(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 January 2014 (23.01.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/013439 A1

(51) International Patent Classification:
G06K 19/07 (2006.01) *G06K 19/077* (2006.01)

(21) International Application Number:
PCT/IB2013/055851

(22) International Filing Date:
16 July 2013 (16.07.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/672,224 16 July 2012 (16.07.2012) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

WO 2014/013439 A1

(54) Title: RFID ELECTRONIC TAG

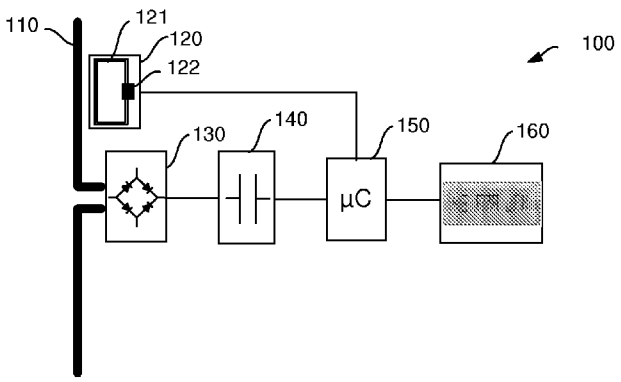


Fig.1

(57) Abstract: The invention relates to an RFID electronic tag (100) comprising: -an RFID microchip (120) for receiving information included in an electromagnetic radiation, -a processing unit (150) for processing said information, -display means(160) for displaying said processed information; -a RF antenna (110) coupled to said RFID microchip and to an energy harvester (130) deemed to collect energy from electromagnetic radiation and to provide energy at least to said processing unit and said display means,and -a means for fixing said tag to an object.

RFID ELECTRONIC TAG

TECHNICAL FIELD OF THE INVENTION

The present invention relates to RFID electronic tags. These tags can be implemented within the framework of the registration and the traceability of objects within an air, sea or land transport network.

PRIOR ART

These RFID electronic tags are classically powered remotely by an electromagnetic field at ISM frequencies which are 13560 kHz and 866-867 MHz in Europe, 902-928 MHz in the USA.

RFID components do not possess any power supply of their own and recover the energy required for their operation via the communication electromagnetic field at the most appropriate ISM frequency, depending on the desired communication distance.

In NFC (Near Field Communication) applications, the frequency at 13 560 kHz allows having communication distances of a few tens of centimeters and makes it possible to easily recover additional energy to power ancillary circuits like a e-Ink type bistable screen, a microcontroller or a D/A (Analog/Digital) converter. The production of a voltage comprised between 2V and 5 V with an available current of several milliamperes is easily achieved with a simple diode-based full-wave rectifier.

In RFID using the UHF band (Far Field Communication), the difficulty in recovering energy in propagation mode

limits the applications to the simplest such as temperature measurement. The UHF voltage rectifier of the tag harvests at best only 10 to 50 mV and must use systems of charge pumps with a high number of stages in order to be able to recover a voltage at a level sufficient to power microcontrollers at low voltage i.e. 0.9 V for Texas Instruments and more commonly 1.8 V for the other manufacturers like STM and Microchip. This greatly limits the number of operations per second that can be performed by the microcontroller.

The state of the art includes document WO201193780A1 which describes a luggage tagging electronic device to be used for transport, comprising at least one communication interface unit for transmitting electromagnetic radiation, a processing unit for processing or transmitting information included in the electromagnetic radiation, a storage device for storing the processed or unprocessed information, the storage device comprising first and second sets of computer-executable instructions for controlling the communication and the basic operations of the luggage tagging electronic device, the luggage tagging device furthermore comprising: a first unit for presenting information and optionally a second unit for presenting information, a first field for presenting information and a second field for presenting information, the first presentation field being designed to present dynamic information, such as itinerary information, in such a way that the information can be updated electronically by way of a communication authorized for the luggage tagging device, and the second fields for presenting static information only. A major drawback of

such a device is that it is not optimized for operation without a built-in battery

Also known is the document US2008/0111675 which pertains to RFID elements that may be passive RFID elements, and whose observable properties may be visible changes which require only very little power to generate them, and very little - or indeed no - power to maintain them. The visible information can comprise information relating to articles tracked by means of the RFID elements such as forwarding information. Certain embodiments comprise passive RFID elements which use a single antenna to power an integrated circuit microchip and a visual identification element. Certain embodiments comprise methods for locating the interrogated RFID elements. Certain embodiments comprise methods for tracking articles.

This state of the art describes a system for tracing objects via passive RFID tags connected to screens not requiring a continuous power supply. But two distinct groups of RFID interrogators are required in order to be able to modify two separately displayed distinct properties. Moreover no mention is made regarding the precise implementation of the energy collection system whatever the position and the composition of the object. Systems for remote powering at operating distances of a few centimeters for example on the basis of NFC applications are known from the prior art. Such systems are implemented in the logistics, for example for the management of plastics trays in mail sorting centers. In such systems, a RFID e-ink tag can be

placed on the edge of the tray and programmed on the fly.

The major drawback of RFID and NFC at high frequency is the short distance of communication and of remote powering, which is lower than 60 cm.

DISCLOSURE OF THE INVENTION

The problem solved by the present invention is to find an efficient means for collecting RFID energy at UHF frequencies, thus permitting to perform more complex auxiliary tasks than the simple reading of a unique identifier or data in a nonvolatile memory.

The solution afforded by the invention consists in widening the spectrum of the ambient radio frequencies that can be rectified and stored in the RFID electronic tag in an opportunistic manner by using GSM and/or Wi-Fi and/or Bluetooth waves within the close environment of the device, such an environment being typically the environment encountered in an industrial and commercial setting. It permits to harvest more energy which is stored in a high-value capacitor.

Another point is that the materials from which objects like items of luggage are manufactured make them to be objects that are highly perturbing for Radio Frequency (hereinafter RF) standpoint: they are often made of metal or of an absorbent material.

So another aim of the invention is to make it possible to separate the electrical antenna of the tag from the metallic parts of the luggage such that the antenna of

the electronic tag is disturbed as little as possible by the materials of the object.

The fixing means attaching the tag to the object is fixed on the object can be designed to include the RF antenna. More specifically, the cord of the tag attaching it to the object can be exploited to form an efficient radiating wire, distancing the tag from metallic parts of the object. It also can be used to separate the antenna from the metallic parts of the object since, in the luggage application, it is tied on a non metallic part of the object (to the plastic handle of the luggage). The tag is thus less disturbed by the material of the object.

Another way to separate the antenna from the object is to use a thick packaging for the tag.

Another way is to use a semi rigid cord of spring type.

Thus the electronic tag according to the invention is capable of operate and communicate at distances of several meters and to do so whatever the orientation of the tag.

More specifically, the invention relates to an RFID electronic tag comprising:

- an RFID microchip for receiving information included in an electromagnetic radiation,
- a processing unit for processing said information,
- display means for displaying said processed information;

- a RF antenna coupled to said RFID microchip and to an energy harvester deemed to collect energy from electromagnetic radiation and to provide energy at least to said processing unit and said display means, and

- a means for fixing said tag to an object.

According to particular embodiments:

- the energy harvester is the RFID microchip;
- the energy harvester is a non radiofrequency energy harvester, for example a harvester collecting solar energy or vibration;
- the fixing means is a cord for retaining the tag, the RF antenna being an electrical wire inside or on the cord;
- the fixing means is a conductive cord;
- the tag is included within a thick dielectric package in order to move away the RF antenna from the object, said package comprising said fixing means;
- the package of the tag is made of material having a dielectric constant comprised between 1 and 5 and $\tan\delta<1/1000$;
- the cord is semi rigid and of spring type allowing the antenna to be routinely distanced from said object;
- the display means is an electronic paper display;
- the object is an item of luggage;
- the tag comprises physical measurement sensors for: temperature, time, humidity, mechanical stress undergone.

This solution adds value-enhancing functionalities to a simple RFID tag replacing a disposable barcode which is used just once for the tracing of objects.

The electronic tag of the invention can be a personal tag for frequent travelers on certain lines. The traveler ties RFID tags and then deposits their luggage in a dedicated self-service deposit counter for fast boarding.

DESCRIPTION OF THE FIGURES

Other advantages and characteristics of the invention will be more apparent on reading the description of a preferred embodiment which follows, with reference to Figure 1, effected by way of indicative and non limiting example:

- Fig.1 shows the electrical scheme of a first embodiment of the tag according to the invention;
- Fig.2 shows the electrical scheme of a second embodiment of the tag according to the invention;
- Fig.3 shows the electrical scheme of a third embodiment of the tag according to the invention;
- Fig.4 shows a first tag according to the invention;
- Fig.5 shows the tag of Fig.5 attached to the handle of a luggage; and
- Fig.6 shows a second tag according to the invention.

EMBODIMENTS OF THE INVENTION

Various embodiments of the RFID electronic tag of the invention are presented hereinafter.

According to Fig.1, the RFID electronic tag 100 comprises a radiofrequency antenna 110 coupled to a RFID microchip 120 and an energy harvester 130. More specifically, the RF antenna is an electrical dipole which is coupled to the magnetic antenna of the RFID

microchip 120. The magnetic antenna of the chip is magnetic loop 121 connected to the integrated circuit 122 of the RFID microchip.

The RF antenna 110 is also connected to the energy harvester 130 to collect energy from electromagnetic radiation.

So the RF antenna 110 is used to improve the communication with the RFID microchip and to collect energy via the energy harvester.

Said RF antenna is able to operate whatever its orientation. It allows the capture of the field whatever the orientation of the tag on an object or the container of a product.

Advantageously, the energy harvester 130 is equipped with a storage capacitor 140 to store the harvested energy. The energy harvester is for example a diode-based full-wave rectifier.

It can also be a non radiofrequency energy harvester. It can be a harvester collecting solar energy or vibration energy or thermocouple energy.

The energy harvester 130 provides energy to a processing unit 150 via the storage capacitor 130. The integrated circuit 122 of the RFID microchip is connected to the processing unit 150. This unit is a low power microcontroller.

The role of this microcontroller is to process information coming from the RFID microchip and to manage the components of the tag.

This microcontroller supplies information to be displayed to a display means 160. It also converts the low voltage coming from the energy harvester 130 into a higher voltage.

The voltage outputted by the energy harvester is for example comprised between 1,8 volts and 2,3 volts. The microcontroller converts it into a voltage of about 15 volts by means pump charge stages.

The display means is advantageously of electronic paper display/screen type (E-paper display) or any other bistable display not requiring input of energy unless there is a change of visual state.

The tag operates in radio bands of ISM (Industrial Scientific and Medical) frequencies, for example at 868 MHz in Europe, at 902-928 MHz in the United States and at 940 MHz in Japan. It depends on the size of the RF antenna determines the operating band of the tag. Other radio bands can be envisaged by modifying the size of the RF antenna. The ISM band 433-435 MHz could also be envisaged for tags having a bigger antenna.

The Figs.2 and 3 show variants of the scheme of Fig.1.

In Fig.2, the energy harvester a RFID microchip 130' which is used only for collecting energy.

In Fig.3, the RFID microchip 120 is used to collect energy and to collect information from the electromagnetic radiation.

According to the invention, the RFID electronic tag also comprises fixing means of the retaining cord type for fixing the tag to the object and more specifically to the handle of the luggage.

Advantageously, the RF antenna 110 is coupled to the fixing means and is arranged with the fixing means in order to move away the RF antenna from metallic parts of the object. Thus, the RF antenna will be less disturbed by these metallic parts.

According to a first embodiment, the fixing means is a cord and the RF antenna is an electrical wire placed inside or on the cord. So the fixing means can act as a RF antenna. In the luggage sector, luggage tagging electronic devices is attached to the handle of the luggage by way of a cord. So this cord is attached to a non-metallic part of the luggage.

In this application, the RF antenna is thus separated naturally from the metallic parts of luggage since it is present near the handle of the luggage which is usually a non-metallic part. So the RF antenna is not disturbed by the metallic part of the object.

The RF antenna 110 is a coupled to the magnetic antenna 121 of the RFID microchip.

This embodiment is illustrated by Fig.4. It shows a tag 200 comprising displays means 260 displaying departure information, destination information and a bar code. This tag is equipped with a cordon 270 wherein the RF antenna is present. Fig.5 shows this tag attached to a luggage. The cord is attached around the handle of the luggage.

In a variant illustrated by Fig.6, the tag 300 is included in a thick dielectric packaging 380 with low losses at the radio frequencies. It permits to move away the RF antenna of the tag from the object from at least half of the thickness of the packaging. This embodiment makes it possible to ally robustness and enhanced protection of the electronics which may be mishandled in the air transport chain. Increasing the distance between the RF antenna of the tag and the metallic parts of the object permits to minimize the mistuning of the antenna and thus to maintain sufficient electric field collection to communicate and remotely power the RFID tag.

This package comprises at least a clamp 381 to fix the tag on the handle of the item of luggage.

Of course, the RF antenna 110 can be distinct from the fixing means.

Some simulation results are now presented for different embodiments of the invention.

In a first embodiment called V1, the tag comprises two RFID chips (EM4325), one for RFID communication and one

for energy harvesting, coupled to an electrical dipole acting as an RF antenna. It corresponds to the architecture of Fig.2.

The first EM4325 chip is configured to as a salve mode handling SPI (Serial Peripheral Interface) and the second EM4325 chip is configured to generate 2 volts DC.

The simulations are made for a load of 39 kΩ, a load of 18 kΩ and for a connection to an ePaper display prototype.

	39k load	18k load	Connected to ePaper display
Harvested power (µW)	102	222	32-56
Range (cm)	90	60	60
Overall efficiency	3%	3%	NA

In a second embodiment, the tag comprises only one EM4325 chip for RFID communication and a specific circuit for energy harvesting. This configuration corresponds basically to the architecture of Fig.1. The EM4325 chip is coupled to an electrical dipole acting as a RF antenna. The EM4325 chip is configured to be a SPI master and the display means is the slave. The energy harvester is a wide band Powercast chip P2110. It can collect energy in the frequency band 400 MHz to 2 450 MHz (WiFi, Bluetooth, GSM).

The E-paper display is disconnected by the EM4325 chip when it is possible to keep high sensitivity on the RFID read.

The tag is controlled to stay 10-20 seconds in the RF field before starting the RFID operations in order to have enough time to load the storage capacitor

With this configuration, a range higher than 100 centimeters for RFID and display activation seems possible.

This configuration gives the following results:

EIRP (W)	Load (Ω)	Voltage (V)	Harvested Power (µW)	Chip Power (µW)	Total Power (µW)	RF Power (µW)	Range (cm)	efficiency
4	12000	3,3	908	32	939	7205	60	13%
4	39000	3,3	279	32	311	1153	150	27%
4	120000	3,3	91	32	122	801	180	15%
4	120000	3,3	91	100	191	648	200	29%

With this architecture, at 2 meters, the EM4325 can be written when the received power is at least -10 dBm, meaning 91 mW and the energy harvester harvests 3.3 Volts on a resistor of 120 kOhms, meaning 100 mW.

The use of two distinct chips, one for RFID communication with a standard chip and a second one dedicated to the collection of energy of the ISM gives better results. These two chips are coupled to a RF antenna tuned to the main ISM frequency.

The invention can be implemented within the framework of luggage tracing with automatic airport check-in. An X-ray sensor is then associated so as to verify transit through check-in. Thus, it will be possible to have an automatic check-in of luggage by remotely powered electronic tag communicating by RFID. In this application, the display means is advantageously a

bistable screen to display information linked to the luggage.

In a variant, the tag comprises a second antenna for collecting RF energy from any ISM Band (27 MHz, 433 MHZ, 940-960 MHz, 2,45GHz, 5,8 GHz). The design of this second antenna is optimized to capture any one of these frequencies.

In another application, the tag comprises physical measurement sensors for measuring temperature, time, humidity, mechanical stress undergone, etc. These sensors give for example information like temperature, time elapsed or maturity to verify the quality of a perishable or sensitive product such as fresh foods.

Claims

1. An RFID electronic tag (100) comprising:

- an RFID microchip (120) for receiving information included in an electromagnetic radiation,
- a processing unit (150) for processing said information,
- display means (160) for displaying said processed information;
- a RF antenna (110) coupled to said RFID microchip and to an energy harvester (130) deemed to collect energy from electromagnetic radiation and to provide energy at least to said processing unit and said display means, and
- a means (270) for fixing said tag to an object.

2. Tag according to claim 1, wherein the energy harvester is the RFID microchip (120).

3. Tag according to claim 1 or 2, wherein it further comprises a non radiofrequency energy harvester.

4. Tag according to the preceding claims, wherein the fixing means is a cord (270) for retaining the tag, the RF antenna being a wire inside the cord.

5. Tag according to the preceding claims, wherein the tag is included within a thick dielectric package (380) in order to move away the RF antenna from the object.

6. Tag according to claim 5, wherein the package is made of a material with a dielectric constant comprised between 1 and 5.

7. Tag according to the preceding claims, wherein said cord is semi rigid and of spring type allowing the antenna to be routinely distanced from said object.

8. Tag according to the preceding claims, wherein the display means (160) is an electronic paper display.

9. Tag according to the preceding claims, wherein said object is an item of luggage.

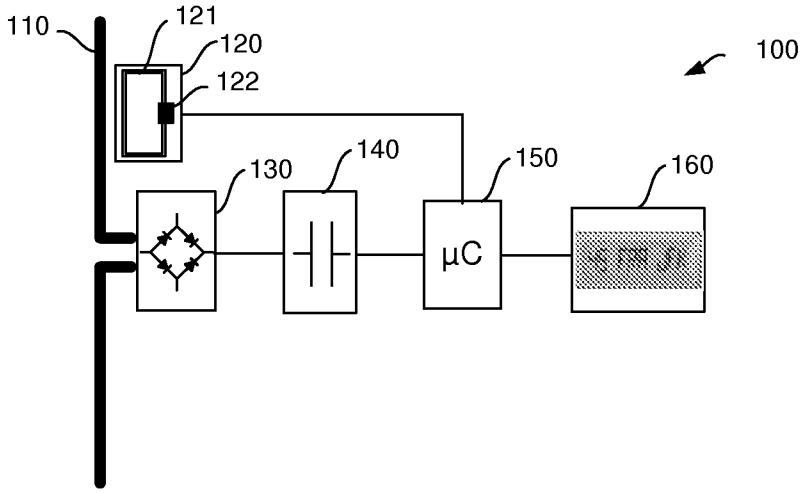


Fig.1

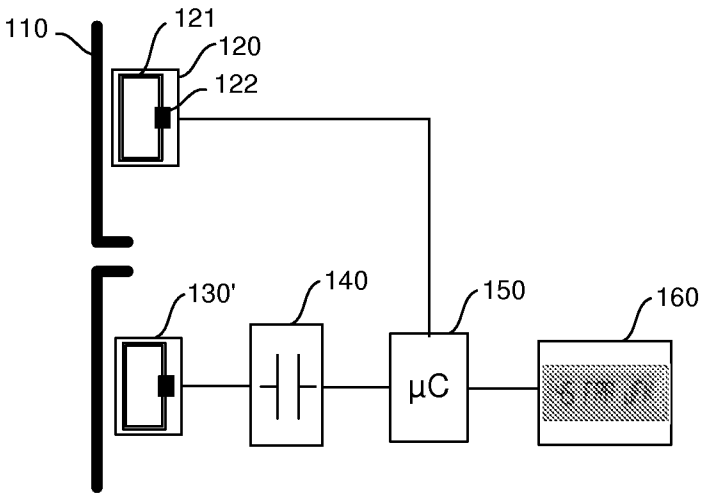


Fig.2

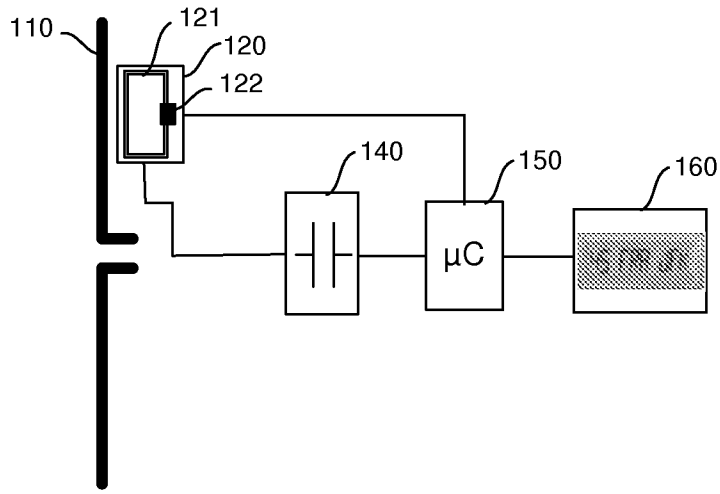


Fig.3

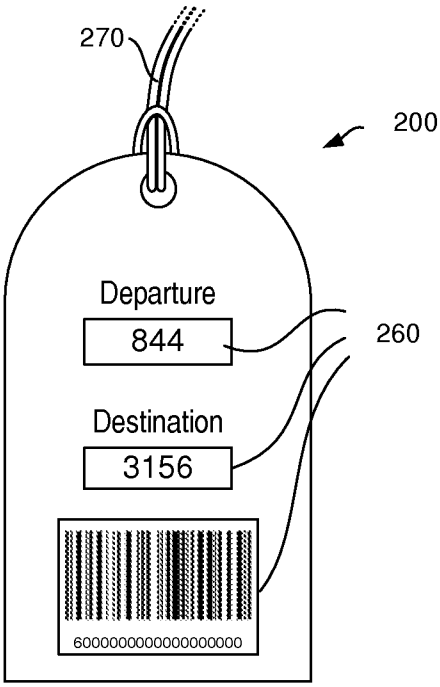


Fig.4

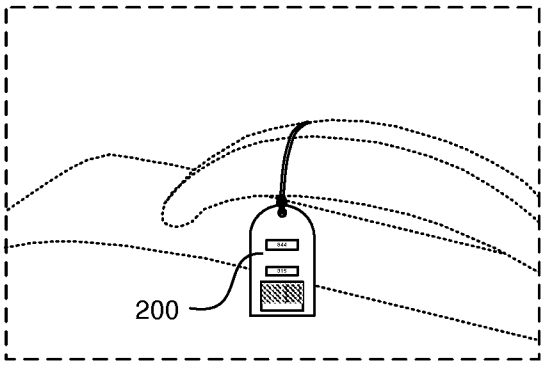


Fig.5

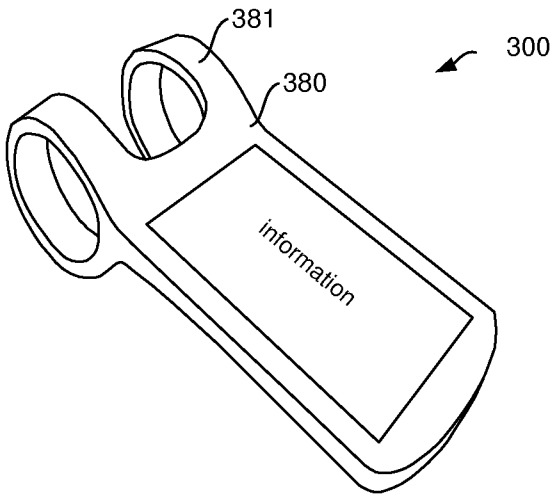


Fig.6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/055851

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06K19/07 G06K19/077
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/068132 A1 (KAYANAKIS GEORGES [FR] ET AL) 20 March 2008 (2008-03-20) paragraph [0025] - paragraph [0034]; figures 2-5	1-9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
8 November 2013	22/11/2013

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2013/055851

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008068132 A1	20-03-2008	AT 539498 T	15-01-2012
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