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(54) **Vehicle antenna array**

(57) A motor vehicle (A) antenna array (1), of the kind coupled with a substantially flat dielectric system (2), comprising: a first plurality of mutually interconnected electrically conductive elements (3) coupled with a feeding source (4); a second plurality of electrically conductive elements (5), each connected with a pair of conductors of the first plurality of conductive elements (3) to form a composite structure in which one or more substantially

polygonal shapes are defined; a feeding element (6) capacitively coupled with the first and second conductive elements (3, 5). The feeding element (6) comprises two or more extraction points of the radiofrequency signals (10, 11) that the antenna array (1) is able to receive. The extraction points (10, 11) are mutually spaced according to a distance substantially equivalent to the half of one of the wavelength related to the radiofrequency signals that said antenna array (1) is able to receive.

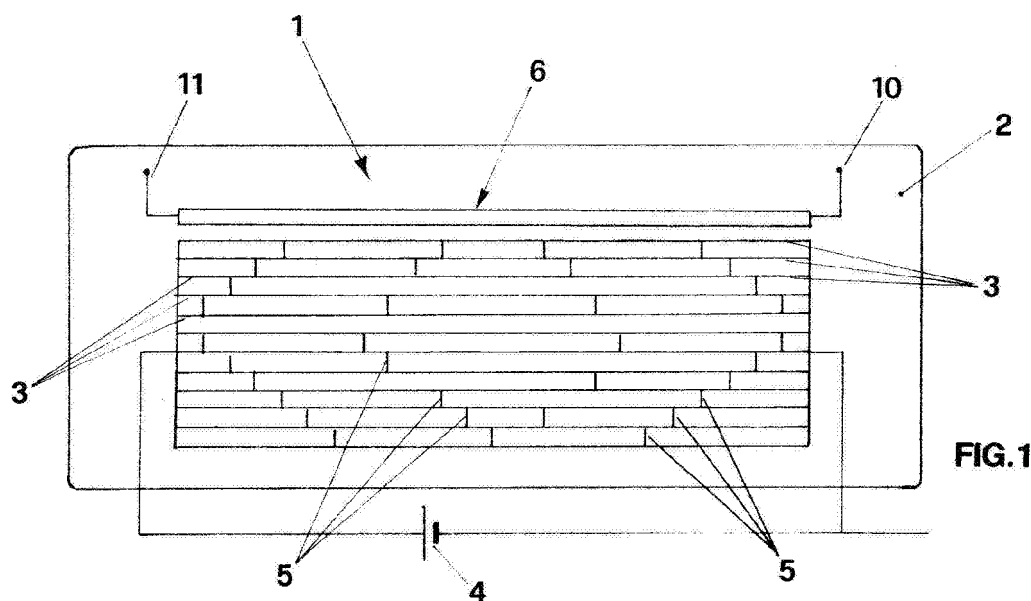


FIG. 1

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Description

[0001] The present invention is about a vehicle antenna array suitable in particular to be installed on the rear window of said vehicle to receive radio waves.

[0002] It is known that there is the need to equip the vehicles with antennas able to receive radio waves related to radiofrequency signals of different applications like, for instance, mobile telephony, FM radio, AM radio, satellite navigation systems and other signals, including television signals.

[0003] Concerning the FM radio, a particular reception technique called "phase diversity", which is explained hereinafter, is also known.

[0004] The radio wave transmitted by the transmitting station reaches the receiving antenna through a path having numerous obstacles, represented by buildings and orographic obstacles like hills or mountains.

[0005] Each of said obstacles has also the effect to deviate the radio waves that hit it.

[0006] The final result is that the receiving antenna is hit by numerous radio waves emitted by the same source and containing the same information, but coming from different directions and in different times.

[0007] Such phenomenon causes the inconvenience of a quality worsening of the received radio signals.

[0008] To overcome said inconvenience, the aforementioned "phase diversity" technique has been introduced, in which two receiving antennas are used, and a phase displacement and attenuation between the two or more received signals are subsequently dynamically introduced, so that the resulting signal is qualitatively better.

[0009] For this purpose, the use of two or more mutually spaced antennas, whose distance is equal to half the wavelengths of the radio wave band that the antenna is able to receive resulted to be optimal.

[0010] A proper circuit, belonging to the electronic circuit processing the received radio signals, provides for properly combining the two signals to obtain a better quality signal.

[0011] In particular, it is evident that the "phase diversity" technique simultaneously uses more receiving antennas whose received radiofrequency signals are added in order to obtain a better resulting signal.

[0012] Such technique, therefore, is different from another technique called "scan diversity", an example of which is described in the Patent JP 58070645, according to which more antennas are used, but they are not simultaneously working.

[0013] Indeed, with the "scan diversity" technique a proper electronic circuit provides to select the antenna which receives the best radiofrequency signal.

[0014] It is known that a kind of vehicle antennas belonging to the prior art provides for the utilization of a plurality of conductors disposed on a dielectric material surface, said surface generally consisting of the rear window of the vehicle.

[0015] It is also known that a plurality of strips of conductive material, generally mutually parallel and short-circuited at their ends, is applied on the rear window of the vehicle and it is connected to the starter battery of said vehicle.

[0016] In this way, a heater for glass defrosting or defogging, i.e. a heated rear window, is obtained.

[0017] Obviously, this function requires that the heated rear window covers the greatest part of the window surface, thus leaving a few space for an antenna.

[0018] A solution of this problem, due to the coexistence of the antenna and the heated rear window in the same glass, provides for the disposition of conductive elements orthogonal to the heated rear window conductors, said conductive elements interconnecting unipotential points so that the defrosting current distribution is not altered.

[0019] In this case, the advantage that the heated rear window acts as a metallic surface able to receive radiofrequency waves is obtained.

[0020] A particular example of such a kind of antennas is described in US Patent no. 6,693,597 B2, where the antenna consists of a plurality of conductors, orthogonally disposed with respect to the heated rear window conductors and defining a substantially polygonal shape.

[0021] In this case, the extraction of the received radio waves takes place according to two possible ways:

- using an additional conductive element, called "feeder" or "feed", capacitively coupled with the heated rear window and galvanically coupled with the electronic device using it;
- through a galvanic electric connection with said heated rear window, this solution being generally used at least in the "phase diversity" application due to the need of space to be interposed between the extraction points of the received radio waves.

[0022] All the antennas of the kind described so far and belonging to the prior art have an acknowledged inconvenience.

[0023] In particular, the heated rear window causes low frequency noises on the antenna affecting, in an irremediable way in some cases, the correct reception of the AM band signals.

[0024] As previously mentioned, the heated rear window is electrically connected to the motor vehicle starter battery, and this connection causes a lot of low frequency noises due to other car devices.

[0025] Such inconvenience is particularly relevant for the extraction of AM band radiofrequency signals from the antenna through a direct electric connection.

[0026] To minimize these effects, there are arrangements which provide for the insertion of low frequency filters between the battery and the heated rear window, but with the disadvantage to increase the manufacturing costs.

[0027] It is an object of the present invention to over-

come the aforementioned inconveniences and disadvantages.

[0028] In particular, it is an object of the present invention to provide for an antenna array for a vehicle rear window which also includes the heated rear window, without the need to add filters between the feeding circuit and said heated rear window.

[0029] It is another object of the present invention to provide for an antenna array for a vehicle rear window which allows to implement the "phase diversity" technique.

[0030] The above mentioned objects are attained by a motor vehicle antenna array of the kind coupled with a substantially flat dielectric system which, according to the content of the main claim, comprises:

- a first plurality of mutually interconnected conductive elements coupled with a feeding source;
- a second plurality of conductive elements, each connected with at least a pair of conductors of said first plurality of conductive elements to form a composite structure in which one or more substantially polygonal shapes are defined;
- a feeding element capacitively coupled with said first and second conductive elements,

and it is characterized in that said feeding element comprises two or more extraction points of the radiofrequency signals that said antenna array is able to receive, at least two of said extraction points being mutually spaced according to a distance substantially equivalent to the half of one of the wavelength related to the radiofrequency signals that said antenna array is able to receive.

[0031] According to the invention, the dielectric element is the motor vehicle rear window, and the conductors belonging to the first plurality of conductive elements are arranged substantially parallel to each other to form the heating elements of the heated rear window.

[0032] The feeder is substantially parallel disposed with respect to the first conductive elements and it is separated therefrom.

[0033] Advantageously, the feeder capacitive coupling with the heated rear window and the disposition of the extraction points of the radiofrequency signal received on said feeder allow to solve the aforementioned inconvenience of the presence of low frequency noises which occur for signal extraction points galvanically connected to the heated rear window.

[0034] The above mentioned objects will be better highlighted in the description of preferred embodiments of the invention, given in an explanatory but not limiting way, with reference to the figures of the annexed drawings, wherein:

- Figure 1 is an axonometric view of the antenna array according to the invention; and
- Figure 2 schematically shows a utilization example of the antenna array according to the invention.

[0035] The vehicle antenna array of the invention is shown in Figure 1, where it is generally indicated with numeral **1** and where one can see that it is supported on a substantially flat dielectric element **2** and it comprises a first plurality of generally mutually parallel electrically conductive elements **3**, interconnected at their heads and coupled with a feeding source **4**.

[0036] A second plurality of electrically conductive elements **5** is furthermore present, each of them being disposed between a pair of conductive elements belonging to the first plurality **3**.

[0037] A feeding element **6** of radiofrequency signals coming from the antenna **1** is another component of the antenna array of the invention.

[0038] According to the invention, the feeding element **6**, which is capacitively coupled with the first and second plurality of conductive elements **3** and **5**, is provided with two extraction points **10**, **11** of radiofrequency signals, mutually spaced according to a distance substantially equivalent to the half of one of the wavelength related to the radiofrequency signals that the antenna array **1** is able to receive.

[0039] In different executive embodiments, not shown herein, the extraction points are more than two, and they are mutually spaced according to distances independent from the wavelength of the radio waves related to the radiofrequency signals that the antenna array is able to receive.

[0040] Concerning the dielectric element **2**, in the preferred executive embodiment shown in Figure 2 it is the rear window of a motor vehicle **A**.

[0041] Concerning the conductors of the first plurality of conductive elements **3**, in the preferred executive embodiment they consist of strips of conductive materials, supported on the rear window **2** of the motor vehicle **A** and able to perform the function of heated rear window.

[0042] For this purpose, the short circuited ends of all the conductive elements belonging to the first plurality of conductive elements **3** are electrically connected to a feeding source **4** which, in the preferred executive embodiment, is the starter battery of the motor vehicle **A**.

[0043] Concerning the conductive elements of the second plurality of conductive elements **5**, in the preferred executive embodiment they consist of a strip of conductive material supported on the rear window **2** of the motor vehicle **A**.

[0044] Each of said conductive elements of the second plurality of conductive elements **5** is disposed between a pair of conductive elements belonging to the first plurality of conductive elements **3** and they form, together with said conductive elements belonging to the first plurality of conductive elements **3**, a composite structure **20** in which substantially polygonal shapes are obtained.

[0045] It should be pointed out that this executive embodiment is given in an explanatory but not limiting way to describe the invention.

[0046] Indeed, other executive embodiments, neither shown nor described herein, could be introduced, for in-

stance providing for more complex and asymmetrically disposed polygonal shapes.

[0047] Concerning the feeding element **6**, as previously mentioned, it is provided with two signal extraction points **10**, **11**; said extraction points **10**, **11** are mutually spaced according to a distance substantially equal to the half of one of the wavelength of the radio waves related to the radiofrequency signal that the antenna array **1** is able to receive.

[0048] It is made of conductive material and, in the preferred executive embodiment, it consists of conductive material strips laid down on the surface of the rear window **2** of the motor vehicle **A**.

[0049] Said conductive material strips are parallelly and closely disposed with respect to the conductive elements belonging to the first plurality of conductive elements **3** in order to form a capacitive coupling.

[0050] Concerning the extraction points **10**, **11** cited so far, they are electrically connected to an electronic device **15** processing the signals through the interposition of an amplifier **16**, both these devices being placed inside the motor vehicle **A**.

[0051] In the preferred executive embodiment, the electronic device **15** comprises, among others, an electronic circuit for performing the aforementioned "phase diversity" function.

[0052] In different executive embodiments, the amplifier is not present and the extraction points are directly connected to the signal processing electronic device.

[0053] In addition to said circuit, a circuit for processing radio signals related to the AM radio and a circuit for processing radio signals related to the FM radio are furthermore present in the electronic device **15**.

[0054] In different executive embodiments, electronic circuits for the satellite navigation system, mobile telephony or television signal are also or alternatively connected to the antenna array of the invention.

[0055] In further different executive embodiments, not shown and not described hereby, the conductive elements and the feeding element consist of conductive filaments embedded in the dielectric.

[0056] Operatively, as previously mentioned, the antenna array **1** of the invention is applied on the rear window **2** of the motor vehicle **A** and, in operative conditions, it also performs the function of heated rear window **2** for the motor vehicle **A**.

[0057] Anyway, it performs the common functions of an antenna array.

[0058] Any radio wave hitting the surface of the rear window **2**, and thus the conductive elements **3**, **5** belonging to the antenna array **1** too, generates currents in said conductive elements **3**, **5** which, in case of electromagnetic waves having a wavelength in accordance with the antenna array **1** structure, are of a considerable value.

[0059] A global current is thus generated, able to be extracted from said antenna array **1** and to be sent to the amplifier **16** and from here to the electronic device **15** processing the received signals.

[0060] The extraction takes place through the feeding element **6**.

[0061] Since said feeding element **6** is separated from the first and second plurality of conductive elements **3**, **5** and it is capacitively coupled therewith, the advantage that the radio signals extracted in this way are not affected by the low frequency noises typical of the signal extraction points galvanically connected to a heated rear window is thus obtained.

[0062] Furthermore, since the extraction points **10**, **11** are mutually spaced according to a distance substantially equivalent to the half of one of the wavelength of the FM band received signals, the antenna array of the invention advantageously allows to optimise the reception of said signals through the "phase diversity" technique.

[0063] The signals extracted from the feeder **6** are sent to the electronic device **15** which processes them by means of the two extraction points **10**, **11** electrically connected to said electronic device **15** through the interposition of the amplifier **16**.

[0064] On the basis of the aforesaid description, the vehicle antenna array of the invention achieves all the intended objects.

[0065] In particular, an antenna array for a motor vehicle rear window has been provided, being coexistent with the heated rear window without requiring to add low frequency filters between the heated rear window feeding and said heated rear window.

[0066] Furthermore, an antenna array for a motor vehicle rear window has been provided, allowing to implement the "phase diversity" technique.

[0067] In the executive stage, further executive variations, although not described and not shown in the drawings, to the vehicle antenna array of the invention could be provided but, if they fall within the scope of protection of the following claims, they should all be intended as protected by the present patent.

Claims

1. A motor vehicle (A) antenna array (1), of the kind coupled with a substantially flat dielectric system (2), comprising:

- a first plurality of mutually interconnected electrically conductive elements (3) coupled with a feeding source (4);
- a second plurality of electrically conductive elements (5), each connected with at least a pair of conductors of said first plurality of conductive elements (3) to form a composite structure in which one or more substantially polygonal shapes are defined; and
- a feeding element (6) capacitively coupled with said first and second conductive elements (3, 5),

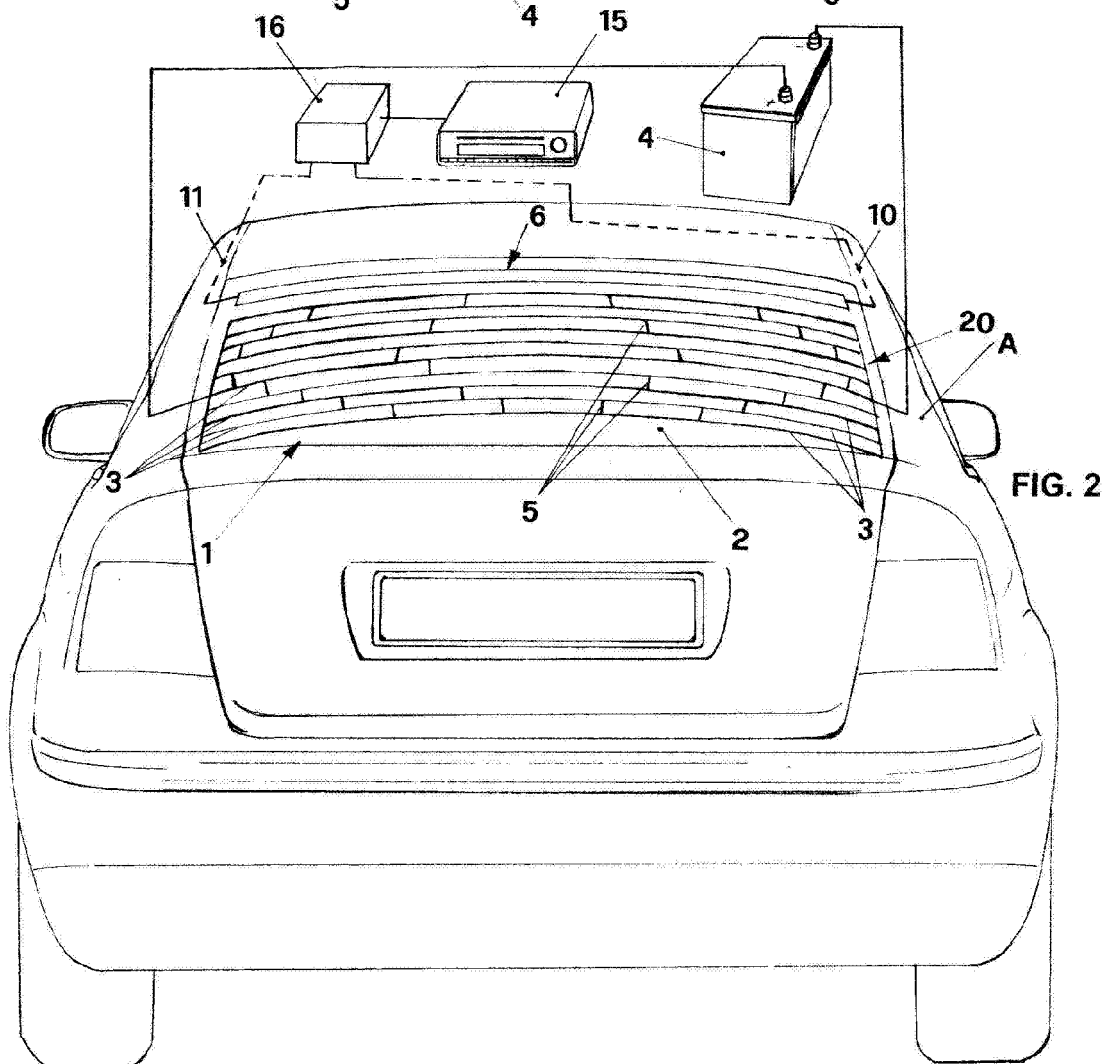
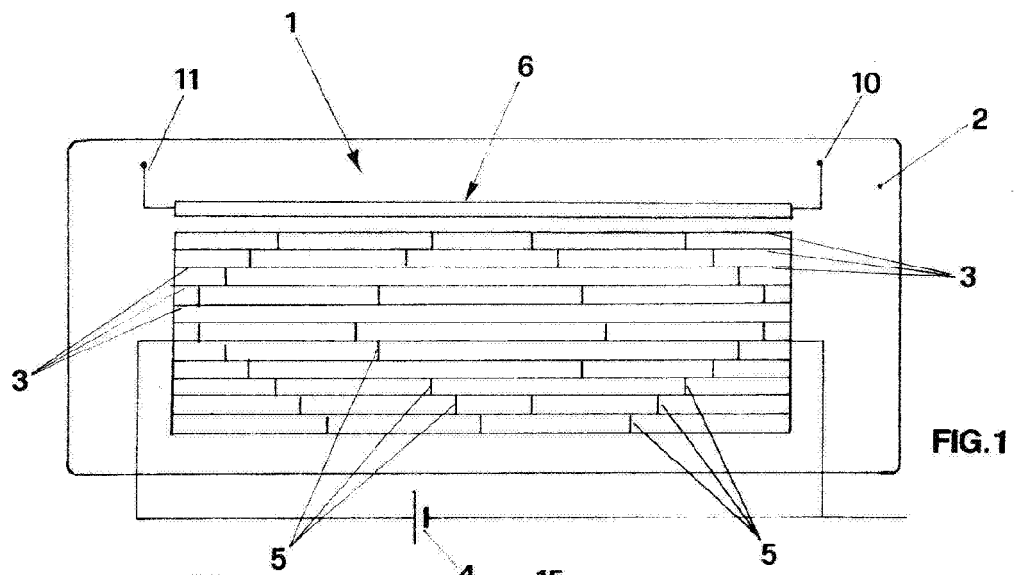
characterized in that said feeding element (6) com-

prises two or more extraction points of the radiofrequency signals (10, 11) that said antenna array (1) is able to receive, at least two of said extraction points (10, 11) being mutually spaced according to a distance substantially equivalent to the half of one of the wavelength related to the radiofrequency signals that said antenna array (1) is able to receive.

2. The antenna array (1) according to claim 1), **characterized in that** said at least two extraction points (10, 11) are coupled with an electronic circuit which performs the "phase diversity" function. 10
3. The antenna array (1) according to claim 1), **characterized in that** at least one of said extraction points (10, 11) is coupled with an electronic circuit processing the radiofrequency signals related to the AM radio. 15
4. The antenna array (1) according to claim 1), **characterized in that** said dielectric element (2) is the rear window of the motor vehicle (A). 20
5. The antenna array (1) according to claim 1), **characterized in that** said conductors belonging to said first plurality of conductive elements (3) are arranged substantially parallel to each other. 25
6. The antenna array (1) according to claim 1), **characterized in that** said feeding element (6) is made of an electrically conductive material. 30
7. The antenna array (1) according to claim 1), **characterized in that** said feeding element (6) define a longitudinal axis substantially parallel to the longitudinal axis defined by said first plurality of conductive elements (3). 35
8. The antenna array (1) according to claim 1), **characterized in that** said first (3) and said second (5) plurality of conductive elements and said feeding element (6) consist of strips of conductive material supported on one of said dielectric element (2) surfaces. 40
9. The antenna array (1) according to claim 1), **characterized in that** said first (3) and said second (5) plurality of conductive elements and said feeding element (6) consist of filaments of conductive material embedded in said dielectric element (2). 45 50
10. The antenna array (1) according to claim 1), **characterized in that** said antenna array (1) is coupled with an electronic device (15) processing the radiofrequency signals received by said antenna array (1). 55
11. The antenna array (1) according to claim 10), **characterized in that** said antenna array (1) is coupled

with said electronic device (15) through the interposition of an amplifier (16).

12. The antenna array (1) according to claim 10), **characterized in that** said electronic device (15) belongs to the electronic device group comprising one or more electronic circuits for processing radiofrequency signals related to AM radio, FM radio, satellite navigation systems, mobile telephony, television signals and their combination.
13. The antenna array (1) according to claim 1), **characterized in that** said first plurality of conductive elements (3) forms the heated rear window of said vehicle (A).
14. The antenna array (1) according to claim 1), **characterized in that** said feeding source (5) is the starter battery of said vehicle (A).





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EUROPEAN SEARCH REPORT

Application Number
EP 06 10 0998

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	PATENT ABSTRACTS OF JAPAN vol. 007, no. 162 (E-187), 15 July 1983 (1983-07-15) -& JP 58 070645 A (TOYOTA JIDOSHA KOGYO KK), 27 April 1983 (1983-04-27) * the whole document *	1-14	INV. H01Q1/12 H01Q21/28
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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 13 April 2006	Examiner Moumen, A
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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EP 06 10 0998

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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13-04-2006

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