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## (54) Remote identifier and an antenna construction for a remote identifier system

(57) The invention relates to a remote identifier (20) and an antenna structure, which remote identifier is intended to communicate with a reading device (20), which remote identifier comprises an RFID circuit (4, 22, 23, 24) to permit communication with the reading device (10), and an antenna (21, 3, 6) connected to the RFID circuit (4, 22, 23, 24). According to the invention, the antenna (21, 3, 6) is tuned in such a way that when the remote identifier (20) is as such detached from the holder (32), it is tuned to a frequency that differs distinctly from the operating frequency, in which case the metal plane (35, 6) of the holder (32) is arranged to tune the remote identifier to the operating frequency when the remote identifier is in the holder (32).

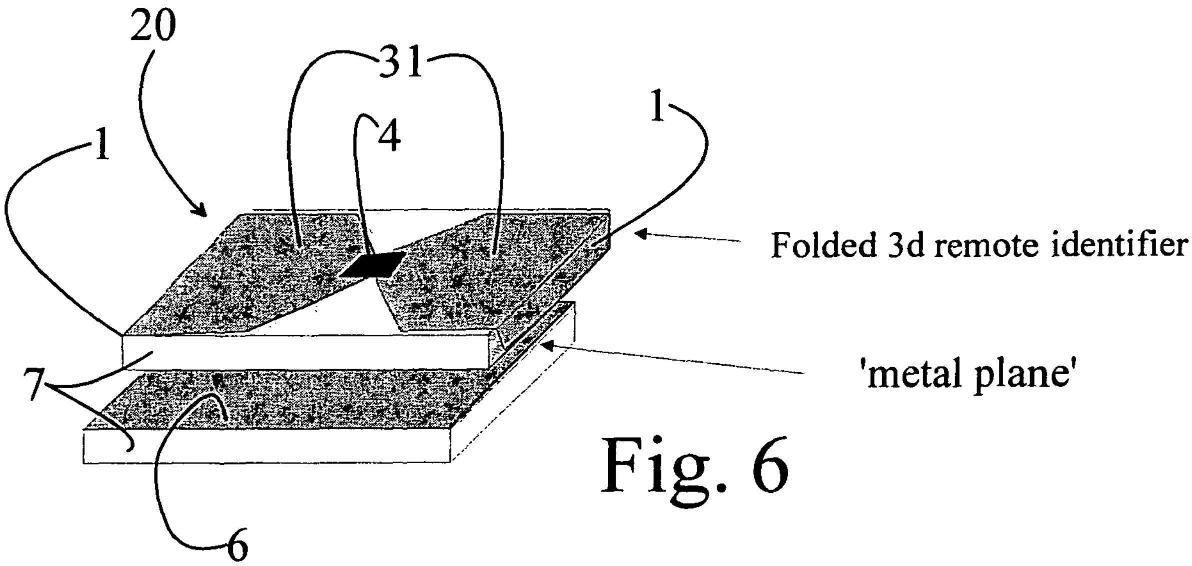


Fig. 6

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## Description

Remote Identifier and Antenna Construction for a Remote-Identifier System

**[0001]** The invention relates to a remote identifier according to Claim 1.

**[0002]** The invention also relates to an antenna structure and a method.

**[0003]** The use of remote identifiers (RFID) will increase during the next few years. For example, they will largely replace optically read barcodes in product marking. An RFID is a mark, which is remotely read using a radio signal, and which comprises an antenna, a voltage-generating circuit, radio-frequency signal modulation/demodulation circuits, logic, and memory. The memory can be both written to and read from with the aid of a radio signal. There are several different types of RFID: passive and active, as well as those that can be connected to a reading device inductively, capacitively, or with the aid of a radio-frequency radiation field. Passive RFIDs generate the electric energy they need from the radio-frequency field aimed at them. In active RFIDs, there is a separate battery or other power source. Inductively connected RFIDs operate typically on the 100 - 125 kHz or 13.56 MHz frequencies.

**[0004]** WO publication 2006/120287 discloses one antenna solution for RFID systems, in which an electronic component, such as an RFID circuit is attached to the second surface of the antenna structure and is connected from one of its antenna terminals to the transmission line and from the other terminal to either a second transmission line or to a fold. The use of this construction creates a planar antenna structure with a very long reading distance. This antenna type also is immune to the surface to which it is attached. The manufacture of this type of antenna is also advantageous, as vias are not required. In addition, the RFID electronics, for example, can be easily combined with the antenna structure at low cost.

**[0005]** A remote identifier (RFID transponder) is a small device comprising an antenna, microcircuit, and memory, which transmits the contents of the memory by backscattering having received a send command from the reader and when the reader illuminates it with a radio signal. In passive RFIDs, there is no battery; instead they take their operating power from the radio signal transmitted to them by the reader. The transmission of power and information between the RFID and the reader can take place with the aid of a magnetic field, electric field, or a radiating radio signal. In many RFID applications, it is important that the distance between the reader and the RFID can be long - even up to several metres.

**[0006]** A PIFA (planar inverted F-antenna) is an antenna very widely used in mobile telephone applications, for example. It is usually fed from near the fold, thus bringing the impedance level brought close to 50 Ohm. The feed also takes place through a 'ground plane'. A PIFA antenna can also be applied in connection with RFID circuits, in which the real part of the impedance of the circuit will be high, if the feed point is taken close to the open end of the antenna. In this application the RFID circuit will require a via to the ground plane of the PIFA. If, in addition to this, the antenna is slightly shorter than a quarter of the wavelength, the antenna will remain inductive and the impedance can be matched to an RFID circuit with a capacitive input impedance. A problem with a PIFA antenna is that it requires a via and this increases manufacturing costs significantly. If the antenna is manufactured utilizing, for example, high-frequency circuit-board technology, the cost of the antenna can be as much as several euros.

**[0007]** An RFID antenna should be very cheap, it should have good radiation efficiency, and its directivity should be sufficient (large antenna gain). These problems are exacerbated in, for example, road-toll applications. In addition, the tuning of the antenna should not depend on the properties of the target. Furthermore, security aspects are emphasized in applications relating to payment.

**[0008]** However, the long reading distances of the solutions described become drawbacks in some applications demanding information security, in which the intention is to prevent the intentional or unintentional reading of the information on an RFID card by undesirable entities.

**[0009]** The present invention is intended to eliminate the drawbacks of the prior art and create an entirely new type of RFID, RFID card, and antenna construction, and a method in connection with the antenna construction.

**[0010]** The invention is based on the fact that the antenna of the moveable, credit-card sized RFID card is typically functionally divided into two parts, in such a way that the RFID card by itself has a short reading distance and its antenna operates non-ideally at the operating frequency, whereas placing the RFID card in the location intended for it functionally creates an antenna with a long reading distance.

**[0011]** With the aid of one preferred embodiment of the invention, the variable reading distance of the RFID circuit is achieved using a double-folded PAFFA antenna (Planar Asymmetrically Fed Folded Antenna, PAFFA), so that in normal operation of the RFID card the efficiency of the antenna is made low and in its operating state the antenna of the RFID card is tuned to the operating frequency with the aid of an additional antenna element at the point of use or in a holder. The additional antenna element is typically a separate conductive surface (a 'ground plane').

**[0012]** More specifically, the RFID according to the invention is characterized by what is stated in the characterizing portion of Claim 1.

**[0013]** The antenna construction according to the invention is, in turn, characterized by what is stated in Claim 5.

**[0014]** The method according to the invention is, in turn, characterized by what is stated in Claim 9.

**[0015]** Considerable advantages are gained with the aid of the invention.

**[0016]** With the aid of applications of the invention, it is possible to make transportable RFID cards containing personal information, which are information-secure during transportation and can thus not be read by undesirable entities and which nevertheless function at long reading distances at their point of use, such as attached to a vehicular holder or card holder.

**[0017]** Advantageous areas of application include identity cards for access control, remotely readable driving licences, or road-toll cards for vehicles.

**[0018]** For example, thanks to the invention a road-toll card in someone's pocket cannot be read, only a card placed in a holder can be read.

**[0019]** On a system level, the solution according to the invention will save system resources, because only cards that are meant to be read will be read by the system.

**[0020]** In the following, the invention is examined with the aid of examples and with reference to the accompanying drawings.

**[0021]** Figure 1 shows an RFID system according to the prior art, for which an antenna according to the invention is suitable.

**[0022]** Figure 2 shows a top view of an antenna according to the prior art.

**[0023]** Figure 3 shows a side view from direction A of the antenna according Figure 2.

**[0024]** Figure 4 shows a perspective view of a second antenna according to the prior art.

**[0025]** Figure 5 shows a perspective view of one antenna according to the invention.

**[0026]** Figure 6 shows a perspective view of the antenna of Figure 5 folded and connected to a ground plane.

**[0027]** Figure 7 shows a perspective view of a second antenna according the invention.

**[0028]** Figure 8 shows a perspective view of the antenna of Figure 7 folded and connected to the vicinity of a ground plane.

**[0029]** Figure 9 shows a cross-sectional side view of one holder for the use of an RFID card.

**[0030]** Figure 10 shows a cross-sectional side view of one holder for the use of an RFID card.

**[0031]** Figure 11 shows a cross-sectional side view of a first alternative construction according to the invention.

**[0032]** Figure 12 shows a cross-sectional side view of a second alternative construction according to the invention.

**[0033]** Figure 13 shows a cross-section side view of a third alternative construction according to the invention.

**[0034]** At present, the use of passive UHF-RFID is rapidly becoming increasingly common. They have been proposed for use in logistics, production control, etc., but recently there has been increasing interest in using it in access control, road tolls, and payment. In these applications the reading distance should be often as great as possible, but the information security problem must be solved. It is extremely difficult to protect telecommunications in passive RFIDs with a great reading distance. Therefore simple methods are based on burning part of the information into the memory making an international agreement concerning this memory space. On the other hand, RFIDs have a password, which when known allows the information to be read. In addition, a so-called changing password can be used. Furthermore, in automotive applications both an 'electronic driving licence' installed on the windshield and an 'electronic registration plate' installed in the vehicle can be required, in which case the security relating to paying can be improved considerably. By combining this with photographing of the registration plate and security arrangements that take place in a network, passive RFID can be used to build a cheap, reliable, and secure remote-identification concept for access control and road traffic.

**[0035]** According to Figure 1, a typical RFID system comprises a reading device 10 and an RFID 20, which have a wireless communication connection with each other. The reader 10 typically comprises a processor 11, a demodulator 12, and RF electronics 13, as well as an antenna 14 for producing and receiving a radio-frequency signal. For its part, the RFID 20 contains an antenna 21, a matching circuit 22, a rectifier with a detector 23, as well as a logic circuit 24 and a memory (not shown). Modulation is implemented using joint operation of the logic 24 and the matching circuit 22. In this application, the RFID 20 is laminated onto a thin sheet, usually of a credit-card size.

**[0036]** One antenna according to the prior art is an antenna with a good efficiency rate and with no need for a via. We refer to the antenna as a Planar Asymmetrically Fed Folded Antenna) PAFFA.

**[0037]** Figure 2 shows an antenna, in which one end of a planar transmission line 3 formed on top of an insulating layer 7 has been brought close to the 'ground plane' of the antenna. The antenna becomes very small, but because the source (fold) 1 of the magnetic field and the source 2 of the electric field (the open end of the resonator) are very close to each other, the situation affects the radiation impedance and the direction of the effect. The fold 1 acts as the primary source of the magnetic field. Simulations show that the antenna functions but its efficiency remains reasonably poor (20 % - 30 %). However, the antenna is extremely small in size (about 30 mm x 30 mm when the frequency is 869 MHz and the relative permittivity of the insulator is 2.5, about 12 mm x 12 mm when the frequency is 2.45 GHz) and can be used in applications, in which a quite short distance is sufficient. In this case, the RFID circuit 4 has been fitted close to the fold 1. The two antenna terminals of the RFID circuit are connected between the source 1 of the magnetic field and the source 2 of the electric field of the antenna. In this embodiment, the length of the transmission line 3 is a quarter of the wavelength of the operating frequency ($\lambda/4$), or at least close to this length. Thus the RFID circuit 4 contains the electronics necessary for communication with the reader 10.

**[0038]** Figure 3 shows the antenna construction of Figure 2, seen from the direction of arrow A. The connection of the RFID circuit 4 between the source 1 of the magnetic field and the source 2 of the electric field can be seen more clearly in this figure.

**[0039]** Figure 4 shows a variation of Figures 2 and 3, in which the RFID circuit 4 is set in the middle of an insulating base 7. On the other side of the insulating layer 7, a uniform metal plane 6 has been formed. This solution has been shown to function extremely well and the application of it to an RFID circuit 4 that is capacitive but has a high impedance to its real part, results in a very small and simple structure and, on the other hand to a high efficiency. Its manufacturing technique is a little difficult, due to the double fold.

**[0040]** Figures 5 - 9 show two antennae of a slightly different type. The 'metal plane' 6 introduced under the antenna, together with the antenna pattern, effectively creates an antenna according to Figure 4. This takes place in such a way that the length of the transmission lines under the antenna are one-quarter of the wavelength, so that the line 3, together with the 'metal plane' 6 forms a transfer line and moves the open end (2) of the line to form a short circuit at the fold 1. The solution according to Figures 5 - 6 brings a manufacturing-technology advantage, because an 'inlayer' type of RFID can be folded on top of a plastic structure 30, so that the part of the inlayers come on top of each other. Because the metalling has been arranged according to the figure, the PET membrane typically used in an inlayer does not form an insulator of the transfer line. This prevents the effect of the losses caused by the PET. The arrangement, of course, leads to the second transfer line being closer to the 'ground plane' 6 beneath to the magnitude of the support membrane (usually PET) but this can easily be taken into account in dimensioning.

**[0041]** According to Figure 5, the RFID blank (the RFID card) is thus formed on a thin, for example PET, plastic membrane 30. The blank is folded from the fold point 1 around the insulator piece 7, so that the blank's transfer paths 3 bend onto the opposite side of the structure relative to the RFID circuit 4. The transfer lines 3 are essentially one-quarter of a wave of the operating frequency (λ/4) long, and are connected through transfer lines 31 of about the same length to the RFID circuit 4. According to the above description, in this solution the fold 1 also acts as the primary source of the magnetic field.

**[0042]** When the blank 30 is finally folded to form a structure according to Figure 6, the metal plane (6) short-circuits at the operating frequency through the fold 1, due to the transfer lines 3, in which case a virtual ground plane is formed on the upper surface of the RFID 20. The antenna of the RFID 20 then tunes to the correct operating frequency and the reading distance of the RFID 20 (RFID card) increases many times.

**[0043]** In the case of Figures 7 and 8, an antenna is patterned on top of a relatively thick (0.5 mm - 3 mm) plastic membrane 40 and an RFID circuit 4 is attached to it, either on the surface or embedded inside the plastic 40. The plastic piece 40 is folded from both sides, so that the ends do not quite touch each other underneath. In the same way as in the antenna of Figures 5 - 6, the metal pattern 3 under the plastic piece 40 forms a 'metal plane' 6 with the transfer line and short-circuits the fold points 1. In both cases (Figures 5 - 9), when separated from its case the RFID 20 (not the metal plane 6) forms, in the case of Figures 7 - 9, a short dipole (resonance frequency extremely high) and, in the case of Figures 5 - 6 a short dipole, which is, however, capacitively short-circuited. In this case too, the first resonance frequencies settle to extremely high frequencies. If we take into account the higher frequency and through it the smaller effective antenna surface area as well as the weakening of the rectifier of the RFID circuit, according to even a conservative estimate the reading distance will shorten to at least one-sixth. In addition, further losses can be brought to the structure at the resonance frequency, in which case the reading distance is brought to a fraction of the original. It is also important that the resonance frequency does not settle to the RFID frequencies.

**[0044]** In the solutions of Figures 7 and 8, the transfer line 3 is formed like a concertina, so that space can be saved in the blank 30, in other ways the operating principle corresponds to the solution of Figures 5 and 6.

**[0045]** Road tolls are beginning to use passive UHF-RFID. On the other hand, in several countries the implementation of traffic control with the aid of RFID is also planned. This means that over some period of time most of the stock of motor vehicles will be marked using UHF RFID circuits and, in addition to this, everyone holding a driving licence will have to have an electronic driving licence. From this, we can estimate that the marking of existing vehicles and holders of driving licences using remotely readable cards will require the production of several billion remotely-readable cards.

**[0046]** Thus the most obvious applications of the technology described here are, on the one hand payment applications relating to vehicles and on the other to personal surveillance. In the road-toll application, the idea is to fit the vehicles permanently with a holder 32 according to Figure 9. The holder 32 can be slightly tilted relative to the corner of the windshield or window 33, in such a way that the direction of the beam of the antenna is nearly straight upwards. This is advantageous if the readers are above the road. In this example, there is a gap between the RFID and the 'metal plane' beneath and the lower part of the RFID, which determines the wavelength and the wave impedance. The holder 32 comprises insertion grooves 34 for the RFID card, as well as a metal plane 35 to tune the antenna of the RFID to the operating frequency.

**[0047]** Figure 10 shows a possible identity card, in which the 'metal plane' 35 is set in low-loss plastic 36 and this structure is attached to an operating holder 32 made of ABS, for example. If we use plastic, the length of the transfer line will be shorter and thus we can make a wider transfer line with lower losses. The important aspect of such a solution is that the RFID 20 can also be pressed against a plastic piece 36, so that the effective permittivity will remain constant.

**[0048]** Figures 11 - 13 outline the application of the solution according to the invention to different kinds of antenna.

**[0049]** Figure 11 shows the use of a dipole antenna in an application according to the invention, in such a way that in the operating situation the metal plane 6 tunes the RFID 20 to the operating frequency.

**[0050]** Correspondingly, Figure 12 shows the use of a PIFA (planar inverted F-antenna) antenna in an application according to the invention, in such a way that, in the operating situation, the metal plane 6 tunes the RFID 20 to the operating frequency, while Figure 13 shows the use of a double-folded PAFFA antenna in an application according to the invention, in such a way that, in the operating situation, the metal plane 6 tunes the RFID 20 to the operating frequency.

**[0051]** Thus, Figures 11 - 13 show a dipole, a PIFA, and a double-folded PAFFA, as well as a metal place 6 set above them. In these solutions, the capacitance over the antenna is increased, in which case the resonance frequency with the 'metal plane' 6 will be lower than without the ground plane. On the other hand, if there is a dielectrically lossy material on the side of the metal plane 6, the ground plane 6 will prevent losses caused by the electric field. Using the technique shown in Figures 11 - 13 a small change (about 10 - 30 %) is obtained in the resonance frequency. This certainly prevents the reading of the RFID at the nominal frequency, but the reading of it will succeed at a lower frequency. For example, in the USA the UHF frequency is 915 and in Europe 869 MHz, so that in Europe an RFID 20 on top of a 'metal plane' 6 could easily be in tune without the 'metal plane' 6 at the USA frequency. In all the antennae, capacitance can be increased by placing the metal plane 6 very close to the antenna structure and by using plastic between the metal layers.

**[0052]** The invention discloses the idea of making an RFID in such a way that it will only operate in a suitable case. In this way it is possible to make RFIDs relating to payment and personal identification as secure as possible. In addition, in some applications the RFID is given a lossy surface, so that the metal place can also be used to eliminate the electric field. Though in this case protection is sought for various antenna solutions, to which a metal plane is connected to tune the antenna, the most important idea to be protected is to make a simple folded antenna, in which a separate metal plane is utilized, and through it the RFID is tuned when attached to a case or base.

**[0053]** According to one embodiment, the RFID can be passivated completely by placing it in a case made of a conductive material.

**[0054]** Suitable frequencies advantageous to the invention include among others 867 MHz and 2.45 GHz.

## Claims

1. Remote identifier (20) which is intended to communicate with a reading device (20), which remote identifier comprises,

   - an RFID circuit (4, 22, 23, 24) to permit communication with the reading device (10), and
   - an antenna (21, 3, 6) connected to the RFID circuit (4, 22, 23, 24),

   **characterized in that**

   - the antenna (21, 3, 6) is tuned in such a way that
     - when the remote identifier (20) is by itself detached from a holder (32), it is tuned to a frequency that differs distinctly from the operating frequency, whereas
     - a metal plane (35, 6) of the holder (32) is arranged to tune the remote identifier to the operating frequency when the remote identifier is in the holder (32).

2. Remote identifier according to Claim 1, **characterized in that** the antenna (21, 3, 6) is a double-folded PAFFA antenna, in which at least one λ/4 transfer line (3) is arranged on the opposite side to the RFID circuit (4) to connect a separate ground plane (6) to the antenna in the operating situation and thus to tune the antenna to the operating frequency.

3. Remote identifier according to Claim 1, **charactereized in that** the antenna (21, 3, 6) is a dipole antenna.

4. Remote identifier according to Claim 1, **characterized in that** the antenna (21, 3, 6) is a PIFA antenna (planar inverted F-antenna).

5. Antenna structure (21, 3, 6), which is intended for an operating frequency $f_0$ and is connected to an electronic circuit (4), and which comprises at least one transfer line (3), one end of which is connected to the electronic circuit (4),
   **characterized in that**

   - the antenna structure (21, 3, 6) is tuned in such a way that
   - when the antenna structure (21, 3, 6) is as such, it is tuned to a frequency differing distinctly from the operating frequency $f_0$, in which case
   - a separate metal plane (35, 6), which is detached from the antenna structure (21, 3, 6) is arranged, in the operating situation, to tune the antenna structure (21, 3, 6) to the operating frequency, in the vicinity of the metal plane (35, 6).

**6.** Antenna structure (21, 3, 6) according to Claim 5, **characterized in that** the antenna (21, 3, 6) is a double-folded PAFFA antenna, in which at least one λ/4 transfer line (3) is arranged on the opposite side to the electronic circuit (4) to connect a separate ground plane (6) to the antenna in the operating situation and thus to tune the antenna to the operating frequency.

**7.** Antenna structure (21, 3, 6) according to Claim 5, **characterized in that** the antenna structure (21, 3, 6) is a dipole antenna.

**8.** Antenna structure (21, 3, 6) according to Claim 5, **characterized in that** the antenna structure (21, 3, 6) is a PIFA antenna (planar inverted F-antenna).

**9.** Method in connection with a remote identifier (20), which is intended to communicate with a reading device (20), in which method

- an RFID circuit (4, 22, 23, 24) is permitted to communicate with the reading device (10) with the aid of an antenna (21, 3, 6) connected to the RFID circuit (4, 22,23,24),

**characterized in that**

- the antenna (21, 3, 6) is tuned in such a way that, when the remote identifier (20) is by itself detached from the holder (32), it is tuned to a frequency that differs distinctly from the operating frequency, in which case the metal plane (35, 6) of the holder (32) is arranged to tune the RFID to the operating frequency when the RFID is in the holder (32).

**10.** Method according to Claim 9, **characterized in that** the antenna (21, 3, 6) is a double-folded PAFFA antenna, in which at least one λ/4 transfer line (3) is arranged on the opposite side to the RFID circuit (4) to connect a separate ground plane (6) to the antenna in the operating situation and thus to tune the antenna to the operating frequency.

**11.** Method according to Claim 9, **characterized in that** a dipole antenna is used as the antenna (21, 3, 6).

**12.** Method according to Claim 9, **characterized in that** the antenna (21, 3, 6) is a PIFA antenna (planar inverted F-antenna).

**13.** Use of an RFID or antenna structure according to any of the above device claims in a road-toll application.

**14.** Use of an RFID or antenna structure according to any of the above device claims in personal identification.

**15.** Use of an RFID or antenna structure according to any of the above device claims in a payment application.

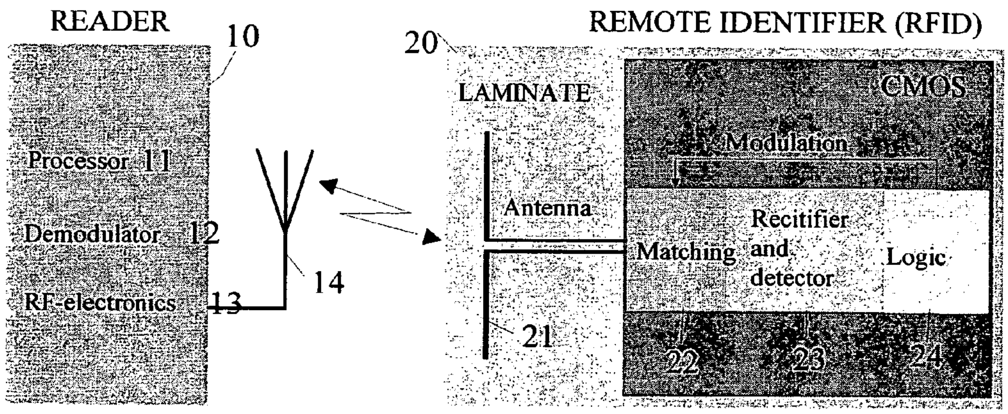



Fig. 1

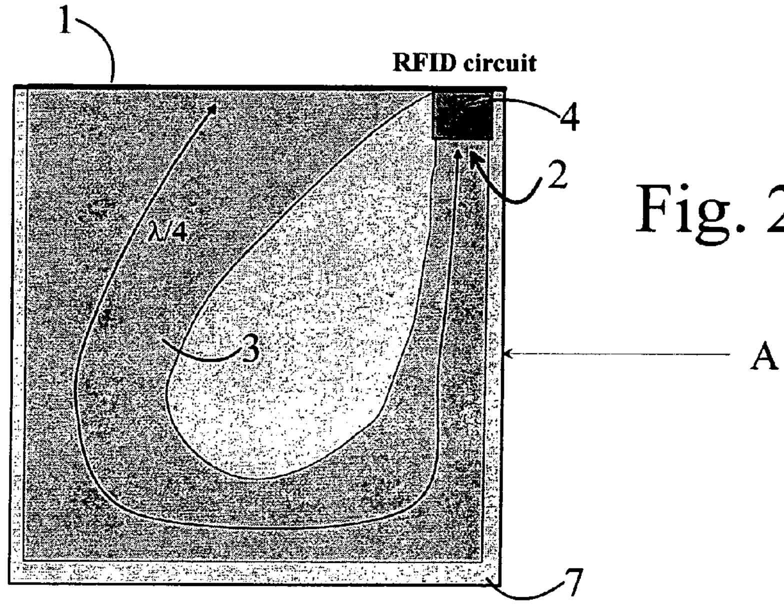



Fig. 2

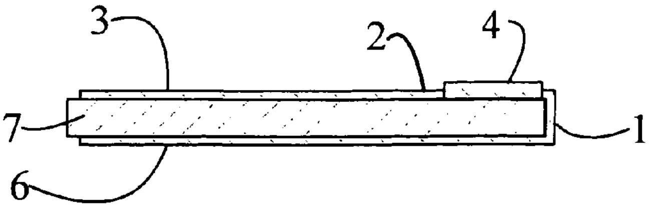



Fig. 3

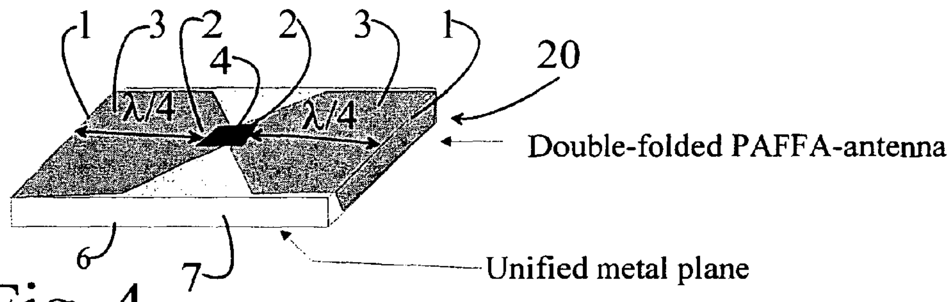



Fig. 4

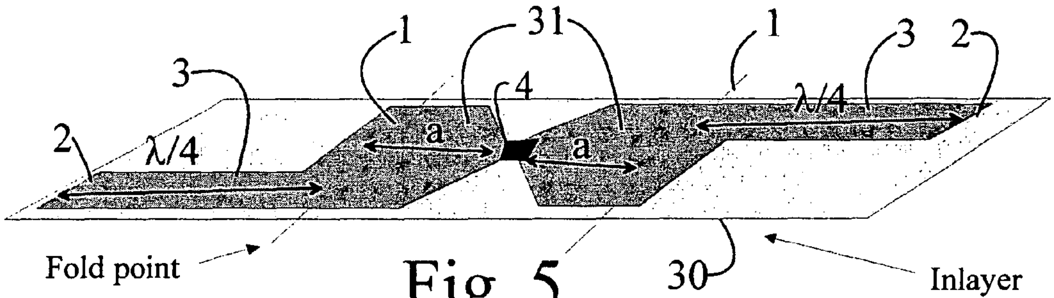



Fig. 5

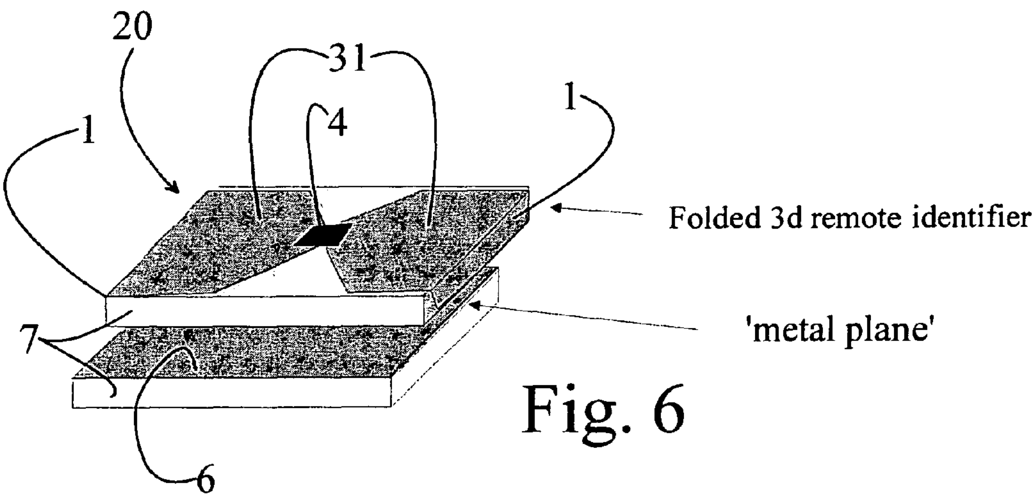



Fig. 6

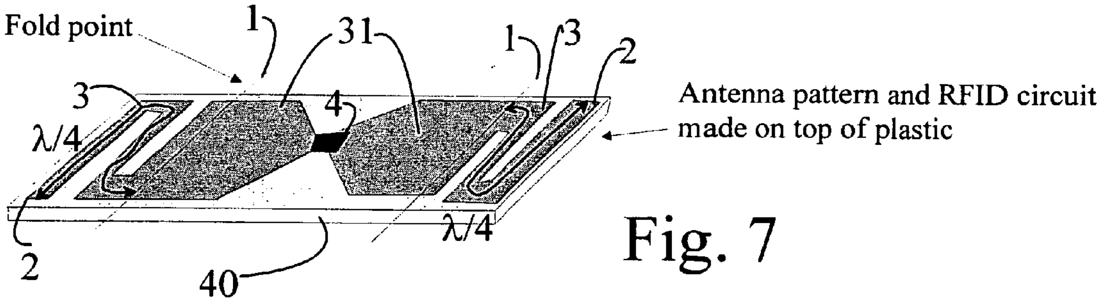



Fig. 7

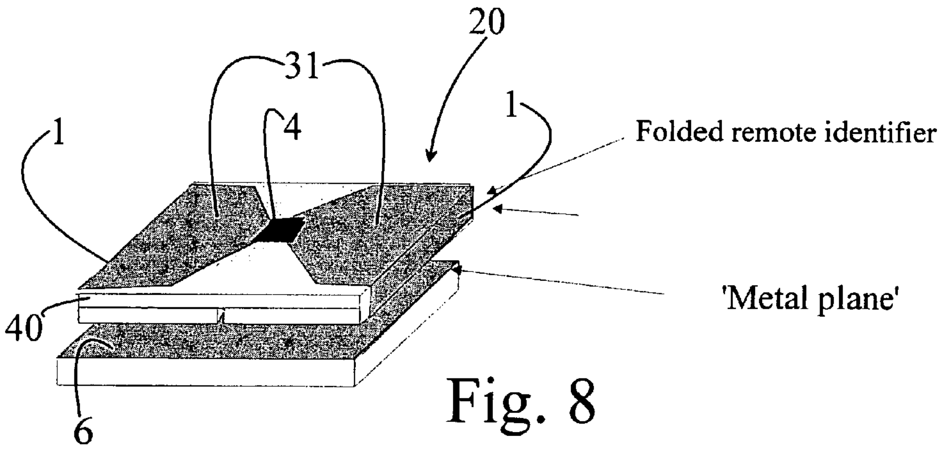



Fig. 8

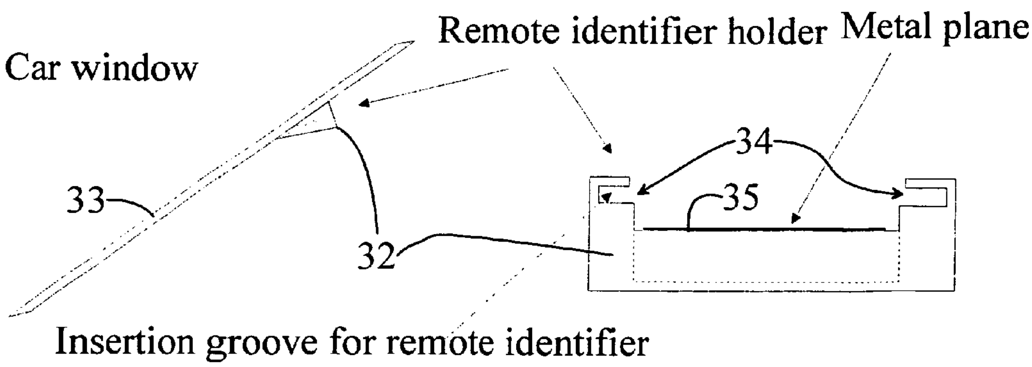



Fig. 9

Fig. 10

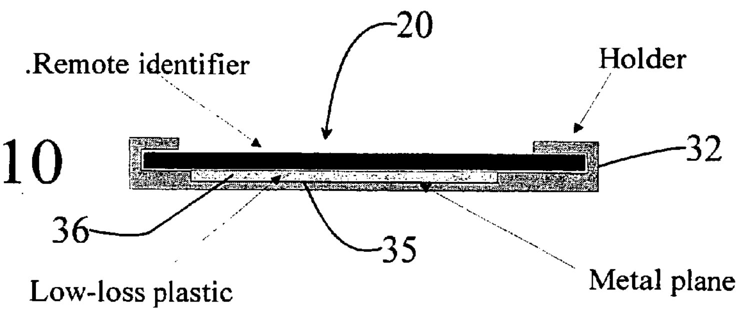



Fig. 11

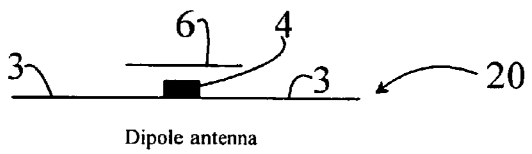



Fig. 12

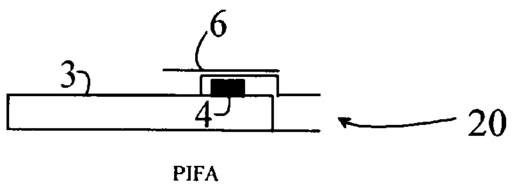
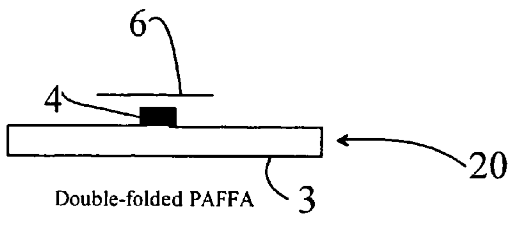



Fig. 13



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# EUROPEAN SEARCH REPORT

Application Number
EP 07 10 5626

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
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