A tamper-proof security device 10 includes a tag 12 and may be worn by persons including babies and patients, or inanimate objects. The tamper-proof security device 10 comprises a tag 12 and a strap 400, with means 360 for attached the strap 400 to the tag 12 so that the strap 400 forms a loop. The strap 400 has at least one electrical conductor 410, made from a conducting polymer material and disposed along at least a portion of a length of the strap 400. A connector (20) is provided for electrically connecting a PCB 200 inside the tag 12 with the electrical conductor 410 of the strap 400. The tag 12 may transmit a unique identification signal at successive time intervals and a reading device may be provided to monitor the signal and provide an alert if the signal is not received by the reading device.

Fig. 3

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.
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SECURITY DEVICE

The present invention relates to security devices. In particular, the invention relates to
security devices comprising a tag to be worn by persons including babies, patients and
other objects whose movements are to be monitored.

BACKGROUND

Security tags are used in a multiplicity of environments to facilitate monitoring of the
movement of objects including persons. For example, security tags may be attached to
items of merchandise in a retail outlet, to persons vulnerable to abduction such as
babies and young children, or other objects or persons whose movements are to be
confined to a particular area. Detectors located at strategic positions such as exit paths
may be employed to detect the tags, and provide an alert in the event that an attempt is
made to remove a tagged object from that area.

RFID tags communicate by transmitting a radio frequency identification (RFID) signal.
Two main categories of tags are known; active tags have their own onboard power
supply, usually in the form of a miniature battery. Passive tags have no onboard power
supply, and are powered by the RF energy transmitted by a tag reader. When
interrogated by a tag reader, an active tag may be designed to transmit a unique
identification code. Active tags have the advantage that communication between the
active tag and a tag reader may be maintained over larger distances than in the case of
a passive tag.

Active tags may fall into one of two categories. The first category comprises tags that
transmit a signal in response to an electromagnetic signal received from a tag reader.
The onboard power supply is typically relatively small and enables the tag to transmit more
complex signals, and to transmit over a longer range. The second category comprises
tags that transmit an electromagnetic signal independently of a signal from a tag reader.
The signal may be transmitted to a passive reader, i.e. to a reader that does not transmit
a signal, but rather waits to receive a signal from a tag. For example, the tag may wake
itself periodically from a 'sleep mode' and transmit a signal for reception by a reader
independently of whether the tag is in range of a reader. The present invention relates
particularly, but not exclusively, to this second category of active tags.
A variety of methods of implementing RFID security tag systems are known. For example, the tag system may be required to raise an alert in the event that the presence of a tag is detected by a tag reader. In retail environments, tag readers are typically located at exit points from the retail outlet. In the event that an attempt is made to pass a tagged object through the exit point, an alert will be triggered.

Alternatively, each of a plurality of tags may have a unique identity, or be associated with a particular ‘class’ of object, such as a class of objects that are permitted to pass through an exit, or a class of objects that are not permitted to pass through an exit. In this situation the tag reader is required to determine the identity of a tag before deciding whether or not to raise an alert.

For certain applications, it is desirable to obtain positive confirmation of the presence of a tag within an environment. For example, in the case of a baby in a maternity unit it is desirable to positively confirm that the baby is still present in the maternity unit, and that the baby has not been abducted. Active tags are the preferred choice in applications such as this one, since the larger communication range of an active tag compared with a passive tag reduces the number of tag readers required to provide continuous coverage in a given area.

Clearly, in applications where it is critical to know at all times that a tag is within a predetermined area, ‘blind transmissions’ by an active tag are sufficient. One or more tag readers within the area may be programmed to listen for transmissions from the tags in order to confirm that each tag is within the predetermined area. In the event that a signal from a tag is not detected, when it is determined that a signal from the tag should be detected, the system may provide an alert so that action may be taken to recover the tagged object.

The problem exists, however, that collisions can occur between a plurality of tags (tag: tag collisions) in the event that they transmit their identification signals simultaneously or substantially simultaneously. In this situation, it may not be possible to determine the identity of the two or more tags making the transmissions.

The overlap of consecutive transmissions of two or more tags, transmitting with substantially similar transmission cycle periods, may occur for an extended period of time. The transmission cycle period is the time period from the start of one transmission
to the start of the next transmission by the same tag. In known systems, overlap of consecutive transmissions has been found to occur for periods of the order of a minute or more. Furthermore, the overlap is likely to recur in a periodic manner.

The inability to detect an RFID transmission by a particular tag for a period of the order of a minute is considered unacceptable in applications such as the monitoring of babies.

In the prior art, protocols exist for minimising an occurrence of collisions between transmissions by tags and transmissions by tag readers in passive tag systems. According to the 'listen before talk' (LBT) protocol, for example, a tag reader 'listens' until a period is detected during which there is no RF signal detected by the reader. The tag reader then makes a transmission to communicate with an RFID tag.

We now consider the attachment of an RFID tag to an object. A variety of methods have been employed to attach RFID tags to objects to be monitored, and known methods include adhesive tape (used widely to detect theft of books and CDs for example), mechanical fasteners such as studs (commonly used in clothing retail environments), and straps. Straps may be particularly convenient for personnel monitoring applications since the strap may be conveniently wrapped around a limb of a person.

The problem exists that attempts may be made to remove the tag from the object by an unauthorised person, allowing the object to be removed from its location undetected. It is therefore desirable to ensure that any attempt to remove a tag from an object will be detected.

It is known to provide a security device for monitoring personnel movement comprising an RFID tag and a non-stretchable strap, the strap comprising an electrical conductor that may be looped around a limb of the wearer. In order to remove the security device from the person the strap must be severed. The act of severing the strap breaks the electrical continuity of the strap, thereby triggering an alert.

In some cases, the strap comprises a pair of flexible members connected to opposing ends of the tag. Each of the flexible members has an electrical conductor running through it, which is connected to a terminal of an electronic circuit. The free ends of the flexible members may be releasably connected to each other by a metal press-stud fastener, which also completes an electrical circuit through the strap, between terminals
of the electronic circuit. If the strap is cut, the electrical characteristics of the strap will change. The change may be detected by the circuit and an alert triggered.

It is important that any personnel security device be as convenient and comfortable to wear as possible, and be produced at the lowest possible cost. Furthermore, it is desirable that the tag be worn continuously without the need to remove it for occasions such as washing of the wearer. Thus, it is desirable that the tag be of waterproof construction. The size of the tag may be of particular concern since in certain applications it is desirable for the devices to be worn by new-born babies. The tag should therefore be small and lightweight in order to minimise discomfort to the baby.

The principal component of the tag is the RFID device and tamper-detection electronics. Thus, in order to reduce the size of the tag it is desirable to reduce the size of the electronic components comprising the tag, and the overall packaging of the device.

Electronic circuit size may be reduced by using integrated circuits and surface-mount electronic components on a circuit board; however, reducing the size of the electrical connection between the circuit board and the strap, and the overall package size, is a particular challenge.

Common methods of forming electrical connections include the use of a melt of a low melting point metal such as a solder, screw-type connectors and plug and socket connectors.

Solder methods suffer the disadvantage that damage may be caused to temperature-sensitive components due to overheating. A further disadvantage is that re-melting and weakening of existing solder joints may occur when further soldering operations are performed nearby.

Screw-type and plug and socket connectors have the advantage that they do not require the use of a melt, and can be disconnected and reconnected more readily. However they tend to be more bulky and more expensive than solder joints. Thus, in applications where there is a substantial volume constraint, manufacturers often resort to the use of solder joints.
In addition to making electrical contact it is also desirable to provide mechanical support for electrical components, such as PCBs, within their packaging. PCBs are typically secured to a wall of the housing in which they are placed. They are either screwed directly to the housing, or spaced apart from the housing using spacer posts. In either case, screws are typically used, resulting in a bulky and labour intensive installation.

In a first aspect of the present invention there is provided a tamper-proof security device comprising a tag and a strap, the device comprising means for attaching the strap to the tag, such that the strap forms a loop, the strap further comprising at least one electrical conductor disposed along at least a portion of a length of the strap, the means for attaching the strap to the tag further comprising means for making electrical contact between the tag and the at least one electrical conductor of the strap such that an electrical flow path is provided through said at least one conductor between a plurality of electrical contacts of the tag, and wherein the electrical conductor comprises a conducting polymer material.

The advantage of using a conducting polymer material is that it may be produced relatively cheaply, it is robust and does not corrode. This is particularly important in applications where the device is attached to a limb of a person. The device may have a significant exposure to moisture for example due to perspiration or during washing of the person. Furthermore, the strap may be conveniently fabricated having the conducting polymer material comprised therewith.

Preferably the strap is made from a substantially non-extensible material.

Preferably the strap may be supplied in the form of a roll. Thus, lengths of strap of an appropriate length may be individually cut to suit a circumference of a limb of a wearer.

At least a portion of the at least one electrical conductor may be in the form of a meander pattern. Alternatively or in addition at least a portion of the at least one electrical conductor may be substantially straight.
Opposed ends of the at least one electrical conductor may be disposed substantially at opposed ends of the strap. Alternatively, opposed ends of the at least one electrical conductor may be disposed substantially at one end of the strap.

The means for attaching of the strap to the tag may comprise a clamp. The clamp may comprise a flap movable between an open condition and a closed condition.

In the closed condition the flap is positioned substantially in juxtaposition with the tag housing. The flap may be swung away from the housing into an open condition. In an open condition a free end of the strap may be inserted between the flap and the housing, and the flap swung into the closed condition wherein the strap is gripped by the flap.

Preferably the strap is compressible.

The means for attaching the strap to the tag may comprise a compression lock mechanism.

Preferably a length of the strap may be adjusted after the strap has been attached to the tag and worn by a user.

Preferably the compression lock mechanism is operable manually without the need for a tool.

Preferably the tag is waterproof, such that ingress of water within the tag from without the tag is prevented.

The compression lock mechanism may be provided outside of a waterproof environment of the tag.

Preferably the strap comprises a polymer material and conducting polymer material. This has the advantage that the amount of conducting polymer material required may be reduced, thereby reducing manufacturing costs. Preferably the polymer material is adapted to provide strength and durability. Preferably the strap is fabricated by co-extrusion of the polymer and conducting polymer materials. Preferably the polymer
material is LLDPE (linear low density polyethylene) and the conducting polymer material is carbon loaded conductive LLDPE.

The surface of the LLDPE material may be corona treated. This has the advantage that marking with a pen is made easier.

The security device may be adapted to transmit an identification signal at successive intervals of time, wherein a length of a successive interval of time is calculated with reference to a random or pseudo-random number.

This device has the advantage that the problem of collision between tags may be substantially ameliorated. Since each tag uses a random or pseudo-random number to determine the period between successive RFID transmissions, the chances of multiple successive transmissions by any one tag colliding with those of another tag is significantly reduced.

Preferably, a length of each of said successive intervals of time is calculated with reference to a random or pseudo-random number. Thus, each tag generates a new random number for each successive transmission and uses this random number to determine the length of the interval of time between said successive transmissions. This further reduces the possibility of collisions between the same tags recurring repeatedly. In the event that a collision occurs between transmissions of a particular group of two or more tags, the probability of each tag of that group generating the same random number (and therefore transmitting a next RFID signal that would collide with another tag of the group) will be very small, provided the possible range of random numbers is sufficiently large. Even if such a collision did occur, the probability of the next transmission also colliding may be made vanishingly small.

Preferably, an initial seed number is provided to each security device. The initial seed number may be used to generate a first random number when a tag is activated. Preferably, the initial seed number is a random number. The initial seed number may be used to generate each random number. Alternatively, each random number generated by the security device may be used as a seed number for generation of a next random number.
The length of an interval of time may comprise a sum of a first value and a second value. The first value may be a constant value and the second value may be a random or pseudo-random number.

Alternatively, both the first value and the second value may be a random or pseudo-random number.

Preferably, a length of each of said successive time intervals lies between a minimum value and a maximum value. The minimum value and said maximum value may be predetermined values.

Preferably at least one of said minimum value and said maximum value may be changed.

The identification signal of a device may comprise identification means for uniquely identifying said device. This has the advantage that the identity of a device that is determined to be missing may be known. This information may assist personnel seeking to retrieve an object to which the device is attached. It may also reduce a panic level in the event that the object is determined to be missing, when the determination that the object is missing is due to a malfunction of a device, e.g. due to battery failure.

Preferably the identification means comprises a unique identification code.

Transmissions of an identification packet by a tag may comprise the unique identification code, battery status information such as a battery status byte; and tamper status information such as a tamper status byte. From this identification packet, software in a receiver or associated system can determine the status of an individual tag and advise a user of the system as to battery status, tamper status, and 'lost tag' warnings when a tag can no longer be detected (eg a tag has 'timed out', by which is meant that a signal tag has not been detected from that tag within an amount of time). An alarm condition may be generated by the system if the battery status information indicates that a battery is low, or if a tag is detected in an unauthorised area.

Preferably, a security system comprises a plurality of tags and at least one tag reader, wherein the system is adapted to monitor RF transmissions received by said at least one
reader and to determine whether a signal is being received from each of said plurality of tags.

The system may be adapted to determine whether a signal is being received from each of said plurality of tags by counting a number of RF signals received from a tag of the system over a predetermined period of time. This has the advantage that each tag does not need to be able to transmit a unique RFID signal, and the system is not required to monitor the unique RFID transmissions of each tag. Thus the complexity of the system may be reduced, and therefore the cost.

Alternatively the system may be adapted to determine whether a signal is being received from each of said plurality of tags by reference to said unique identity signal of each tag.

In a second aspect of the present invention there is provided a connector, the connector comprising:
a body portion, a head portion, and a neck portion connected therebetween, the body portion having a shoulder proximate the neck portion, the head and neck portions being adapted for insertion through an elongate aperture of a printed circuit board (PCB), the aperture being formed between opposed faces of the PCB, such that the shoulder abuts one side of the PCB, the neck being capable of being deformed by a twisting action of the head relative to the body portion thereby to shorten a distance between the head and the body, the body comprising a conducting material.

The connector has the advantage of enabling both a structural connection and an electrical connection to be made using a single component. The connection is completed by a single mechanical twisting action of the head. The twisting action shortens the distance between the head and the shoulder, which has the effect of urging the shoulder and the head against opposed faces of the PCB. Electrical contact may thereby be made to contact pads located on one or both sides of the PCB. Thus the invention has the advantage over prior art methods of simplifying product manufacture, thereby reducing manufacturing costs and enhancing the yield of working systems.

The shoulder of the body may further comprise a tapered portion proximate the neck. The width of the tapered portion of the body may be substantially equal to that of the neck where the neck portion joins the body portion.
A width of at least a portion of the tapered portion may exceed a length of the elongate aperture. This has the advantage that when a PCB is urged against the shoulder, a friction fit may be established between a wall of the aperture of the PCB and the connector. This feature enhances the stability of both the physical and the electrical connection between the PCB and the connector.

Preferably, the connector is substantially flat. This has the advantage of reducing the cross-sectional area of a length of the connector, thereby reducing both the weight of the connector and the force required to twist the head portion relative to the body portion.

The contact pads may be disposed so as to contact the shoulder of the connector. For example, the electrical contact may be located proximate an end of the elongate aperture of the PCB. Alternatively or in addition, the electrical contact may be disposed so as to contact the head of the connector.

Preferably, the contact pads are formed as plated through hole (PTH) pads, whereby the pads are formed over walls of the aperture.

The neck may further comprise at least one notch. This has the advantage of reducing the cross-sectional area of the neck, thereby reducing the force required to twist the head relative to the body. Furthermore, the amount of spring-back of the head upon release of the twisting force is also reduced. The at least one notch may be disposed proximate the head.

Preferably, a pair of notches are provided in opposite edges of the neck. This has the advantage that the gripping action provided by the head against the PCB remains substantially even on either side of the elongate aperture.

The body portion may comprise head and neck portions disposed at opposing ends of the body portion. Furthermore the body portion may be U-shaped. This enables a single connector to form two connections to a PCB. This feature has the advantage of enhancing a rigidity of a connection between the connector and the PCB.

The body portion may further comprise means for attachment to a structural member. The means for attachment may be at least one member projecting from the body.
Alternatively or in addition, the means for attachment may be an aperture capable of receiving fixing means therethrough, such as a screw.

Alternatively or in addition the connector may comprise means for electrical connection to a further electrical element. The means for electrical connection may comprise at least one tab of the connector. The tab may be connected to the body portion of the connector.

The connector may be die cut from sheet material, or made by casting, injection moulding, or any other suitable technique. The connector may be made from a conducting material such as a metal, or from any other suitable material. Alternatively the connector may be fabricated from an insulating material such as a plastics material, and at least a portion of the connector coated with a conducting material.

In a third aspect of the invention there is provided a tamper-proof security device comprising a tag and a strap,
the device comprising means for attaching the strap to the tag, such that the strap forms a loop,
the strap further comprising at least one electrical conductor disposed along at least a portion of a length of the strap,
the means for attaching the strap to the tag further comprising means for making electrical contact between the tag and the at least one electrical conductor of the strap
such that an electrical flow path is provided through said at least one conductor between a plurality of electrical contacts of the tag,
wherein the electrical conductor comprises a conducting polymer material,
the strap further comprising a connector,
the connector comprising:
a body portion, a head portion, and a neck portion connected therebetween,
the body portion having a shoulder proximate the neck portion,
the head and neck portions being adapted for insertion through an elongate aperture of a printed circuit board (PCB) such that the shoulder abuts one side of the PCB, the neck being capable of being deformed by a twisting action of the head relative to the body portion to thereby shorten a distance between the head and the body, the connector comprising a conducting material,
the tag further comprising means for urging the at least one electrical conductor of the strap against the connector.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, and to show how it may be carried into effect, reference shall now be made by way of example to the accompanying drawings, in which:

FIGURE 1 is a perspective view of a security device according to a first embodiment of the invention;

FIGURE 2 is a cross-sectional schematic diagram of a security device according to the first embodiment showing clamping members in an open configuration with a strap installed ready to be clamped;

FIGURE 3 is a cross-sectional schematic diagram of a security device according to the first embodiment showing the clamping members in a closed configuration with a strap clamped by the members;

FIGURE 4 is a schematic diagram of a connector according to the first embodiment showing (a) a side elevation and (b) a front elevation;

FIGURE 5 is a schematic diagram of a PCB having elongate apertures suitable for use with the first embodiment of the invention;

FIGURE 6 shows a perspective view of a pair of connectors according to the first embodiment of the invention showing (a) the connectors prior to installation in a package, (b) the connectors seated in a package prior to installation of a PCB, (c) the connectors connected to a PCB showing a battery side of the PCB, (d) the connectors installed in a package showing a component side of the PCB;

FIGURE 7 is a perspective view of the tag housing;

FIGURE 8 is a cross-sectional schematic diagram of a connector according to the second embodiment of the invention connected to a PCB;
FIGURE 9 is a plan-view schematic diagram of a connector according to the second embodiment of the invention connected to a PCB;

FIGURE 10 is a cross-sectional schematic diagram of a strap according to the preferred embodiment of the invention; and

FIGURE 11 is a side view of a tool according to the preferred embodiment of the invention.

DETAILED DESCRIPTION

In a first embodiment of the invention, a security device 10 is provided comprising a tag 12 and a strap 400 (Figures 1 to 3). The strap 400 comprises a pair of parallel conducting tracks 410 formed in a non-conducting, substantially non-stretchable plastics material 420. The conducting tracks are formed from carbon loaded conductive linear low density polyethylene (LLDPE) whilst the non-stretchable carrier material is non-conductive LLDPE. A cross-sectional schematic diagram of the strap is shown in figure 10. The strap is formed by a process of coextrusion of the non-conductive LLDPE and conductive LLDPE.

The tag 12 comprises a housing 300 comprising a body 310 and a cover 320. A pair of flaps 360 are provided, the flaps being movably attached to opposite edges of the body 310 of the housing 300 by hinges 365. The flaps are capable of being moved between an open condition (Figure 2) and a closed condition (Figure 3). In the open condition, a passageway 362 is formed through the tag housing 300 allowing a free end 430 of a strap 400 to be passed from one side of the tag housing 300 to the other.

The flaps 360 may be swung to a closed condition (Figure 3), wherein the flaps are disposed to lie substantially in juxtaposition with the body 310 of the housing 300. With the flaps in juxtaposition with the body 310 a latch 370 positioned along the leading edge 361 of each flap 360 engages an aperture 375 of the housing. With a flap 360 in the closed condition, kinks 450 are formed in the strap 400 (Figure 3) due to urging of a shoulder 360A of each flap 360 against the strap. The kinks 450 inhibit movement of the strap 400 relative to the housing 300 without the requirement for a strong clamping action of the flaps 360 and housing 300 against opposite sides of the strap 400.
Furthermore, the shape of the face 365 of each flap 360 facing the strap 400 results in the strap 400 being urged against electrical contacts 55 of a connector 20 connected to a PCB 200 of the tag.

The flaps 360 have apertures 369 formed therein (see Figure 7). A tool 600 (Figure 11) is provided for opening the flaps 600. The flaps 600 may be opened by manipulation of the tools such that a pair of adjacent protrusions 630 of a tongue 620 of the tool saddle the latch, depression of the tool resulting in a pressure on the latch 370 so as to release the latch 370 from the aperture 375.

There is further provided a connector 20 (Figure 4, Figure 5, Figure 6) capable of forming an electrical connection between a printed circuit board (PCB) 200 and a strap 400. The connector is further capable of providing a structural support for the PCB 200 within the housing 300 of the PCB 200.

The connector 20 comprises a single sheet of stainless steel comprising a U-shaped elongate body 50, and connecting means disposed at opposite ends of the body 50, the connecting means comprising a head 70 and a neck 60 connecting the head 70 to the body 50.

The neck 60 is of a lower width than the head 70 and body 50, whilst the width of the head 70 is lower than that of the body 50. The dimensions are such that the head 70 may be inserted through an aperture 210 of a PCB 200 such that a shoulder 90 of the body 50 abuts one side of the PCB 200, and at least a substantial portion of the head projects from the opposite side of the PCB 200.

The connector 20 is deformable such that the neck 60 may be permanently deformed by a twisting action of the head 70 relative to the body 50. Deformation of the head in this manner prevents the head 70 from being withdrawn from the aperture 210, thereby securing the connector 20 to the PCB 200. Twisting of the head 70 such that the head 70 is permanently deformed through an angle of substantially 30° relative to the body 50 has been found to give good results in practice, although any suitable angle may be used.

The dimensions of the neck 60 and the tapered portion 80 of the body 50 are such that upon twisting the head 70 relative to the body 50 the distance between the head 70 and
body 50 decreases, thereby urging the PCB against the head 70 and neck 50. The tapered portion 80 of the body 50 proximate the neck 60 further allows a 'friction-fit' feature to be established between the connector 20 and the PCB 200, enhancing both the resulting structural connection of the connector 20 to the PCB 200, and the electrical connection of the connector 20 to the contact pad 220.

In alternate embodiments of the invention the tapered portion 80 of the body 50 may have a gradient more or less severe than the first embodiment shown in Figure 1(b), where the taper angle 85 is substantially 60°, or any other suitable profile. In further alternate embodiments the body is not tapered (i.e. the taper angle is 0°).

The connector enables a substantial reduction in the size of the tag to be realised, in a simple and relatively quick assembly operation.

In Figure 6(a) a pair of connectors 20 are shown, disposed in a parallel, spaced apart configuration with their respective pairs of tabs 55 oriented to project away from each other. In Figure 6(b) the connectors 20 are shown in a configuration wherein tabs 55 of the connectors 20 are received within cavities provided in raised portions 315 of a body 310 of a housing 300.

The housing 300 is moulded such that the body 50 of each connector 20 fits snugly within the body 310 of the housing 300. The housing further comprises a base 320 removably attachable to the body 310.

A PCB 200 has a battery 260 mounted to a battery side 250 of the PCB 200 (Figure 6(c)), and components 280 mounted to a component side 270 of the PCB 200 (Figure 6(d)). The connectors 20 are connected to the PCB 200 such that the body 50 of each connector 20 is disposed on the component side 270 of the PCB. This configuration permits the battery 260 to be changed by removal of the cover 320 without the need to remove the PCB 200 from the body 310 of the housing 300.

In the present embodiment the connector is die cut from a sheet of stainless steel, however in alternate embodiments the connector may be made by casting, injection moulding, or any other suitable technique.
In a second embodiment of the invention (Figure 8, Figure 9), a security device 10 comprises a connector 600 comprising an elongate U-shaped body portion 650, having connecting means disposed at opposite ends of the body portion 650. The connecting means comprises a head 670, and a neck 660 disposed between the body 650 and the head 670. The neck 660 and head 670 are of a similar width, which is less than that of the body 650.

Notches 665 are formed in the neck 660 proximate the head 670, resulting in a substantial reduction in the width of the neck in this region. This feature reduces the force required to twist the head relative to the body. Furthermore, the amount of spring-back of the head upon release of the twisting force is also reduced.

A security device 10 according to the first or second embodiments of the invention comprises a transmitter 205 comprising a PCB 200 having a PIC device. The transmitter 205 is programmed to transmit an RFID signal in the form of a data packet, 7ms in length, uniquely identifying the security device 10.

The transmitter 205 is programmed to 'wake up' from a sleep (energy save) mode every 1.4s. When the transmitter 205 wakes up, a random delay period of between 14ms (twice the data packet length) and 140ms (twenty times the data packet length) is generated. The data packet is transmitted when this delay period has expired, following which the transmitter 205 returns to its sleep mode.

The random number is calculated in the following manner. When the transmitter 205 wakes up, a period of substantially 1.4s from the previous time the transmitter 205 woke up, the unique 3 byte id number of each transmitter 205 is used as a 'seed' number for the internal random number generator of the microprocessor software. Once the random seed has been generated, subsequent random numbers are generated every time the transmitter 205 wakes up. The probability of two transmitters 205 making overlapping transmissions is small; the probability of consecutive overlapping transmissions being made by the same transmitters 205 is extremely small.

A system controller monitors RFID transmissions received by the at least one RFID reader. If a received transmission corresponds to a security device 10 logged as belonging to the system, the system controller registers the security device 10 as being present, and logs the time at which the transmission was received. Periodically, the
system controller checks when each security device 10 logged as belonging to the system was last logged as being present. If the last logged time is more than a predetermined critical time prior to the current time, the system alerts the personnel responsible for monitoring the system to this fact.

Authorised personnel may override the system controller such that an alert is not generated in the event that an RFID transmission is not received from a security device 10. This may be desirable for example in the event that a battery is required to be changed, or when a tagged object is permitted to be temporarily removed from the area.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", means "including but not limited to", and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.

Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.
CLAIMS

1. A tamper-proof security device comprising a tag and a strap, the device comprising means for attaching the strap to the tag, such that the strap forms a loop, the strap further comprising at least one electrical conductor disposed along at least a portion of a length of the strap, the means for attaching the strap to the tag further comprising means for making electrical contact between the tag and the at least one electrical conductor of the strap such that an electrical flow path is provided through said at least one conductor between a plurality of electrical contacts of the tag, and wherein the electrical conductor comprises a conducting polymer material.

2. The device of claim 1 wherein the strap comprises a substantially non-extensible material.

3. The device of any one of the preceding claims wherein the strap is formed by cutting a length of material from a roll of strap material.

4. The device of any one of the preceding claims wherein opposed ends of the at least one electrical conductor are disposed substantially at opposed ends of the strap.

5. The device of any one of claims 1 to 4 wherein opposed ends of the at least one electrical conductor are disposed substantially at one end of the strap.

6. The device of any one of the preceding claims wherein the means for attaching the strap to the tag comprises a clamp.

7. The device of claim 6 wherein the clamp comprises a flap, the flap being movable between an open condition wherein a free end of the strap may be inserted between the flap and a portion of the body of the device, and a closed condition wherein the free end of the strap is gripped between the flap and a portion of the body of the device.

8. The device of any one of the preceding claims wherein the strap is compressible.
9. The device of any one of the preceding claims wherein the means for attaching the strap to the tag comprises a compression lock mechanism.

10. The device of any one of the preceding claims wherein a length of the strap may be adjusted after the strap has been attached to the tag.

11. The device of claim 9 or claim 10 wherein the compression lock mechanism is operable manually and without the need for a tool.

12. The device of any one of the preceding claims wherein the tag is waterproof, such that ingress of water within the tag from without the tag is prevented.

13. The device of any preceding claim wherein the strap further comprises a non-conducting polymer material.

14. The device of claim 13 wherein at least one of the non-conducting polymer material and the conducting polymer material is adapted to provide strength and durability to the strap.

15. The device of claim 13 or claim 14 wherein the strap is fabricated by co-extrusion of the non-conducting polymer material and the conducting polymer material.

16. The device of any one of claims 13 to 15 wherein the non-conducting polymer material is linear low density polyethylene (LLDPE).

17. The device of any one of the preceding claims wherein the conducting polymer material is carbon loaded conductive LLDPE.

18. The device of claim 16 or claim 17 wherein the LLDPE material is corona treated.

19. A connector, the connector comprising:
a body portion, a head portion, and a neck portion connected therebetween,
the body portion having a shoulder proximate the neck portion,
the head and neck portions being adapted for insertion through an elongate aperture of a printed circuit board (PCB), the aperture being formed between opposed faces of the
PCB, such that the shoulder abuts one side of the PCB, the neck being capable of being deformed by a twisting action of the head relative to the body portion to thereby shorten a distance between the head and the body, the body comprising a conducting material.

20. A connector according to claim 19 wherein the shoulder of the body further comprises a tapered portion proximate the neck.

21. A connector according to claim 20 wherein a width of said tapered portion of the body is less than or substantially equal to that of the neck where the neck portion joins the body portion.

22. A connector according to claim 20 wherein a width of at least a portion of said tapered portion exceeds a length of the elongate aperture.

23. A connector according to any one of claims 19 to 22 wherein the connector is substantially flat.

24. A connector according to any one of claims 19 to 23 in combination with said PCB having an elongate aperture, wherein at least a portion of the contact pad is disposed such that the contact pad is capable of contacting the connector when the head is twisted.

25. A connector according to claim 24 in combination with said PCB wherein a contact pad of the PCB is disposed so as to contact the shoulder of the connector.

26. A connector according to claim 24 or claim 25 in combination with said PCB wherein a contact pad of the PCB is disposed so as to contact the head of the connector.

27. A connector according to any one of claims 24 to 26 in combination with said PCB wherein a contact pad is formed as a plated through hole pad.

28. A connector according to any preceding claim wherein the neck comprises at least one notch.
29. A connector according to claim 28 wherein the at least one notch is disposed proximate the head.

30. A connector according to claim 28 or claim 29 wherein a notch is formed in each of two opposite side edges of the neck.

31. A connector according to any one of claims 19 to 30 wherein the body portion comprises a head portion and a neck portion disposed at each of two opposing ends of the body portion.

32. A connector according to claim 31 wherein the body is U-shaped.

33. A connector according to any one of claims 19 to 32 wherein the body further comprises means for attachment to a structural member.

34. A connector according to claim 33 wherein the means for attachment comprises at least one tab of the body.

35. A connector according to claim 33 or 34 wherein the means for attachment comprises an aperture of the body capable of receiving fixing means therethrough.

36. A connector according to claim 35 wherein the fixing means is a screw.

37. A tamper-proof security device comprising a tag and a strap, the device comprising means for attaching the strap to the tag, such that the strap forms a loop, the strap further comprising at least one electrical conductor disposed along at least a portion of a length of the strap, the means for attaching the strap to the tag further comprising means for making electrical contact between the tag and the at least one electrical conductor of the strap such that an electrical flow path is provided through said at least one conductor between a plurality of electrical contacts of the tag, wherein the electrical conductor comprises a conducting polymer material, the strap further comprising a connector, the connector comprising:
a body portion, a head portion, and a neck portion connected therebetween,
the body portion having a shoulder proximate the neck portion,
the head and neck portions being adapted for insertion through an elongate aperture of
a printed circuit board (PCB) such that the shoulder abuts one side of the PCB, the neck
being capable of being deformed by a twisting action of the head relative to the body
portion to thereby shorten a distance between the head and the body, the connector
comprising a conducting material,
the tag further comprising means for urging the at least one electrical conductor of the
strap against the connector.

38. The device of claim 37 wherein the tag is adapted to transmit an identification
signal at successive intervals of time, wherein a length of a successive interval of time is
calculated with reference to a random or pseudo-random number.

39. The device of claim 38 wherein the length of a successive interval of time is
calculated with reference to a random or pseudo-random number.

40. The device of claim 38 or claim 39 wherein the length of a successive interval of
time comprises a sum of a first value and a second value.

41. The device of claim 40 wherein said first value is a constant value and said
second value is a random or pseudo-random number.

42. The device of claim 40 wherein said first value and said second value are each a
random or pseudo-random number.

43. The device of any one of claims 38 to 42 wherein the length of each successive
interval of time lies between a minimum value and a maximum value.

44. The device of claim 43 wherein said minimum value and said maximum value are
predetermined values.

45. The device of claim 43 or 44 wherein at least one of said minimum value and
said maximum value may be changed.
46. The device of any one of claims 37 to 45 wherein the identification signal of a
device comprises a unique identification code.

47. A security system comprising a plurality of devices according to any one of
claims 37 to 46 and at least one device reader, wherein the system is adapted to monitor
RF transmissions received by said at least one reader and to determine whether a signal
is being received from each of said plurality of devices.

48. The system of claim 47 wherein the system is adapted to determine whether a
signal is being received from each of said plurality of devices by counting a number of
RF signals received from said plurality of devices over a predetermined period of time.

49. The system of claim 48 as dependent on claim 46 wherein the system is adapted
to determine whether a signal is being received from each of said plurality of devices by
reference to said unique identification code.

50. A tamper-proof security device substantially as herein described with reference to
the accompanying drawings.

51. A connector substantially as herein described with reference to the
accompanying drawings.

52. A security system substantially as herein described with reference to the
accompanying drawings.
Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

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<td>Y</td>
<td>1, 2, 6-8, &amp; 12</td>
<td>US 2005/0280535 A1 (GARY, JR) - See figures 2 &amp; 6 to 8 and paragraphs 29, 30 &amp; 56</td>
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<td>EP 0344138 A2 (DIGITAL PRODUCTS CORP) - See figure 4 to 6, column 10 lines 16 to 28 and column 12 lines 11 to 19</td>
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<td>US 5627520 A (PROTELL SYSTEMS INTERNATIONAL) - See figures 1 to 5, column 4 line 54 to column 5 line 12, column 6 lines 10 to 13 and column 8 lines 57 to 65</td>
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<td>GB 2225141 A (TOTAL ALERT CORP) - See figures 2, 5 &amp; 8 and page 10 line 8 to page 11 line 9</td>
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<td>US 6246327 B1 (MOTOROLA INC) - See figure 1 and column 3 line 40 to column 4 line 3</td>
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Y Document indicating lack of inventive step if combined with one or more other documents of same category
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Field of Search:
Search of GB, EP, WO & US patent documents classified in the following areas of the UKC:
G4N; H2E

Worldwide search of patent documents classified in the following areas of the IPC
G08B; H01R

The following online and other databases have been used in the preparation of this search report:

WPI, EPODOC
Application No: GB0603231.2  
Examiner: Rhiannon Jenkins  
Claims searched: 19-36 & 51  
Date of search: 19 June 2006

Patents Act 1977  
Further Search Report under Section 17

Documents considered to be relevant:

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| X        | 19, 23-30, 33 & 34 | GB 1202184 A  
(ELCO CORP) - See figures 2 & 5, page 2 lines 96 to 130 and page 3 lines 61 to 89 |
| X        | 19, 23 & 28-30    | JP 07030277 A  
(TOSHIBA) - See figures 1 to 3 and WPI & EPODOC abstracts |

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