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## (54) A method and apparatus for security tagging

(57) The electronic security alarm system (1) of the present invention detects the theft or loss of valuable items of personal property, for example briefcases, wallets, purses and such like.

The system includes an alarm unit (2) that monitors one or more tag units (14a, 14b) each of which is attached to a valuable item of property.

The alarm unit (2) has two main operating states. In the first state, the alarm unit (2) registers new tags (14a, 14b) when they are brought within a short distance of the alarm unit (the first state detection range (20)). In the second state these registered tag units (14a, 14b) are monitored so that if any of them are moved outside a second distance (22) (the second state detection range) an alert is activated.

Once the alarm is activated it can be deactivated by either bringing the missing item back into the second state detection range (22) or by switching the alarm unit (2) into the first state.

Additionally, items may be registered whilst the alarm unit (2) is in the second state. This is achieved by registering the newly detected item if it passes within the first state detection range (20).

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## Description

Field of Invention

**[0001]** The present invention relates to the field of property security and in particular, but not exclusively to, electronic security alarms.

Background to the Invention

**[0002]** Portable alarm systems for monitoring value items such as wallets and brief cases, and for monitoring children, are known in the art. Examples of typical devices are described in GB-A-2,228,814, GB-A-2,276,025 and EP-A-0,324,564. Each of these devices comprises a battery-powered portable alarm unit and one or more tagging units affixed to or carried by, the item or person to be monitored. Each of the prior art devices suffers from drawbacks, however, such as relatively high power consumption and a relative difficulty in adding and removing items or persons to be monitored. It is accordingly an object of the present invention to provide an improved alarm system.

Summary of Invention

**[0003]** According to a first aspect of the present invention there is provided an alarm unit for monitoring one or more tag units in an alarm system, the alarm unit comprising: an alarm unit including a transmitter for transmitting an alarm signal, a receiver, a processor means and an alert means; the alarm unit being switchable under control of the processor means between first and second states in each of which the alarm signal is transmitted over a detection range, the alarm unit further being arranged: (a)in the first state, to identify the presence of one or more tag units by detecting tag signals generated by the or each tag unit in response to a received alarm signal when said tag unit is currently within the detection range; and (b) in the second state, to detect when the or each thus identified tag unit moves outside the detection range and to cause the alert means to be actuated in consequence of such detection.

**[0004]** The alarm unit of the present invention allows monitoring of a wide variety of objects and requires a minimum amount of user interaction in order to 'capture' and to 'release' tagged items from protection.

**[0005]** Preferably, the alarm unit may be further configured to receive the tag signals from the said tag unit over a first detection range in the first state and over a second, longer, detection range in the second state.

**[0006]** The alarm unit may be further configured to transmit the alarm signal over a first detection range in the first state, and over a second, longer detection range in the second state.

**[0007]** Further, the processor in the alarm unit may be arranged to adjust the power at which the transmitter of the alarm unit transmits the alarm signal dependent upon the alarm unit being in the first or second state respectively.

**[0008]** Power saving features may be provided. For example, in the second state, the processor means may reduce the alarm signal power until at least one of the protected tag units is no longer detected. The processor means then increments the power by a fixed amount until all the previously captured tag units are detected or until the second detection range is attained whereupon, if one or more of the tags have not been detected, an alarm condition will exist. The alarm signal power is then maintained at this reduced level. This procedure provides for optimal power consumption allowing longer periods between the battery replacement or re-charging in the alarm unit.

**[0009]** The processor means in the alarm unit may be arranged to adjust the power at which the alarm signal is transmitted whilst the alarm unit is in the second state, such that the second detection range is variable in magnitude.

**[0010]** Preferably the sensitivity of the alarm unit to the tag signal whilst the alarm unit is in the second statewill be variable such that the second detection range is variable in magnitude.

**[0011]** In a further embodiment of the present invention, there may also be provided the automatic detection of new tag units in a third, "New Item", state. This is similar to the first state but the difference is that the unit does not lose items previously captured that are outside the first detection range. Where the capture of new tags is to be accomplished by means of this proximity detection (i.e. the tag approaches to within the open state distance from the alarm unit), the presence within this range is to be detected by means of the high signal strength that is measured when the tag unit's transmitter is very close to the reader unit's receiver, this being similar to the method used to capture tags in the first state. When the alarm unit is operating in the second state, previously undetected tag units may enter the first detection range. If this occurs, the processor means will automatically switch to the new item state, then the new tag unit is preferably stored by the processor means in the alarm unit. This new tag unit is typically stored in addition to at least one previously stored tag unit. The alarm unit may then revert back to the second state quickly.

**[0012]** Further, when the alarm unit is in the second state, the processor may be arranged to adjust the power to the alarm unit transmitter so as to sweep the second detection range between a maximum and a minimum range, the new tag unit being included as a further one of the previously identified tag units when the said new tag unit is detected both within the maximum and also within the minimum range.

**[0013]** The alarm unit may further include a display to indicate the number of tag units within the detection range when the alarm unit is in the first state.

**[0014]** The transmitter means and receiver means of

the tag unit or units may comprise a separate transmitter and receiver or a combined transmitter and receiver (a transceiver).

**[0015]** When the alarm unit is in the second state, the processor means may be arranged to reduce the power at which the said alarm signal is transmitted until at least one tag unit is determined to fall outside the detection range, and may be further arranged subsequently to incrementally increase the said power at which the alarm signal is transmitted until the most distant of the identified tag units from the alarm unit once again falls within the said detection range. By this method the power consumption of the reader unit can be reduced thus increasing the interval before batteries must be changed.

**[0016]** The alarm unit and the or each tag unit may include an anti-grabbing mechanism. This will mitigate the problem of a third party intercepting identification codes communicated between the alarm unit and the or each tag unit. This may consist of spread spectrum modulation or other well known techniques.

**[0017]** In a further aspect of the present invention, there is provided an alarm system comprising at least one tag unit, the or each tag unit comprising transceiver means for receiving an alarm signal and transmitting a tag signal, together with the alarm unit of the invention.

**[0018]** The tag units may be passive devices, that is, the tag units use the energy supplied by the received signal from the alarm unit to generate the retransmission signal containing the tag unit's unique identification code.

**[0019]** In a preferred embodiment, there may be provided at least one active tag unit. The active tag unit may or may not replace all passive tag units. An active tag unit generates the transmission signal containing the unique identification code using a separate power supply. This means that the active tag unit may have an increased protected proximity area as it can transmit signals further.

**[0020]** In another embodiment of the present invention, there may be also provided variable range control. This control may, for example, be effected by means of a preset potentiometer in the alarm unit accessed by means of a recessed, slotted spindle. The alarm unit may transmit signals to tag units located within an open state proximity area and a protected proximity area. It may be advantageous to allow the user to define either one or both of the proximity areas. This is useful because for example, if the current desired protected proximity area is smaller than previously required then the user can define this area as being smaller ensuring the earliest possible indication when a tagged item is lost. Conversely the proximity area may be increased in order to allow items to be moved further from the alarm unit without causing the alarm means to be activated unnecessarily. It is anticipated that this range control be controlled by a control means. Additionally or alternatively, the microprocessor may be arranged so as to provide for automatic range optimisation. Although, preferably, the control means defines the proximity area by adjusting the sensitivity of the alarm unit to the received tag signal.

**[0021]** The alarm unit may also include a switch means that comprises a button which, when activated, causes the processor means to switch the alarm unit between the said first and second states.

**[0022]** The switch means may also comprise a keypad having a plurality of data entry keys, the processor means being arranged to switch the alarm unit between the first and second states in response to an input of a predetermined sequence of keys.

**[0023]** According to a further aspect of the present invention, there is provided a method of monitoring one or more tag units in an alarm system, the alarm system comprising an alarm unit having a transmitter, a receiver, a processor means and an alert means, and being switchable between first and second states under control of the processor means, and at least one tag unit comprising a transceiver means; the method comprising: (a) transmitting an alarm signal over a detection range when the alarm unit is in the said first state; (b) identifying the presence of one or more tag units by detecting tag signals generated by the or each tag unit in response to a received alarm signal and which is currently within the detection range; (c) switching the alarm unit from the first to the second state; (d) detecting when the or each thus identified tag unit moves outside the detection range; and (e) causing the alert means to be actuated in consequence of such detection. The alarm unit may adjust the power at which the transmitter of the alarm unit transmits the alarm signal dependent upon the alarm unit being in the first or second state respectively.

**[0024]** The alarm unit may further adjust the power at which the alarm signal is transmitted whilst the alarm unit is in the second state, such that the second detection range is variable in magnitude.

**[0025]** The alarm unit, when in the second state, may reduce the power at which the said alarm signal is transmitted until at least one tag unit is determined to fall outside the detection range, and subsequently incrementally increasing the said power at which the alarm signal is transmitted until the most distant of the identified tag units from the alarm unit once again falls within the said detection range.

**[0026]** The power to the alarm unit transmitter may also be adjusted so as to sweep the second detection range between a maximum and a minimum range, when the alarm unit is in the said second state; and including any new tag unit as a further one of the previously identified tag units when the said new tag unit is detected both within the maximum and also within the minimum range.

**[0027]** Further advantageous features of the invention are set out in the dependent claims appended hereto.

Brief Description of Drawings

**[0028]** One embodiment of the invention will now be described by way of example only and with reference to the drawings in which:

Figure 1 shows a block diagram of an alarm system embodying the present invention and having an alarm unit and a plurality of tag units.;
Figure 2a shows, schematically, the alarm unit of Figure 1, in a first state;
Figure 2b shows, schematically, the alarm unit of Figure 1, in a second state wherein a signal is generated over a detection range; and
Figure 2c shows, schematically, the detection of a tag unit as it moves outside the detection range shown in Figure 2b.

Detailed Description of a Preferred Embodiment of the Present Invention

**[0029]** Figure 1 shows a block diagram of a preferred embodiment of the present invention. An alarm system 1 is composed of an alarm unit 2 and a plurality of tag units 14. Although only two tag units 14a, 14b are shown in Figure 1 for clarity, it will be appreciated that many more tag units could in fact be used. Indeed, in certain circumstances only a single tag unit 14 may be necessary or desirable.

**[0030]** Each tag unit 14 is in communication with the alarm unit 2 and is attached to a personal possession by, for example, a clip, adhesive backing, or the like (not shown). In the preferred embodiment, communication is effected using radio frequency signals. It should be noted however that microwave signals, infra red signals, magnetic fields and optical signals may be used in addition to or instead of radio frequency signals.

**[0031]** The hardware employed in the system of the preferred embodiment will first be described, still referring to Figure 1.

**[0032]** The alarm unit 2 comprises a transmitter 8 and a receiver 6, each of which are under the control of a microprocessor 4 such as the Atmel(™) AVR or the Microchip ® PICmicro ® processor. In use, an alarm signal is produced by the microprocessor 4 and is passed to the transmitter 8 in the alarm unit 2. The alarm signal passed to the transmitter may be pre-processed by the microprocessor 4 to encode the signal and thereby prevent "grabbing" of the signal. "Grabbing" is a known problem where a third party may unlawfully intercept the transmitted signals. This problem can be mitigated using known techniques such as spread spectrum modulation. The transmitter 8 in the alarm unit 2 modulates the signal to be transmitted. The transmission frequency is preferably at standard short range device frequencies such as 418MHz(in UK) or 433MHz and the future European Ultra High Frequency (UHF) standards, for example, 869MHz. Outside the EC other frequency standards shall be used such as 915MHz in USA. It is anticipated however that transmission may be effected at other appropriate frequencies including microwave, infra red and optical transmission frequencies or any other transmissible signals.

**[0033]** The thus transmitted alarm signal has a defined proximity of coverage within which any tag unit 14 will be able to receive the alarm signal. It is preferable that the defined proximity of coverage is determined by the strength of the signal received from each of the tag units 14. If at least one of the tag units 14 is located within this proximity of coverage, the signal received by the alarm unit 2 from the tag unit 14 will exceed a given signal strength, indicating to the alarm unit 2 that the tag unit 14 is within a defined proximity. Alternatively, this defined proximity of coverage may instead be determined by defining the transmitted alarm signal power. If at least one of the tag units 14 is located within this proximity of coverage, the signal transmitted by the alarm unit 2 will be returned to the alarm unit 2 from the tag unit 14, indicating to the alarm unit 2 that that tag unit 14 is within the defined proximity.

**[0034]** Each tag unit 14 comprises a tag receiver 10, a tag identifier 16 which generates an identifier that uniquely identifies each individual tag unit 14, and a tag transmitter 12. It should be noted that the tag transmitter 12 and the tag receiver 10 may be incorporated into a single tag transceiver and is designed and arranged such that the power generated for the processing and transmission of the signal to the alarm unit 2 is derived from the signal received by the tag unit 14 from the alarm unit 2. This technique is well known in the art and shall not be discussed further here. The tag receiver 10 is arranged to operate at substantially the same frequency as the transmitter 8, in the alarm unit 2. The tag transmitter 12 is arranged to operate at substantially the same frequency as the receiver 6, in the alarm unit 2. Also, the tag identifier 16 may consist of a microcontroller and software that can generate an identifier such as a random number, store and retrieve the identifier. The identifier is then available for transmission to the alarm unit 2 in a frame.

**[0035]** The tag receiver 10 demodulates an alarm signal received from the alarm unit 2 to a frequency which is less than the alarm signal transmission frequency, i. e., an intermediate frequency or a baseband frequency. The demodulated signal is then passed to the tag identifier 16 which alters the signal in such a way that an identifier signal output from one of the tag units 14 is distinguished from that of the other tag units. This may be done by outputting a unique digital data word identifying the particular tag unit 14. The tag identifier may be generated randomly by each of the tag units 14, fixed at manufacture of the tag unit 14 or may be supplied, based on a random code, from the alarm unit 2 and sent to the tag unit 14 when the tag unit 14 is within the first proximity zone of the alarm unit 2 when the alarm unit 2 is in the open state.

**[0036]** Alternatively, each tag unit 14 may output an identifier, that identifies the alarm unit 2 with which it is communicating. Each tag unit 14 however transmits this digital word in a particular item time frame within a periodic duty cycle of several such frames. The tag units 14 are Time Division Multiplexed (TDM), where each tag unit 14 is assigned a particular item time frame within the periodic duty cycle in which it is to transmit the unique identifier. By transmitting a data word identifying the alarm unit 2, a number of alarm units 2 can be used within a particular locality, where each alarm unit 2 is distinguished by the digital data word. In this case the tag identifier is supplied by the alarm unit and sent to the tag unit when the tag unit is within the first proximity zone of the alarm unit when the alarm unit is in the open state.

**[0037]** The identifier signal which is output by the tag identifier 16 is passed to the tag transmitter 12. The tag transmitter 12 modulates the signal so that the transmitted tag signal is at the transmit frequency.

**[0038]** The receive/transmit cycle is completed when the receiver 6 in the alarm unit 2 receives the tag signals generated by the tag units 14. The received tag signals are pre-processed by the alarm unit 2 before being passed to the microprocessor 4. Preprocessing reduces the frequency of the received tag signals to an intermediate or baseband frequency and decodes the tag signal as appropriate. The resulting information is processed in a manner to be described in connection with Figure 2 below.

**[0039]** Having described the hardware, the functionality of the microprocessor 4 will now be described by means of an example and with reference to Figures 2a to 2c.

**[0040]** Figure 2a shows three tag units 14 in proximity with the alarm unit 2. The alarm unit 2 is activated by a user by pressing a button (not shown). This will cause the alarm unit 2 to move from a standby mode into a first state, hereinafter referred to as the "open state". As the alarm unit enters the open state, an LED (not shown) lights to indicate this to the user.

**[0041]** In the open state, the alarm unit 2 defines a first proximity zone as shown by the dashed lines 20. The first proximity zone 20 may be defined in a number of ways. For example, the range may be set by adjusting the signal power emitted by the transmitter 8, which is in turn controlled by the microprocessor 4. Preferably, the sensitivity of the alarm unit 2 to the strength of the received tag signal may be adjusted in order to achieve the same result. The sensitivity to the strength of the tag signal received by the receiver 6 is adjusted by the microprocessor 4 utilising the received signal strength measured by means of a signal strength indicator output provided by the receiver 6. This measurement means is provided by techniques well known within the art.

**[0042]** In the preferred embodiment, the transmitter radiates omnidirectionally and so, strictly, the proximity area is in fact a proximity volume. The tag units 14 within the first proximity zone 20 respond to the alarm signal transmitted by the alarm unit 2.

**[0043]** It should be noted that by receiving the alarm signal from the alarm unit 2, the tag unit 14 may be switched from a standby mode if the preceding alarm signal was received greater than, say, 5 minutes ago. Alternatively the tag unit 14 may carry a switch means implemented as a button to be operated by the user in order to switch on the tag unit 14 if the preceding alarm signal was received greater than, say, 5 minutes ago.

**[0044]** The alarm signal received by each of the tag units 14 is uniquely coded as described above and transmitted as a tag signal.

**[0045]** Collision detection, collision avoidance and error recovery will be described below.

**[0046]** The alarm unit 2 receives the tag signals transmitted by each of the tag units 14 which are within the first proximity zone. These signals comprise unique identification codes as previously described, which are passed to the microprocessor 4. The microprocessor 4 stores the identification codes that identify each individual tag unit 14 within the first proximity zone 20. These codes are stored in a memory store (not shown) that represents a table of cells, each representing a tag or a spare frame, within the microprocessor 4.

**[0047]** Alternatively, the microprocessor 4 stores the item time frame in which each individual tag unit 14 transmits the identification code. The item time frame in which each tag unit 14 communicates with the particular alarm unit 2 is unique to the tag unit 14 and so allows the alarm unit 2 to distinguish each tag unit 14 within the first proximity zone 20. In this case the identification code can identify the alarm unit 2 rather than the tag.

**[0048]** Additionally, if appropriate, the identification code of each tag unit 14 is fixed once the tag unit 14 has been registered with the alarm unit 2 in the open state.

**[0049]** In the first tag state the tag unit 14 can receive an alarm signal that may consist of a series of valid Identification codes (addresses) each within a fixed item time frame ('frame') that being within a fixed duty cycle of such frames. In addition to this an indicator is received by the tag unit 14 to identify the frame number within this duty cycle and a flag that indicates to the tag unit 14 whether or not the current frame is in use. Once a frame is identified that can be utilised the tag unit 14 sends a random locally unique identification code to the alarm unit 2. This code acts as a request for the frame to be allocated to the tag unit 14. On the next duty cycle the alarm unit 2 acknowledges the tag unit 14 by setting the above indicator to 'in use' and at this time the tag unit 14 may store the said identifier. The tag unit 14 will then be able to switch using the button, under processor control, to the second state in which it will transmit in the current frame and on each successive duty cycle of the alarm unit 2, an identification code; either that received from the alarm unit 2 or one generated or embedded in the tag unit 14 read only memory or an identification code generated by some other means. It should be not-

ed that the processor control can be implemented in both active and passive tags.

**[0050]** It will be appreciated that the number of tag units 14 that can be accommodated within this scheme is exactly equal to the number of frames within a duty cycle of the alarm unit 2.

**[0051]** Furthermore the above locally unique code is arranged such that if more than one tag unit 14 happens to request the same frame then the combined local identification codes of the tags will be invalid and the microprocessor 4 of the alarm unit 2 will not allocate the frame to either tag. In the rare cases where this happens the user will remove all but one of the tags from the first detection range and this will allow the first tag to be captured.

**[0052]** In the event of more than one tag unit 14 requesting a frame at the same time, each tag may delay by a random time period then re-try. The random time period could be generated based on an electronic noise source. These techniques are well known in the art.

**[0053]** Power saving at the tag unit 14 is achieved by means of switching off the tag receiver 10 once the tag has been captured. The receiver 10 will be switched on occasionally in order to ensure the tag signal does not drift out of its allocated frame due to unavoidable variance of the processor operating frequency.

**[0054]** Further power savings are achieved by running the tag identifier 16 at the minimum possible clock speed, such as 32768Hz, compatible with the required data transfer rate.

**[0055]** Security may be increased by changing the identification code each time synchronisation occurs. Once the alarm unit 2 has transmitted the alarm signal and the tag signal has been received from each of those tags within the first proximity zone 20, the microprocessor 4 indicates to the user the number of individual tag units 14 that are present within the first proximity zone 20. This is determined by the number of unique identification codes detected or alternatively the number of item time frames on which the tag units 14 are communicating with the alarm unit 2 as appropriate. The indication means is a seven segment Liquid Crystal Display (LCD) or a Light Emitting Diode (LED) array. Alternatively a single LED or buzzer may be used to pulse an appropriate number of times, for example one pulse per individual tag unit 14 within the first proximity zone 20. The LED light which indicates the state of the alarm unit 2 may be used for this purpose in addition. The rate of pulsing of the buzzer or LED may be related to the number of identified tag units 14.

**[0056]** The alarm unit 2 next retransmits the alarm signal with the alarm unit 2 still in the open state.

**[0057]** The above process is thus repeated. If it is decided to remove one or more of the tag units 14 from protection, then those tag units 14 which are not required to be protected are simply moved outside the first proximity zone 20. They will not then be detected by the alarm unit 2 during the next duty cycle, and their code or item time frame will be removed from the memory store at the end of that duty cycle. Thus, those tags will not later be recognised when the alarm unit 2 is switched into a protected state (described below).

**[0058]** In the open state, the alarm unit 2 continues to transmit alarm signals with a duty cycle of, say, a fraction of a second. Thus, the status of individual tag units 14 may be switched between protected and not protected very straightforwardly as all that is required is that the tag units 14 be moved into or out of the first proximity zone 20 whilst the alarm unit 2 is operating in the open state.

**[0059]** Figure 2b shows three tag units 14 communicating with the alarm unit 2 operating in a second or "protected" state. The alarm unit 2 is switched into the protected state when the required number of tag units 14 has been identified by the alarm unit 2 when in the open state, as described above. The button on the alarm unit 2 acts as a toggle between the open and protected states. The protected state allows any tag unit 14, whose identification code or item time frame was stored within the memory store of the alarm unit 2 at the end of the preceding duty cycle in the open state, to be protected. Preferably, the alarm unit 2 will only enter the protected state, when activated to do so, if one or more tag units 14 are stored in the memory store of the alarm unit 2. If no tags are within the first detection range, then the unit will go into a standby state. Once in the protected state, the alarm unit 2 deactivates the LCD and/or other indicators in order to conserve power. The LED status light is also extinguished as the alarm unit switches from the open to the protected state, and a distinctive, audible sound may be emitted. If there are no tag units 14 stored in the memory store of the alarm unit 2 when it is activated to enter the protected state, the alarm unit 2 switches into a low power standby mode in order to conserve power and again a distinct audible sound may be emitted.

**[0060]** In the protected state, the alarm unit 2 defines a protected proximity area defined by the markings 22. As Figure 2b shows, in this case three tag units 14 are free to move within the protected proximity area 22. Once again, the protected proximity area 22 may be defined by the signal power transmitted by the transmitter 8 although preferably, the proximity area is defined by the strength of the signal received from the tag unit 14. Toggling from the open to the protected state may cause the microprocessor 4 to increase the power to the transmitter 8 so that the protected proximity area is larger than the first proximity zone 20, although it is preferable for active tag units 14 that the sensitivity, to the tag signal, of the alarm unit 2 is altered to define the first proximity zone 20. So, for example, increasing the sensitivity of the alarm unit 2 increases the first proximity zone 20. By adjusting the sensitivity of the alarm unit 2, each tag unit 14 can operate using a fixed transmitter power and the first proximity zone 20 can be adjusted by altering the alarm unit 2 sensitivity. It is to be understood that the

tag units do not need to be active to allow the proximity area 20 to be adjusted by variation of the alarm unit sensitivity. Passive tags can equally be used.

**[0061]** The alarm signal transmitted by the alarm unit 2 when it is operating in the protected state is replied to by each protected tag unit 14 that is within the protected proximity area 22 at a time defined by its frame within the duty cycle. The tag signal transmitted by each tag unit 14 contains an identification code as explained previously. The alarm unit 2 continues to transmit alarm signals and receive tag signals, again with a suitable duty cycle such as a fraction of a second. Alternatively, when the alarm unit 2 is operating in the protected state the tag units 14 will transmit tag signals that do not identify the particular tag but are within the appropriate item time frame, which will be received by the alarm unit 2, with a suitable duty cycle of, say, a fraction of a second.

**[0062]** After a given alarm signal has been transmitted, the alarm unit 2 receives, within each allocated item time frame of its duty cycle, the identification code from each tag unit 14 and compares the identification code received from each tag unit 14 with those identification codes stored in the memory store of the alarm unit 2. If a received identification code is identical to an identification code stored by the alarm unit 2, this is noted against the stored identification code as described below. The table of tags stored in the memory will record the statistics of tags not found. Each tag cell in the table will accumulate tag exceptions by means of a resettable number representation (binary numbers in the memory). This number representation will be set to zero each time the corresponding tag is detected but will be incremented by one integral unit on each duty cycle for which the tag is missing. If for a given tag this number exceeds a predetermined value, then an alarm condition will exist. Thus at any time, a zero against the identification code will indicate that within the latest duty cycle, that tag was within the detection range. This indicates that the tag unit 14 to which the stored unique identification code is assigned is located within the protected proximity area 22 of the alarm unit 2.

**[0063]** If a received identification code is not identical to an identification code stored by the alarm unit 2, the microprocessor 4 determines if the received identification code originated from a protected tag unit 14 and that the code word had been corrupted by electrical noise or the like.

**[0064]** If the alarm unit 2 determines that a received identification code does not exactly match any of the stored identifications, the alarm unit will use fuzzy matching to determine if it is likely to be a known code or if the received signal is garbage. In the former case, the processor means will cause a second tag exception count to be incremented, to the extent that the received code partially matches one of the expected codes. Thus repeated communications errors will result in a detectable condition that may indicate a faulty tag or unsuitable operating conditions. Unsuitable conditions might include operating with tags at or near the limit of the second detection range. Also low battery power might result in this condition.

**[0065]** If the alarm unit 2 determines that the received identification code has been corrupted, the alarm unit 2 ignores the received code, and waits for the next transmit/receive cycle. Because the alarm unit 2 ignores corrupted identification codes, any transient errors in transmission will not affect the correct working of the alarm system 1. Only if a corrupted signal is received repeatedly will the alarm unit 2 alert the user to a fault (e.g. by a suitable indication on the LCD). This allows the user to move the alarm unit 2 back into the open state, remove a tag unit 14 that is no longer required or is faulty, move other tag units 14 into the open state proximity zone, allow new tag units 14 to be identified as explained, and then toggle back to the protected state. The effects of transient noise can in any event be mitigated by employing techniques such as convolution interleaving or the simple matching scheme described above.

**[0066]** Figure 2c shows a tag unit 14 located outside the protected proximity area 22. After at least one signal transmission by the alarm unit 2, the microprocessor 4 scans through the stored identification codes. If the number stored against any ID exceeds the predetermined threshold at this time, (and not due to corruptions as explained above), the alarm unit concludes that the corresponding tag unit 14 has not responded to the signals transmitted by the alarm unit 2 and so is therefore deemed to be located outside the protected proximity area 22. Thus, the alarm unit 2 causes an alarm (not shown) to be activated. The alarm may include a buzzer to audibly alert the user that a tag unit 14 is outside the protected proximity area 22. Alternatively, the alarm unit 2 may be caused to vibrate to discreetly alert the user that a tag unit 14 is outside the protected proximity area 22. An LED may also be caused to flash.

**[0067]** The microprocessor 4 in this case preferably signifies to the user the identity of the tag unit 14 that is deemed to be outside the protected proximity area 22, using the indication LCD.

**[0068]** To deactivate the alarm once actuated, the tag unit 14 which was previously identified as being taken outside the protected proximity area 22 is placed back within the protected proximity area 22.

**[0069]** Alternatively the user may deactivate the alert means manually by pressing the button on the alarm unit 2, thus placing the alarm unit into the protected state (with the old tag unit no longer captured).

**[0070]** If the alert means was deactivated manually, the alarm unit 2 goes into the open state and deletes all the identification codes from the alarm unit memory.

**[0071]** It will thus be appreciated that the alarm unit 2 can provide a wide range of functions with a very limited amount of features (that is, a small amount of necessary user input). A single button allows toggling between the open and protected states (which allows the tags to be identified and then monitored), and also manual cancel-

ling of the alarm when a tag moves outside the protection area. The alarm system of the present invention can be used in two distinct ways, depending upon the nature of the article to be protected. In a first arrangement, the alarm unit 2 is carried by the user and tag units 14 are attached to nearby items such as wallets, handbags, briefcases, etc. In a second arrangement, a single tag unit 14 is carried by the user and the alarm unit 2 is instead attached to the value item. In this case, the alarm unit has an audible alert. When the value item is removed from the vicinity of the person, the alarm sounds on the article itself. This arrangement is preferred for protecting larger items where an additional benefit is that if the item is removed then attention is drawn to the item itself by means of the audible alarm. The second arrangement does not preclude protection of other items of property but then the alarm condition is triggered from those items when any one of them is separated from the alarm unit on the "main" item to be protected. It is to be appreciated that some or all of the tags may be provided with their own power supplies to permit functions such as encoding, which generally requires processor control, to be provided. Active tags are preferred and also provide a greater range and allow the proximity area to be varied by altering the sensitivity of the alarm unit 2 to the received tag signals. Nevertheless, there are advantages to using passive tag units, that is, tag units which do not require batteries. Here, a tag signal is returned to the alarm unit 2 by collecting and utilizing the energy in the received alarm signal. This procedure provides a technique for distinguishing between separate tag units 14, even in a passive device where there may not be sufficient power (from the received alarm signal) to drive the IC logic such as would be needed to encode the tag signal with an identifier. Instead, the alarm unit may utilize the delay between transmission of the alarm signal and receipt of the tag signal as a tag unit discrimination technique. In particular, the distance between the alarm unit 2 and a given tag unit 14 will determine the energy of the alarm signal at its reception by that tag unit. For a passive device, the time taken to collect sufficient energy to retransmit a tag signal is linked to the energy in the received alarm signal. It is this delay which permits a degree of tag unit collision avoidance. In the case of an active tag a random delay could be programmed into the tag.

**[0072]** Although one specific embodiment has been described, it has to be understood that this is for the purposes of illustration only and that various modifications can be made without affecting the scope of protection which is defined by the following claims. For example, the tag identifier 16 may be omitted from the tag unit if only one tag unit is to be used with one alarm unit. Instead of a single button, a keypad may instead be provided on the alarm unit 2. This allows switching of the alarm unit between the open and protected states by entering a personal identification number (PIN). The keypad can then also be employed to cancel an alarm when an item moves outside the protected proximity area 22, requiring a PIN to be entered. This prevents a thief from deactivating an alarm when the alarm unit 2 is affixed to the value item rather than being held on the person.

**[0073]** In yet a further variant, the system may be employed to protect vehicles and other valuable items of property. Here, the alarm unit may be fixed (e.g. wall-mounted) in the house, and can then be mains powered. This allows the effective transmission range of the alarm unit 2 to be increased.

**[0074]** The alarm system may also be used in reverse to allow detection of lost objects such as TV remote controls. In that case, the alarm unit may be switched so that it is capable of detecting such lost objects (to which a tag has been attached) even when such objects have not previously been captured in the open state.

**[0075]** In this case, the alarm unit 2 will need to operate in a searching state. The searching state means that the alarm is actuated when a tagged item passes within a third detection range. The third detection range is greater than the first detection range and may be greater or less than the second detection range, as will be appreciated.

**[0076]** When the alarm unit 2 is operating in the searching state, each tag unit 14 will be -instructed by the alarm unit 2 to transmit the identification code to the alarm unit 2 as previously described. The alarm unit 2 will operate in the searching state upon instruction from the user. Preferably, the alarm unit 2 enters the searching state when a user presses the button within a specified time, typically less than 1 second, after the activation of the open state. The button is further pressed to return the alarm unit 2 to the open state. Whilst the alarm is in the searching state, the alarm unit 2 indicates this state to the user, for example by flashing the LED or the like.

**[0077]** In the foregoing described embodiments, where the detection range within the open state and the protected state is to be controlled by means of the received signal strength, the power at which the alarm signal is transmitted is the same in both the open and the protected state. However, the power of the transmitter 8 in the alarm unit 2 may be automatically swept so as to determine the minimum amount necessary for the currently protected items. In particular, the processor 4 may initially generate the alarm signal in the protected state to be transmitted at the maximum power available from the alarm unit 2. The processor 4 then causes the power at which the alarm signal is transmitted to be reduced incrementally until one (or more) of the tag units identified in the open state is no longer detected. In other words, the protected proximity area 22 is gradually reduced until one or more tag units 14 is no longer inside that area. The power is then incrementally increased until all of the tag units are back inside the (reduced) protected proximity area 22. This technique causes the amount of power consumption to be minimized. If a tag

unit moves outside the reduced protected proximity area, then the power output of the transmitter 8 is increased again to its maximum, to check that the tag unit really has been removed, before the alarm is activated.

**[0078]** Similar means can be employed in order to minimise the power consumption of the transmitter 12 on the tag unit 14 Instead of the need manually to switch back to the open state each time it is desired to add a new tag unit to the tag units which have already been identified by the alarm unit 2, the microprocessor 4 may be programmed automatically to identify new tag units and include them. It is also noted that alternatively an electrical contact or switch or a proximity device such as a magnetically operated reed relay or Hall effect switch on the alarm unit 2 can be utilised to detect a new tag. When the alarm unit 2 is in the protected state, and a new tag unit is detected within the open proximity area 22, the alarm unit may enter a third, "new item" state. Then the ID of that tag is added to the memory store of the alarm unit. Once the ID is stored in the memory store, the alarm unit shall automatically revert to the protected state. Alternatively, the alarm unit transmitter power may simply be swept in the protected state between the maximum range and the range it would be in the open state. A new tag unit would automatically be remembered if it was detected even when the maximum transmitter power was at the open proximity range.

**[0079]** Although certain technical features have been described in respect of active tags, and others in respect of passive tags, it is to be understood that such features are not necessarily mutually exclusive.

## Claims

**1.** An alarm unit for monitoring one or more tag units in an alarm system, the alarm unit comprising:

an alarm unit including a transmitter for transmitting an alarm signal, a receiver, a processor means and an alert means;
the alarm unit being switchable under control of the processor means between first and second states in each of which the alarm signal is transmitted over a detection range, the alarm unit further being arranged:

(a) in the first state, to identify the presence of one or more tag units by detecting tag signals generated by the or each tag unit in response to a received alarm signal when said tag unit is currently within the detection range; and
(b) in the second state, to detect when the or each thus identified tag unit moves outside the detection range and to cause the alert means to be actuated in consequence of such detection.

**2.** The alarm unit as claimed in claim 1 further configured to receive the signals from the tag units over a first detection range in the first state, and over a second, longer, detection range in the second state.

**3.** The alarm unit as claimed in either of claim 1 or 2, further including a receiver control means coupled to said receiver wherein said receiver control means is arranged to adjust the sensitivity of said alarm unit to the received signal strength so as to adjust said second detection range in accordance with the sensitivity of said alarm unit.

**4.** The alarm unit of either of claims 2 or 3, in which the processor means is configured, when the alarm unit is in the second state, to detect when a new tag unit, not previously identified when the alarm unit was in the first state, moves into the first detection range, and if so, to henceforth include the said new tag unit as a further one of the previously identified tag units.

**5.** The alarm unit as claimed in any preceding claim, further comprising switch means to switch the alarm unit between the first state and the second state.

**6.** The alarm unit of any preceding claim, in which, after the or each identified tag unit has moved outside the detection range in the second state, and the alert means has been actuated in consequence, the processor means is further arranged automatically to deactivate the alert means once the or each identified tag unit is brought back inside the detection range.

**7.** The alarm unit of claim 5, in which the processor means is arranged to deactivate the alert means, once activated, in response to activation of the said switch means.

**8.** An alarm system comprising:

at least one tag unit, the or each tag unit comprising transceiver means for receiving an alarm signal and transmitting a tag signal; and an alarm unit as claimed in any one of the preceding claims.

**9.** The alarm system as claimed in claim 8, wherein the said or each tag unit is a passive device.

**10.** The alarm system of claim 9, in which the processor means of the alarm unit is arranged to identify separate tag units in dependence upon the total time taken between broadcast of an alarm signal and receipt of a tag signal from a particular tag unit.

**11.** The alarm system as claimed in any of claims 8 to

10, wherein said the or each tag unit further comprises unique identification means.

**12.** The alarm system as claimed in claim 11, wherein said unique identification means is field programmable identification means.

**13.** The alarm system as claimed in claim 12, wherein said field programmable identification means is a randomly generated identification code generated during the said first state.

**14.** The alarm system as claimed in 13, wherein said randomly generated identification code corresponds to said unique identification means during said second state.

**15.** A method of monitoring one or more tag units in an alarm system, the alarm system comprising an alarm unit having a transmitter, a receiver, a processor means and an alert means, and being switchable between first and second states under control of the processor means, and at least one tag unit comprising transceiver means; the method comprising:

(a) transmitting an alarm signal over a detection range when the alarm unit is in the said first state;
(b) identifying the presence of one or more tag units by detecting tag signals generated by the or each tag unit in response to a received alarm signal and which is currently within the detection range;
(c) switching the alarm unit from the first to the second state;
(d) detecting when the or each thus identified tag unit moves outside the detection range; and
(e) causing the alert means to be actuated in consequence of such detection.

**16.** The method of claim 15, in which the tag signal is received over a first detection range when the alarm unit is in the first state, and receives the tag signal over a second, longer, detection range when the alarm unit is in the second state.

**17.** The method of either of claims 15 or 16 further comprising coupling a receiver control means to said receiver wherein the sensitivity of the alarm unit to the received tag signal is adjusted by said control means such that said second detection range is adjusted in accordance with the sensitivity of the alarm unit.

**18.** The method of either of claims 16 or 17, further comprising, when the alarm unit is in the second state, detecting when a new tag unit, not previously identified when the alarm unit was in the first state, moves into the first detection range and henceforth including the said new tag unit as a further one of the previously identified tag units.

**19.** The method of any of claims 15 to 18, further comprising, after the or each identified tag unit has moved outside the detection range in the second state, and the alert means has been actuated in consequence, automatically deactivating the alert means once the or each identified tag unit is brought back inside the detection range.

**20.** The method of claim 17, further comprising deactivating the alert means, once activated, in response to activation of a switch means.

FIG. 1.

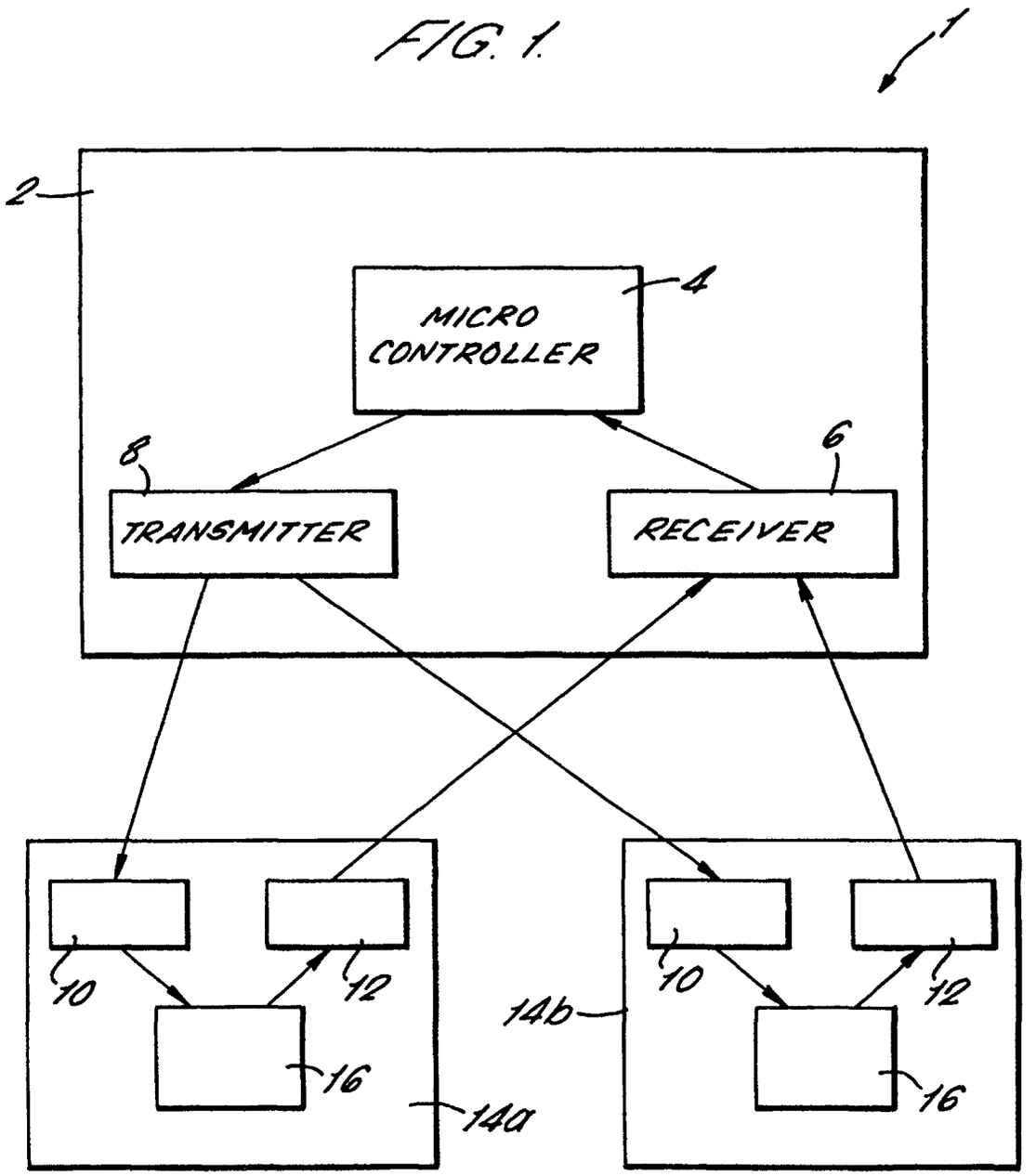
1
2
MICRO CONTROLLER
4
8
6
TRANSMITTER
RECEIVER
10
12
16
14a
14b
10
12
16

FIG. 2a.

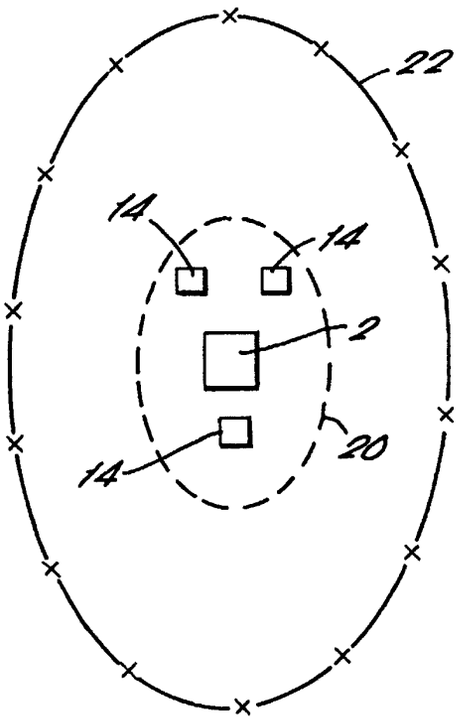


FIG. 2b.

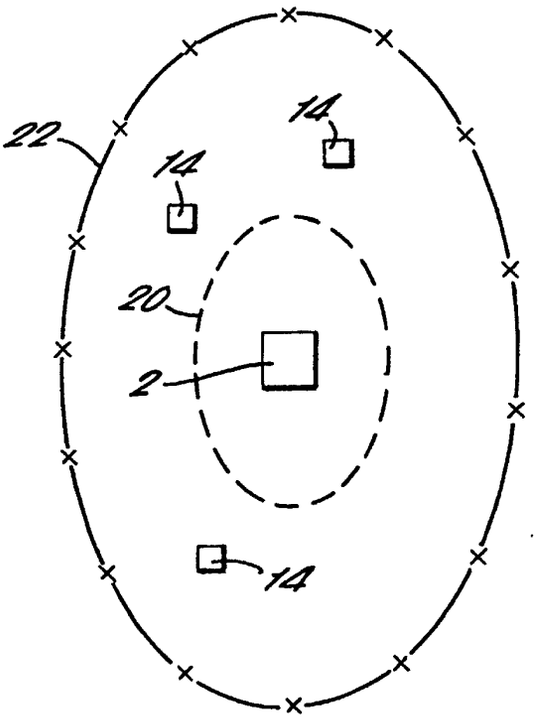


FIG. 2c.