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(71) Applicant *(for all designated States except US)*: MICROLISE LIMITED [GB/GB]; Farrington Way, Eastwood, Notthingham NG16 3AG (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: NIXON, Lee [GB/GB]; 17 Rolleston Drive, Arnold, Nottinghamshire NG5 7JA (GB).

(74) Agents: SKINNER, Michael et al.; Swindell & Pearson, 48 Friar Gate, Derby DE1 1GY (GB).

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(54) Title: RFID PORTAL ARRANGEMENTS

(57) Abstract: An RFID portal arrangement (10) can detect the passage of RFID tags (12) past the arrangement (10). First and second antennas (14, 16) communicate with the tags. A sequence of transactions is conducted with each tag (12), using one or both antennas (14, 16). Each antenna (14, 16) has a respective region (22) within which it may communicate with RFID tags. Accordingly, monitoring the sequence of transactions with each tag allows detection of a tag moving from one region (22A) to the other (22B), in either direction, or remaining within one of the regions (22A, B), or entering one of the regions without moving on to the other region.

RFID Portal Arrangements

The present invention relates to RFID portal arrangements.

RFID (Radio Frequency Identification) technology has become increasingly widely used in recent years. Small radio devices, called tags, are attached to articles or their containers. Each tag includes a small radio antenna and control circuit. The tag can communicate with an external interrogating device (often called a "reader") to indicate its presence, and to identify itself or the item to which it is attached. Consequently, RFID technology provides the possibility of monitoring items as they pass along a supply chain, for example.

Locations at which RFID tags are interrogated are commonly called "portals", because they are often located at the entrance or exit to premises, such as warehouses, store rooms of retail shops, or the like. The portal typically incorporates a detection arrangement which includes a reader and an antenna and can communicate with an RFID tag in the vicinity of the portal, allowing the presence of the tag at the portal to be detected. Although an RFID portal is commonly associated with a doorway or other conventional access point, and is thus called a portal, it is to be understood that in this specification, the term "portal" is used more broadly and by analogy, to refer to any arrangement providing communication with RFID tags in the vicinity of the portal.

The present invention provides an RFID portal arrangement for detecting the passage of RFID tags past the portal arrangement, comprising first and second antenna means operable to communicate with tags passing the portal arrangement, and control means operable to conduct a sequence of transactions with each RFID tag, while passing the arrangement, and to determine the sequence of antenna means used for the sequence of transactions, the control means being further operable to use the antenna sequence to recover information relating to the direction of movement of the correspondence RFID tag relative to the portal arrangement.

Preferably, at least one antenna means is directional, to define a region within which communication can be established with RFID tags. Preferably both antenna means are directional. The regions defined by respective antenna means are preferably substantially without overlap.

The control means may operate to detect an antenna sequence which uses substantially only a first of the antenna means and subsequently uses substantially only a second of the antenna means, to indicate movement past the portal arrangement in the direction from the region of the first antenna means to the region of the second antenna means. The control means may be operable to interpret a minimum number of consecutive uses of a first of the antenna means, without any use of the second antenna means, as a sequence which uses substantially only that antenna means.

The control means may be operable to update a record of RFID tags which have been detected. The record may include information relating to the last detected direction of movement relative to the portal arrangement.

The portal arrangement is preferably operable for communication with passive RFID tags. The portal arrangement is preferably operable for communication with RFID tags at UHF frequencies. The portal arrangement is preferably mobile and preferably vehicle-mounted. The portal arrangement may be mounted in the vicinity of an entry point to the vehicle, to detect RFID tags entering or leaving the vehicle and to distinguish between entering and leaving. The control means may maintain a record of RFID tags which have entered the vehicle, at least until they are detected leaving the vehicle, thereby identifying the RFID tags currently on the vehicle.

The invention also provides a vehicle having an RFID portal arrangement as defined above.

Examples for the present invention will now be described in more detail, by way of example only, and with reference to the accompanying drawings, in which:-

Fig. 1 is a schematic diagram of a portal arrangement;

Figs. 2 and 3 are flow diagrams of procedures used in the arrangement of Fig. 1;

Fig. 4 is a schematic diagram of a vehicle in which a portal arrangement is fitted; and

Fig. 5 is a diagram of a tracking system using static and mobile portal arrangements.

Fig. 1 illustrates an RFID portal arrangement 10 for detecting the passage of RFID tags 12 past the arrangement 10. The portal 10 comprises first antenna means 14 and second antenna means 16. The antenna means 14, 16 are operable to communicate with the tags 12, as they pass the portal 10. Control means indicated generally at 18 are operable to conduct a sequence of transactions with each tag 12 whilst passing the portal 10, and to determine the sequence of antenna means 14, 16 used for the sequence of transactions. The control 18 is further operable to use the antenna sequence to recover information relating to the direction of movement of the corresponding tag 12, relative to the portal 10.

In more detail, each tag 12 is shown attached to an item 20, which may be an item of commerce or a container. Each tag 12 incorporates information identifying itself and may also incorporate information identifying the item 20 to which the tag 12 is attached. Alternatively, the identify of the tag 12 may be sufficient to identify the item 20, from a record of the item to which the tag 12 has been attached, prior to use.

Each antenna means 14, 16 is illustrated as having a transmitting antenna 14A, 16B and a receiving antenna 14A, 16B. Alternatively, a single antenna can be used for transmission and reception. The following description can readily be related to the use of single antennae 14, 16 for both reception and transmission by considering the single antenna, when in transmission mode, separately from the same antenna, when in reception mode.

Each antenna 14A, 14B, 16A, 16B preferably has directional characteristics, so that communication is possible substantially only in a particular direction or range of directions relative to the antenna means 14, 16. Both the transmitting antenna and the receiving antenna may be directional, or one may be directional and the other omni-directional.

Consequently, each antenna means 14, 16 defines a region 22A, 22B within which communication can be established with tags 12. A tag 12 outside the region 22 will normally not be able to communicate with the corresponding antenna means 14, 16.

The regions 22, defined by the respective antenna means 14, 16 are shown in Fig. 1 as being substantially without overlap. This is a preferred arrangement.

In this embodiment, the antennas 14, 16 and tags 12 operate at UHF frequencies. For example, UHF RFID systems currently operate in Europe at a frequency band based on around 865 to 868MHz. In the U.S. UHF RFID systems work at a frequency band based on 915MHz. Other UHF frequencies could be chosen, but will normally be required to comply with a standard in order to achieve interoperability and to comply with spectrum licence arrangements.

The skilled reader will be aware of many technologies for achieving directional antennae at UHF frequencies. For example, directional plate antennae could be used.

The control means 18 is illustrated as including an RF generator 24 able to drive the transmitter antennae 14A, 16A under control of a central processor 26, which may be a computer, microprocessor or the like. The processor 26 can instruct the generator 24 to create UHF signals for transmission from a specified antenna 14A, 16A and which can be either a general call asking for tags 12 to identify themselves, or a specific call addressed to a particular tag 12. Alternatively, each antenna 14A, 16A may have an associated RF generator, in which case the processor 26 will choose which generator to instruct, thereby making use of the corresponding antenna 14A, 16A.

This example is based around passive RFID tags 12, which receive signals from the transmitting antennae 14A, 16A (when present within the corresponding region 22) and use part of the energy of the incoming signal to power the internal systems of the tags 12. This allows the signal content of the transmitting signal to be assessed, particularly to distinguish between a general call and a specific call. If the tag 12 detects a general call, a reply is sent to identify the tag 12, allowing its presence to be detected. If a specific call is received, addressed to the receiving tag 12, an appropriate reply is sent, which may be a reply providing information such as to confirm the identity of the tag 12, or to provide information about the item 20.

Consequently, each of the antenna means 14, 16 can continuously monitor the corresponding region 22A, 22B, identifying tags 12 from their responses to general calls, as they move into the area, and maintaining contact with the tags 12 by means of specific calls, until the tags 12 leave the corresponding region 22A, 22B.

Signals returned from the tags 12 to the corresponding receiving antenna 14B, 16B are passed to a decoding circuit 28 which passes the decoded signal to the processor 26.

Accordingly, the processor 26 is able to initiate general calls by means of the generator 24, and listen to replies, through the decoder 28. Once a tag 12 has been detected as present in one of the regions 22, further transactions with the particular tag 12 can be controlled by the processor 26, by instructing specific calls to that tag, and listening for replies.

When instructing the generator 24, the processor 26 will indicate which transmitting antenna 14A, 16A is to be used. Signals from the decoder 28 to the processor 26 will identify the receiving antenna 14B, 16B which received the reply from the corresponding tag 12. Accordingly, the processor 26 has information, in relation to each transaction with a tag 12, identifying the antenna means 14, 16 used for the transaction and thus, identifying the region 22 in which the tag 12 is currently located. This allows the processor 26 to use a sequence of transactions with a particular tag 12 to recover information relating to the direction of movement of the tag, relative to the portal 10, as can now be described in more detail.

When a tag 12 first enters the region 22A of the first antenna means 14, for example, the tag 12 will respond to a general call from the first transmitting antenna 14A. This is sent as step 32 of Fig. 2, which is the sequence of steps used for one of the antennae 14, 16. The same sequence is also used for the other. The response is received at 34. The processor 26 identifies the tag 12 at 36 and allows the processor 26 to determine that the identified tag 12 is in the region 22A. Calls are transmitted from the antenna means 14, 16 many times a second, such as at 50Hz. Consequently, it is possible to assume that a tag 12 will respond a plurality of times from within a particular region 22, even if moving through that region 22.

The processor 26 monitors for repeated responses from a particular tag 12, by sending repeated calls specific to the identified tag, at 38. Replies are received at 40. The processor 26 also identifies the sequence of antenna means used for the transactions. Thus, in this example, a sequence which uses substantially only the first antenna means 14 will be identified, while the tag 12 is in or passing through the region 22A.

In this example, the processor 26 incorporates an algorithm which requires a minimum number of consecutive uses of one of the antenna means 14, 16, without any use of the other antenna means 16, 14, before interpreting that sequence as indicating that only that antenna means is being used, and thus that the tag 12 is within the region 22A or 22B. This helps avoid problems arising from spurious responses, such as reflected signals, which might suggest the presence of the RFID tag 12 in one region 22A, 22B, when the tag 12 is in fact in the other region 22B, 22A, or outside both regions. In this example, a minimum of three consecutive uses of one or other antenna means 14, 16 is required, before the processor 26 interprets the sequence as indicating that the tag 12 is in the corresponding region 22A, 22B. The minimum number is assessed at step 42. Other values could be used for the minimum number. If the minimum number has not been reached, a further specific call is made (step 38). When the minimum number has been reached, step 44 makes the decision that the tag is in the corresponding region 22.

The processor 26 maintains a record 46 which includes details of the tags 12 which have been identified, and the region 22A, 22B in which they are present (in accordance with the algorithm just described). Whenever a sequence of the required minimum number of consecutive uses of one antenna means 14, 16 is detected, the processor 26 checks the record 46. If the most recent result indicates that the tag 12 is in the same region 22 as is indicated in the record 46, no further action is required. If the latest information indicates a variation from the content of the record 46, action to update the record 46 is required, as follows.

The processor 26 waits at step 50 for a reply to be received or a decision at 44 that the tag is present. Step 52 checks the record 46 to determine if the replying tag is already present in the record. If not, the record 46 is updated at 54 and the processor 26 returns to wait at step 50.

If step 52 determines that the replying tag is currently present in the record 46, step 56 determines if the latest reply or decision relates to the same region 22 in which the replying tag 12 is currently recorded. If it is currently recorded as being in the same region, the record 46 is left unamended and the processor 26 returns to step 50 to await a further reply.

In the event that step 56 determines that the replying tag 12 has now replied from the other region 22, the record 46 is updated at 58, the reflect the change. Information is also incorporated in the record 46 to show that the replying tag has been detected as moving from one of the regions 22 to the other region. Thus, comparison of the latest location of the replying tag, with the recorded location in the record 46, allows the processor 26 to recover information relating to the direction of movement of the corresponding tag, relative to the portal arrangement. Specifically, the direction of movement from one region 22 to the other, or in the reverse direction, can be detected. [It should be understood that the term "direction" is being used to refer to movement from one region to another, rather than to a narrowly defined linear movement].

The sequence of Fig. 3 is preferably preceded by the sequence of Fig. 2, so that the step 50 may be interpreted as the final step of the sequence of Fig. 2. Thus the sequence of Fig. 3 does not begin until the required minimum number of consecutive replies have been received for the sequence of Fig. 2 to confirm the presence of the replying tag in the corresponding region 22.

The portal which has been described may be used at a fixed location or may be portable. The portal is expected to be particularly advantageous for portable use, as can now be described with reference to Fig. 4. Fig. 4 illustrates a vehicle 60, which has a single entry point at 62, such as a rear door closed by a roller shutter arrangement 64, for example. In this example, the antenna means 14, 16 are mounted near the roof 66 of the vehicle 60. In other examples, side-mounted or floor-mounted antenna means could be used instead of, or in addition to roof-mounted antenna means. The control 18 is also shown roof mounted in this example, but can be at any alternative convenient location within the vehicle 60.

The first antenna means 14 has directional characteristics which result in the corresponding region 22A being to the rear of the vehicle 60, and outside the vehicle. Consequently, the first antenna means 14 is looking for RFID tags which are off the vehicle, but close to the entry door 62.

The second antenna means 16 is designed to create a corresponding region 22B which is onboard the vehicle 60, just inside the door 62.

The arrangement illustrated in Fig. 4 can be used in the manner described above to identify RFID tags entering the region 22A and then moving to the region 22B, or entering the region 22B and moving to the region 22A. Accordingly, the arrangement can be used to maintain, in the record 46, a record of tags 12 which are on the vehicle, as follows.

A tag attached to an article which is currently not on the vehicle, but is to be loaded onto the vehicle, will first be brought to the rear of the vehicle 60, for loading through the door 62. As the article approaches the door 62, the tag will enter the region 22A and thus be detected and recorded as being present in that region 22A.

If the article to which the tag is attached is then loaded onto the vehicle 60, the tag will leave the region 22A and move into the region 22B. The tag will then be detected in the region 22B, confirming that the tag and associated article are now loaded onto the vehicle 60. The record 46 may be updated to record the tag and item as being on board, either in response to movement detected from the region 22A to the region 22B, or merely from the presence in the region 22B.

If the interior of the vehicle is larger than the region 22B, the article may be moved out of the region 22B, further into the vehicle. Thus, if the article ceases to be present in region 22B, but is not detected in region 22A, it is interpreted as being still on the vehicle, and the record 46 does not need to be amended. If the region 22B covers most of all of the interior of the vehicle, a loaded item may remain in the region 22B and the record 46 will remain unaltered. It is likely that at least some items will remain in the region 22B when the vehicle is full or nearly full.

When an item is unloaded from the vehicle 60, the item and the corresponding tag 12 will first enter the region 22B, if not already present in the region, and be identified as present in that region. As the item 20 leaves the door 60, the corresponding tag 12 will be detected in the region 22A. Thus, the detected movement from the region 22B to the region 22A can be interpreted as unloading from the vehicle 60 and the record 46 updated accordingly. Alternatively, the decision may be taken by checking the current recorded location of the item 20, when newly detected in region 22A. In the event that the item is detected in region 22A, but recorded as being on the vehicle, the record 46 can be updated to show that the item has been unloaded from the vehicle. However, if an item is newly identified in region 22A, but is not recorded as being present on the vehicle 60, this will indicate that the item has been brought to the rear of the vehicle 60, but not onto the vehicle 60, and thus this information is ignored until the same item is subsequently identified as present in the region 22B, indicating that it has now been loaded onto the vehicle.

We envisage that the arrangements described above can be incorporated within a supply chain monitoring system, as illustrated simply and schematically in Fig. 5.

The system of Fig. 5 includes several vehicles 60, each equipped as described above in relation to Fig. 4. The control 18 of each vehicle 60 is provided with communication arrangements 68 (Fig. 4) allowing two way communication with a central computer 70. The computer 70 is also in communication with fixed portals 72, for example at a collection point (such as a warehouse) and a delivery point 76, such as a retail store. Communication between the computer 70 and the fixed portals 72 and the portals on the vehicles 60 allows the computer 70 to maintain a current record allowing RFID tags to be tracked through the supply chain represented by the warehouse 74, vehicles 60 and retail store 76. Thus, the computer 70 can maintain a record indicating whether a specified RFID tag is currently at the warehouse 74, the retail store 76 or in one of the vehicles 60. In the event that the vehicles 60 are also fitted with tracking devices, such as GPS based systems, the computer 70 will also be able to identify the location of the vehicle 60. This information can be provided by means of terminals 78, for management purposes.

Accordingly, the system of Fig. 5 allows goods to be tracked from the warehouse 74 to the retail store 76, either by tracking the RFID tags attached to the goods, or attached to containers containing the goods. When containers are used, RFID tags attached to the containers can also be used to track the containers in return journeys from the retail store 76 to the warehouse 74.

Returning to Fig. 4, it can be seen that the arrangement of the regions 22 is such that it is substantially impossible to remove items 20 from the vehicle 60, without this removal being detected. This is expected to reduce theft and other losses. Similarly, it is substantially impossible to put items onto the vehicle, without this being detected. The record 46 can thus be seen as a reliable record of the current stock on the vehicle 60. This can help trace theft or losses arising between a warehouse 74 (for example) and a vehicle 60, arising from items being removed from the warehouse, but stolen or lost before being loaded on to the vehicle 60.

Many additional features can be incorporated within the systems described above, for particular applications. In particular, in the supply chain system of Fig. 5, the computer 70 may provide and update information for drivers of the vehicle 60, including information relating to the nature or number of items which are to be loaded or unloaded at a particular location, and the like. A display 80 (Fig. 1) can be provided for this reason. The record 46 may be carried by the vehicle, so that the driver always has an accurate inventory of the items currently being carried, even if communication is not available with the computer 70. Alarm arrangements could be incorporated in the systems, to alert the driver when unauthorised removal of an item occurs, such as mistaken unloading, or theft.

An arrangement, such as a switch, may be incorporated to disable the system, when the entry door 62 is closed.

The bandwidth available in UHF RFID arrangements allows multiple tags to be in communication simultaneously, using a time division multiplexing arrangement. Thus, it is possible for multiple tags to be moving through the portal at the same time. This is expected to allow multiple personnel to be assisting simultaneously in loading or unloading a vehicle, for example, or to allow items within containers or delivery crates to be individually tagged and tracked.

Many variations and modifications can be made to the apparatus described above, without departing from the scope of the present invention. Many different designed of antenna, driver, signal processing and the like can be chosen for particular applications, according to the particular requirements of that application.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

CLAIMS

1. An RFID portal arrangement for detecting the passage of RFID tags past the portal arrangement, comprising first and second antenna means operable to communicate with tags passing the portal arrangement, and control means operable to conduct a sequence of transactions with each RFID tag, while passing the arrangement, and to determine the sequence of antenna means used for the sequence of transactions, the control means being further operable to use the antenna sequence to recover information relating to the direction of movement of the corresponding RFID tag relative to the portal arrangement.

2. A portal arrangement according to claim 1, wherein at least one antenna means is directional, to define a region within which communication can be established with RFID tags.

3. A portal arrangement according to claim 1 or 2, wherein both antenna means are directional.

4. A portal arrangement according to claim 3, wherein the regions defined by respective antenna means are substantially without overlap.

5. A portal arrangement according to any preceding claim, wherein the control means is operable to detect an antenna sequence which uses substantially only a first of the antenna means and subsequently uses substantially only a second of the antenna means, to indicate movement past the portal arrangement in the direction from the region of the first antenna means to the region of the second antenna means.

6. A portal arrangement according to claim 5, wherein the control means is operable to interpret a minimum number of consecutive uses of a first of the antenna means, without any use of the second antenna means, as a sequence which uses substantially only that antenna means.

7. A portal arrangement according to any preceding claim, wherein the control means is operable to update a record of RFID tags which have been detected.

8. A portal arrangement according to claim 7, wherein the record includes information relating to the last detected direction of movement relative to the portal arrangement.

9. A portal arrangement according to any preceding claim, wherein the portal arrangement is operable for communication with passive RFID tags.

10. A portal arrangement according to any preceding claim, wherein the portal arrangement is operable for communication with RFID tags at UHF frequencies.

11. A portal arrangement according to any preceding claim, the arrangement being mobile.

12. A portal arrangement according to any preceding claim, wherein the arrangement is vehicle-mounted.

13. A portal arrangement according to claim 12, wherein the portal arrangement is mounted in the vicinity of an entry point to the vehicle, to detect RFID tags entering or leaving the vehicle and to distinguish between entering and leaving.

14. A portal arrangement according to claim 12 or 13, wherein the control means maintains a record of RFID tags which have entered the vehicle, at least until they are detected leaving the vehicle, thereby identifying the RFID tags currently on the vehicle.

15. A vehicle having an RFID portal arrangement according to any preceding claim.

16. An RFID portal arrangement substantially as described above, with reference to the accompanying drawings.

17. Any novel subject matter or combination including novel subject matter disclosed herein, whether or not within the scope of or relating to the same invention as any of the preceding claims.

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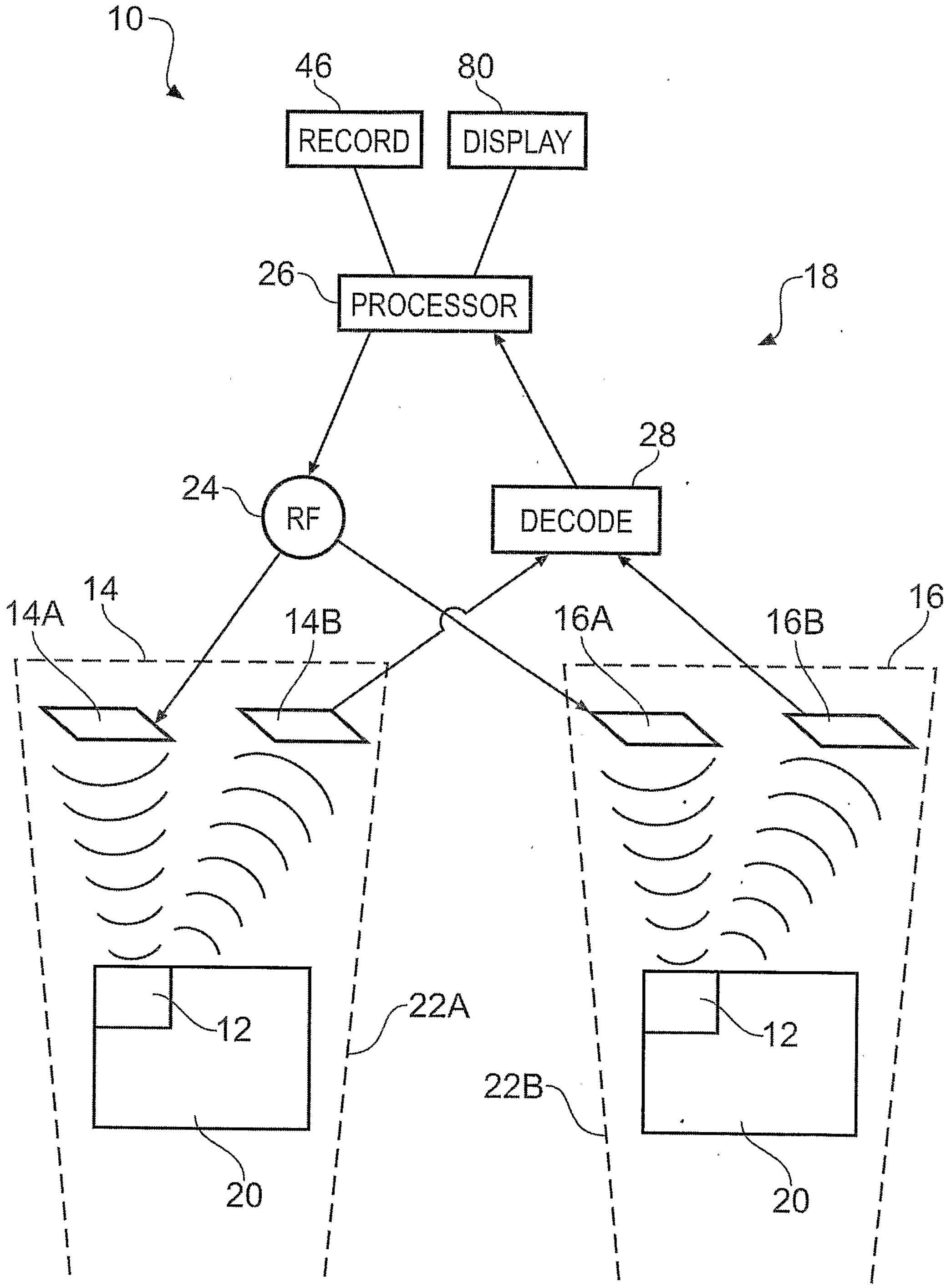
10
46
RECORD
80
DISPLAY
26
PROCESSOR
18
28
24
RF
DECODE
14A
14
14B
16A
16B
16
12
22A
22B
12
20
20

Fig. 1

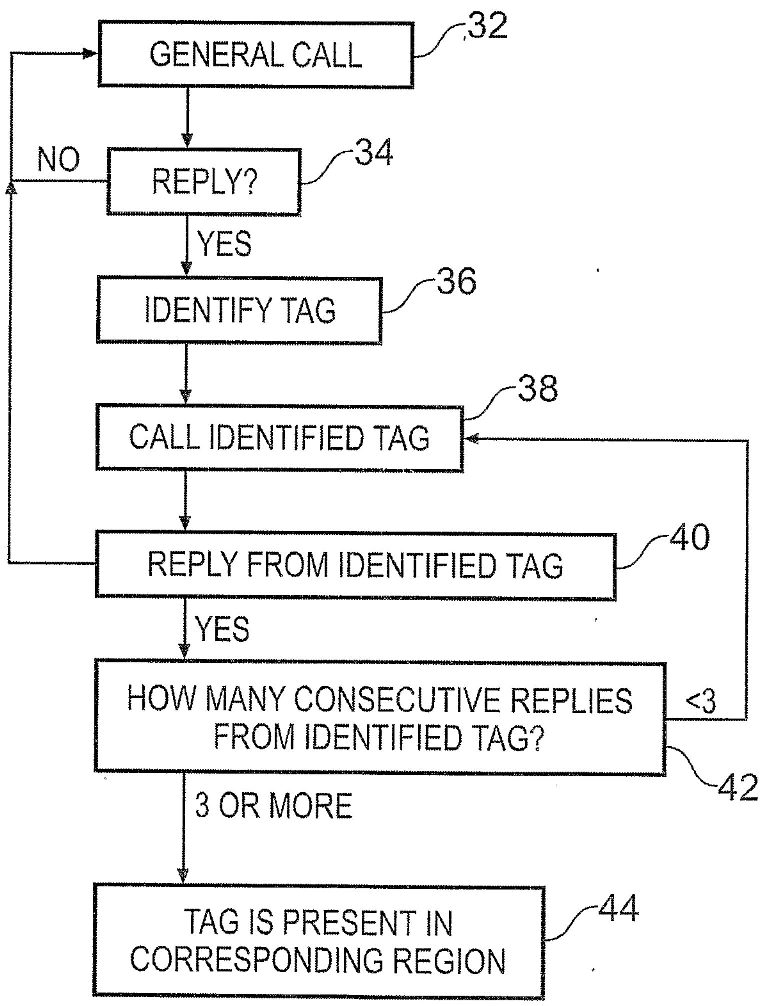
GENERAL CALL
32
NO
REPLY?
34
YES
IDENTIFY TAG
36
CALL IDENTIFIED TAG
38
REPLY FROM IDENTIFIED TAG
40
YES
HOW MANY CONSECUTIVE REPLIES FROM IDENTIFIED TAG?
<3
42
3 OR MORE
TAG IS PRESENT IN CORRESPONDING REGION
44

Fig. 2

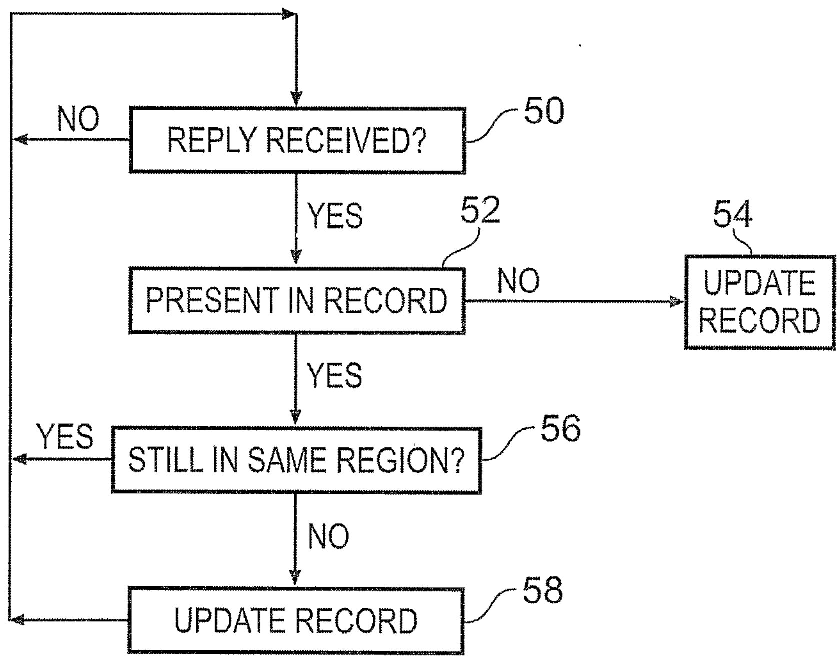
NO
REPLY RECEIVED?
50
YES
52
54
PRESENT IN RECORD
NO
UPDATE RECORD
YES
YES
STILL IN SAME REGION?
56
NO
UPDATE RECORD
58

Fig. 3

4/5

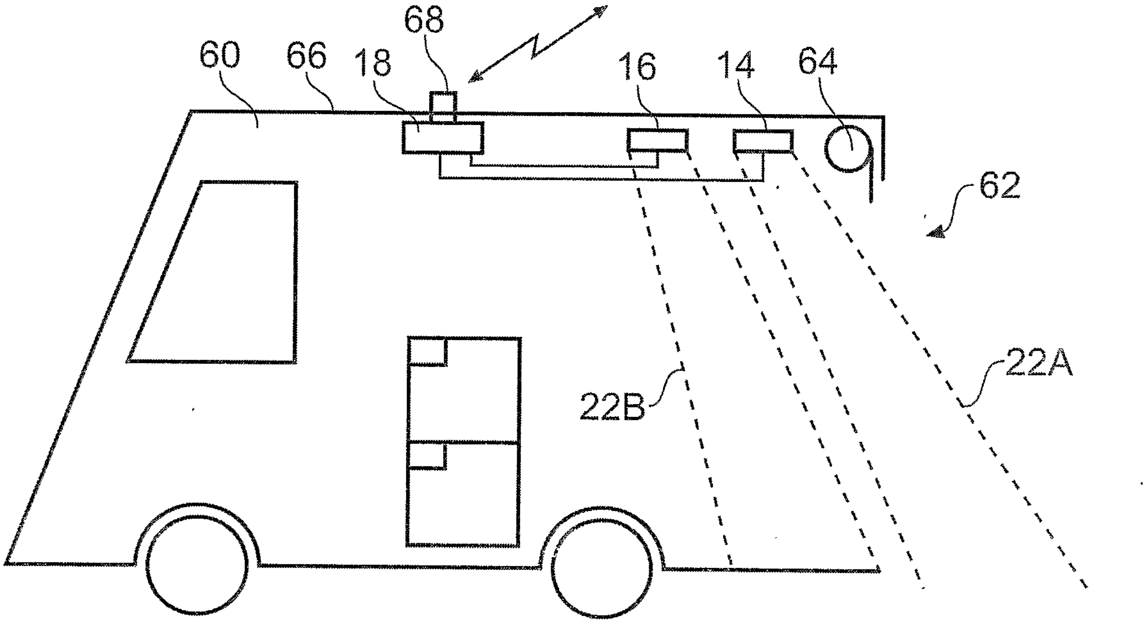

Fig. 4

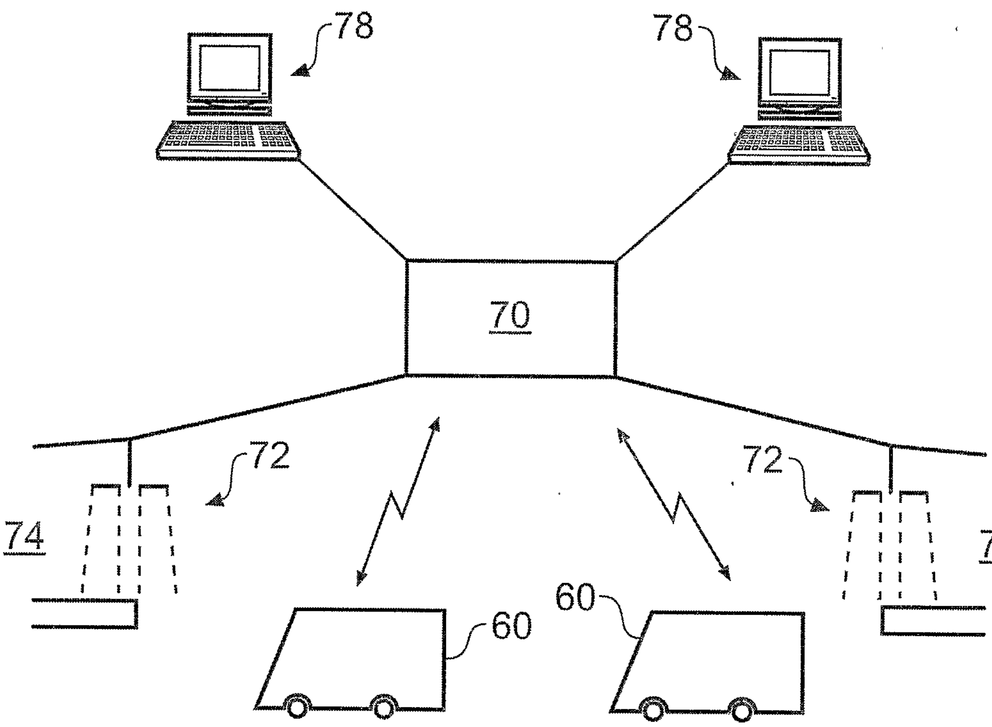

Fig. 5