(19) DANMARK

(10) **DK/EP 3488377 T3**

Patent- og Varemærkestyrelsen

(12) Oversættelse af europæisk patentskrift

---

(51) Int.Cl.: ***G 06 K 7/10 (2006.01)*** ***G 06 K 19/07 (2006.01)*** ***H 04 Q 1/02 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2021-12-06**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2021-09-08**

(86) Europæisk ansøgning nr.: **17771976.2**

(86) Europæisk indleveringsdag: **2017-07-24**

(87) Den europæiske ansøgnings publiceringsdag: **2019-05-29**

(86) International ansøgning nr.: **CZ2017000048**

(87) Internationalt publikationsnr.: **WO2018019314**

(30) Prioritet: **2016-07-25 CZ 20160452**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

(73) Patenthaver: **Vysoké Ucení Technické V Brne, Antonínská 548/1, 601 90 Brno, Tjekkiet**

(72) Opfinder: **NESPOR, Dusan, Husova 601, 69145 Podivin, Tjekkiet**
FIALA, Pavel, U Hrusek 872, 66401 Bilovice nad Svitavou, Tjekkiet

(74) Fuldmægtig i Danmark: **Gotapatent AB, Box 3127, S-550 03 Jönköping, Sverige**

(54) Benævnelse: **RADIOFREKVENS IDENTIFIKATOR INDSTILLELIG VED HJÆLP AF DIELEKTRISKE INDSATSER**

(56) Fremdragne publikationer:
EP-A1- 1 811 432
EP-A1- 2 286 485
US-A1- 2005 280 539
US-A1- 2010 134 254

DESCRIPTION

Field of Invention

[0001] The invention relates to a radio-frequency identifier tunable by dielectric inserts, using radiofrequency identification (RFID), which uses resonance structures as a coding medium and is tunable by means of dielectric inserts.

State of the Art

[0002] In present, two basic concepts are used for radio frequency identification (RFID) in safety and security systems - a passive one and an active one. In case of the passive system, the transmitter transmits electromagnetic pulses periodically into surroundings. If passive RFID device appears nearby, it uses received energy to charge its power supply, triggers the device and sends the answer. The passive devices may transmit either one number (electronic number of EPC product) assigned during their production, or they have additional memory, into which additional information may be written and read. Active RFIDs are more complex and more demanding in terms of production, as they comprise their own power supply, and they can transmit their own identification - therefore, they are used for active localization/identification. Besides its identification number, active RFID devices usually have space for additional information, which (on a signal similar to identification command) may be saved or sent together with the identification number.

[0003] The US patent US 7471199 B2 discloses a mobile key comprising an RFID tag associated with a memory. A secure access code is saved in the memory. Authorization status for a person or item associated with the mobile key is determined by interrogating the mobile key using an RFID interrogation field. Security information, such as a secure identifier access codes, physical measurement data, or biometric data may be provided by the mobile key. The key may also comprise a wireless communication device, such as a telephone, by means of which security information from the mobile key may be provided.

[0004] The US patent application US 20060226948 A1 discloses an electronic lock assembly including a transponder. The key is inserted into the electronic lock assembly through an opening, in which the electronic assembly is arranged. The electronic assembly comprises a coil assembly powered by a switch engaging with the key. Subsequently, the coil assembly generates a magnetic field, which activates the transponder. The transponder transmits the signal received by a controller. The controller controls the key assembly depending on the received signal, wherein it moves the locking member into unlocked position. The key provides energy for unlocking the latch and therefore no additional power supply is needed for controlling the motor. The key assembly, its controller and transponder, are powered by small amount of electricity and may thus be used as a power supply as well as a commercially available battery.

[0005] A reader and RFID tag distance measuring system are disclosed in the US patent application US 2007241904 A1. RFID tag and the whole distance measuring system comprises a reader, which supplies a pre-determined carrier signal to a tag and receives a reflected signal of the carrier signal from the RFID tag. The reader comprises a signal output means for output of signals at multiple frequencies, which are different from each other (such as carrier and transmitting signals). The signal output means transmits the signal on the signal output to the tag in the receiving section, which receives the reflected signals at multiple frequencies, wherein these signals are different from each other. Measurement of distance between the tag and the reader depends on the number of phase changes between the reflected signals, received by the receiving section, and carrier signals and their frequencies. Transmitting and receiving sections have two pairs of transmit and receive antennas, which can receive multiple signals, in which the strength of reflected signal differs, received by the receive antenna.

[0006] Device for detecting of electrical circuit switching described in the US patent application US 20060180647 A1 comprises a RFID tag, a conductive loop and a switch connected to the conductive loop, creating a control circuit. The switch is controlled so as to provide the on and off state, which causes closing or opening of the control circuit. The RFID tag detects the state of the conductive circuit of the loop and transmits a signal representing the on/off state into the RFID reader. The device for detecting of electrical circuit switching is integrated in the on/off switching mechanism. The device for detecting of electrical circuit switching comprising a lever assembly, latch lock assembly, window wing lock assembly, tachometer wheel, a hinge provided with a first joint member and a second joint member connected by a central axle, door closer and a rotatable switch or rotatable lock.

[0007] The US patent application US 2010134254 A1 describes a chip-less RFID system, comprising a tag and a reader. The tag may comprise metamaterial regions having at least two resonance frequencies and disposed on a paper layer in a periodical geometrical layout forming a linear structure or a matrix. The reader may change the frequencies of the first electromagnetic wave transmitted to the tag. Subsequently, the reader reads and identifies the tag by means of the second electromagnetic wave transmitted from the tag, corresponding with the first electromagnetic wave. The identification method of the chip-less RFID system comprises a step of creating a tag having metamaterial with various resonance frequencies. The frequency of the first electromagnetic wave to be transmitted by the reader to the tag is then changed, and subsequently, the frequency spectrum of the second electromagnetic wave corresponding to the first electromagnetic wave is analyzed. A drawback of such system is that it uses properties of metamaterials, which are difficult to produce. Another drawback is that the system uses 100% periodicity of the metamaterial structure, which makes this structure predictable and may be easily reproduced by a third party, thus not acquiring the required safety of the key-lock system.

[0008] An RF tagging system with resonant circuits is disclosed in the international patent application WO 9410663 A1. The tagging principle is as follows: when the tag enters the detection zone, resonance frequencies of each resonant circuit are determined, and a corresponding code is produced. Detection of resonance frequency is performed simultaneously with radiation signals at each possible resonance frequency for tagging circuits. The radiated signals are phase-shifted during the detection process and the signal received by the receiving antennas, except for the transmitting signals, may be tracked in order to improve reliability of the resonant circuits' detection. Antenna beams may be used for radiation of signals into the detection zone, so that each position of the resonant circuit on the tag could be tracked independently.

[0009] A method for tuning of dielectric antennas designed for operation, especially in the microwave range, and the antennas are described in the European patent application EP 1251588 A2. The antenna is tuned by removing material from dielectric block arranged between conductive elements, increasing the resonance frequency of the antenna. Conductive elements on the opposing surfaces of the dielectric block are shaped identically and are located symmetrically, so that tuning of the antenna would not affect other electric properties of the antenna, but the resonance frequency. An advantage of such invention is that the method according to the invention allows more precise tuning of the antenna, as removal of small amount of metamaterial from the dielectric medium only slightly changes the resonance frequency of the antenna.

[0010] The European patent application EP 2495805 A1 describes a radio-frequency tag identifier comprising an RFID chip, an antenna and a feed line, electrically coupling the RFID chip with the antenna. A code reader (EIR - "encoded information reading") comprises a microprocessor and a memory communicatively coupled to the microprocessor. The RFID reading device may further comprise an antenna and a feed line. RFID tag antenna or RFID reading device may be made of metamaterial (MTM), such as artificial composite materials engineered to produce desired electromagnetic behavior. MTM antenna can be sized, for example, on the order of one tenths of a signal's wavelength.

[0011] A method for manufacturing a communication device to operate in near field and communication device thereof is disclosed in the international patent application WO 2015004232 A1. The communication device comprises a metamaterial guiding structure and at least one feed point. The method comprises exciting the communication device by means of the feed point using transmission of electromagnetic energy, subsequent controlling the values of wavenumber by modifying the metamaterial guiding structure, and calculation of imaginary value of transversal component (ky) of the wavenumber in free space (K) so that the electromagnetic field of modified metamaterial guiding structure is enclosed around the said metamaterial guiding structure.

[0012] An arrangement described in the German patent application DE 4338554 A1 is related to a method for electronic identification of items using passive resonators by means of electromagnetic fields and connection for implementing the said method. The solution is that **n** switchable resonators with associated detection frequency and burn-out frequency are designed as a matrix, and **n** resonators are encoded from **n** frequencies in a contactless way by connecting to electromagnetic fields. Connection of **n** switchable resonators arranged in a matrix flatly and/or in multiple layers. These resonators consist of connection of at least one detection resonator with at least one burn-out resonator.

[0013] The French patent application FR 2992758 A1 describes a radio-frequency identification system with a chip-less radio-frequency identification tag comprising a conductive pattern created on a dielectric pad, defined resonators and a reading device transmitting linearly polarized reading signal in the required direction and the method for RFID tag reading. The system comprises a chip-less reader for identification of high frequencies (RFID) comprising a conductive pattern formed on a dielectric pad. The conducive pattern determines resonators, wherein each resonator receives linearly polarized signal in one direction and repeatedly transmits a part of the signal polarized in direction other direction separate from the first direction. The reading device transmits linearly polarized reading signal in the first direction and at the same time receives linearly polarized signal in the second direction.

[0014] The drawbacks of the above described technical solutions are characterized in that they use properties of metamaterials, which are difficult to produce, as well as 100% periodicity of metamaterial structure, working on the basis of known and pre-defined resonance frequency, making the structure predictable and easily reproducible by a third party.

[0015] A photovoltaic system comprising an elementary resonator for use in power plant engineering is described in the Czech patent application CZ 2012636 A3. A solar element comprises the elementary resonator arranged in a dielectric structure consisting of an area with minimum electromagnetic damping, the upper part of which forms an impact plane, and an area with minimum electromagnetic damping is transparent in relation to the impinging electromagnetic wave, while being limited by material properties changes. At least one 2D-3D resonator is surrounded by a dielectric and is arranged in a dielectric structure. At least one more area with different resonance frequency of the elementary resonator follows the area with minimum electromagnetic damping. The system either terminates into free space or is terminated with a solar element (system) to fully absorb the remaining energy of the impinging electromagnetic wave.

[0016] The disadvantages of the state of the art are characterized in low adaptability - changes in code, while preserving the safety level, unavailability of technologies and speed of change of the code for the most common users - households.

[0017] The European patent application EP 2286485 A1 discloses a radio frequency transponder, in which information is encoded in a resonator/antenna structure, which may be interrogated in order to retrieve the information via radio frequency (RF) excitation. The resonator/antenna structure comprises a multiresonator including a plurality of substructures and exhibits a plurality of resonances in the RF domain. Characteristic frequencies of the resonances depend upon the substructures, which may be modified in accordance with information to be encoded within the resonator/antenna structure. The resonator/antenna may be formed as a conductive structure disposed upon a dielectric substrate and may be useful for encoding information within chip-less RFID tags, security documents, negotiable instruments, and so forth. A variety of suitable multiresonator structures are disclosed, including multi-stop-band filters comprising cascaded spiral resonators, a "wheel and spoke" structure, an interleaved resonant circuit, and a fractal resonator structure. The multiresonator structures may be arranged in a linear periodical structure.

[0018] The US patent application US 2005280539 A1 describes an RFID system and method for encoding and decoding information by use of radio frequency antennas. The system includes one or more interrogator devices and RFID data tags. The RFID data tags include a plurality of antenna elements which are formed on a substrate or directly on an object. The antenna elements are oriented and have dimensions to provide polarization and phase information, whereby this information represents the encoded information on the RFID tag. The interrogator device scans an area and uses radar imaging technology to create an image of a scanned area. The device receives re-radiated RF signals from the antenna elements on the data tags, whereby the data tags are preferably represented on the image. The re-radiated RF signals preferably include polarization and phase information of each antenna element, whereby the information is utilized using radar signal imaging algorithms to decode the information on the RF data tag. The orientation of the antenna elements is neither specified in terms of periodical geometrical layouts, nor with respect to the substrate.

[0019] The European patent application EP 1811432 A1 discloses an RFID barcode and RFID barcode reading system. The RFID barcode includes a plurality of sets of conductive strips and a plurality of inductors arranged in a geometric layout forming a matrix. Each of the plurality of sets of conductive strips respectively includes a plurality of conductive strips separated by at least one gap, and each of the plurality of inductors is disposed in the at least one gap of a corresponding set of conductive strips and connects two of the plurality of conductive strips of the corresponding set of conductive strips. The sets of conductive strips are arranged in parallel and separated from one another in a predetermined distance. The RFID barcode may further include a dielectric substrate supporting the sets of conductive strips and the inductors, and a metal layer provided on all of a rear surface of the dielectric substrate. The dielectric substrate does not appear to have any periodical geometric relation to the plurality of sets of conductive strips and the plurality of inductors.

Summary of the Invention

[0020] The aim of the invention is to provide a radio-frequency identifier tunable by inserts made of dielectric material, which uses radio-frequency identification (RFID) on radio frequency (RF), which allows coding of information using simple exchangeable inserts in combination with periodic structure of elementary resonators, conceived, for example, on the basis of metamaterial structures or resonance structures, periodic or multiplayer structures, and periodic structures with 100% periodicity or partial periodicity.

[0021] The above-mentioned object is achieved by an arrangement of a radio-frequency identifier tunable by dielectric inserts as defined by claim 1.

[0022] Within the scope of the present invention, it is essential that the carrier is provided with elementary resonators arranged into a periodic structure, wherein the carrier together with the elementary resonators forms a matrix.

[0023] There are various possible mutual arrangements of the carrier and the dielectric insert - one or more carriers can be provided with adjacent dielectric inserts on one or both of its sides.

[0024] Moreover, the elementary resonators may be advantageously produced as divided square or annular or dipole structures.

[0025] In addition, the dielectric insert may be provided with at least one additional dielectric block adapted on its surface or at least one opening formed inside the dielectric insert. The dielectric block may comprise of an additional dielectric block, having a circular shape in its cross-section, or an additional dielectric block having a square shape in its cross-section, or an additional dielectric block having an oval shape in its cross-section, or an additional dielectric block having a rectangular shape in its cross-section, or an additional dielectric block having a shape of n-walls with optional wall ratio for n = 4,5,6,...20, wherein these additional blocks with various shapes may be combined and the opening has a circular shape in its cross-section, or the opening has a square shape in its cross-section, or the opening has an oval shape in its cross-section, or the opening has a rectangular shape in its cross-section, or the opening has a shape of n-walls with optional aspect ratio for n = 4,5,6,...20, wherein variously shaped openings may be combined.

[0026] The invention is based on using resonance properties of the periodic structure of electromagnetically bound elementary resonators, and on the change of structure periodicity measured in relation to impinging electromagnetic wave, on structure resonance and on interference of the resulting electromagnetic wave of the whole structure. The present invention uses the above-mentioned arrangement to obtain easily reproducible devices with a clear electromagnetic wave response, which is used as identification of a device - a key for radio-frequency identification system.

[0027] An advantage is that such arrangement of radio-frequency identifier does not use already known principles of radio-frequency identification, such as those known in access systems - signal reception, signal processing and a response forwarding a code to an interrogation device. The present arrangement, merely with its structure, forms a device which can be clearly identified by means of radiofrequency and which does not need electrical circuits for signal reception, processing and coding the signal back to be sent to the external reading device. The change of code is made very easily, by replacing/changing the shape of insert made of dielectric material.

[0028] The advantage of the present solution is also the fact that the matrix of elementary resonators is an integral part of the RFID device, particularly a part of the key structure based on periodic structure properties of elementary resonators in an electromagnetic field, represented by an electromagnetic wave of the structure. This is identical for the set of solutions, and only by changing the insert made of dielectric material, it is possible to easily change the response of the electromagnetic wave of the key on the impact of the electromagnetic wave, and thus identification of the evaluated key structure in the decoding device is differentiated.

Brief Description of Drawings

[0029] The radio-frequency identifier tunable by dielectric inserts will be further described by means of the attached drawings, where Fig. 1 illustrates a periodic structure of elementary resonators arranged in a matrix in interaction with electromagnetic wave in the impact area, Fig. 2a illustrates periodic structures of elementary resonators arranged in two matrices opposite each other, Fig. 2b illustrates a two-sided variant of a periodic structure of elementary resonators arranged in a matrix, Fig. 2c illustrates a combination of a two-sided and two one-sided periodic structures arranged in matrices, Fig. 3 illustrates an arrangement of the fixed part of radio-frequency identifier and the key with the bond to the secured element, Fig. 4 illustrates a geometric dimension of the carrier with the arrangement of elementary resonators forming a matrix together, Fig. 5 illustrates exemplary shapes of elementary resonators, Fig. 6a illustrates exemplary shapes of elementary resonators with their basic dimensions, Fig. 6b illustrates exemplary shapes of an elementary resonator in spatial view, Fig. 7 illustrates an exemplary embodiment of a periodic structure of elementary resonators with indicated spacing dimensions of elementary resonators forming a matrix arranged on a carrier, Fig. 8a illustrates a basic shape of the block and the opening, with which the dielectric insert may be provided, Fig. 8b illustrates an exemplary shape of blocks and openings intended for the dielectric insert modification, Fig. 9 illustrates an exemplary arrangement of blocks of the radio-frequency identifier tunable by dielectric inserts with the arrangement of transmission, reception and decoding device for a two-sided arrangement of the matrix in the key, Fig. 10 illustrates an exemplary arrangement of the blocks of radio-frequency identifier tunable by dielectric inserts with the arrangement of transmission, reception and decoding device for a one-sided arrangement of the carrier with the dielectric insert in the key, Fig. 11 illustrates an exemplary arrangement of the blocks of radio-frequency identifier tunable by dielectric inserts with the arrangement of transmission, reception and decoding device for two one-sided arrangements of the carrier with the dielectric insert in the key, Fig. 12 illustrates an exemplary arrangement of the blocks of radio-frequency identifier tunable by dielectric inserts with the arrangement of transmission, reception and decoding device for two two-sided arrangements of the carrier with the dielectric insert in the key and Fig. 13 illustrates an exemplary arrangement of the keys of the radio-frequency identifier tunable by dielectric inserts, which are arranged in the carrier.

Description of Exemplary Embodiments

[0030] The invention will be described by means of the following description of exemplary embodiments of the radio-frequency identifier with reference to respective drawings. In the drawings, the invention is illustrated by means of exemplary embodiments of the particular parts, elements and combinations thereof, describing the arrangement of the radio-frequency identifier tunable by dielectric inserts.

[0031] An exemplary embodiment of the radio-frequency identifier is shown in Fig. 3. In this embodiment, the radio-frequency identifier comprises a fixed part **92** and a key **9** controlling a secured element **10,** wherein these two components form a key assembly. In this embodiment, the fixed part **92** comprises an indication element **91** and a decoding device **8,** which comprises a power supply unit **84,** an evaluation and control unit **83,** a decoding unit **82** and a control element **81.** The decoding device **8** is coupled to a receiver **7,** which comprises a receiving antenna **71,** an input amplifier **72** and a block **73** of filters and shaping circuits. Further, the decoding device **8** is connected with a transmitter **6** comprising a transmitting antenna **61,** an output amplifier **63** and a signal generator **62.** The decoding device **8** is further connected with a code setting block **85** in the fixed part **92.**

[0032] The radio-frequency identifier functions as follows. Upon insertion of a correct key **9,** the fixed part **92** by means of indication of status via the indication element **91,** the indication element will send information about the status, i.e. presence of a key **9,** to the decoding device **8.** The status is evaluated in the evaluation and control unit **83** and the evaluation and control unit **83** sends a signal for initiation of an electromagnetic wave **2** from the transmitter **6,** which using the signal generator **62** and the output amplifier **63** and the transmission element, i.e. the transmitting antenna **61,** initiates the transmission of the electromagnetic wave **2** by transmitting the electromagnetic **2** in the range of tuned periodic structure **1.** The frequency range f_r of the transmitted electromagnetic wave is specific and depends on dimensions and arrangement of elementary resonators **11** and further on electromagnetic properties of the carrier **32** as well as electromagnetic properties of the material of the dielectric insert **3,** which is relative permittivity ε_r. At the same time, the frequency range f_r moves in the range of f_r= 1MHz- 1000 THz and these ranges will be closer specified for particular exemplary embodiments using the technology and the dimensional categories of the lock key **9.** The method of transmission of the electromagnetic wave **2** is realized by means of the signal generator **62,** the output amplifier **63** as well as the transmission element - the transmitting antenna **61** of the transmitter **6.** The generated signal has the frequency of f_V and may show repeatedly frequency-swept harmonics or it may have a rectangular shape in the time interval, or a shape of a saw or a triangle, or short narrow impulse, or combinations thereof in repeat mode. The repetition of the generated signal is temporally separated by a time interval t_{del}, which reaches values ranging from 1 microsecond to several seconds. The electromagnetic wave **2** transmitted in this manner spreads through the area near the transmission element - the transmitting antenna **61** - and falls on the matrix **31** in the impact area **4** of the electromagnetic wave **2.** The electromagnetic wave **2** initiates the reflected electromagnetic wave **5** in the periodic structure **1** arranged on the carrier **32** connected with the dielectric insert **3.** The reflected electromagnetic wave **5** is transmitted to the receiving element - the receiving antenna **71,** which transforms it and the wave in the form of a signal is further amplified by the input amplifier **72** and modified into a processable form in the block **73** of filters and shaping circuits. The signal modified in this way is forwarded to the decoding device 8. In case information resulting from such processed signal corresponds with the pre-set information in the form of a code in the decoding unit **82,** a command to ensure that the secured/controlled element **10** is given by means of the evaluation and control unit **83** and the control element **81.**

[0033] Evaluation and decoding of the signal at the output of the block **73** of filters and of the shaping circuit entering the decoding unit **82** may be performed by means of the code setting block **85** using several methods.

[0034] When generating the signal using the signal generator **62** with repeatedly swept harmonic waveform with the frequency f_V in the frequency range f_r, resonance spectrum of the signal coming from the filter block 73 and the shaping circuit of the receiver **7** is recorded in the decoding unit **82.** The recorded spectrum is compared to the saved values of the required spectrum. If there is a match in case of multiple comparisons of both spectrums, the information about the match of the code set in the code setting block **85** and the code obtained from the key **9** is forwarded. Further, the information about the code match is forwarded to the evaluation and control unit **83,** which evaluates it and gives command to the control element **81** to release the secured element **10.** The evaluation and control unit **83** sets other system elements into the status of successful signal evaluation. In case there is not match detected during multiple comparisons of both spectrums, the information about different code setting in the code setting block **85** and the code evaluated by means of inserting the key **9** into the fixed part of the radio-identification device **92** is forwarded to the evaluation and control unit **83.** The evaluation and control unit **83** sets the other system elements to the status of unsuccessful signal evaluation and further to the mode of identification of another key **9.**

[0035] During generation of a signal in the signal generator **62** in a time interval, having a rectangular shape or a shape of a saw, a triangle, a short narrow impulse or combinations thereof, in the repeat mode, with the frequency of f_V in the frequency range f_r, evaluation of the resonance spectrum of the signal coming from the filter block **73** and the shaping circuit of the receiver **7** is performed in the decoding unit **82** using known mathematical methods/tools, such as Fourier transform, fast Fourier transform, and the like. The recorded spectrum is compared with the saved values of the required spectrum. In case there is a match detected during multiple comparisons of both spectrums, the information about the match between the code set in the code setting block **85** and the code obtained from the key **9** is forwarded. Further, the information about the match is received by the evaluation and control unit **83,** which evaluates the information and gives command to the control element **81** to release the secured element **10.** The evaluation and control unit **83** set the other system elements into the status of successful signal evaluation. If there is no match detected during multiple comparisons of both spectrums, the information about different code setting in the code setting block **85** and the setting of the code evaluated by inserting the key **9** into the fixed part **92** of the radio frequency device is forwarded to the evaluation and control unit **83.** The evaluation and control unit **83**

sets the other system elements to the status of unsuccessful signal evaluation and further to the mode of identifying another key 9.

[0036] In the basic embodiment, the key 9 comprises the carrier 32, which is provided by at least two elementary resonators 11 arranged in a periodic structure 1, and the dielectric insert 3. The dielectric insert 3 is provided with at least one dielectric block 20 or at least one shaped opening 200 or combinations thereof. The dielectric insert 3 is adjacent to the carrier 32 on one of its sides or on both sides. Other embodiments of the key 9 may be combined by means of the above-described carrier 32 and the dielectric insert 3, as it is apparent from Fig. 13.

[0037] Other exemplary embodiment of the radio-frequency identifier, in which the key 9 comprises the carrier 32 with the dielectric inserts 3 adjacent from the both sides, is illustrated in Fig. 9. Such arrangement comprises the transmitter 6 together with the transmitting antenna 61, the key 9, the receiver 7 with the receiving antenna 71, connected to the decoding device 8.

[0038] Another exemplary embodiment of the radio-frequency identifier, in which the key 9 comprises the carrier 32, with the dielectric insert 3 adjacent on one side, is illustrated in Fig. 10. Such arrangement comprises the transmitter 6 together with the transmitting antenna 61, the key 9, the receiver 7 with the receiving antenna 71, connected to the decoding device 8.

[0039] Another exemplary embodiment of the radio-frequency identifier, in which the key 9 comprises two one-sided embodiments of the carrier 32, with the dielectric insert 3 adjacent on one of its sides, wherein in this embodiment two carriers 32 with the dielectric inserts 3 facing each other are used, is illustrated in Fig. 11. Such arrangement comprises the transmitter 6 together with the transmitting antenna 61, the key 9, the receiver 7 with the receiving antenna 71, connected to the decoding device 8.

[0040] Another exemplary embodiment of the radio-frequency identifier, in which the key 9 comprises the carrier 32, with the dielectric inserts 3 adjacent to it from both sides, and the carrier 32 with the dielectric insert 3 adjacent from one side, while the free side of the first carrier 32 adjoins the dielectric insert 3 of the other carrier 32, is illustrated in Fig. 12. Such arrangement comprises the transmitter 6 together with the transmitting antenna 61, the key 9, the receiver 7 with the receiving antenna 71, connected with the decoding device 8.

[0041] Resonance structures arranged in the periodic structure 1 are designed as the matrix 31. The matrix 31 comprises elementary resonators 11 arranged together and provided on the carrier 21 made of dielectric material. Such material may be synthetic polymer, natural polymer or available dielectric materials, it may further be ceramic material, semiconductor substrates based on Si, Ge, As and other materials known in the field of semiconductor techniques.

[0042] Fig. 1 illustrates a scheme of the arrangement of one-sided variant of the matrix 31, which comprises the carrier 32 with the elementary resonators 11, which are arranged in the periodic structure 1, wherein the periodic structure 1 interacts with the electromagnetic wave 1 in the impact area **4** and forms the reflected electromagnetic wave **5.** In the exemplary embodiment, the matrix **31** comprises the carrier **32,** on which the periodic structure **1** of elementary resonators **101** is arranged, wherein these elementary resonators **101** form a periodic structure **1** spatially or in a plane, as it is apparent from Fig. 7.

[0043] Fig. 2a illustrates two one-sided variants of the matrix **31,** in which the elementary resonators **11** are arranged opposite each other on the carrier **32** of the periodic structure **1.** Such arrangement is advantageous for increasing the number of setting combinations of the resulting codes, known as code strength.

[0044] Fig. 2b illustrates two-sides variant of the matrix **31,** where one carrier **32** is provided with periodic structures **1** with elementary resonators **11** on both sides. Such arrangement is advantageous for increasing the multiple number of setting combinations of the resulting codes, known as code strength.

[0045] Fig. 2c illustrates a combination of a two-sided variant and two one-sided variants of the matrix **31,** which are provided with periodic structures **1** with elementary resonators **11** on the carriers **32.** Such arrangement is advantageous for increasing the number of setting combinations of the resulting codes, known as code strength, however, this combination is also more resistant to unwanted eavesdropping of the communication between the key **9** and the fixed part **92.**

[0046] The elementary resonators **11** are produced as divided square, annular or dipole structures, or eventually their combinations, such as a CC-type resonator **101**, LL-type resonator **102,** C-type resonator **103,** I-type resonators **104**, U-type resonators **105** and other shapes of resulting from various combinations or divisions of the said shapes, as it is illustrated in Fig. 5. The elementary resonator **11** may also consist from, for example, straight broken or divided conductors or other combinations of shapes of the said elementary geometric arrangements of conductors, and these are provided on the carrier **32,** which is a part of the matrix **31.**

[0047] The elementary resonators **11** may be tuned to their own operating frequency f_r by means of their geometry, mutual arrangement of the conductor geometry, properties of the carrier **32,** such as its electric permittivity ε_S, magnetic permeability μ_S, electrical conductivity γ_S, electrical permittivity of the surroundings ε_O, magnetic permeability of the surroundings μ_O, electrical conductivity of the surroundings γ_O, electrical conductivity of the conductors γ_V of the elementary resonator **11,** and mutual electromagnetic-physical bonds between elementary resonators **11** (known as the capacity C_V, inductance L_V, conductivity G_V). Near the matrix **31** and periodic structure **1** of the elementary resonators **11** arranged on the carrier **32,** the dielectric insert **3** made of dielectric material with specific geometry and properties of the electric permittivity ε_d, magnetic permeability μ_d, electrical conductivity γ_d of dielectric material is arranged, and this connection allows tuning of the required periodic structure **1** of elementary resonators **11** to the required frequency f_S, and the electromagnetic structure created in this way forms a unique response of the reflected electromagnetic wave **5** detected by the receiver **7** provided with the receiving element - the receiving antenna **71,** upon impact of the electromagnetic wave **2** transmitted by the transmitter **6** using the transmitting antenna **61** by, which is hardly achievable by any other means.

[0048] The degree and strength of the code created by the response information of the reflected electromagnetic wave **5** in the impact area **4** of the electromagnetic wave **2** on the signal transmitted by the transmitter **6** by means of the transmission element - the transmitting antenna **61,** depends on the number and type of combinations of elementary resonators **11,** and on their mutual tuning to the operating frequency f_S.

[0049] The periodic structure **1** may be formed, for example, by means of the CC-type resonator **101,** LL-type resonator **102,** C-type resonator **103,** I-type resonator **104,** U-type resonator **105** and combinations thereof. The arranged elementary resonators **11** form the matrix **31** provided on the carrier **32.** Electromagnetic property of the carrier **32** also depends on the electric permittivity ε_S of the material of the carrier **32**, magnetic permeability μ_S of the material of the carrier **32,** electrical conductivity γ_S of the material of the carrier **32,** permittivity ε_S of the material of the carrier **32,** electrical permittivity ε_0 of the surroundings of the carrier **32,** magnetic permeability μ_0 of the surroundings of the carrier **32,** electrical conductivity γ_0 of the surroundings of the carrier **32,** and electrical conductivity γ_V of the conductors of the elementary resonator **11.**

[0050] Fig. 4 illustrates an example of the matrix **31,** in which U-type resonators **105** are used, arranged on the carrier **32,** having an Y-width of its geometric dimension.

[0051] Depending on the type of the used production technology, dimensions of elementary resonators **11** vary in the range of cm to nm, wherein their specific dimensions are illustrated in the figs. 6a, 6b, 7 and 8a.

[0052] Dimensions of the elementary resonators **11,** dimensions of the periodic structure **1** of the resonators, dimensions of the arrangement of the elementary resonators **11** in the matrix **31** on the substrate **32,** dimensions of the additional dielectric block **20,** shaped circuit **200** and the dielectric insert **3** made of dielectric material for various application of the present invention may be categorized into the following ranges:

Ranges of nanometer order, particularly dimensions in the intervals of A=1000nm -10 000nm, B=1000nm -10 000nm, C=100nm-1000nm, D=100nm-1000nm, E=100nm-5000nm, F=100nm-5000nm, G= 200nm-5000nm, H=100nm-1000nm, I= 100nm-1000nm, X=100nm-100000nm, Y=100nm-100000nm, Z=1nm-1000nm,

ranges of micrometer order, particularly dimensions in the intervals of A=10μm - 100μm, B=10μm - 100μm, C=1μm - 10μm, D=1μm - 10μm, E=1μm - 500μm, F=1μm - 500μm, G= 2μm - 500μm, H=1μm - 10μm, I= 1μm - 10μm, X=0.1μm - 1000μm, Y=0.1μm - 1000μm, Z=0.01μm-10μm, ranges of millimeter order, particularly dimensions in the intervals of A=1mm - 10mm, B=1mm - 10mm, C=0.1mm - 1mm, D=0.1mm - 1mm, E=0.1mm - 50mm, F=0.1mm - 50mm, G= 0.2mm - 50mm, H=0.1mm - 1mm, I= 0.1mm - 1mm, X=0.1mm - 100mm, Y=0.1mm - 100mm, Z=0.01mm-1mm,

ranges of centimeter order, particularly dimensions in the intervals of A=1cm - 10cm, B=1cm - 10cm, C=0.1cm - 1cm , D=0.1cm - 1cm, E=0.1cm - 50cm, F=0.1cm - 50cm, G= 0.2cm - 50cm, H=0.1cm - 1cm, I= 0.1cm - 1cm, X=0.1cm - 10cm, Y=0.1cm - 10cm, Z=0.1mm-10mm.

[0053] The additional dielectric blocks **20** are made of, for example, plastic material based on polymers, as microscopic as Si, Ge, As, and others, as well as of nanoscopic structures such as Ag, Zn, Ni, Co and others, and they may be produced using available 3D print, lithographic technologies, steaming, stamping, and other, and the shaped openings **200** may be formed using classic machining techniques, material removal techniques, as well as using 3D print technologies together with burning, etching, grinding, abrasive processing, compressed air and waterjet processing, and other methods, when producing the insert **3** made of dielectric material.

[0054] An advantage of the present solution and the concept of the radio-frequency identifier is that the period structure **1** of elementary resonators **11** arranged on the carrier **32** together with the insert **3** made of dielectric material form the key **9**. Upon transmission of the electromagnetic wave **2** by the transmitter **6** using the transmission element, i.e. the transmitting antenna **61,** its impact on the impact area **4** forms the reflected electromagnetic wave **5,** which is detected by means of the receiving element, i.e. the receiving antenna **71,** and forwarded to the receiver **7.** The key **9** based on this coding method can be easily modified and produced, replicated or modified, using 2D/3D printing technology as well as other technologies. These changes are characterized in changing the motive, structure or material of the insert **3** made of dielectric material. The dielectric insert **3** may be provided with the dielectric block **20** arranged on its surface or shaped openings **200** may be formed in it, as it is apparent from Fig. 8a. The additional dielectric block **20** may consist of the additional dielectric block **21** having a circular shape in its cross-section, or the additional dielectric block **22** having a square shape in its cross-section, or the additional dielectric block **23** having an oval shape in its cross-section, or the additional dielectric block **24** having a rectangular shape in its cross-section, or the additional dielectric block **25** having a shape of n-walls in its cross-sections with optional wall ratio for n = 4,5,6,...20, wherein these additional blocks **20** may be combined for forming various shapes.

[0055] The shaped openings **200** may consist of the opening **201** having a circular shape in its cross-section, or the opening **202** having a square shape in its cross-section, or the opening **203** having an oval shape in its cross-section, or the opening **204** having a rectangular shape in its cross-section, or the opening **205** having a shape of polyhedron with n-walls in its cross-section, with optional wall ratio for n = 4,5,6,...20 and combinations thereof, and further it may consist of optional combination of the said additional dielectric blocks **20** and the shaping openings **200,** as it is apparent from Fig. 8b.

[0056] According to the suitable dimensions of the elementary resonator **11** and the chosen dimensional category of the resulting key **9,** the corresponding production technology of replaceable dielectric inserts **3** made of dielectric material is chosen. Particularly, for the dimensional category in the range of nanometers a technology based on lithographic techniques, lift-off technique, spraying technique or steaming technique, etc., is suitable. For the dimensional category in the range of micrometers, it is possible to choose a technology based on chemical processes of applying and removing coatings, lithography, plasma spraying, sputtering, etching, etc. For the dimensional category in the range of millimeters, it is possible to choose a technology based on etching, grinding, sputtering, spraying, mechanical processing, steaming, applying of heat-treated polymers, plasma machining, abrasive machining, 3D printing, etc. For dimensional category in the range of centimeters it is possible to choose a technology based on mechanical applications, mechanical processing of surfaces, applications using plasma spraying, etching, abrasive machining using particles, water processing, emulsification, fluid machining technology, 3D printing, etc.

[0057] An advantage of the present solution is that by repeating the motive of the insert **3** made of dielectric material, using inexpensive available technologies as well as 2D/3D printing technologies, it is possible to repeatedly create the desired shape of the insert **3** made of dielectric material, which ensures the identical resulting response of the electromagnetic field in the form of reflected electromagnetic wave **5,** confirming that identification of the overall setting of the key **9** in the decoding device **8** is identical, or only by changing the motive of the insert **3** made of dielectric material, the matrix **31** - periodic structure **1** or resonators and the elementary resonators **11** - it is possible by means of inexpensive available technologies as well as 2D/3D printing technologies create such shape of the insert **3** made of dielectric material, which ensure different resulting response of the electromagnetic field in the form of reflected electromagnetic wave **5**, and the identification of the overall setting of the key **9** in the decoding device **8** is modified. By changing the shapes of geometry of the arrangement of dielectric blocks **20,** or separately or simultaneously shaped openings **200**, it is possible to change the identification of the RFID structure code, and thus the key **9.**

Industrial Applicability

[0058] The invention is intended for use as a new generation of RFID structures serving as a personal accession element, a key, replacement of conventional door keys, and the like. The first portion of the resonance structure will always remain identical, while the surrounding dielectric structure may be reproduced by means of 3D print or changed in case of change of code, and thus also change the RFID code. The solution appears to be very advantageous in relation to widespread usage of 3D printers.

LIST OF REFERENCE SIGNS

[0059]

1
periodic structure of the elementary resonators
11
elementary resonator
101
CC-type resonator
102
LL-type resonator
103
C-type resonator
104
I-type resonator
105
U-type resonator
2
electromagnetic wave
3
dielectric insert
31
matrix
32
substrate
4
impact area of the electromagnetic wave
5
reflected electromagnetic wave
6
transmitter
61
transmitting antenna
62
signal generator
63
output amplifier
7
receiver
71
receiving antenna
72
input amplifier

73
filters and shaping circuits
8
decoding device
81
control element
82
decoding unit
83
evaluation and control unit
84
power supply unit
85
code-setting block
9
key
91
indication element
92
fixed part
10
secured/controlled element
20
additional dielectric block
21
circular base of the additional dielectric block
22
square base of the additional dielectric block
23
oval base of the additional dielectric block
24
rectangular base of the additional dielectric block
25
n-wall base of the additional dielectric block
200
shaped openings
201
circular base of the dielectric block opening
202
square base of the dielectric block opening
203
oval base of the dielectric block opening
204
rectangular base of the dielectric block opening

205
n-wall base of the dielectric block opening

REFERENCES CITED IN THE DESCRIPTION

Cited references

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US7471199B2 [0003]
- US20060226948A1 [0004]
- US2007241904A1 [0005]
- US20060180647A1 [0006]
- US2010134254A1 [0007]
- WO9410663A1 [0008]
- EP1251588A2 [0009]
- EP2495805A1 [0010]
- WO2015004232A1 [0011]
- DE4338554A1 [0012]
- FR2992758A1 [0013]
- CZ2012636A3 [0015]
- EP2286485A1 [0017]
- US2005280539A1 [0018]
- EP1811432A1 [0019]

RADIOFREKVENS IDENTIFIKATOR INDSTILLELIG VED HJÆLP AF DIELEKTRISKE INDSATSER

PATENTKRAV

1. En indretning bestående af en radiofrekvens identifikator indstillelig ved hjælp af dielektriske indsatser (3), ved anvendelse af radiofrekvens identifikation og omfattende en fast del (92) og en nøgle (9), hvori den faste del (92) omfatter et identifikations element (91) og en afkodnings anordning (8) som omfatter en strømforsynings unit (84), en evaluerings og kontrol unit (83), en afkodnings unit (82) og et kontrol element (81), hvori afkodnings anordningen (8) er forbundet med en modtager (7) som omfatter en modtager antenne (71), en modtageforstærker (72) og en blok (73) af filtre og formgivende kredsløb, hvori afkodnings anordningen (8) endvidere er forbundet til en sender (6) som omfatter en sendeantenne (61), en udgangsforstærker (63) og en signalgenerator (62), hvori nøglen (9) omfatter mindst en bærer (32) forbundet med mindst en dielektrisk indsats (3), bæreren (32) er forsynet med elementære resonatorer (11) anbragt i en periodisk struktur (1), hvori bæreren (32) sammen med de elementære resonatorer (11) danner en matrix (31).

2. Indretningen bestående af en radiofrekvens identifikator i henhold til patentkrav 1, **kendetegnet ved at** nøglen (9) omfatter en bærer (32) med den dielektriske indsats (3) stødende op til en af dens sider.

3. Indretningen bestående af en radiofrekvens identifikator i henhold til patentkrav 1, **kendetegnet ved at** nøglen (9) omfatter bæreren (32) forsynet med den dielektriske indsats (3) fra begge sider.

4. Indretningen bestående af en radiofrekvens identifikator i henhold til patentkrav 1, **kendetegnet ved at** nøglen (9) omfatter et sæt af bæreren (32), som er forsynet med den dielektriske indsats (3) fra begge sider, til hvilken bæreren (32) er forbundet med den dielektriske indsats (3) på en af dens sider.

5. Indretningen bestående af en radiofrekvens identifikator i henhold til patentkrav 1, **kendetegnet ved at** nøglen (9)

omfatter et par af bærerne (32), hvori en af deres sider er forsynet med den dielektriske indsats (3) vendt mod hinanden.

6. Indretningen bestående af en radiofrekvens identifikator i henhold til et af de foregående patentkrav, **kendetegnet ved at** de elementære resonatorer (11) er fremstillede som delte kvadratiske eller ringformede eller dipole strukturer.

7. Indretningen bestående af en radiofrekvens identifikator i henhold til et af de foregående patentkrav, **kendetegnet ved at** indsatsen (3) er forsynet med mindst en ekstra dielektrisk blok (20) modificeret på dens overflade eller i hvert fald forsynet med en åbning (200) dannet indeni den dielektriske indsats (3).

8. Indretningen bestående af en radiofrekvens identifikator i henhold til patentkrav 7, **kendetegnet ved at** den dielektriske blok (20) omfatter en ekstra dielektrisk blok (21) med en cirkulær form i tværsnit, eller en ekstra dielektrisk blok (22) med en kvadratisk form i tværsnit, eller en ekstra dielektrisk blok (23) med en oval form i tværsnit, eller en ekstra dielektrisk blok (24) med en rektangulær form i tværsnit, eller en ekstra dielektrisk blok (25) med en form som et polyeder med n-væge i tværsnit, med valgfrie væg forhold for n = 4,5,6,...20, hvori disse forskelligt formede ekstra blokke (20) kan gensidigt kombineres.

9. Indretningen bestående af en radiofrekvens identifikator i henhold til patentkrav 7, **kendetegnet ved at** åbningen (200) omfatter en åbning (201) med en cirkulær form i tværsnit, eller en åbning (202) med en kvadratisk form i tværsnit, eller en åbning (203) med en oval form i tværsnit, eller en åbning (204) med en rektangulær form i tværsnit, eller en åbning (205) med form som et polyeder med n-væge i tværsnit, med valgfrie væg forhold for n = 4,5,6,...20, hvori disse forskelligt formede åbninger (200) kan gensidigt kombineres.

DRAWINGS

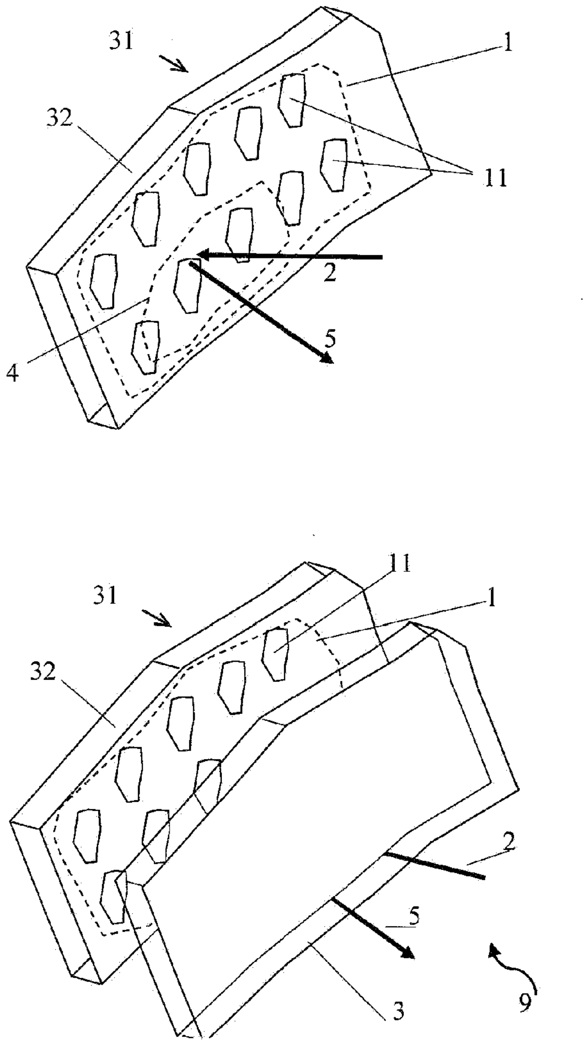

Fig. 1

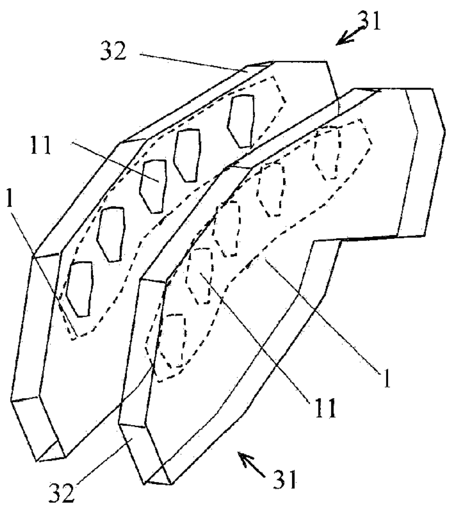

Fig. 2a

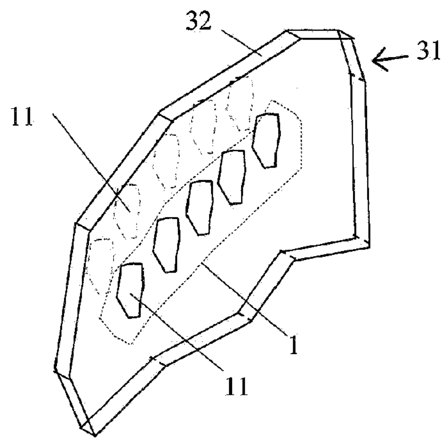

Fig. 2b

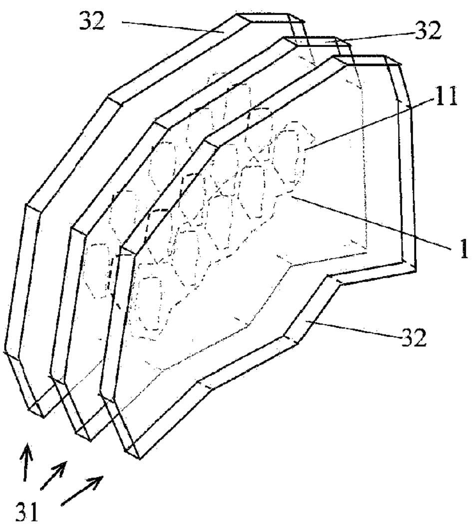

Fig. 2c

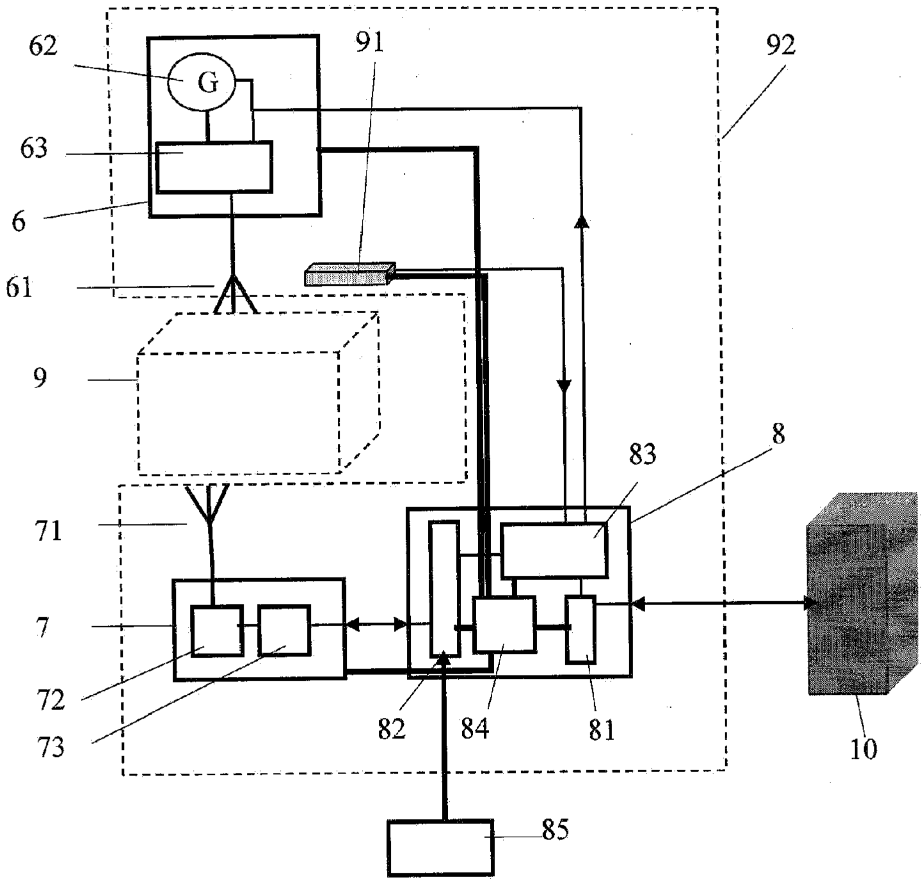

Fig. 3

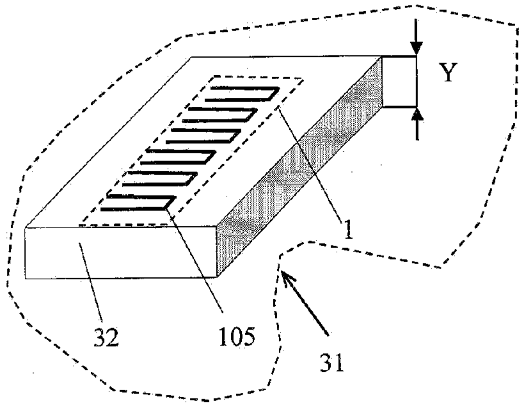

Fig. 4

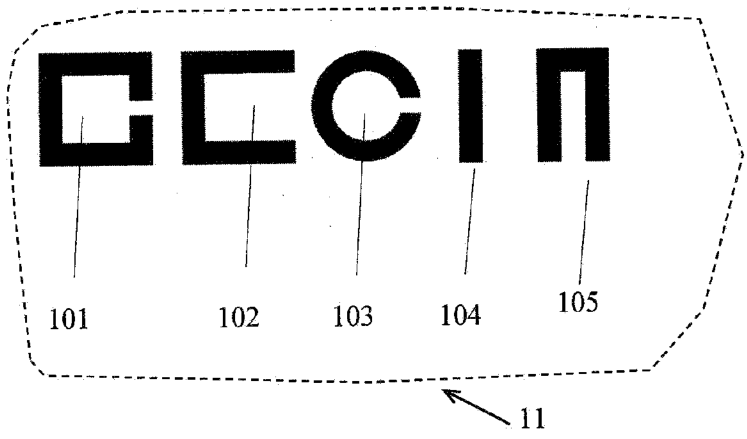

Fig. 5

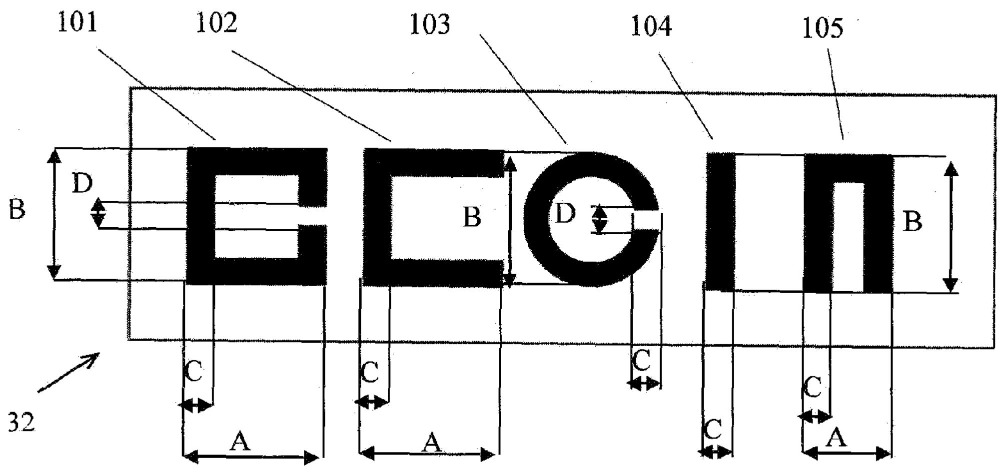
101
102
103
104
105
B
D
B
D
B
C
C
C
C
C
A
A
A
32

Fig. 6a

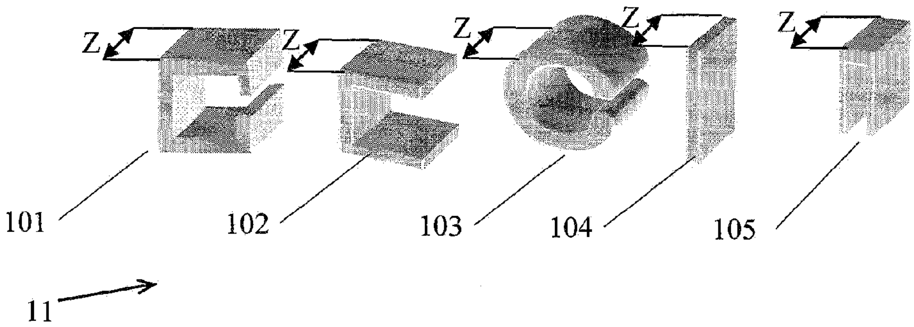
Z
Z
Z
Z
Z
101
102
103
104
105
11

Fig. 6b

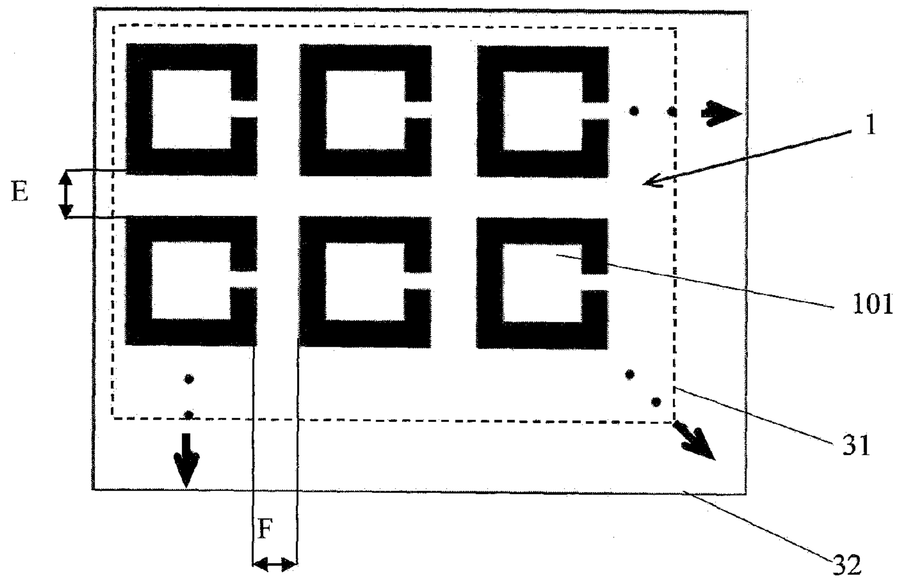

Fig. 7

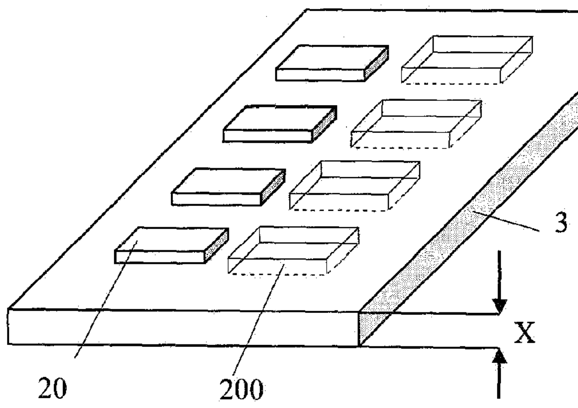

Fig. 8a

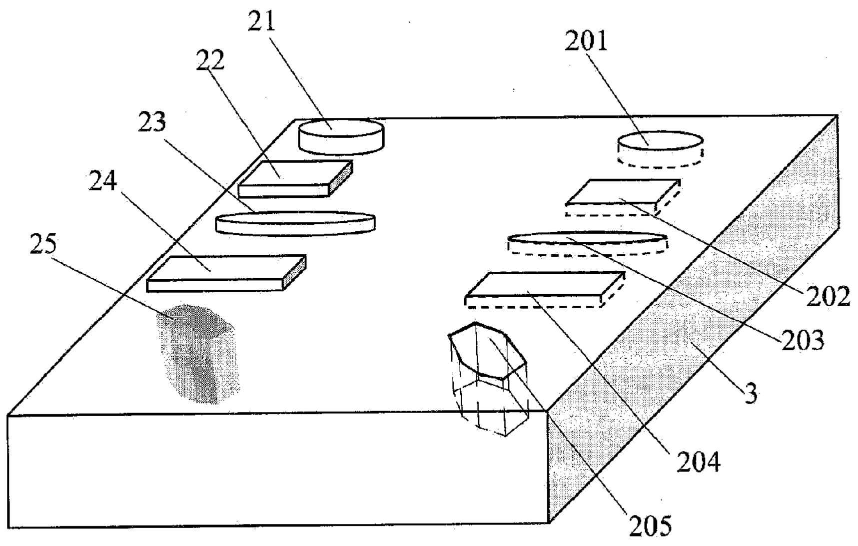

Fig. 8b

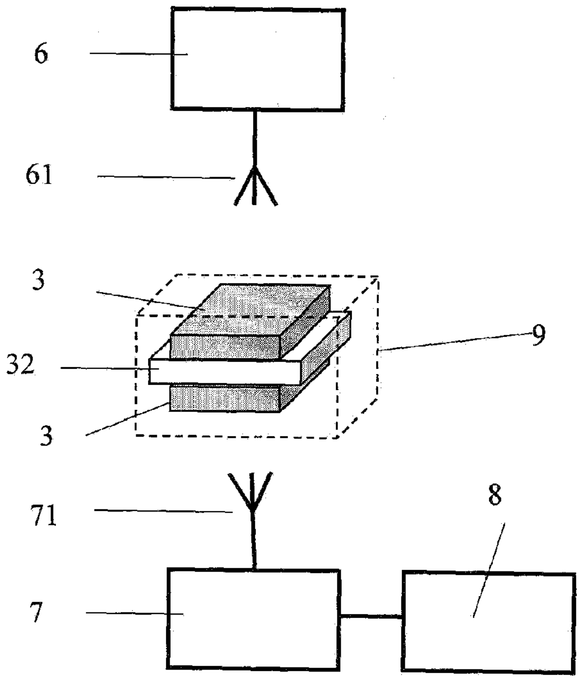

Fig. 9

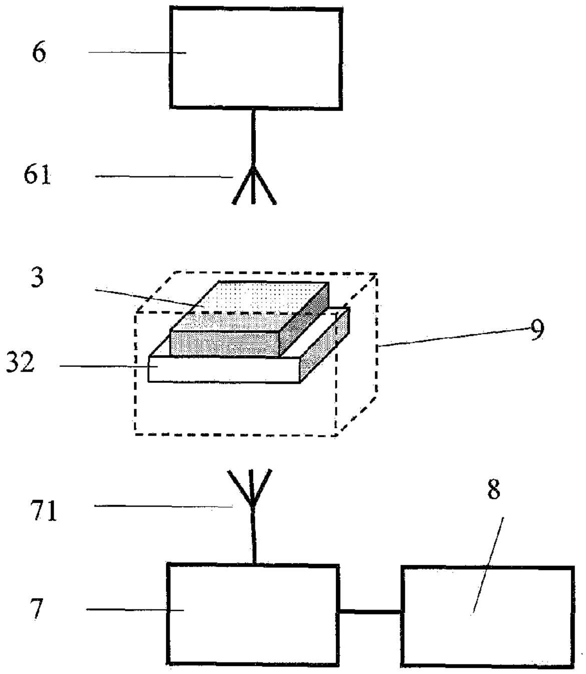

Fig. 10

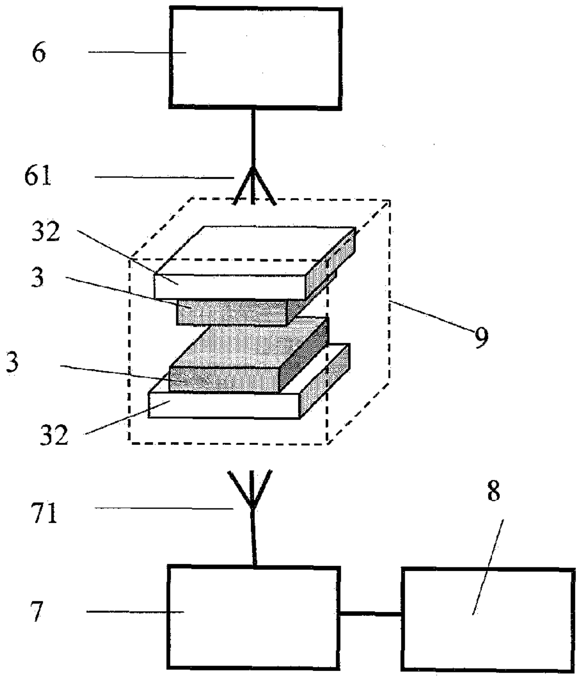

Fig. 11

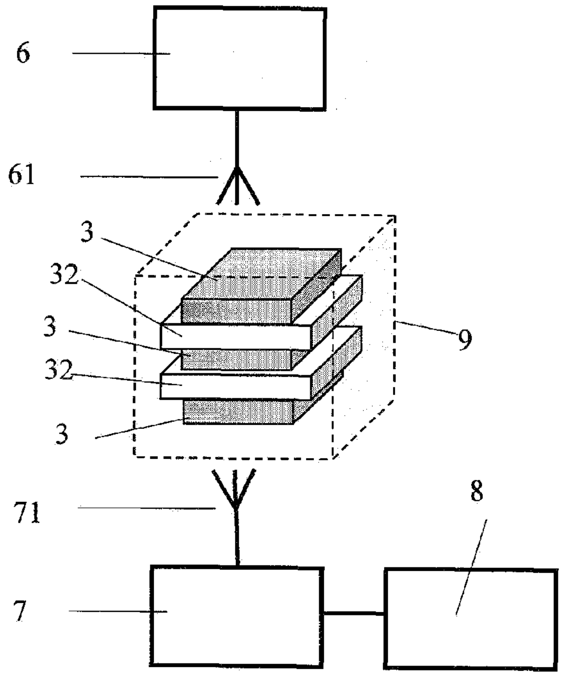

Fig. 12

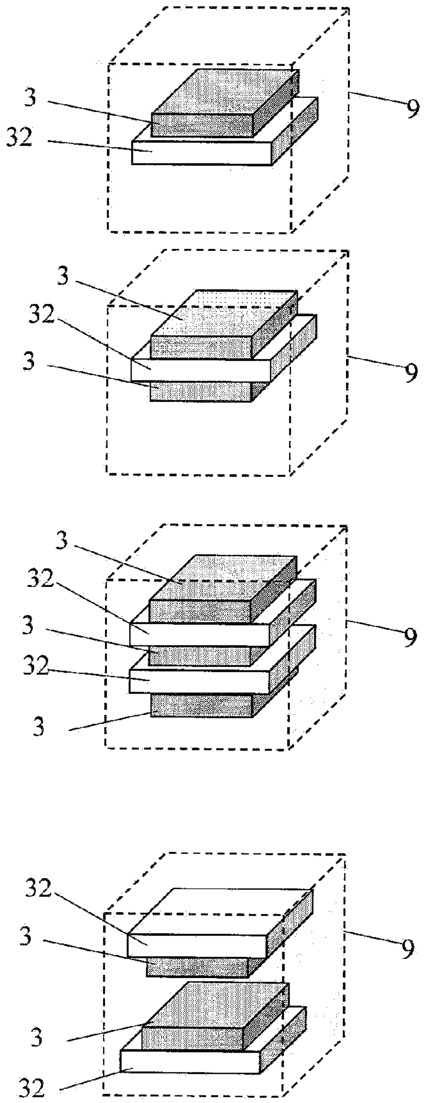

Fig. 13