have more than one turn, i.e. be a multi turn loop, and then in a suitable turn include

a connection to the components shown to the left in the figures and in a suitable turn include a connection to the components shown to the right in the figures. These two suitable turns may be the same or different depending upon balancing issues.

Claims

1. A device for wirelessly receiving electric energy to be transferred from a source (2) of alternating current by electromagnetic coupling through a conducting transmitter loop (3) connected to this source, said device comprising

- at least one conducting receiver loop (4, 20, 21) configured to receive electric energy from a said source in the form of current induced therein through electromagnetic coupling when placed close to a said conducting transmitter loop,
- at least one capacitor (5, 24, 25) connected into said receiver loop (4, 20, 21) for being charged with electric energy through said current induced in the receiver loop,
- an arrangement (9) configured to allow a portion of the current induced in said receiver loop to only reach one pole of the capacitor for charging the capacitor and not flow in opposite direction and discharge the capacitor, and
- a capacitance (12) connected to the receiver loop to tune this to a determined frequency,

characterized in that said at least one capacitor (5, 24, 25) is connected into the receiver loop by having opposite poles thereof directly connected to the receiver loop (4, 20, 21) at a first location (8) therealong, that said arrangement comprises at least one rectifying member (10, 22, 23) connected into the receiver loop at a second location (11) therealong spaced with respect to said first location and configured to allow a rectified portion of the current induced in the receiver loop to only flow in one direction there-through, and that said capacitance (12) is connected into the receiver loop at said second location (11).

2. A device according to claim 1, **characterized in that** said first (8) and second (11) locations are at opposite positions along said receiver loop (4, 20, 21).
3. A device according to claim 1 or 2, **characterized in that** said tuning capacitance (12) is connected in parallel to said rectifying member (10, 22, 23).
4. A device according to any of the preceding claims, **characterized in that** said rectifying member is a rectifying diode (10, 22, 23).
5. A device according to claim 4, **characterized in that**

said tuning capacitance is an inherent capacitance of said rectifying diode or is provided by a capacitor (12) connected in parallel to said diode (10, 22, 23).

6. A device according to any of the preceding claims, **characterized in that** the general shape and size of the receiver loop (4, 20, 21) defined by receiver loop portions between said first (8) and second (11) locations are substantially identical to the shape and size of a said conducting transmitter loop (3) from which the receiver loop is configured to receive electric energy.
7. A device according to claim 6, **characterized in that** said general shape of the receiver loop (4, 20, 21) is symmetrical with rectifying member (10, 22, 23) and capacitor (5, 24, 25) to be charged on opposite sides.
8. A device according to any of the preceding claims, **characterized in that** it comprises a plurality of said conducting receiver loops (20, 21) superimposed, and that a rectifying member (22, 23) connected into an individual receiver loop is configured to allow current induced in that receiver loop to only flow in the opposite direction therethrough with respect to what a rectifying member in a neighbouring receiver loop is configured to allow.
9. A device according to claim 8, **characterized in that** all said at least one capacitor (24, 25) of the receiver loops are interconnected to together form an assembly storing electric energy.
10. A device according to claim 9, **characterized in that** said interconnected capacitors (24, 25) are connected in parallel to each other.
11. A device according to claim 9, **characterized in that** said interconnected capacitors (24, 25) are connected in series to provide a voltage of said assembly formed by an addition of the voltages across all said capacitors.
12. A device according to any of claims 8-11, **characterized in that** the number of receiver loops (20, 21) is even.
13. 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 (4, 20, 21) configured to receive electric energy by electromagnetic coupling from a transmitter in said rail vehicle antennas when passing the balise,
 - a transmitter (26) configured to be powered by

the electric energy received by the receiver loop,
and

- a conducting transmitter loop (27) configured to be fed by said transmitter to transmit data to said railway vehicle antennas passing the balise,

characterized in that it comprises a device (1) according to any of the preceding claims for wirelessly receiving electric energy from a said transmitter.

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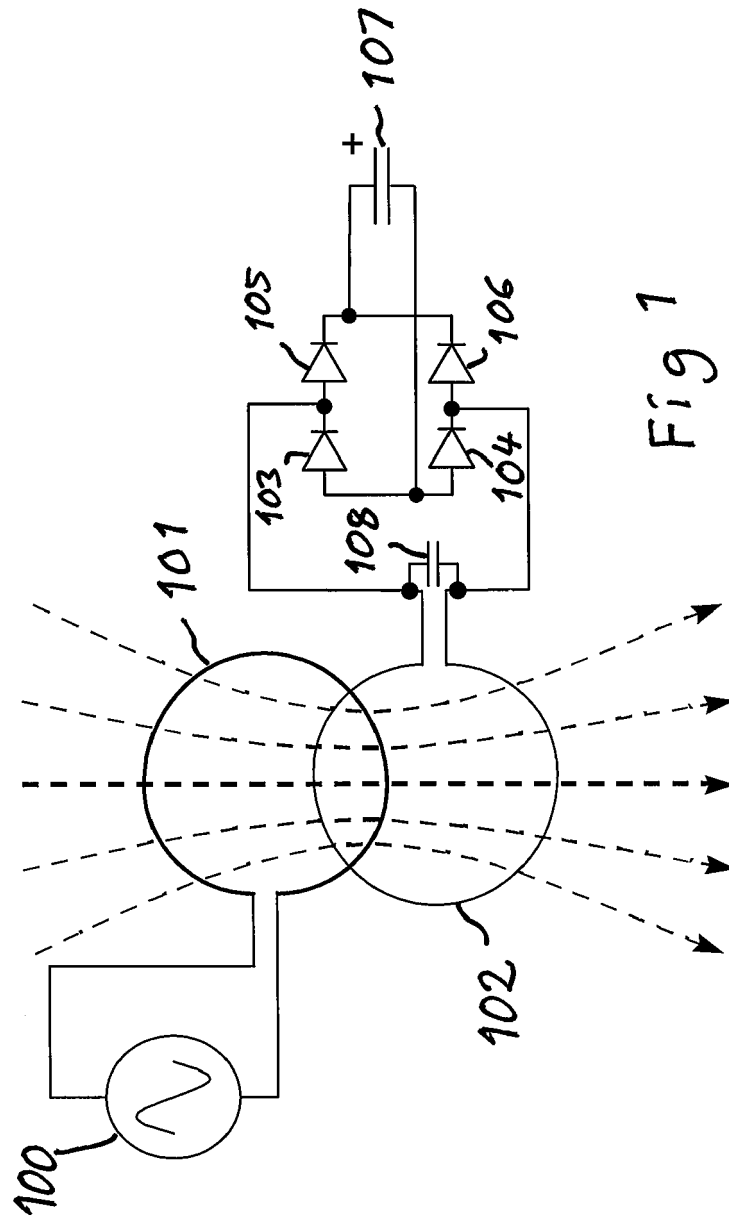
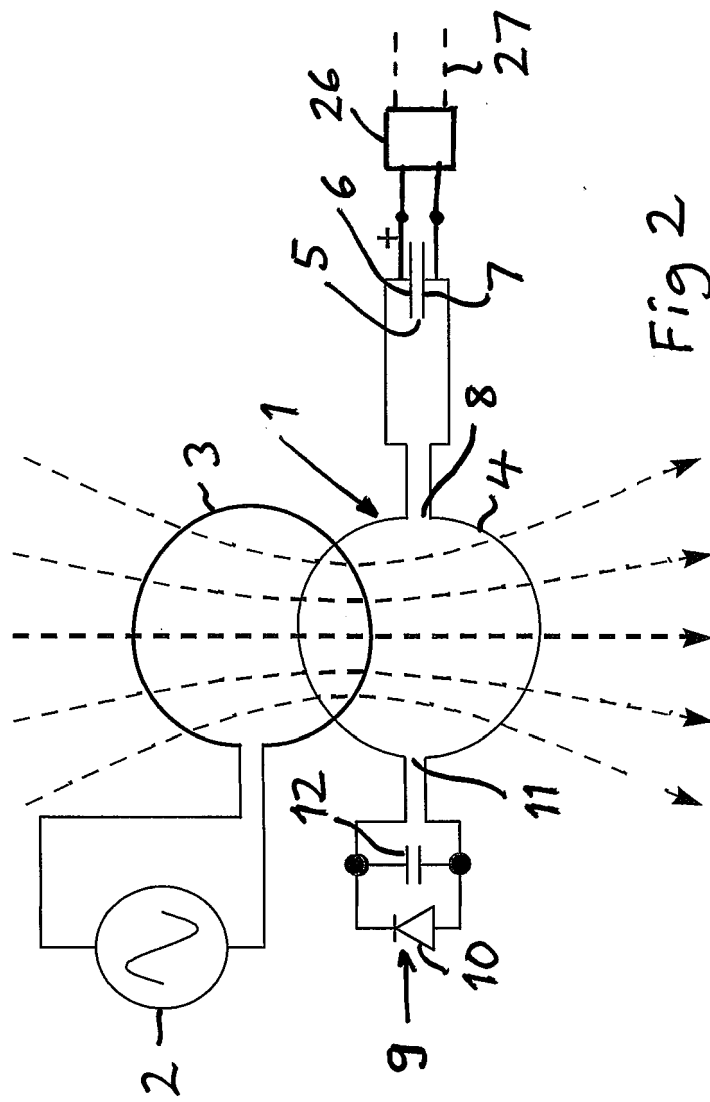
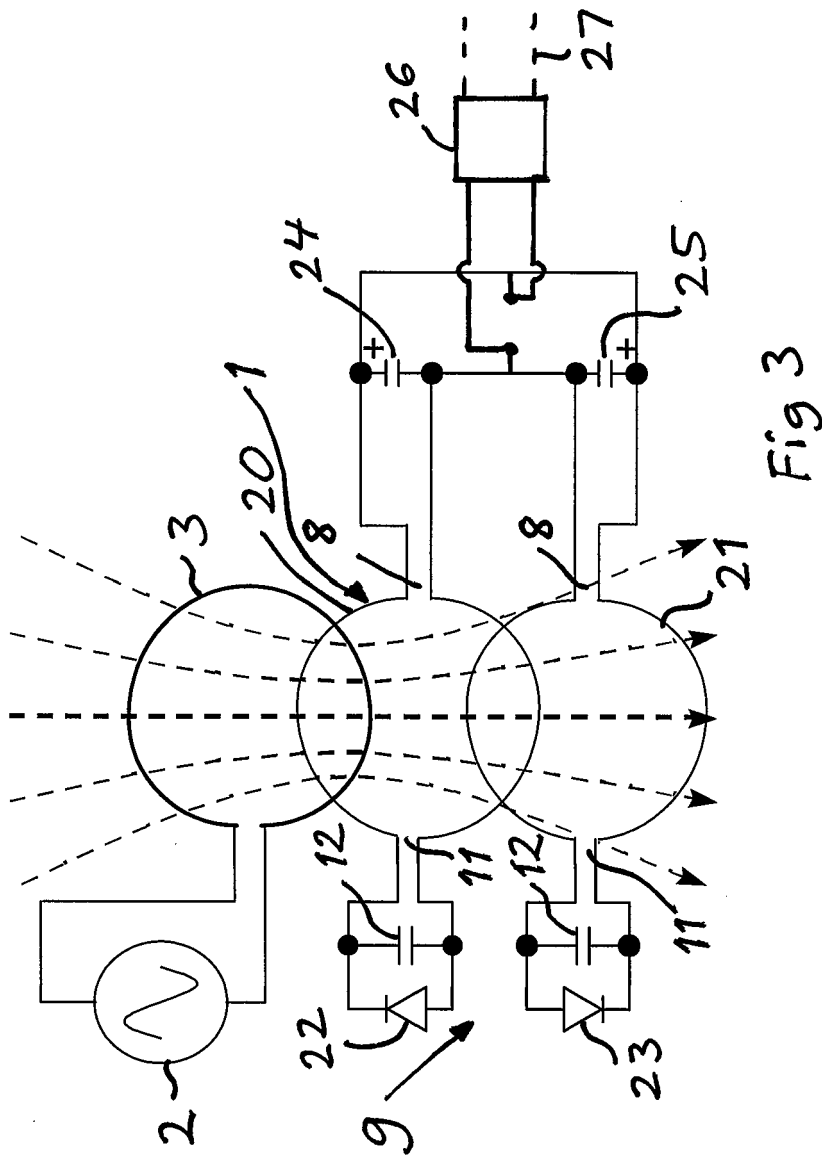
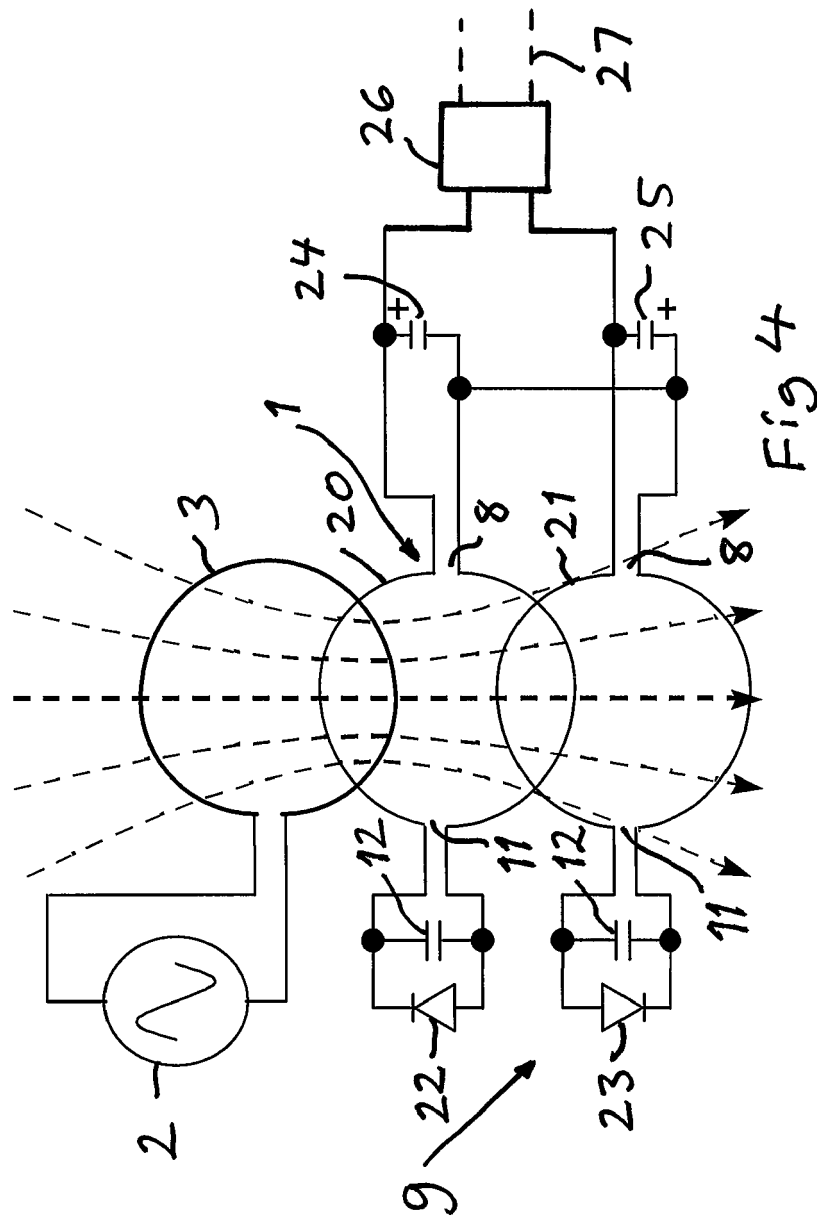


Fig 1







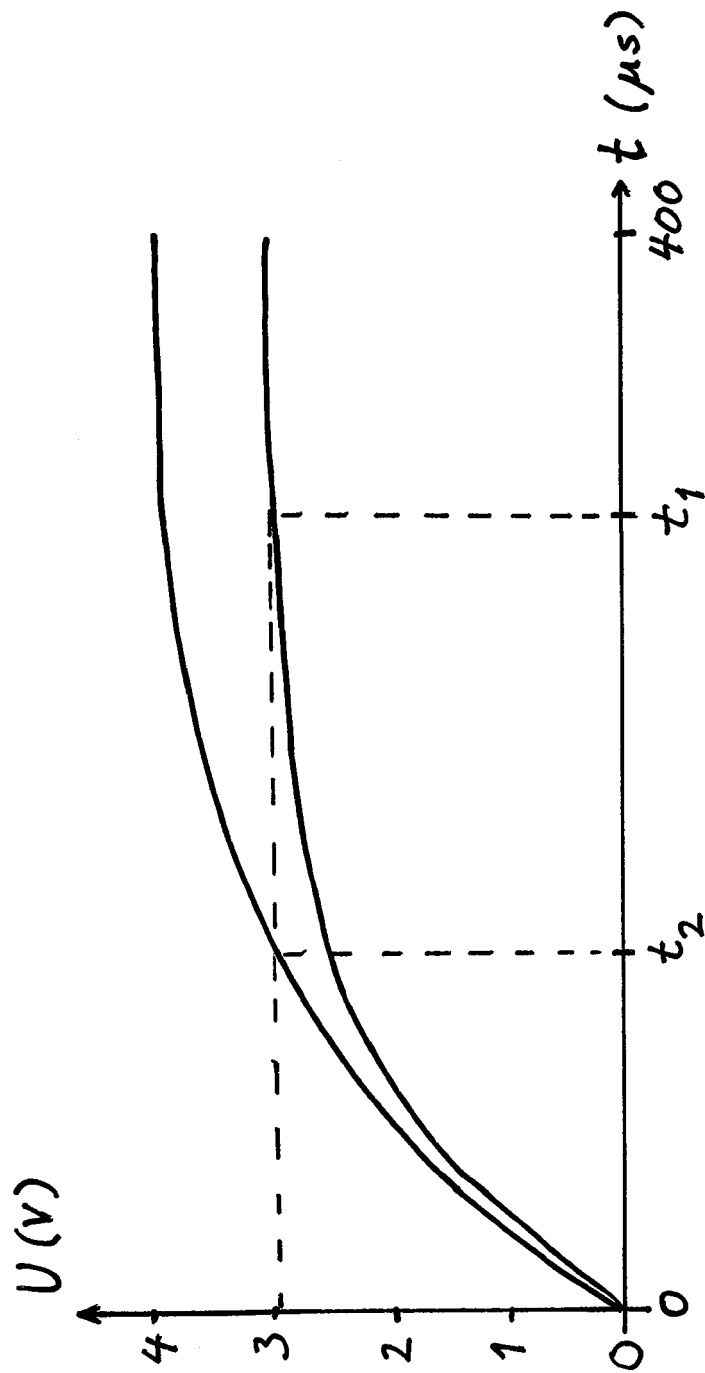


Fig 5



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CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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