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(71) Applicant: **Devoy, Ralph P**
100 Wingarden Court, Apartment 1910
Scarborough, Ontario M1B 2P4(CA)

(72) Inventor: **Devoy, Ralph P**
100 Wingarden Court, Apartment 1910
Scarborough, Ontario M1B 2P4(CA)

(74) Representative: **Cline, Roger Ledlie et al**
EDWARD EVANS & CO. Chancery House
53-64 Chancery Lane
London WC2A 1SD(GB)

(54) **Location identification system.**

(57) An identification system for identifying individuals within a facility and having a plurality of individual tags T to be carried on the person, each tag continuously emitting tag pulse rates unique to that tag at a predetermined frequency, at least one location detector unit placed at a monitor location, and having a signal processor unit 4, an antenna 1 to receive tag signals and a direction sensor 2 to generate a direction signal responsive to movement of an individual, so that the signal processor unit 4 will examine a tag signal only when a direction signal has been received from the direction sensor 2 and, a central processing unit 7 to communicate with each signal processing unit 4, and a method of detecting individuals in such a facility using such tags T and location detector units U.

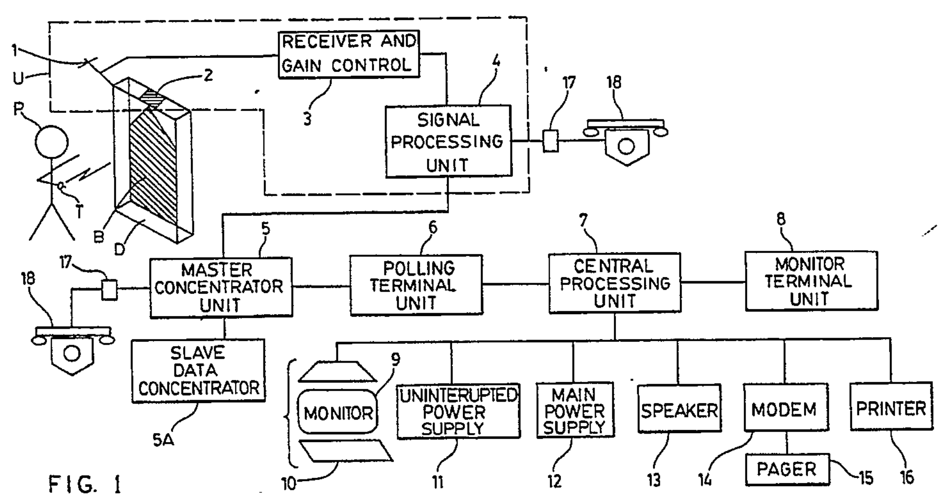

FIG. 1

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LOCATION IDENTIFICATION SYSTEM

FIELD OF THE INVENTION

The invention relates to an identification system, for identifying individuals within a facility.

BACKGROUND OF THE INVENTION

In various different facilities and institutions, it is desirable to be able to identify, and pinpoint the location of individual personnel within the facility or institution. For example, in an institution such as a hospital, caring for persons suffering from some degree of loss of memory or mental impairment, it is well known that such persons tend to wander erratically from room to room, or from zone to zone, within the institution, and frequently simply leave the institution, without anyone noticing they have left. Such persons may place themselves in positions of danger, without being able to care for themselves, and without any nursing staff or care person being aware of the situation.

This type of situation is merely one example of the application of the present invention. It will be appreciated that the invention would also be applicable to a situation where it is desirable to be able to pinpoint the location and identity of individuals within a facility or institution, for any other reason. For example, in hospitals it may be desirable to be able to locate key care persons, or medical personnel, in emergencies. In other facilities or institutions where security is a requirement, it may be desirable to be able to locate and identify individuals in any secure location.

In all these cases, the system must be able to satisfy certain key requirements.

1. It must be able to identify an individual as either "identified" or "unidentified", or "untagged".

2. It must be capable of detecting movement of an individual from one selected zone or room in a facility to another.

3. It must be capable of providing individual "tags", each emitting a signal on a predetermined standard frequency, each containing a tag pulse rate unique to that tag.

4. Each detector unit within the system must be capable of receiving signals from any of the tags, worn by any of the individuals at least when moving past a detector unit.

5. Each of the detector units must be such that it it can screen out signals from tags which are located within a zone, but which are not moving from one zone to another.

6. Each of the detector units must be capable of detecting a signal from a tag which is moving from one zone to another, and of reading the unique tag pulse rate to identify the individual.

7. Each of the detector units must be capable of detecting the direction of movement of the tag from one zone to the other.

8. Each of the detector units must be capable of storing information concerning movements of identified individuals, and transmitting such information at appropriate intervals to a central processing unit (CPU).

9. Each of the detector units must be capable of being controlled by a CPU to control the sensitivity of its detector circuits.

10. Each of the detector units must be able to discriminate between and detect movement by an individual with a tag (an identified individual), and movement of an individual without a tag (an untagged individual), or an individual with a tag who is not recognized by the system (an unidentified individual).

In this system the signal transmitter in the tag is permanently "on". Each tag signal has a tag pulse rate unique to that tag, which the tag will be emitting continuously twenty-four hours a day. The tag will be battery-powered, and will have a life time equivalent to the life of the battery.

It will be appreciated that in a large facility there will be many people wearing tags, all of which will be transmitting simultaneously on the same frequency. Clearly, this creates significant problems in the design of the detector units. If the detector units are receiving numbers of tag signals from different tags simultaneously, it will be impossible for the detector unit at any one location to identify a particular tag, or its direction of movement. In this case, the problem then presents itself of designing a detector unit which will screen out all of the signals of tags which are not moving through a controlled doorway or other controlled location, but are merely present within a zone, while detecting and identifying signals from tags which are actually moving through a controlled doorway or other location between two zones.

It is also necessary for a detector unit to receive and identify more than one tag moving through a controlled location simultaneously.

SUMMARY OF THE INVENTION

With a view to satisfying the various criteria identified above, the invention comprises a location identification system which, in turn, comprises a plurality of individual tag means adapted to be carried on the person, each tag being adapted to continuously emit signals at a tag pulse rate unique to that tag, and at least one location detector unit adapted to be placed at a detector location, said detector unit, in turn, comprising a signal processing unit having micro-processing means, antenna means adapted to receive tag signals from said tags and connected to said signal processing unit, direction sensor means adapted to generate direction signals responsive to an individual at said detector location and connected to said signal processing unit whereby said signal processing unit will respond to tag signals from said antenna means only when said direction signals have been received from said direction sensor means, and central processing means adapted to communicate with said at least one signal processing unit, and to receive from said signal processing unit movement signals indicating the movement of an individual past said detector unit.

More particularly, the invention comprises an identification system having the foregoing advantages which, in turn, comprises a direction sensor means responsive to the direction of movement of an individual relative to said direction sensor means.

More particularly, the invention comprises an identification system having the foregoing advantages which, in turn, comprises a plurality of said detector units, and master data concentrator means for receiving signals from said signal processing units of said plurality of detector units, and transmitting data therein to said central processing means.

More particularly, the invention comprises an identification system having the foregoing advantages and further including receiver means connected to said antenna means and, in turn, connected to deliver signals from said antenna means to said signal processing unit, whereby to amplify signals from said antenna means.

More particularly, the invention comprises an identification system having the foregoing advantages and in which said and said receiver means includes gain control means operable to adjust said receiver means.

More particularly, it is an objective of the present invention to provide an identification system wherein said direction sensor means comprises heat responsive sensor means, adapted to sense the heat of an individual at a said monitor locations.

The various features of novelty which characterize the invention are pointed out with more particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic perspective illustration, illustrating a typical detector location, provided with a detector unit in accordance with the invention, and other components of the system connected schematically to a central processing unit (CPU);

Figure 2 is a block diagram of the detector unit illustrated in Figure 1;

Figure 3 is a schematic perspective illustration showing an alternate embodiment of the detector unit;

Figures 4 and 5 are two portions of a flow-chart of the door monitor tag array evaluation routine;

Figure 6 is a block diagram of the communication link;

Figure 7 is a flow-chart of the CPU system of the present invention;

Figure 8 is a flow-chart of the detector unit foreground function loop;

Figures 9A and 9B are flow-charts of functions of the detector unit function;

Figures 10A, 10B, 10C and 10D are flow charts of various interrupt sequences which may occur in the flow chart of Figure 8, at the time of an "event".

Figure 11 is a diagram showing the tag factor;

Figure 12 is a diagram showing an activity window, and,

Figure 13 is a block diagram showing connection with the computer at the service facility.

DESCRIPTION OF A SPECIFIC EMBODIMENT

Referring first of all to Figure 1, the invention is illustrated schematically, with reference to what may be called a detector location, in this case represented as doorway D. An individual or person indicated as P is shown wearing a tag T. While the tag T is shown mounted on the wrist, it will, of course, be appreciated that such a tag T may be any form of a badge, or body pack, wrist band, convenient for attachment to the person.

Such a tag T is not illustrated herein in detail, but it will be appreciated that each tag will incorporate a battery source of power, and a small radio transmitter emitting a signal at a predetermined frequency. The tag signal will, in a well known manner, incorporate a tag pulse rate unique to that tag, such pulse rate indicating the identity of the individual.

Tags emitting signals are known per se, and the manner in which a unique tag pulse rate is incorporated in the signal is also well within the knowledge of the state of the art.

Generally speaking, within a facility there will be a plurality of detector locations, all of the individuals within the facility will be wearing tags emitting signals at the same predetermined frequency. The tag pulse rate of each tag will, of course, be personalized to each individual.

There may also be individual wearing tags which are defective, or are unauthorized, or there may be individuals wearing no tags at all.

The detector locations may be located around key doorways, passageway locations, or at entrances to and exits from the facility.

At each detector location, there will be a location detector unit U comprising at least two sensors, namely a radio signal sensor or antenna indicated as 1 and a direction sensor indicated as 2. The direction sensor 2, in the particular embodiment illustrated, is in the form of a heat sensor, adapted to respond to the body heat of an individual, and generate a direction signal.

The direction sensor 2 of Figure 1 functions to emit a generally fan-shaped beam B, over an arc of approximately 120 degrees. The depth of the beam B is confined, being in the region of about eight inches, i.e., corresponding to not much more than the depth of a typical doorway. The beam functions so that when it is interrupted by an individual, it will cause the direction sensor to send out a direction signal. The signal will indicate both movement of an individual and the direction of movement of the individual through the beam. The direction sensor will thus sense any movement by an individual whether tagged or untagged.

In accordance with a further embodiment of the invention, as shown in Figure 3, the direction sensor 2 may be replaced by a pair of direction sensors 2a and 2b, mounted on side portions of the doorway indicated as D.

Such sensors 2a and 2b emit two shallow beams B1 and B2 along generally spaced-apart axes so that a person moving through the doorway or other detector location, cuts one beam and then the other, and thus determines the direction of movement.

This information is then recorded by the signal processing unit and activates the unit to examine tag signals, and the information is, in turn, transferred to the central processing unit as described below.

In this way, persons who may simply be near the doorway but are not actually passing through the doorway, will not trigger the direction sensor. The signal will only be triggered by somebody actually passing through the doorway.

The direction sensor 2 is connected to a signal processing unit 4 mounted at the monitored location.

The signal processing unit 4 includes suitable micro processing means for processing signals from antenna 1 and sensor 2.

The function of the direction sensor is to send direction signals as they are generated, to the signal processing unit 4. The signal processing unit 4, in the absence of receiving a direction signal, will not examine any tag signals, which may have been picked up at the antenna.

However, as soon as a direction signal is detected, the processing unit is then activated so that it processes the tag signal, from the tag which is passing through the doorway.

The signal processing unit will process all tag signals from any tag within the vicinity of the detector units. However, the signal processing unit is able to identify each individual who is actually passing through the doorway, or other location, in a manner described below.

The signal from the direction sensor to the signal processing unit, in addition to simply activating the signal processing unit to make it responsive to a tag signal, also informs the signal processing unit as to the direction of movement of that individual. The signal processing unit will thus store both information regarding the direction of movement of the individual as detected by the direction sensor, and also information regarding the tag, and the unique pulse rate emitted by the tag.

In the event that the individual is wearing a defective tag, or no tag at all, then of course that information will also be recorded by the signal processing unit.

The antenna 1 is connected to a receiver and gain control 3 which is, in turn, connected to the signal processing unit 4. The receiver and gain control 3 has two functions. In the first place, it tunes the receiver sensitivity to the particular location or doorway, and in the second place, it amplifies signals received, for transmission to the signal processing unit 4.

The nature and construction of any particular monitor location may vary considerably from location to location within a facility. For example, some may be close to areas normally used by tagged individuals, and others may be distant. Accordingly, the receiver and gain control 3 is timeable at the time installation is made, so as to optimize the performance of the receiver 3. As will appear below, the gain control can also be reset from time to time, if the characteristics of the monitor location are changed in such a way which affect the performance of the receiver 3.

The antenna 1 is designed to operate over a limited range, so as to avoid picking up too many unwanted signals. Its design is such as to operate satisfactorily within a normal sized doorway in a facility. In some cases, however, doorways or other locations may be made oversize. In other cases, monitor locations may be required in passageways or hallways. In this case, two or more such antennas may be required, mounted at spaced intervals.

In this case, there will be two or more receivers 3a, etc., and they will all be connected to the signal processing unit 4.

Groups of signals processing units will be connected to master concentrator units 5. There may be up to eight such signal processing units 4 connected to one master concentrator unit 5. The function of the master concentrator unit 5 is to transmit data from the signal processing unit 4. Such a connection is made via an six-wire system. The connection provides the following services, namely, power supply, a shielded ground, polling of the door processing units 4, receiver sensitivity, telephone communications, and audible alarm signals.

A plurality of slave data concentrators 5a, etc., are connected to the master concentrator unit 5. Each of the slave data concentrators will be connected to a further group of signal processing units 4.

The master concentrator Unit 5 is, in turn, connected to a polling terminal unit 6, the function of which is to send polling signals to each of the signal processing units 4, in turn, to obtain updated data regarding signals detected at each location. The polling terminal unit 6 is, in turn, connected to a central processing unit 7. Also connected to the central processing unit is a monitor terminal unit 8, the function of which is to analyze and display the results of the polling process. A central processing unit 7 typically has a monitor 9 and a keyboard 10. The central processing unit 7 would typically be located in a nurses' station, administrative office, or security office in the facility. It would be adapted to continuously update information from the polling terminal unit 6, and to store the information received.

In one function, the central processing unit 7 will collect data of movements of all individuals who passed through a monitor location, and store in its memory the identities of individuals who have been identified as having passed. For the sake of simplicity, an area between any two monitoring locations is referred to as a zone. For the purposes of this discussion, the zones will be referred to simply as zone A, zone B, and zone C, for simplicity in understanding the following explanation, and without any limitation. In practice, such zones may represent adjacent connected rooms, where a detector unit is located at the doorway from one room to another and so on. In other cases, the zones may be wards, or wings of a facility, or simply exit doorways.

Thus, when a tagged individual passes from zone A to zone B, but has not yet passed to zone C, the central processing unit 7 will receive a signal to the effect that an individual has passed. It will then store that information, indicating that that individual is presently located in zone B. It will also record the previous information in a permanent file and delete from its current memory information to the effect that the individual was in zone A.

The central processing unit 7 will also store information regarding individuals who have moved from zone B to zone A or to zone C etc.

In this way, the central processing unit 7 will, at any given time, provide lists of tagged individuals, present in each of the zones being monitored.

The central processing unit 7 will also be adapted to provide a visual and audible warning signal in the event of an individual moving into or out of a zone in an unauthorized manner.

The central processing unit 7 will also respond to signals indicating the presence and movement of individuals who are either wearing tags which are not functioning, or which are not authorized, such persons being referred to as "unidentified" and also to the presence and movement of individuals who are not wearing tags, and are, therefore, referred to as "untagged".

The central processing unit 7 will, in a typical case, be connected to a monitor terminal unit, and a monitor and keyboard, an uninterrupted power supply 11, and to a main power supply 12, a speaker 13, a modem 14, a printer 15, and, for example, possibly to the facility paging system 16.

In the event that an unauthorized movement by an individual is recorded in the central processing unit

7, it will first of all, in a typical situation, emit visual and audible warning signals. In the event of a predetermined time delay occurring after the warning signal, it will then send out a paging signal to locate the security person responsible for the monitored areas or zones where the movement occurred. The security person responsible, can then check the central processing unit and in the case of an unauthorized movement of a person wearing a tag, the security person can then send someone to check on that individual. In the event that the signal indicates an unidentified or untagged person, then other appropriate steps can be initiated.

The present system is provided with a control means placed between each of detector unit and central processing unit to permit communication between systems service personnel. This control means comprises telephone jacks 17 which are incorporated in each signal processing unit 4, and in each master concentrator unit 5. A telephone indicated as 18 may be connected directly to a signal processing unit, or to a master concentrator unit, by service personnel, for reasons to be described below.

Through the jack 17, a telephone indicated as 18 plugged into a signal processing unit 4 or a master concentrator unit 5, may be connected directly to a service facility located thousands of miles away via modem 14 (Figure 13) such a service facility is indicated generally as a CPU 20 and modem 22. Through the various circuits in the central processing unit, and the software programs, it will be possible for such a remote service facility 20 to check the performance of the signal processing unit, or the master concentrator unit. If the components are found which have gone out of adjustment, or if, for example, the signal processing unit 4 requires some adjustment of its receiver and gain control 3, then the service personnel at the remote location can send the appropriate signals over the telephone wire, and any possible corrections, and adjustments will be made.

In the event that during the process of this checking, it is found that the circuits, and signal processing unit 4, or any other component cannot be checked and reset, then it may simply send an out-of-service signal. That component would then be removed and replaced by a back-up component and returned for service.

It will also be noted that, in Figure 2, the signal processing unit 4 is provided with a port 4a for connection of future devices (not shown) which may be developed. In this case, an interface has been provided in the hardware to connect the master concentrator unit to another processor. In the event that an application of the system emerges which uses the same algorithm, but requires greater speed or capacity, a second processor may be added to the system with appropriate specifications to manage the increased demand. The first processor will function as the communications controller.

The operation of the system proceeds, in general, as follows. Assuming no one is passing a controlled location or doorway, then the direction sensor 2 will not detect the presence of an individual. Consequently, the signal processing unit 4 will ignore any signals picked up by the antenna 1. The antenna 1, on the other hand, will pick up signals from tags which may happen to be within the range, from persons moving around in one zone but not moving past the direction sensor. However, these tag signals will be ignored by the signal unit, so long as no direction signal has been received.

However, once a direction signal is received, the signal processing unit 4 will then start examining tag signals from the antenna. The processing unit will acquire the combined information both from the direction signals and the tag signals, and evaluate them in the manner described below. This evaluation is carried out by a microprocessor in the signal processing unit 4, and consists of evaluating the direction signal as to the direction of movement, and determining the tag pulse rate, or rates, if more than one is present, from the tag signals being received.

This information is stored in the signal processing unit 4 until the polling terminal unit 6 sends, through the master data concentrator, to the signal processing unit 4, a request for information. The signal processing unit 4 then responds by sending back information through the master data concentrator to the polling terminal unit together with an ID signal indicating the location of the signal processing unit 4 itself. The polling terminal unit 6 is polling signal processing units 4 in fact every two to eight seconds, depending upon the size of the facility and the number of different signal processing units 4.

The polling terminal unit 6 will, in turn, deliver the information received to the central processing unit 7. The central processing unit 7 will than identify the

threshold value, the tag is shown as not present. Because of the way the tag factor is manipulated the tag is required to be detected at least twice so as to avoid problems with random noise bursts. A detailed explanation follows under the heading "Activity Window".

Tags are detected and stored in the signal processing unit 4 using the tag calibration number. This number is the period in micro-seconds between the tag pulses. The method for detecting tags is described below as well as in the flow chart shown as tag array evaluation routine on Figures 4 and 5. It is important to note that the tag calibration number will vary by a few counts from one sample to the next. For this reason, when comparisons are made of the tag calibration number, the comparison is always an approximate compare rather than an absolute compare. This allows for system jitter as well as the normal +/- 1 count error normally encountered in digital counting function.

Referring to flow-chart of Figures 4 and 5 wherein:

PXPY = 16 bit pointers to array entries
D = 16 bit arithmetic accumulator
AB = pointer to first entry remaining in array
VC = the number of times the tag was found in the array
LC = the number of times through the array (trap loop forever)
TA = pointer to last entry in array
GS = total number of samples associated with tags during eval
TS = total number of samples in array (from array fill function
REF = first sample used to compare subsequent samples
D = ref is an approximate compare, i.e., D = Ref +/- 2
TFACT = tag factor
TBUF = array of detected tags with tag factor
YF = valid tag flag
BP = pointer to TBUF

Referring to Figure 6, the central processing unit 7 provides control of the communication process with each detector unit by means of a two-wire multi-drop system. This type of system requires that only one device on the network can be transmitting at one time. Each location is given a unique address which is set in hardware when the unit is installed. The communication process consists of a message sent to each detector unit by the central processing unit 7. This message includes the address of the location detector unit being polled as well as data specifying what action is requested. This message from the central processing unit will always result in a reply message from the location detector unit. The message from the location detector unit will always be in a predictable format, and in the case of a poll for tag data the response will also include an error checking byte, to ensure date integrity. The message to the location detector unit will either be a request for tag data (a poll), or a command function. The format of the communication protocol is described below.

The central processing unit's flow chart, shown on figure 7, describes the system in the monitor mode. This is the normal operating mode polling each location detector unit, and displaying the alarm data. The software includes other functions whose purpose is to modify the data in the various data files. These functions are not shown in the flow chart.

The location detector unit data file relates the address of the location detector unit to data describing the actual location. This includes the location name as well as priority data.

The tag data file and patient data file relates the tag calibration number to the assigned patient information. This includes the patient name, ward or room, a comment or description, and priority data.

Each patient is assigned a priority from 1 to 9. Each monitored location is independently configurable as to which priorities are considered alarm conditions.

The priority data allows the system to respond differently to different patients at different locations. The system has had ten levels of priority which can be related to the display function, to each location, to the alarm sound map, and to the paging schedule. For example, using the priority capability, one category of patients may be allowed to go through a particular monitored location while another category is not. As well, one supervisory person may be paged for a certain category of patients while another supervisory person will be paged for a different category of patients.

A category has been assigned for instances when a person goes through a monitored location without a tag, called "Untagged". Usually it is unnecessary to monitor untagged people going through a monitored location. In this case, the display of untagged events will be ignored by the system using the priority system. In a situation when it is important to note the entry or exit of any person it is possible to allow the display of untagged persons as well as normally tagged persons.

The alarm sound file relates one of four unique alarm sounds, or the lack of sound, to each priority level. This allows supervisory people working in the area of the central processing unit to be aware of priority without seeing the monitor screen.

The paging function allows up to three pagers 16 to be optionally used with the system. Using a pager frees the system supervisor from having to continually monitor the screen. When an alarm condition occurs, the paging is initiated and the supervisory person is notified.

Referring to Figures 8, 9A and 9B, 10A, 10B, 10C and 10D, the fundamental operations of the signal processing unit 4 include detecting the tags, servicing the serial channel, and sending status information back to the central processing unit to allow it to monitor the location for error conditions. The following error conditions may be signalled to the central processing unit from the location detector unit:

1) Reset - The power has been lost at the location detector unit.

2) COP error - The MPU used (Motorola 68HC11) includes a computer operating properly watchdog function. If the MPU hangs, this timer will cause the system to restart.

3) RAM error - if the software causes a RAM memory write or a stack write runaway, this flag will be set.

4) Illegal op - The MPU has an illegal operation trap resulting in a system restart.

5) Tag buffer overrun - More tags have been detected than would fit in the buffer (8 maximum).

There is a foreground timeout before the end of the main program loop. This timeout forces each loop at default to be about .25 seconds long. This controls the timing of the damping function. A longer loop allows tags to remain in the tag buffer longer, and a shorter loop allows people to be detected more quickly. The length of this timeout may be changed if necessary using a command function.

The serial service consists of an interrupt function which stores each byte as it is received and checks to see if it is an address byte. The format of each message has the address byte last in the message. When the serial interrupt detects its address as the last received byte, the receive interrupts are turned off while the serial service routine responds to the message. The message will have already been stored in the buffer.

The calibration functions are used to adjust the calibration and configuration of the location detector unit and associated receivers. To set the system range and normalize multiple receiver sensitivity, a number of computer controlled adjustments have been included. As well, each receiver channel (1 - 4) may be turned on and off remotely to support adjustment and test.

In operation, when any error occurs an error flag is set in the status byte. This is checked by the CPU system and the central processing unit will request the error status byte. This will contain one or more of the error flags noted above.

When a normal tag data poll or the error status request occurs, a repoll flag is set. The signal processing unit 4 will not delete information from the error status or the tag butter until the central processing unit indicates that the information has been received correctly. The central processing unit will repoll a unit 4 if the message from the unit 4 is not received or is in an incorrect format. If the central processing unit receives the message from the unit 4 correctly, it will poll the next location detector unit U. For this reason, a repoll flag is set when the tag data or the error status byte is sent to the central processing unit. The data will not be deleted until an address byte is detected for a different location detector unit U, indicating that the message was received correctly. When the different address byte is seen the repoll flag is cleared allowing the data to be deleted.

The byte echo command allows a simple error rate test to be run over the communication channel. The central processing unit sends a byte and the location detector unit echoes the bytes back to the central processing unit.

The fill tag array function accumulates the data required to test for the presence of one or more tags near the location detector unit. The array fill function is terminated by reception of 64 samples or 32 milliseconds, whichever comes first.

The tag array evaluation routine is described in detail below.

The interrupt functions are as short as possible to minimize interference with other functions. The real time clock controls several time delays. The norm oper LED counter blinks an LED indicator showing the normal MPU operation. The activity reset counter creates a delay after a door activity event for two seconds to minimize the incidence of multiple responses to the same event.

Activity Window

As was mentioned before, a single sample of a tag signal may be lost for a number of reasons. The orientation of the tag and the receiver will vary the strength of the tag signal and may momentarily cancel the signal at the receiver. To minimize the unreliability caused by these effects, a special strategy is used to accumulate the presence of a tag with multiple samples. This technique also allows the detection of a tag which is present at the receiver a few moments before the direction sensor signal occurs, or a few moments afterwards.

To accomplish this, when a tag is detected its calibration number is saved along with a number, the tag factor, which indicates how often or how recently the tag has been detected.

Referring to figure 11, tag samples indicate a series of samples detecting a particular tag. The darkened samples indicate tag detect; and the empty samples indicate no tag detect. Each time the tag is detected the tag factor is increased by 4; and when the tag is not detected the factor is decreased by 1. The tag factor ranges from 0 to 14. When the factor is above 6, the tag is considered to be present. As seen in figure 11, it is not necessary for a tag to be detected at each sample to remain a valid tag. Also note that a tag is not valid until it has been detected at least two times. This tends to eliminate random noise sources from being detected as a valid tag. After a tag disappears the tag factor continues to decrease but will remain valid until the factor decreases below the threshold. When the tag factor reaches 0, it is deleted from the array.

In operation, figure 11 shows a typical tag detect. At point A, the tag is first detected, the calibration value is saved, and the factor increases to four. The second time it is detected, the tag factor increases to 8, and at point B, it becomes a valid tag. At point C, the tag factor reaches max factor value, the factor will not increase above this value no matter how long the tag is being detected. At point D, the tag signal is lost, the tag factor begins to decrease. Even though the tag is no longer detected, it continues to remain a valid tag for a period of time until point E, when the tag factor falls below the minimum factor threshold.

Tags may be detected at any time, but they do not become part of an event until door activity is sensed by the direction sensor 2. When a person is detected by the sensor 2, the location detector unit begins an activity window which lasts for approximately two seconds. During this period, any tag which appears above the minimum tag factor threshold is locked into the tag buffer until it is polled by the central processing unit.

Referring to figure 12 showing the activity window diagram, there are two tag detects shown and belonging to two different persons. Tag A detect occurred before the first person walked through the door. Because of the effect described above, the tag factor is still above the minimum tag factor threshold when the activity window starts. Because the tag factor is above the minimum factor, it is locked into the buffer at point B. Tag B detect occurs after the second person has gone through the door. During the activity window any tag with a factor above the minimum tag factor threshold is locked into the buffer. Tag B is locked into the buffer at point C. After the activity window ends, at D, no more tags are locked into the buffer. However the tags do not disappear as shown above, rather they are kept locked in the buffer until they are polled by the central processing unit. In this way, tag detect does not have to occur at the moment the door activity occurs, but may occur from approximately two seconds before to two seconds afterwards.

For approximately two seconds after the end of the activity window, there is a mask which inhibits activity detect. This is done to minimize multiple entries of the same event. At the end of this period another event may occur.

When a tag is detected during an activity window, it remains locked in the buffer until after it is polled by the central processing unit. If the central processing unit is not in monitor mode this can be a long time. When a second event occurs before polling occurs additional tags will continue to be locked into the buffer as door events occur. The buffer can hold up to a maximum of eight tags. When the next poll occurs all tags in the buffer are sent to the central processing unit.

The present method permits reliable detection of up to four tags simultaneously. This is limited by the number of samples stored for evaluation, and represents a practical upper limit for this application of the technology.

The input to the receiver 3 contains a series of pulses. The source of these pulses will be one or more tag transmitters. Each tag transmitter will have a specific pulse rate, this rate will range from approximately 500 Hz to 1000 Hz.

The central processing unit is configured to include a free-running 16 bit counter with a count rate of .5 usec per count. Each time a pulse occurs an interrupt is generated taking the count state and storing it in a table in memory. During the sample period a table of up to 64 pulse events will be created. After the sample period, the table of entries will be evaluated to determine which tag transmitter or transmitters were the source of the pulses

An example shows a table of pulse rates wherein the tag frequency is related to the MPU counter running at 2 Mhz.:

Transmitter Rate (Hz)	CPO Counts	Tag ID No.
1000	2000	1
996	2008	2
992	2016	3
988	2024	4
.		.
.		.
.		
501	3992	

Evaluation of the table of pulse events would be accomplished by starting at the beginning of the table and noting the difference between the first and the second entries. If this difference is between 2000 and 3992, they are probably the result of a single transmitter; if the difference is less than 2000 it is assumed that the two entries are from different transmitters. The third and fourth entries will be examined until a difference between 2000 and 3992 is found. The difference between the two entries will predict a series of table entries which will be tested. If sufficient numbers of these table entries exist the related transmitter will be detected. All the entries in the table related to that transmitter will be deleted. The CPU will return to the beginning of the table and look for a non-deleted entry. If none are found only one transmitter will be detected; if there are still non-deleted entries they will be evaluated as above.

When multiple transmitters are being detected, it is possible for the pulse from one transmitter to occur at the same time as the pulse of another. In this case, a single table entry would be made for both events. For this reason the table would be evaluated to note that a number of the possible counter entries are present, not requiring that all of the possible pulse events are included in the table.

The MPU chosen for this system has a built-in hardware function allowing the counter value to be saved without software intervention. This eliminates the problem of measurement skew as a result of interrupt response latency.

Example 1 - a single transmitter with a 996 pulse rate with pulses 2008 counts apart.

Table		Entry		Difference
1				1 1 6 2 5
2		13633		2008
3		15641		2008
4	17649		2008	
	.			
	.			
	.			
99	nnnnn			

The table entries 1 and 2 would suggest a valid card with the 2008 pulse interval. Entries 3,4,5,6, etc., would be examined to validate that possibility. All entries would be deleted with the value of 11625 + (n x 2008), related to that transmitter. With the exception of spurious noise pulses all entries would be deleted from the table.

Example 2 - two transmitters:

- a first transmitter with the 996 pulse rate with pulses 2008 counts apart;
- a second transmitter with the 976.6 pulse rate with pulses 2048 counts apart.

Table		Entry	Difference
1			2 3 4 2 8
2		23508	80
3			2 5 4 7 6
4			2 5 5 1 6
5			2 7 5 2 4
6			2 9 5 3 2
7			2 9 5 7 2
	.		
	.		
	.		
9 9			n n n n n

The difference between first two table entries is only 80; it is assumed that they are from two different transmitters. The difference between entry 1 and entry 3 is 2048 which is a possible transmitter. The table is examined for all possible entries which will be 23428 + (n x 2048). Entries 3,5,7, etc., are found to satisfy this. The 976.6 transmitter is detected and all related entries are deleted leaving entries 2,4,6, etc. The difference between entry 2 and 4 is 2008 which is a possible transmitter. The table is searched for all possible entries which will be 23508 (n x 2008). n=2 is found at entry 6, etc. A sufficient number of multiples is found and the 996 transmitter is detected. All the entries associated with this transmitter are deleted which will remove the remaining entries from the table.

Communication Protocol

This protocol describes the communication between the central processing unit and the location detector unit.

The main goals of this protocol are as follows:

1. Design for minimum message length and turn-around time to minimize system latency in a heavily populated system.

2. System is always CPU controlled. The central processing unit sends a command to each location detector unit consisting of a polling request or a command, the location detector unit then acknowledges with an appropriate reply.

3. The communication system must be transparent to system configuration, such as number of installed location detector units, location detector units out of service, processor speed, or installation of network.

4. The communication system is based on the installation of from 1 to 30 location detector units.

5. A method of error detection is included to allow repolling of a location detector unit if the location detector unit fails to acknowledge correctly. Each location detector unit will retain the contents of the communication buffer to allow for the possibility of a retransmission request. The repoll flag is reset by polling a different location detector unit. If a repoll is required, it must follow immediately after a failed poll and before a different location detector unit is polled.

The data from the central processing unit will consist of three possible messages: a polling request, a command, or a string of data. Polling request and command bytes are sent last byte first with the address byte last. Block data transfers are made with the lowest address or first byte first, and the highest address byte last.

```
Following Request:
Byte 0    (1 byte)
     100AAAAA          AAAAA = 5 bit address
     |||  ......... not assigned
     ||   ......... 0 = poll
     |........      1 = always 1 for address byte only

Command byte:
(two or more bytes)
Byte 0 -
     110AAAAA          AAAAA = 5 bit address
     |||  ......... not assigned
     ||.........      1 = command byte
     |  ..            1 = always 1 for address byte only
Byte 1 -
     [ command byte described below ]
```

This information is typical of the command format, in fact, new command functions have been added but they follow the general format shown below.

```
Command byte format:
Calibrate command:
(byte 1)
     010RUSSG ...... G - 0 = Threshold
        |||              1 = Gain
        |||  ......  SS - select one of four receivers
        ||      ..    U - 0 = count down
        |                 1 = count up
        | .........     R - 0 = one count
```

1 = 100 counts

Config command: (byte 1)

```
    0010DTSS          SS - select one of four channels
    ||             T - 0 = receiver channel control
      |                1 = turn on\off test tone
      1 ......... D - 0 = turn recv on\test tone off
                       1 = turn recv off\test tone on
```

Special command set:

Status request:

Byte 1 -

```
   00001000 ......... request status word from location
                      detector unit
```

Echo byte:

Byte 1 -

```
   00001001--------- echo following byte back to central
                     processing unit
```

Byte 2 -

```
   0DDDDDDD ......... data byte to echo
```

Dump memory:

Byte 1 -

```
   00001010--------- send 256 bytes of RAM from the HC11
                     back to the CPU. NOTE: This command
                     can only be used with a single
                     location detector unit monitor
                     connected to avoid conflict
                     with other location detector units.
```

Set utilo:

Byte 1 -

```
   000011AB              state
        | .        0 = UTILOA
                   1 = UTILOB
```

Messages from location detector unit:

Acknowledge - no data :

Byte 0 -

```
    000AAAAAA ....... AAAAAA - location detector unit address
```

Byte 1 -

```
    00XXXXXX ........ Number of bytes in tag array
```

Byte 2 -

```
    00XXXXXX ........ Number of hits in tag array
```

Byte 3 -

```
    000012AB ........ Direction sensor B state
          |||         Direction sensor A state
          ||  ....... UTil1 state
          |   ....... Util2 state
```

Byte 4 -

| status byte 1

Byte 5 -

```
    01CCCCCC ........ CCCCCC - checksum
     1 .............. 1 indicates last byte in message
```

Note that last byte bit is only used for variable length messages, i.e., a poll, and is not used for fixed length messages.

Acknowledge - tag data present:

Byte 0 -

010AAAAA   AAAAA - location detector unit address

Byte 1 -

00HHHHHH ..... HHHHHH - high 6 bits of tag number (lsb in bit 0 position)

Byte 2 -

00LLLLLL ..... LLLLLL - low 6 bits of tag number (lsb in bit 0 position)

Byte 3 -

00XXXXXX   Number of bytes in tag array

Byte 4 -

00XXXXXX---------- Number of hits in tag array

Byte 5 -

000012AB ..... Direction sensor B state

||| ..... Direction sensor A state

|| ..... UtilI1 state

| ..... Util12 state

Byte 6 - [Status Byte]

Byte 7.8...(two bytes per tag) (as above)

Byte 9 -

01CCCCCC ..... CCCCCC - checksum

| ..... 1 indicates last byte in message

Note: Checksum is least significant 6 bits of the address without carry sum of the entire message starting with the address byte but excepting the checksum itself.

The number of bytes/number of hits bytes are the results of the last sample. They are significant only to the CALIB functions to descriminate between no tag data and too much noise.

Command response from location detector unit:

All commands result in a response from the location detector unit. The first byte is normally the address byte with the valid tag detect bit set appropriately. The valid tag bit is used in calibration to detect that the gain/threshold has reached the threshold of detection. The second byte of a command response is the command sent by the CPU. Exceptions to this are inherent in the command type, e.g., echo byte and dump memory respond with their appropriate data.

```
Status request:
Byte 0 -
   000AAAAA' ........ AAAAA - location detector unit address

Byte 1 -
   000012AB .......... Direction sensor B state
        |||........... Direction sensor A state
        ||             Util1 state
        |  .......     Util2 state
(status byte.)
Byte 2 -
   00RE0DNA .......    A - 1 = Door activity
      |||||.......... N - 1 = Recv high noise detect
      ||||        .... D - 1 = AB Direction bit
      |||........... not used
      ||  ............ E - 0 = system ready
      |                    1 = error condition
      |  ............... R - 0 = normal
                        1 = system has reset since last
                            poll
Echo byte request:
Byte 0 -
   000AAAAA .......... AAAAA location detector unit address

Byte 1 -
   0DDDDDDD           Echo byte sent by central
                      processing unit
```

To reduce the difficulty of servicing systems in remote locations, the present system is including the capability to do maintenance, troubleshooting, and calibration from a remote location using modems.

In the event that something occurs at a given location detector unit location, which has the effect of changing the performance of "gain" of the antenna 1, then the system will not function as intended, and it is necessary then to adjust the performance of the receiver 3 by adjusting the gain. It is not normally intended that this function shall be carried out by the security staff at the facility itself. It is preferable that it be carried out by the service personnel installing the system. For this reason, a modem 14 is provided, connected to the central processing unit 7. When the security personnel notice that any portion of a location detector unit U is not functioning satisfactorily, they will plug in a telphone 18 at jack 17, at that unit U. They will then telephone via CPU 7 and modem 14 to the manufacturer or distributor who is supplying the service. The service personnel will then connect their CPU 20 in their premises via the modems 22 and 14 with the central processing unit 7. Through suitable software programs, the serviceman can then check the condition of the microprocessor and the receiver 3 at the location in question, via the receiver sensitivity circuit. In this way, they can test and evaluate the condition of all of the components and circuits in both the door processing unit 4 and the receiver 3. Once the problem is determined, and assuming it is a problem affecting the gain of the receiver 3, then the receiver 3 is adjusted so as to correct the gain of the receiver 3 back to its optimum performance. If, on the other hand, some other problem is detected, then it is simply necessary for the security personnel at the facility to replace either the door processing unit 4 or the receiver 3 with a backup unit, and return the faulty one to the service personnel for repair.

As shown on Figure 12, all CPU systems in the field are supplied with two serial ports. One is connected to the master concentrator units and one is connected to a modem 14. In normal operation, the modem 14 is optionally used to support the paging capability. In the remote diagnostic mode, the modem 14 is used to allow a remote system to access a location detector unit U permitting diagnostic and calibration functions.

The communication link between the central processing unit and the location detector unit is a poll/response system. The central processing unit sends a poll or command request and the addressed location detector unit responds with the poll status or a command acknowledge. The data rate is 480 baud. The remote diagnostic capability uses the same arrangement except that the data transmission rate is 2400 baud. The polling and command requests originate from the computer at the service facility. The response to polling and command data from the location detector units will be sent back over the telephone line to the central processing unit at the service location. At the service computer, the response data is used to control display information such that the tech support person at the service facility is seeing the same screen information as would be presented on the central processing unit.

In the remote diagnostic mode, the central processing unit acts only as a communication buffer. It accepts a polling request at 2400 baud from the modem and sends it out via the other serial channel to the location detector unit. The central processing unit then accepts the response from the location detector unit and sends it out to the service computer at 2400 baud.

In addition to the normal polling functions, the remote support function also provides for file transfers between the two systems. At the beginning of a diagnostic session, the significant data files are transferred from the remote system to the service facility computer. This allows the service computer to see the system with the same setup as the central processing unit. At the end of the diagnostic session, the modified files are sent back to the central processing unit to reflect the changes made during the diagnostic session.

Claims

1. An identification system comprising:
a plurality of individual tag means T adapted to be carried on the person, and adapted continuously to emit tag signals containing coded information at a predetermined frequency and unique pulse rate;
at least one location detector unit U adapted to be placed at a monitor location, said detector unit, in turn, comprising:
a signal processing unit 4 having microprocessor means;
antenna means 1 adapted to receive tag signals from said tags, and being connected to said signal processing unit 4;
direction sensor means 2 adapted to generate direction signals responsive to the movement of an individual adjacent to said detector unit U, and connected to said signal processing unit 4, whereby said unit will detect tag signals from said antenna means and said direction signals received from said direction sensor means, wherein said direction sensor means is adapted to be activated only when said individual is passing said detector unit U, and,
central processor means 7 adapted to communicate with said at least one detector unit U, and to receive from said detector unit movement signals indicating the movement of an individual from one monitor location to the other.

2. An identification system is claimed in Claim 1, and wherein said signal processing unit 4 responds both to said direction signals, and to said tag signals, and records information from both said signals, and subsequently communicates information from both said signals to said central procesisng means 7.

3. An identification system is claimed in Claim 1 and wherein said signal processing unit 4 will respond to said direction signals, and to an absence of tag signals, and store said information, and subsequently communicates same to said central processing means 7.

4. An identification system is claimed in Claim 1 and including polling means 6, for communicating with said signal processing units 4 in sequence, whereby a said signal processing unit 4 will communicate information stored therein to said central processing means 7 only when said polling means 6 is

communicating with said signal processing unit 4.

5. An identification system as claimed in Claim 1 wherein said signal processing unit 4 is also adapted to communicate a location signal, together with said movement signal.

6. An identification system as claimed in Claim 1 in which said direction sensor means 2 is further responsive to movement of a said individual relative to said direction sensor means 2, both towards and away therefrom.

7. An identification system as claimed in Claim 2 including a plurality of said detector units U, and data concentrator means 5 for receiving signals from said plurality of detector units U, for communication to said central processing means 7.

8. An identification system as claimed in Claim 1 and further including receiver means 3 connected to said antenna means 1 and, in turn, connected to deliver signals from said antenna means to said signal processing unit 4, whereby to amplify signals from said antenna means 1.

9. An identification system as claimed in Claim 1 and including gain control means 3 operable to adjust said receiver means.

10. An identification system as claimed in Claim 1 wherein said direction sensor means 2 comprises heat responsive sensor means, adapted to sense the heat of an individual moving relative to said direction sensor means 2, and to sense the direction in which said individual is moving.

11. An identification system as claimed in Claim 1 including control means 17 for each said detector unit and connectible to said central processing unit to control the performance and sensitivity of each of said detector units U.

12. An identification system as claimed in Claim 11 wherein said control means includes telephone connection means 17 placed at each said location detector unit U, and telephone communication means 14 connected to said central processing unit 7, and adapted to communicate through a telephone system to a remote service location 20 whereby each said door processing unit U can be connected directly, through said central processing unit 7 to said remote service location 20 for checking of its circuits and for adjustment of said receivor and gain control.

13. An identification system is claimed in Claim 1 wherein said direction sensing means 2 comprises first and second direction sensing devices, each said device is emitting first and second beams, said beams being located in spaced-apart planes whereby to determine the direction of movement of an individual therethrough.

14. The method of identification of individuals and their locations within a facility, said method comprising the steps of:
detecting an individual passing through at least one monitored location by means of at least one detector unit U;
evaluating the identity and direction of movement of said individual by said detector unit U;
storing received information concerning the movement of said individual in said detector unit U;
transmitting said stored information to a central processing unit 7, adapted to communicate with said detector unit U, and,
analyzing and storing said transmitted information in said central processing unit 7.

15. The method according to Claim 14 further comprising a step of controlling the sensitivity and performance of said detector unit U by means of said central processing unit 7.

16. The method according to Claim 14 further comprising a step of emitting by said central processing unit 7 an appropriate command to a security personnel in case of unauthorized movement of one of said individuals.

17. The method according to Claim 14 wherein there are a plurality of monitored locations and a like plurality of location detector units U and wherein said central processing unit 7 receives the information from said detector units U by means of polling.

18. The method according to Claim 14 wherein said individuals are provided with an individual tag means T adapted to be carried on the person, and adapted continuously to emit tag signals containing coded information at a predetermined frequency and a unique pulse rate.

19. The method according to Claims 14 and 18 wherein said detector unit U comprises:
a signal processing unit 4 having microprocessor means;
antenna means 1 adapted to receive tag signals from said tags T, and being connected to said signal processing unit 4, and,
direction sensor means 2 adapted to generate direction signals responsive to the movement of an individual adjacent to said detector unit U, and connected to said signal processing unit 4, whereby said unit will respond to tag signals from said antenna means 1 only when said direction signals have been received from said direction sensor means 2 and wherein said direction sensor means 2 is adapted to be activated

only when said individual is passing said detector unit U.

20. The method according to Claim 19 wherein in said detecting step said signal processing unit 4 responds both to said direction signals, and said tag signals, and record information from both said signals, and subsequently communicates information from both said signals to said central processing unit 7.

21. The method according to Claim 19 wherein said signal processing unit 4 will respond to said direction signals, and to the absence of tag signals, and store said information, and subsequently communciates same to said central processing unit 7.

22. The method according to Claim 19 wherein in said detecting step said signal processing unit 4 will respond to said direction signals, and store said information, and subsequently communicate same to said central processing unit 7.

23. The method according to Claims 17 and 19 wherein said polling is provided by polling means 6, whereby said signal processing unit 4 will communicate information stored there into said central processing unit 7 only when said polling means 6 is communicating with said processing unit 4.

24. The method according to Claim 19 wherein said signal processing unit 4 is also adapted to communicate a location signal, together with said movement signal.

25. The method according to Claim 19 wherein said direction sensor means 2 is further responsive to movement of said individual relative to said direction sensor means, both towards and away therefrom.

26. The method according to Claims 18 and 19 wherein said detector unit U detects the presence of said tag signal at least twice, and thereafter stores information of said tag signal.

27. The method according to Claim 26 including the step of generating a tag factor number and assigning same to said tag signal.

28. The method according to Claim 27 including the step of varying said tag factors in response to the presence or absence of further said tag signals after said storing thereof.

29. The method according to Claim 26 wherein detecting of said tag signal is provided by means of tag factor and wherein the information of the presence of said tag signal is locked in the memory of said detector unit U only when said tag factor exceeds predetermined threshold value.

30. The method according to Claim 29 wherein said locked information about the presence of said tag signal is transmitted to said central processing unit 7 by means of polling.

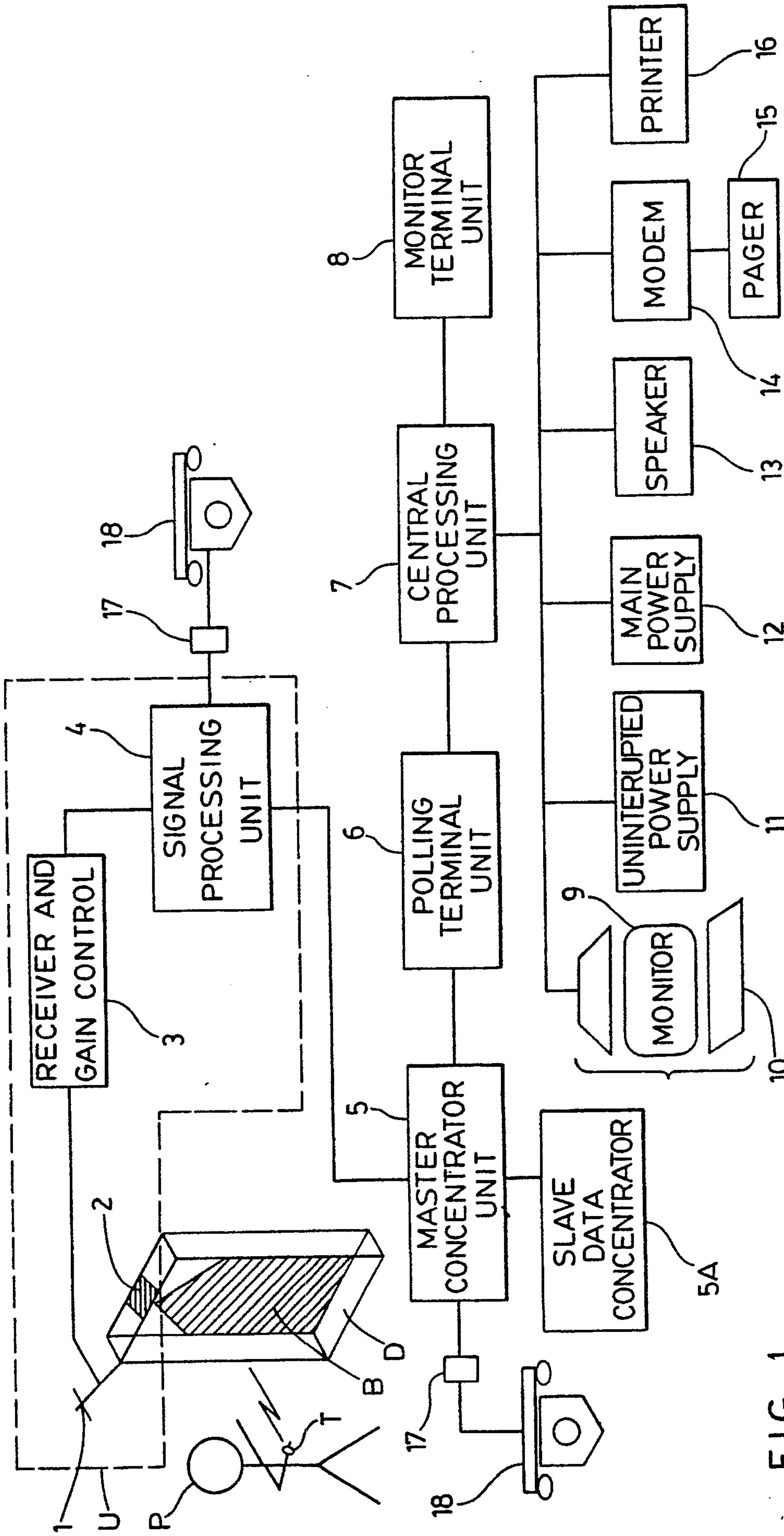
RECEIVER AND GAIN CONTROL
SIGNAL PROCESSING UNIT
MASTER CONCENTRATOR UNIT
SLAVE DATA CONCENTRATOR
POLLING TERMINAL UNIT
CENTRAL PROCESSING UNIT
MONITOR TERMINAL UNIT
MONITOR
UNINTERUPTED POWER SUPPLY
MAIN POWER SUPPLY
SPEAKER
MODEM
PAGER
PRINTER
1
2
3
4
5
5A
6
7
8
9
10
11
12
13
14
15
16
17
18
U
P
T
B
D

FIG. 1

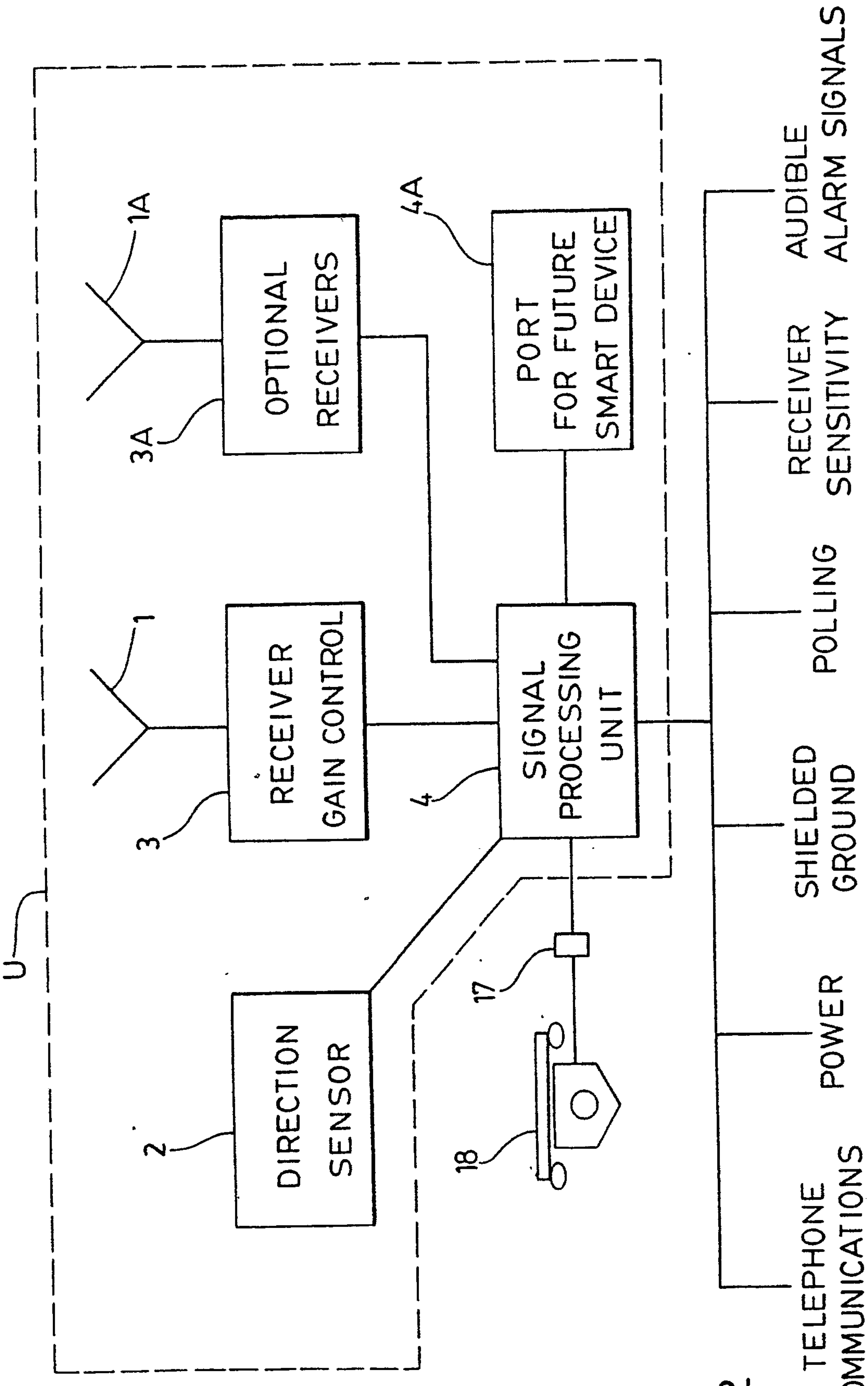
U
1A
3A
OPTIONAL RECEIVERS
4A
PORT FOR FUTURE SMART DEVICE
1
3
RECEIVER GAIN CONTROL
4
SIGNAL PROCESSING UNIT
2
DIRECTION SENSOR
17
18
AUDIBLE ALARM SIGNALS
RECEIVER SENSITIVITY
POLLING
SHIELDED GROUND
POWER
TELEPHONE COMMUNICATIONS

FIG. 2

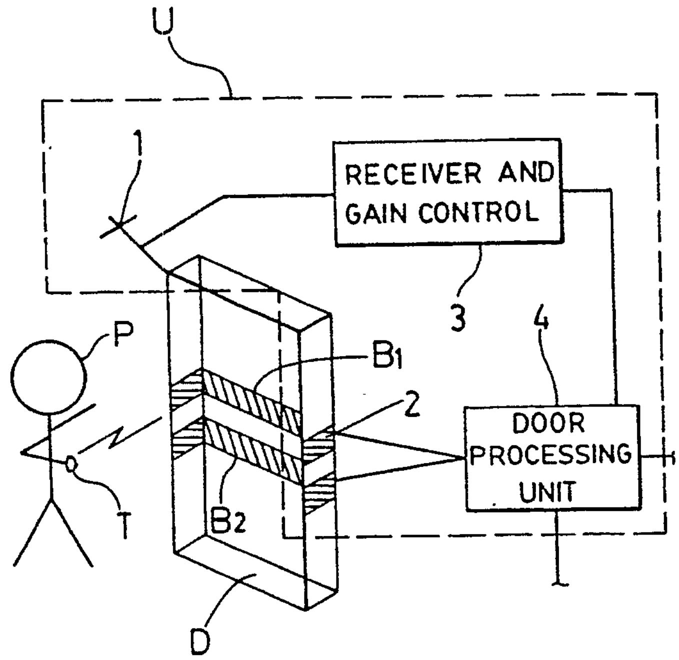
U
1
RECEIVER AND GAIN CONTROL
3
4
P
B1
2
DOOR PROCESSING UNIT
T
B2
D

FIG. 3

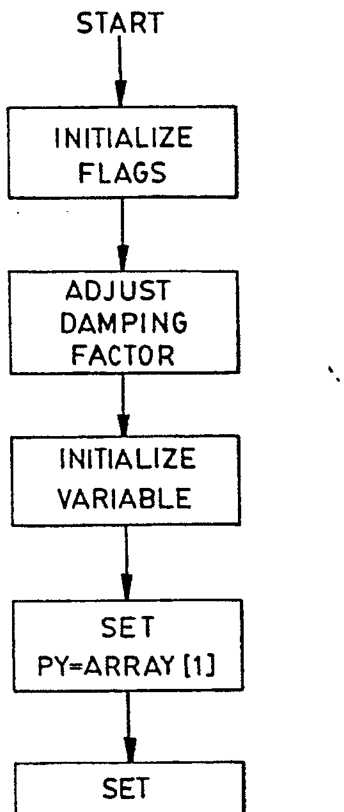
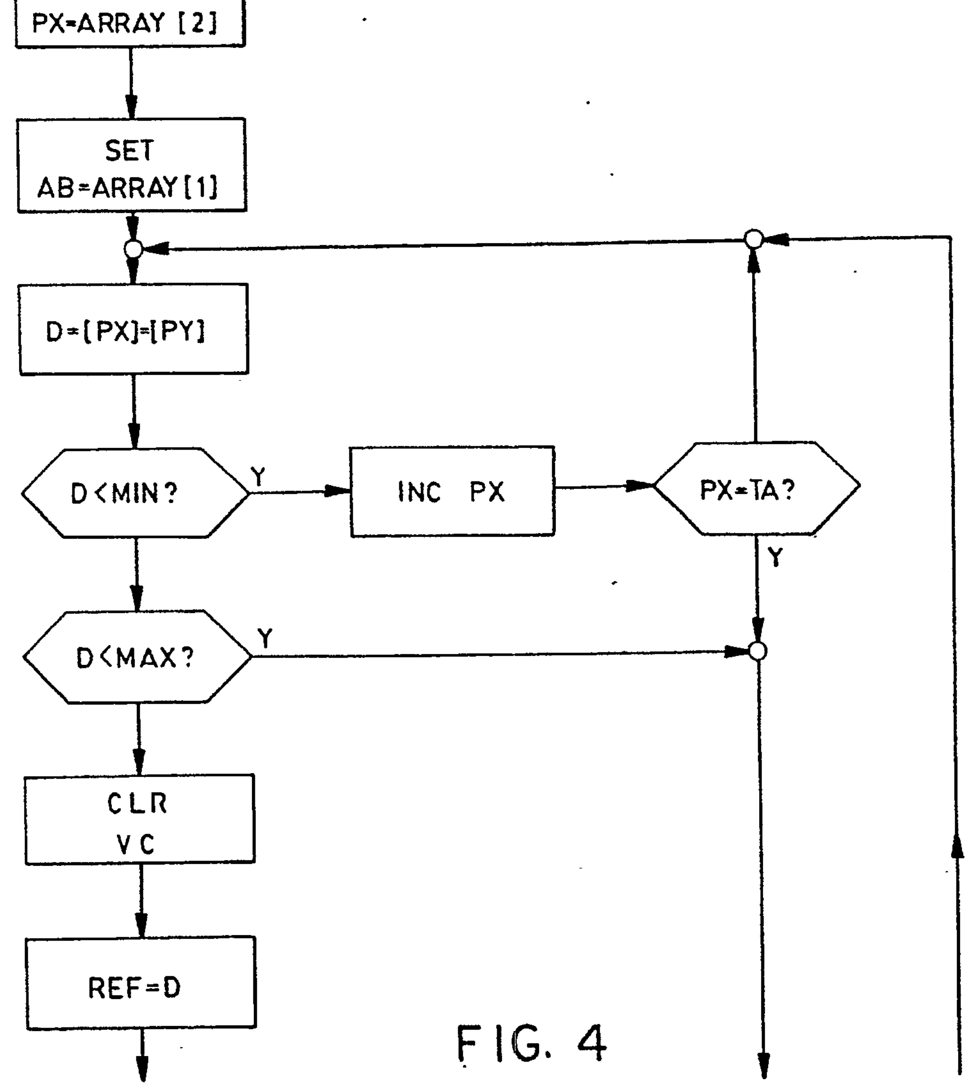
START
INITIALIZE FLAGS
ADJUST DAMPING FACTOR
INITIALIZE VARIABLE
SET PY=ARRAY [1]
SET PX=ARRAY [2]
SET AB=ARRAY [1]
D=[PX]-[PY]
D<MIN?
Y
INC PX
PX=TA?
Y
D<MAX?
Y
CLR VC
REF=D

FIG. 4

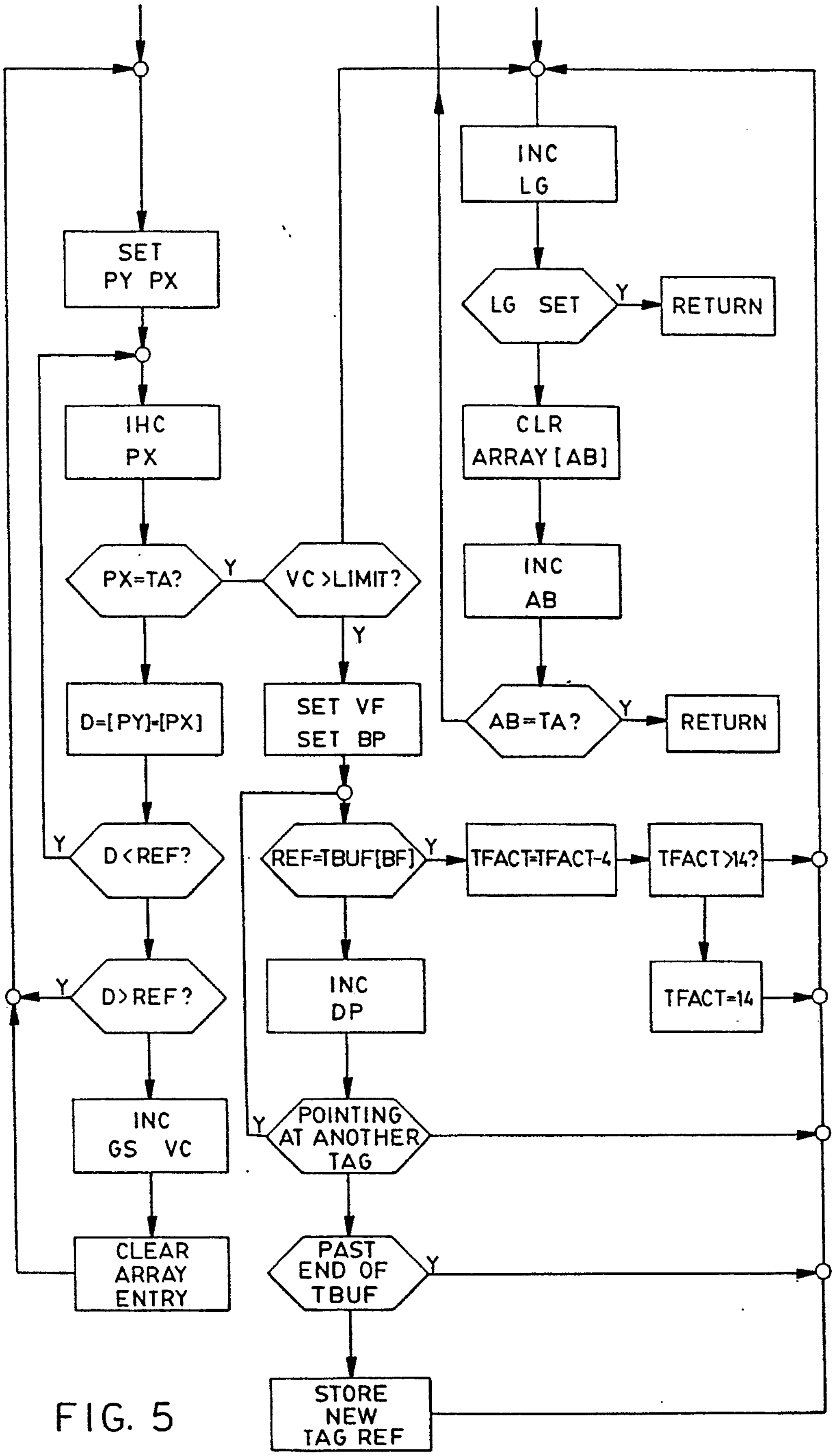
SET
PY PX
IHC
PX
PX=TA?
Y
VC >LIMIT?
Y
D=[PY]-[PX]
SET VF
SET BP
Y
D<REF?
REF=TBUF[BF]
Y
TFACT=TFACT-4
TFACT>14?
Y
D>REF?
INC
DP
TFACT=14
INC
GS VC
Y
POINTING
AT ANOTHER
TAG
CLEAR
ARRAY
ENTRY
PAST
END OF
TBUF
Y
STORE
NEW
TAG REF
INC
LG
LG SET
Y
RETURN
CLR
ARRAY [AB]
INC
AB
AB=TA?
Y
RETURN

FIG. 5

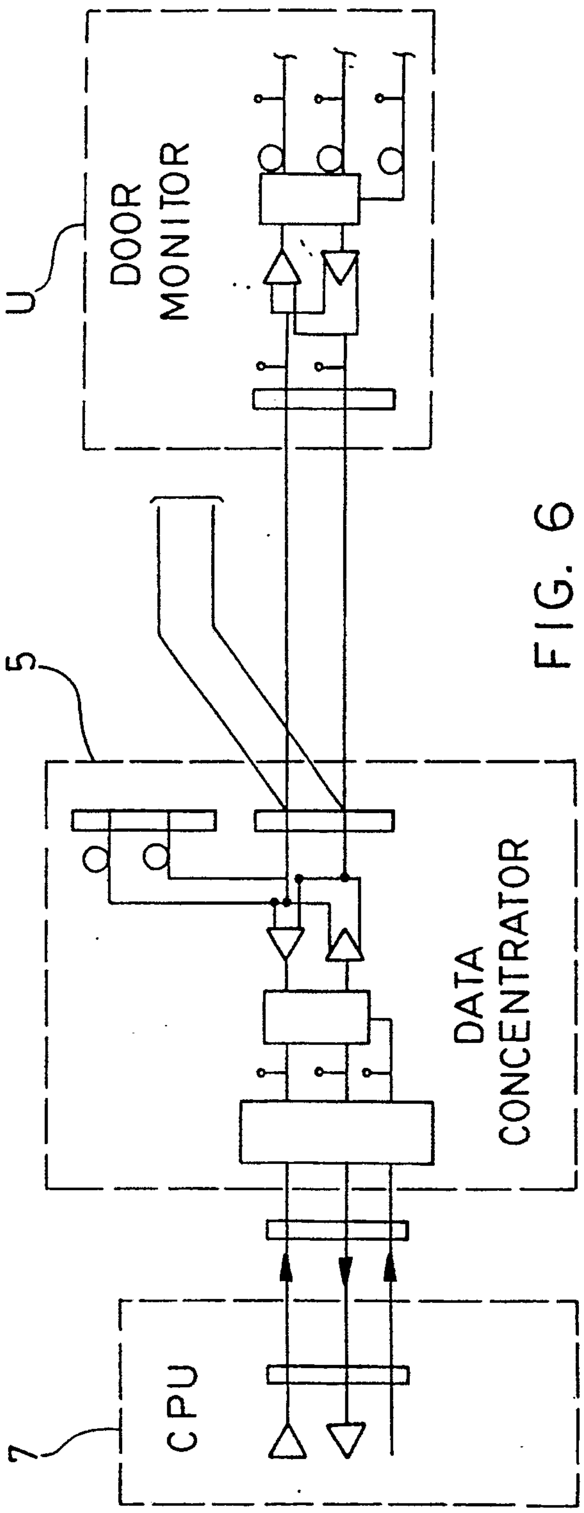
U
DOOR
MONITOR
5
DATA
CONCENTRATOR
7
CPU

FIG. 6

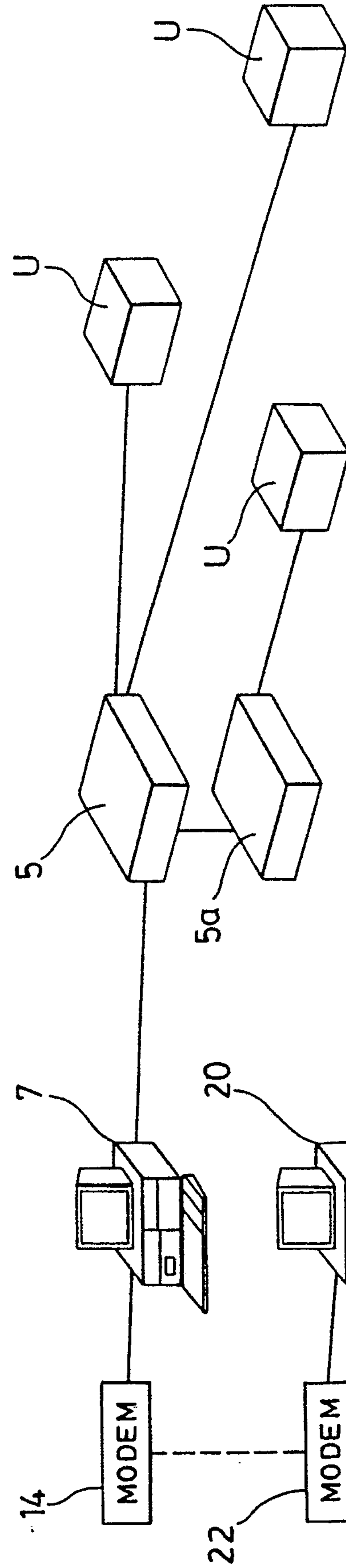
U
U
U
5
5a
7
20
MODEM
MODEM
14
22

FIG. 13

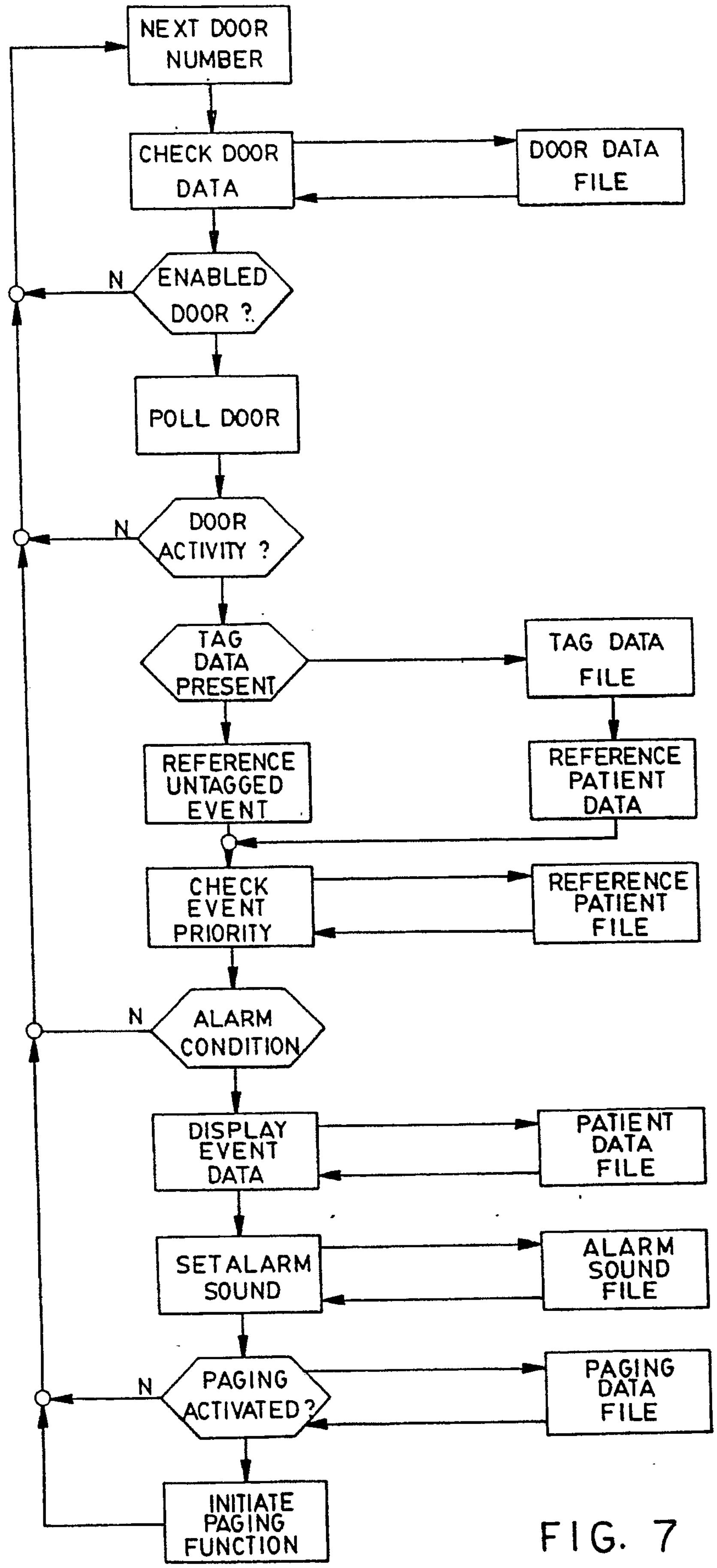
NEXT DOOR NUMBER
CHECK DOOR DATA
DOOR DATA FILE
N
ENABLED DOOR ?
POLL DOOR
N
DOOR ACTIVITY ?
TAG DATA PRESENT
TAG DATA FILE
REFERENCE UNTAGGED EVENT
REFERENCE PATIENT DATA
CHECK EVENT PRIORITY
REFERENCE PATIENT FILE
N
ALARM CONDITION
DISPLAY EVENT DATA
PATIENT DATA FILE
SET ALARM SOUND
ALARM SOUND FILE
N
PAGING ACTIVATED?
PAGING DATA FILE
INITIATE PAGING FUNCTION

FIG. 7

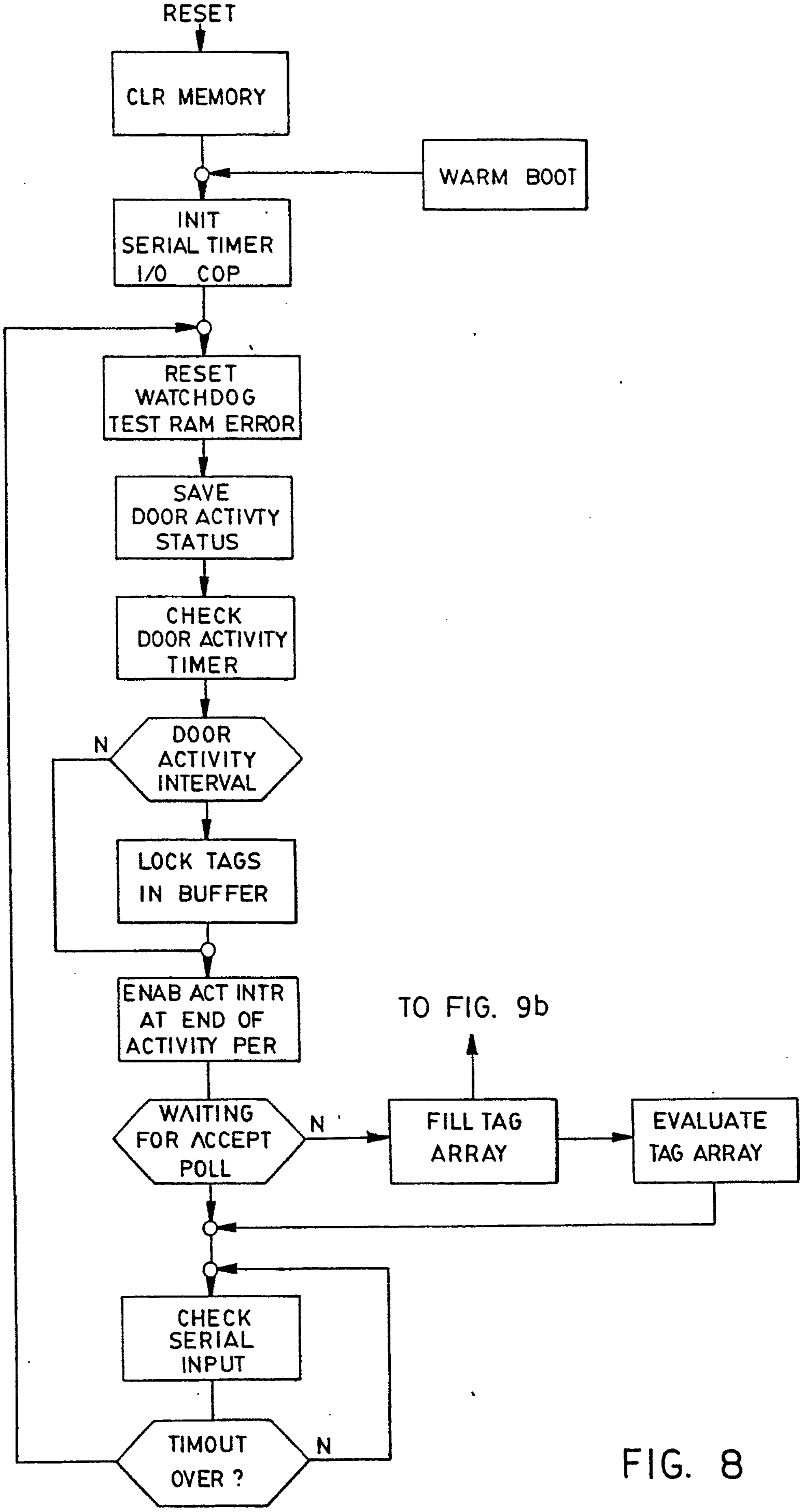
RESET
CLR MEMORY
WARM BOOT
INIT SERIAL TIMER I/O COP
RESET WATCHDOG TEST RAM ERROR
SAVE DOOR ACTIVTY STATUS
CHECK DOOR ACTIVITY TIMER
DOOR ACTIVITY INTERVAL
N
LOCK TAGS IN BUFFER
ENAB ACT INTR AT END OF ACTIVITY PER
TO FIG. 9b
WAITING FOR ACCEPT POLL
N
FILL TAG ARRAY
EVALUATE TAG ARRAY
CHECK SERIAL INPUT
TIMOUT OVER ?
N

FIG. 8

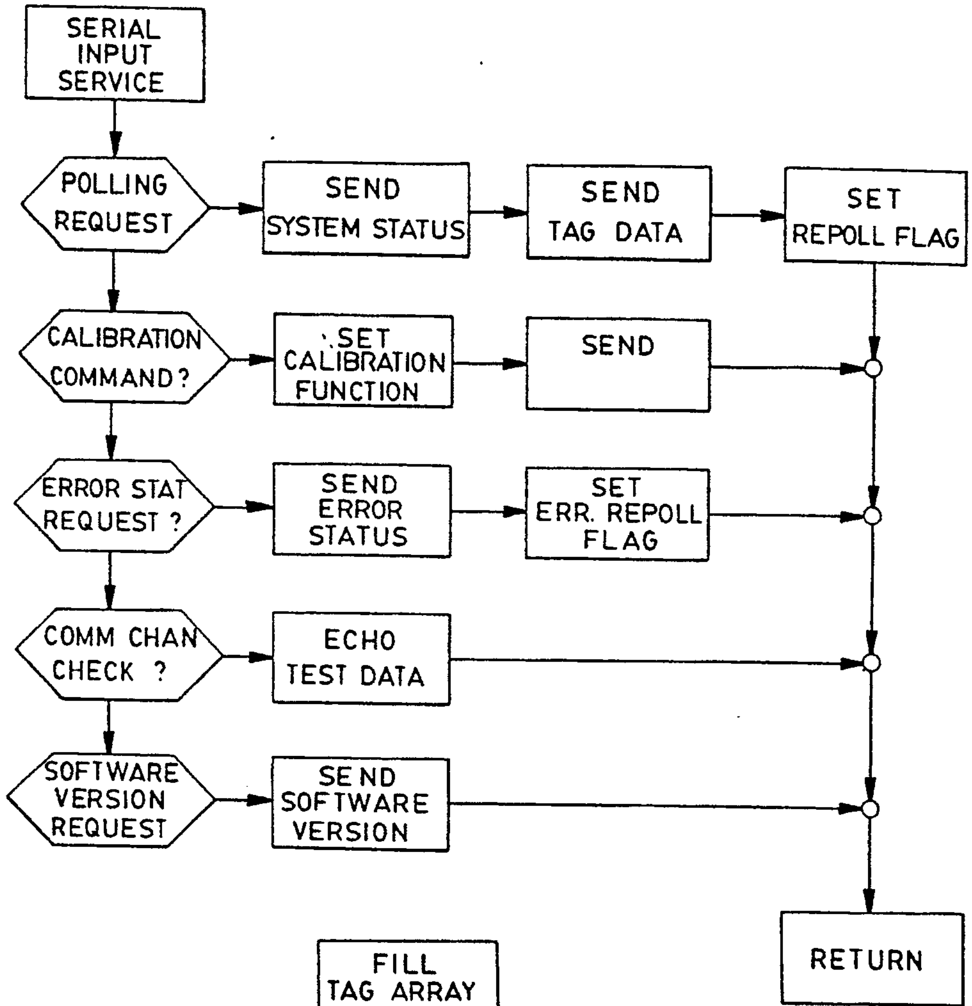
SERIAL INPUT SERVICE
POLLING REQUEST
SEND SYSTEM STATUS
SEND TAG DATA
SET REPOLL FLAG
CALIBRATION COMMAND?
SET CALIBRATION FUNCTION
SEND
ERROR STAT REQUEST ?
SEND ERROR STATUS
SET ERR. REPOLL FLAG
COMM CHAN CHECK ?
ECHO TEST DATA
SOFTWARE VERSION REQUEST
SEND SOFTWARE VERSION
RETURN

FIG. 9a

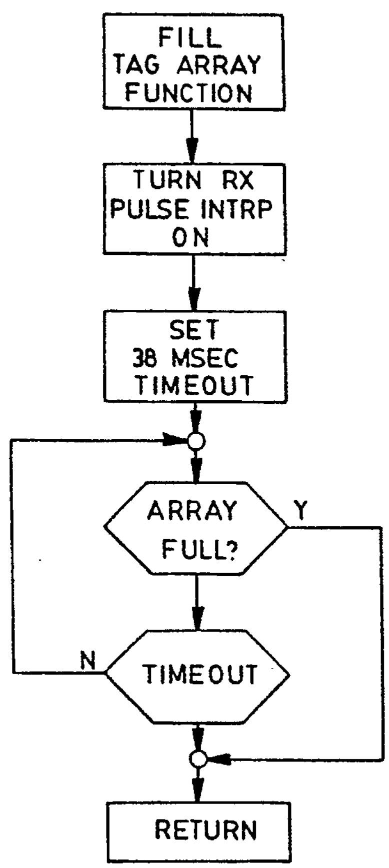
FILL TAG ARRAY FUNCTION
TURN RX PULSE INTRP ON
SET 38 MSEC TIMEOUT
ARRAY FULL?
Y
TIMEOUT
N
RETURN

FIG. 9b

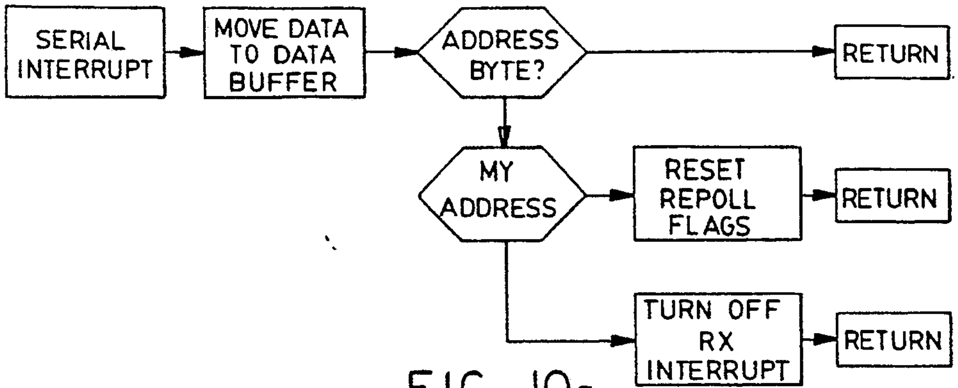

FIG. 10a

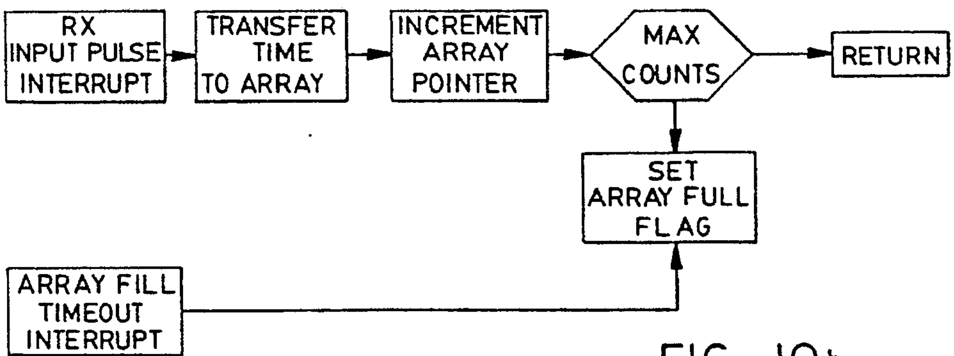

FIG. 10b

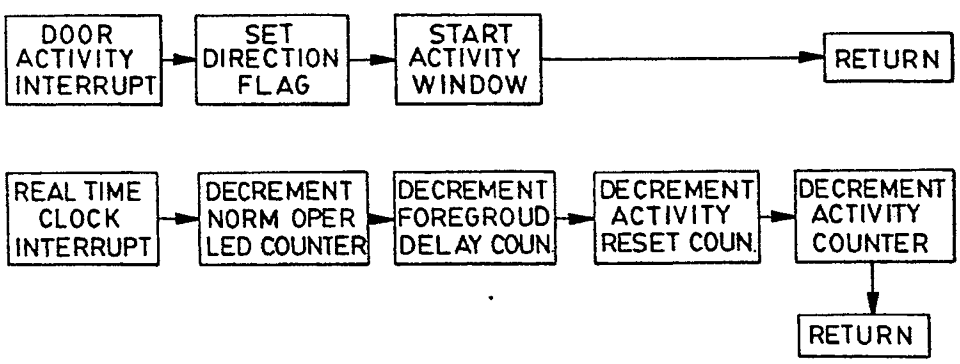

FIG. 10c

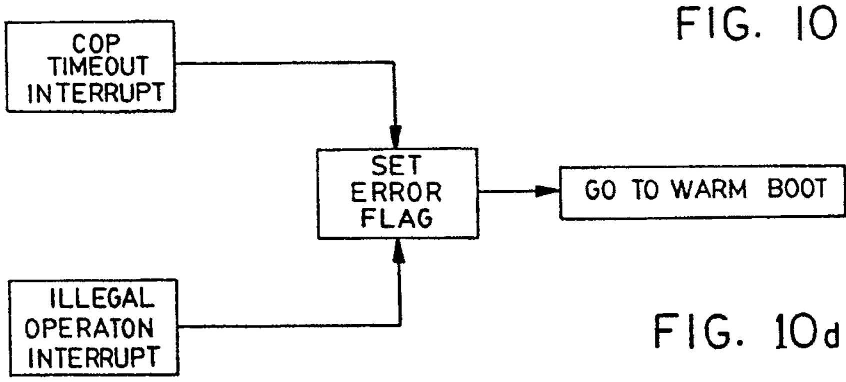

FIG. 10d

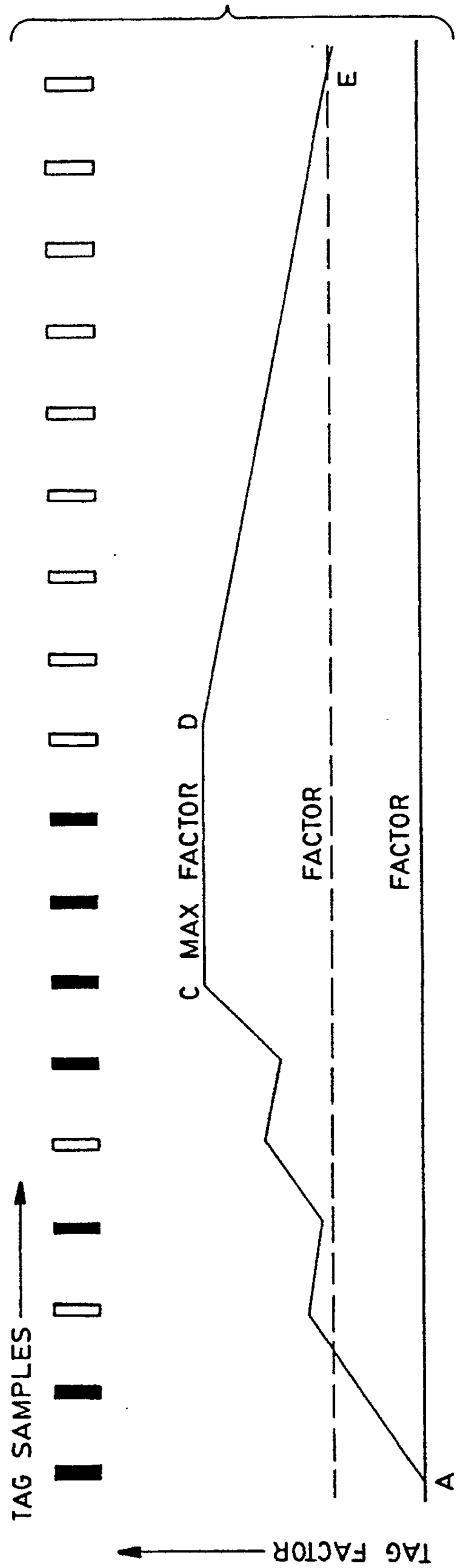
TAG SAMPLES
TAG FACTOR
A
C
MAX FACTOR
D
E
FACTOR
FACTOR

FIG. 11

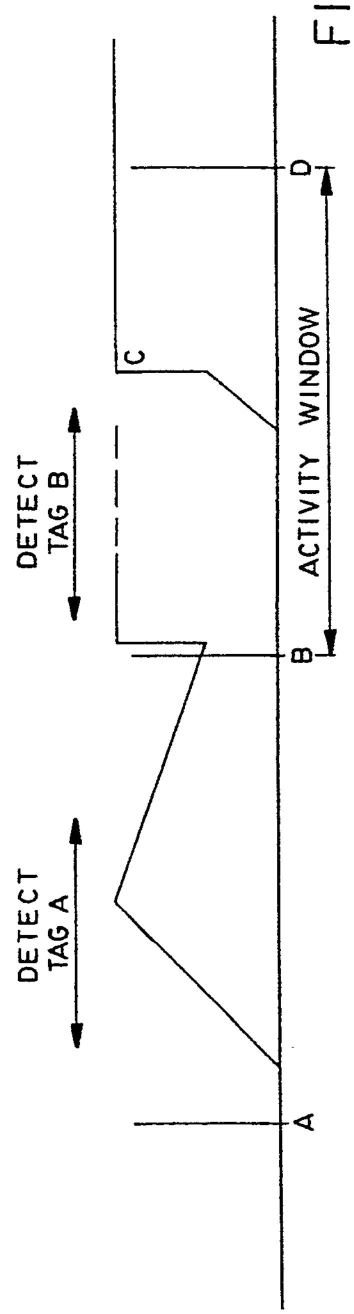
DETECT TAG A
DETECT TAG B
A
B
C
D
ACTIVITY WINDOW

FIG. 12