

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
24 July 2003 (24.07.2003)

PCT

(10) International Publication Number  
**WO 03/060626 A2**

- (51) International Patent Classification<sup>7</sup>: **G06F**
- (21) International Application Number: PCT/IL03/00045
- (22) International Filing Date: 16 January 2003 (16.01.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
10/052,427 18 January 2002 (18.01.2002) US
- (71) Applicant (for all designated States except US): **IM-AGEID LTD.** [IL/IL]; Amal Street 11, 48092 Rosh Ha'ayin (IL).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **SHNIBERG, Moti** [IL/IL]; P.O. Box 603, 44814 Elkannah (IL). **NEMET, Yaron** [IL/IL]; P.O. Box 183, 44856 Kedumim (IL). **SALI, Erez** [IL/IL]; Hadagan Street 11, Savion 56505 (IL).

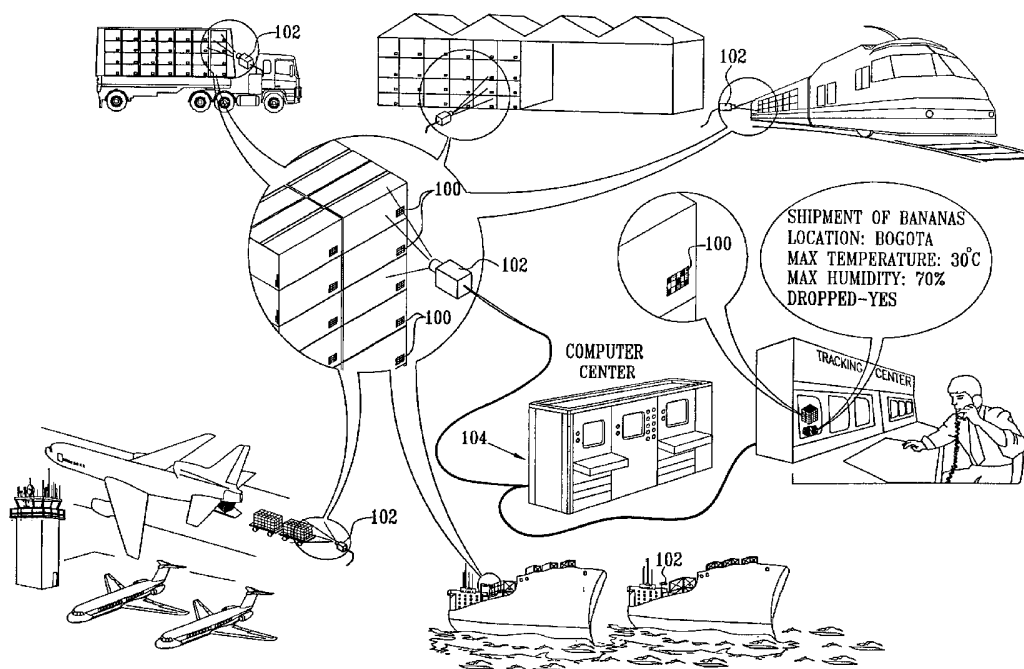
Published:

— without international search report and to be republished upon receipt of that report

(74) Agents: **SANFORD T. COLB & CO.** et al.; P.O. Box 2273, 76122 Rehovot (IL).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SYSTEM AND METHODOLOGY FOR TRACKING OBJECTS USING VISUALLY SENSIBLE INDICATORS



(57) Abstract: A system for tracking objects including visually sensible indicators on objects being tracked, at least one imager capturing images of the objects being tracked which images also show the visually sensible indicators and at least one image processor receiving outputs of the at least one imager and extracting from the outputs coded information indicated by the visually sensible indicators.

SYSTEM AND METHODOLOGY FOR TRACKING OBJECTS  
USING VISUALLY SENSIBLE INDICATORS

REFERENCE TO RELATED APPLICATIONS

Applicant hereby claims priority of U.S. Patent Application Serial No.10/052,427, filed January 18, 2002 entitled "METHOD FOR AUTOMATIC IDENTIFICATION AND CAPTURE".

FIELD OF THE INVENTION

The present invention relates to logistics systems and methods generally and more particularly to systems and methods for tracking objects.

BACKGROUND OF THE INVENTION

Various systems and techniques are known for tracking the location of objects. These involve the use of bar-codes and other optically sensible codes.

The following U.S. Patents and Published PCT Applications are believed to represent the current state of the art:

U.S. Patents: 6,460,769; 6,456,239; 6,445,810; 6,442,476; 6,433,732; 6,427,913; 6,424,260; 6,405,924; 6,400,830; 6,384,409; 6,381,509; 6,339,745; 6,317,044; 6,295,977; 6,286,763; 6,265,977; 6,285,342; 6,283,375; 6,259,408; 6,252,508; 6,206,286; 6,127,928; 6,070,801; 6,098,877; 6,027,022; 5,996,895; 5,988,508; 5,912,980; 5,828,049; 5,828,048; 5,825,012; 5,646,389; 5,621,864; 5,600,121; 5,528,228; 5,468,949; 5,384,859; 5,224,373; 4,924,799; 4,844,509; 4,794,238; 4,636,950; 4,340,810; 4,340,008; 4,268,179; 4,044,227 and 3,961,323.

Published PCT Applications WO 00/04711 and WO 98/10358.

The disclosures of the foregoing U.S. Patents and Published PCT Applications are hereby incorporated by reference.

## SUMMARY OF THE INVENTION

The present invention seeks to provide highly efficient and cost effective systems and methodologies for tracking objects.

There is thus provided in accordance with a preferred embodiment of the present invention a methodology for tracking objects including affixing at least one imagable identifier onto each of a multiplicity of objects to be tracked, imaging at least a portion of at least one of the multiplicity of objects at a known location to provide an at least partial image of the at least one of the multiplicity of objects, containing the at least one imagable identifier and employing the at least partial image of the object containing the at least one imagable identifier to provide an output indication of the location of the at least one of the multiplicity of objects.

There is also provided in accordance with another preferred embodiment of the present invention an object tracking system including at least one imagable identifier affixed onto each of a multiplicity of objects to be tracked, an imager, imaging at least a portion of at least one of the multiplicity of objects at a known location to provide an at least partial image of the at least one of the multiplicity of objects, containing the at least one imagable identifier and a processor employing the at least partial image of the object containing the at least one imagable identifier to provide an output indication of the location of the at least one of the multiplicity of objects.

Preferably, the methodology also includes communicating at least one of the at least partial image and the output indication to a remote location.

Affixing preferably includes adhesively attaching the at least one imagable identifier onto a surface of each of the multiplicity of objects. Alternatively or additionally, affixing includes molding the at least one imagable identifier onto a surface of each of the multiplicity of objects. Alternatively or additionally, affixing includes printing the at least one imagable identifier onto a surface of each of the multiplicity of objects.

In accordance with a preferred embodiment of the present invention, the at least one imagable identifier includes a multi-color identifier. Preferably, the at least one imagable identifier includes a multi-segment, multi-color identifier.

In accordance with a preferred embodiment of the present invention, the multi-segment, multi-color identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = (n \times (n - 1)^{(p-2)} \times (n - 2))/p$$

where  $n$  is the number of different colors and  $p$  is the number of segments.

More preferably, the multi-segment, multi-color identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = n \times (n - 1)^{(p-2)} \times (n - 2)$$

where  $n$  is the number of different colors and  $p$  is the number of segments.

In accordance with a preferred embodiment of the present invention, the multi-segment, multi-color identifier has an inherent orientation.

Preferably, imaging includes photographing and may include imaging a plurality of the objects together within a single image. Additionally or alternatively, imaging may include sequentially imaging a plurality of the objects passing a given imaging location.

Preferably, the at least one imagable identifier includes a plurality of imagable identifiers arranged in at least predetermined propinquity to each other.

In accordance with another preferred embodiment of the present invention, employing the at least partial image of the object containing the at least one imagable identifier includes extracting an identification code from the at least partial image.

Preferably, the object tracking system also includes a communicator, communicating at least one of the at least partial image and the output indication to a remote location.

In accordance with still another preferred embodiment of the present invention, the processor is operative to extract an identification code from the at least partial image.

Preferably, output from the imager of the object tracking system, as well as output from the imaging of the methodology, can be stored for future retrieval.

There is further provided in accordance with a preferred embodiment of the present invention a system for tracking objects including visually sensible indicators on objects being tracked, at least one imager capturing images of the objects being tracked which images also show the visually sensible indicators and at least one image processor receiving outputs of the at least one imager and extracting from the outputs coded information indicated by the visually sensible indicators.

There is still further provided in accordance with yet another preferred embodiment of the present invention a system for monitoring objects including a plurality of sensors associated with objects being monitored, visually sensible indicators associated with each of the objects, receiving sensor outputs of the plurality of sensors and providing visually sensible indications of the sensor outputs, at least one imager capturing images of the visually sensible indicators and at least one image processor receiving image outputs of the at least one imager and extracting from the image outputs coded information indicated by the visually sensible indicators.

In accordance with another preferred embodiment of the present invention, the at least one monitor is remotely located from the objects being monitored.

In accordance with yet another preferred embodiment of the present invention the system also includes at least one monitor receiving and displaying the coded information from the image processor. Alternatively, the at least one monitor is also operative to display the images of the objects in conjunction with the coded information.

Preferably, the visually sensible indicator indicates object identity information. Alternatively or additionally, the visually sensible indicator also indicates at least one additional parameter relating to the object.

In accordance with another preferred embodiment of the present invention the visually sensible indicator is a dynamic indicator. Additionally, the visually sensible indicator provides non-alphanumeric indications of multiple parameters relating to an object onto which the indicator is mounted. Alternatively or additionally, the visually sensible indicator provides a coded indication of at least two of the following parameters: object location, object identity, object maximum temperature

history; object maximum humidity history; object minimum temperature history; object minimum humidity history; object tilt history, object G-force history.

In accordance with another preferred embodiment of the present invention the at least one imager includes a plurality of imagers, which plurality is greater than the number of the at least one image processor.

Preferably, the at least one imager includes at least one scanning imager.

There is still further provided in accordance with yet another preferred embodiment of the present invention a method for tracking objects including associating visually sensible indicators with objects being tracked, capturing images of the objects being tracked which images also show the visually sensible indicators and image processing outputs of the at least one imager and extracting from the outputs coded information indicated by the visually sensible indicators.

There is also provided in accordance with still another preferred embodiment of the present invention a method for monitoring objects including associating a plurality of sensors with objects being monitored, associating visually sensible indicators with each of the objects, providing to the visually sensible indicators, sensor outputs of the plurality of sensors, operating the visually sensible indicators to provide visually sensible indications of the sensor outputs, employing at least one imager to capture images of the visually sensible indicators and employing at least one image processor to receive image outputs of the at least one imager and extract from the image outputs coded information indicated by the visually sensible indicators.

In accordance with another preferred embodiment of the present invention the method for tracking objects also includes remotely receiving and displaying the coded information from the image processor. Additionally or alternatively, the method also includes displaying the images of the objects in conjunction with the coded information.

Preferably, the visually sensible indicator indicates object identity information. Additionally, the visually sensible indicator also indicates at least one additional parameter relating to the object.

In accordance with yet another preferred embodiment the visually sensible indicator changes its visual display in real time in accordance with the parameters indicated thereby. Additionally, the visually sensible indicator provides non-

alphanumeric indications of multiple parameters relating to an object onto which the indicator is mounted. Alternatively or additionally, the visually sensible indicator provides a coded indication of at least two of the following parameters: object location, object identity, object maximum temperature history; object maximum humidity history; object minimum temperature history; object minimum humidity history; object tilt history, object G-force history.

In accordance with still another preferred embodiment of the present invention the image processor processes images captured at plural locations.

Preferably, the capturing images employs at least one scanning imager.

### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description in which:

Fig. 1 is a simplified illustration of a multiple location object tracing and tracking system constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 2 is a simplified illustration of a multiple location object tracing and tracking system constructed and operative in accordance with another preferred embodiment of the present invention;

Fig. 3 is a simplified illustration of a multiple location object tracing and tracking system constructed and operative in accordance with yet another preferred embodiment of the present invention;

Fig. 4 is an illustration of a methodology for correct affixation of an imagable identifier to an object;

Fig. 5 is a simplified pictorial illustration of a multi-parameter object tracking system and methodology constructed and operative in accordance with another preferred embodiment of the present invention;

Figs. 6A, 6B, 6C and 6D are simplified pictorial illustrations of four features which are preferably included in the system of Fig. 5;

Fig. 7 is a simplified illustration of an identification indicator including a location and orientation locator, useful in the system and methodology of Fig. 5;

Figs. 8A and 8B are simplified illustrations of an identification indicator embodied in an electronic display, such as a liquid crystal display, useful in the system and methodology of Fig. 5;

Fig. 9 is a simplified illustration of the use of identification indicators having subpixel resolution in the system and methodology of Fig. 5;

Fig. 10 is a simplified illustration of the use of dynamic visually sensible multi-parameter identification indicators in the system and methodology of Fig. 5; and

Fig. 11 is a simplified flow chart illustrating a preferred mode of operation of the system of Fig. 5.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is now made to Fig. 1, which is a simplified illustration of a multiple location object tracing and tracking system constructed and operative in accordance with a preferred embodiment of the present invention.

As seen in Fig. 1, there is preferably provided a tracing and tracking system which covers multiple geographically disparate locations at which it is sought to trace and track objects. At typical such locations, such as warehouses, a plurality of objects, such as stacked, collapsed containers 10, each bear an imagable identifier 12. The imagable identifier preferably comprises a multi-segment, multi-color identifier preferably in the form of a multi-segment color-coded disc wherein various segments have various colors. A preferred imagable identifier is commercially available from ImageID Inc. of One Penn Plaza, Suite 2210, New York, NY, U.S.A. under the trade name Imagecode. The identifier is described in the following references, the disclosures of which are hereby incorporated by reference:

U.S. Patent Application 09/508,300

Published PCT Patent Application WO 00/04711.

It is a particular feature of the present invention that the imagable identifiers on a plurality of objects may be imaged together, as in a single photograph,



by a conventional imager 14, such as a digital camera. This is principally due to the fact that the various colors appear in the imagable identifier in two dimensional areas which are relatively easily differentiated from each other both spatially and in color space.

The image output of the imager is preferably provided to a computer 16, which may process the image output locally and provide an output indication 18 representing a plurality of numerical or alphanumerical identifiers corresponding to all of the imagable identifiers imaged in a given image or series of images. Alternatively or additionally, computer 16 may communicate via any suitable computer network, such as the Internet, with a remote tracking center 20, which may receive either image outputs for processing or alternatively may receive the plurality of numerical or alphanumerical identifiers corresponding to all of the imagable identifiers imaged in a given image or series of images. The image outputs may also be stored for future retrieval, either locally in computer 16 or in remote tracking center 20.

The remote tracking center 20 preferably compiles records of tracked numerical or alphanumerical identifiers from a multiplicity of geographically disparate locations so as to enable ready counting, tracking and locating of objects identified thereby. Remote tracking center 20 preferably maintains a database which is updated based on communications received from various geographically disparate locations.

Reference is now made to Fig. 2, which is a simplified illustration of a multiple location object tracing and tracking system constructed and operative in accordance with another preferred embodiment of the present invention. As seen in Fig. 2, there is preferably provided a tracing and tracking system which covers multiple geographically disparate locations at which it is sought to trace and track objects. At typical such locations, such as warehouses, a plurality of objects, such as multiple stacks of containers 30 or objects stored on shelves, each bear an imagable identifier 32. The imagable identifier preferably comprises a multi-segment, multi-color identifier preferably in the form of a multi-segment color-coded disc wherein various segments have various colors. A preferred imagable identifier is commercially available from ImageID Inc. of One Penn Plaza, Suite 2210, New York, NY, U.S.A. under the trade name Imagecode. The identifier is described in the following references, the disclosures of which are hereby incorporated by reference:

U.S. Patent Application 09/508,300

Published PCT Patent Application WO 00/04711.

It is a particular feature of the present invention that the imagable identifiers on a plurality of objects may be automatically imaged together, as in a single photograph or a series of photographs, by a conventional imager 34, such as a panoramic digital camera. This is principally due to the fact that the various colors appear in the imagable identifier in two dimensional areas which are relatively easily differentiated from each other both spatially and in color space.

The arrangement of Fig. 2 is particularly useful for continuously updating inventory records of a large number of objects automatically, without the necessity of approaching each object or stack of objects or moving the objects past a tracking station.

The image output of the imager is preferably provided to a computer 36, which may process the image output locally and provide an output indication 38 representing a plurality of numerical or alphanumerical identifiers corresponding to all of the imagable identifiers imaged in a given image or series of images. Alternatively or additionally, computer 36 may communicate via any suitable computer network, such as the Internet, with a remote tracking center 40, which may receive either image outputs for processing or alternatively may receive the plurality of numerical or alphanumerical identifiers corresponding to all of the imagable identifiers imaged in a given image or series of images. The image outputs may also be stored for future retrieval, either locally in computer 36 or in remote tracking center 40.

The remote tracking center 40 preferably compiles records of tracked numerical or alphanumerical identifiers from a multiplicity of geographically disparate locations so as to enable ready counting, tracking and locating of objects identified thereby. Remote tracking center 40 preferably maintains a database which is updated based on communications received from various geographically disparate locations.

Reference is now made to Fig. 3, which is a simplified illustration of a multiple location object tracing and tracking system constructed and operative in accordance with yet another preferred embodiment of the present invention. As seen in Fig. 3, there is preferably provided a tracing and tracking system which covers multiple geographically disparate locations at which it is sought to trace and track objects. At typical such locations, such as warehouses, a plurality of objects, such as multiple

containers 50, each bear a plurality of imagable identifiers 52. Each imagable identifier preferably comprises a multi-segment, multi-color identifier preferably in the form of a multi-segment color-coded disc wherein various segments have various colors. A preferred imagable identifier is commercially available from ImageID Inc. of One Penn Plaza, Suite 2210, New York, NY, U.S.A. under the trade name Imagecode. The identifier is described in the following references, the disclosures of which are hereby incorporated by reference:

U.S. Patent Application 09/508,300

Published PCT Patent Application WO 00/04711.

It is a particular feature of the present invention that multiple imagable identifiers on one or more objects may be automatically imaged together, as in a single photograph or a series of photographs, by a conventional imager 54, such as a digital camera. This is principally due to the fact that the various colors appear in the imagable identifier in two dimensional areas which are relatively easily differentiated from each other both spatially and in color space.

The arrangement of Fig. 3 is particularly useful for providing a relatively large number of available numerical or alphanumerical identifiers. For example, use of a single Imagecode™ imagable identifier typically provides approximately 60,000 combinations. The use of two Imagecode™ imagable identifiers in a predetermined relative spatial orientation may provide approximately 60,000 x 60,000 combinations.

The image output of the imager is preferably provided to a computer 56, which may process the image output locally and provide an output indication 58 representing a plurality of numerical or alphanumerical identifiers corresponding to all of the pluralities of imagable identifiers imaged in a given image or series of images. Alternatively or additionally, computer 56 may communicate via any suitable computer network, such as the Internet, with a remote tracking center 60, which may receive either image outputs for processing or alternatively may receive the plurality of numerical or alphanumerical identifiers corresponding to all of the imagable identifiers imaged in a given image or series of images. The image outputs may also be stored for future retrieval, either locally in computer 56 or in remote tracking center 60.

The remote tracking center 60 preferably compiles records of tracked numerical or alphanumerical identifiers from a multiplicity of geographically disparate

locations so as to enable ready counting, tracking and locating of objects identified thereby. Remote tracking center 60 preferably maintains a database which is updated based on communications received from various geographically disparate locations.

In accordance with a preferred embodiment of the present invention, the multi-segment, multi-color identifier 12, 32 and 52 is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = (n \times (n - 1)^{(p-2)} \times (n - 2))/p$$

where

n is the number of different colors and

p is the number of segments.

The foregoing calculation does not assume any predetermined orientation of the imagable identifier.

More preferably, the multi-segment, multi-color identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = n \times (n - 1)^{(p-2)} \times (n - 2)$$

where

n is the number of different colors and

p is the number of segments.

This calculation assumes a known or constant orientation of the imagable identifier.

In accordance with a preferred embodiment of the invention, the multi-segment, multi-color identifier has an inherent orientation. It is appreciated that this need not necessarily be the case. When the multi-segment, multi-color identifier does not have an inherent orientation, the methodology exemplified in Fig. 4 is particularly useful.

Reference is now made to Fig. 4, which is an illustration of a methodology for correct affixation of an imagable identifier to an object. It is appreciated that due to the circular symmetry of the Imagecode™ imagable identifier, consistency of affixation orientation is important in order to maximize the number of available combinations of numerical or alphanumerical identifiers while avoiding misidentification of objects.

One technique for ensuring correct affixation orientation is to mold or otherwise form onto a container 70, a three-dimensionally defined affixation location 72 and to provide an imagable identifier carrier 74, such as an adhesive backed sticker, which has a configuration, such as a notched configuration, which allows it to be placed in the three-dimensionally defined affixation location 72 only in one unique orientation relative to the container. Clearly, the structure and methodology shown in Fig. 4 is applicable to imagable identifier carriers 74 which bear multiple as well as single imagable identifiers 76. It is appreciated that other suitable techniques of unique orientation affixation may be employed, such as printing or molding of an imagable identifier directly onto an object.

It is noted that for the sake of clarity, the features of Figs. 1, 2, 3 and 4 have been described separately. It is to be appreciated that the features of any one or all of Figs. 1, 2, 3 and 4 may be advantageously combined in a given system or methodology.

Reference is now made to Fig. 5, which is a simplified pictorial illustration of a multi-parameter object tracking system and methodology constructed and operative in accordance with another preferred embodiment of the present invention. As seen in Fig. 5, objects, such as crates of various goods, each bear optically sensible identification indicators 100, preferably comprising multiple colored regions, defining a unique pattern which corresponds to a unique code. The objects are imaged in situ in various locations, such as while loaded on a truck, stored in a warehouse, being hauled on a train, about to be loaded onto an aircraft or onboard a ship. Imaging may be carried out by a conventional, relatively low cost camera 102, such as a color CCD camera.

In accordance with one preferred embodiment of the present invention, the identification indicators 100 are static indicators, such as those shown and described in assignee's Published PCT Application WO 00/04711, the disclosure of which is hereby incorporated by reference. Alternatively or additionally, the identification indicators 100 are dynamic indicators, such as those described hereinbelow with reference to Figs. 8A – 10.

The outputs of camera 102 or multiple cameras 102 are preferably supplied to a computer 104 which analyzes the images produced thereby to extract a

code corresponding to the combination of colored regions on each optically sensible identification indicator. As will be described hereinbelow in greater detail, this code may contain object identification information as well as information relevant to various additional parameters relevant to the object. A preferred embodiment of the methodology of decoding the identification indicators is described hereinbelow with respect to Fig. 11.

Preferably, as illustrated in Fig. 5, the identification indicators 100 are imaged or photographed together with the objects which they identify, thus providing the possibility of visual verification of information coded onto the identification indicators 100. In the illustrated embodiment of Fig. 5, the identification indicator 100 not only identifies the object but also indicates its present contents, the maximum temperature and humidity to which it has been exposed and whether it has been dropped.

It is appreciated that a suitable device (not shown) for the generation of identification indicators 100 is preferably provided as part of the multi-parameter object tracking system. In accordance with one embodiment of the present invention, static identification indicators 100 may be generated by any suitable printing device equipped with encoding software, so that an operator could print an encoded identification indicator by selecting the applicable parameters, such as from a menu of available parameters or by any other suitable method. In another preferred embodiment, dynamic identification indicators 100 may be generated as described hereinbelow with reference to Fig. 10.

Additionally, the identification indicator 100 may be used in conjunction with an electronic article surveillance (EAS) device or a radio frequency identification device (RFID). In this embodiment, the visually sensible identification indicator 100 preferably contains an indication that the item has an EAS or RFID device and may also indicate the type of the device. Such a combination of identification indicator and EAS/RFID device may also be used to control asset flow, where the EAS device will indicate that an item is leaving a location which will require the operator to utilize a camera, such as camera 102, to image the visually sensible identification indicator 100. Suitable EAS and RFID devices are manufactured by HID Corporation, 9292 Jeronimo

Road, Irvine, CA 92618 USA or Sensormatic, 6600 Congress Ave., P.O. Box 310700, Boca Raton, Florida 33431-0700 USA.

Reference is now made to Figs. 6A, 6B, 6C and 6D, which are simplified pictorial illustrations of four features which are preferably included in the system of Fig. 5. Fig. 6A illustrates multiple fixed position imagers 200, such as CCD cameras, each providing an imagewise output to a common computer 202, which analyzes the images output from imagers 200, extracts and decodes the identification indicators and provides coded identification outputs together with the images captured by the imagers 200 to a remote computer 204.

Fig. 6B illustrates the use of a variable orientation imager 210 to scan a given region and provide at different times, images of different objects. As in the embodiment of Fig. 6A, a common computer 212 analyzes the images output from imager 210, extracts and decodes the identification indicators and provides coded identification outputs together with the images captured by the imager 210 to a remote computer 214.

Fig. 6C illustrates the use of variable orientation imagers 220 and 222 in respectively high and low illumination environments to provide images of the objects under differing levels of illumination. As in the embodiment of Figs. 6A and 6B, a common computer 224, analyzes the images output from imagers 220 and 222, normalizes the images for illumination, extracts and decodes the identification indicators and provides coded identification outputs together with the images captured by the imagers 220 and 222 to a remote computer 226.

Fig. 6D illustrates the use of imagers 230, 232 and 234 to provide images of the objects. As in the embodiment of Figs. 6A - 6C, a common computer 236, analyzes the images output from imagers 230 - 234, fills in information missing from a damaged identification indicator, here designated by reference numeral 238, using one or more mathematical error correction algorithms, extracts and decodes the identification indicators and provides coded identification outputs together with corrected images captured by the imagers 230 - 234 to a remote computer 240. Suitable mathematical error correction algorithms, such as BCH coding or Reed-Solomon codes, are well known in the art and are described in The Theory of Error-correcting Codes, by F.J. Macwilliams and N. Sloane, 1977, North-Holland Publishers.

Reference is now made to Fig. 7, which is a simplified illustration of an identification indicator 300 including a location and orientation locator 302, here in the shape of a T, useful in the system and methodology of Fig. 5. It is seen that the identification indicator 300 has a pattern which includes a relatively large number of colored pixels, here 72 in number.

Reference is now made to Figs. 8A and 8B, which are simplified illustrations of an identification indicator embodied in a dynamic electronic display, such as a liquid crystal display, useful in the system and methodology of Fig. 5. The identification indicator 400 in the embodiment of Figs. 8A and 8B is distinguished from that shown in Fig. 7 in that it is dynamic, and can be changed over time in order to provide a visually sensible output indication of changing parameters. It may be appreciated by comparing Figs. 8A and 8B that the identification indicator 400 may provide differing resolutions over time and different configurations of identification indicators as well as indications of different parameters.

Reference is now made to Fig. 9, which is a simplified illustration of the use of identification indicators having subpixel resolution in the system and methodology of Fig. 5. As seen in Fig. 9, an imager 500 images a multiplicity of objects 502, each of which bears an information indicator 504. The image outputs of the imager 500 may be analyzed by computer 506 at differing resolutions. At a first resolution, a first level of information may be provided, such as in this case, the identification of the crate and the general classification of its contents. At a second resolution, an additional level of information may be obtained from the identification indicators, such as, for example, the specific product contained and its weight.

Reference is now made to Fig. 10, which is a simplified illustration of the use of dynamic visually sensible multi-parameter identification indicators in the system and methodology of Fig. 5. As seen in Fig. 10, a multi-parameter sensor assembly 600 may be provided, including a location sensor 602, such as a GPS sensor, which senses location based on receipt of transmissions from satellites 604, a temperature sensor 606, a humidity sensor 608 and an inertial sensor 610, all of which preferably output to a processor 612, which preferably stores extreme values of the various parameters and displays them in suitably coded form on a dynamic identification indicator, such as an LCD display 614. Sensors 602, 606, 608 and 610



need not generate a visually sensible output, since processor 612 generates visually sensible output based on the inputs received from these sensors. Multi-parameter sensor assembly 600 may also include additional sensors which generate visually sensible output and may or may not be connected to processor 612, such as a visually sensible output sensor 616 located within the imaged area of LCD display 614 or a visually sensible output sensor 618, located within the imaged area of multi-parameter sensor assembly 600.

It is appreciated that processor 612 is preferably also operable to receive additional input parameters, by any suitable method, such as a wired or wireless input device, which are also encoded as part of LCD display 614.

Visually sensible output sensors 616 and 618 may include, but are not limited to, the following environmental sensors:

TILTWATCH tilt indicator and SHOCKWATCH shock indicator, commercially available from Switched On I & T Services of Braeside, Victoria, Australia;

Humidity Indicator Cards and Plugs commercially available from Sud-Chemie Performance Packaging – the Americas Rio Grande Industrial Park 101 Christine Drive, Beten, NM 87002 USA;

COLDMARK and WARMMARK temperature history indicators, commercially available from IntroTech BV, P.O. Box 3, NL-7370 AA Loenen, the Netherlands.

It is appreciated that sensors 602, 606, 608 and 610 may also be selected from the above list or may be any other suitable sensor.

It is appreciated that while processor 612 is preferably operative to change LCD display 614 in real time, processor 612 may alternatively be operative to change LCD display 614 on a periodic basis, not necessarily in real time.

Reference is now made to Fig. 11, which is a simplified flow chart illustrating a preferred mode of operation of the system of Fig. 5. As seen in Fig. 11, images of objects, which typically include multiple objects, each bearing an identification indicator, are captured, preferably by a conventional camera, such as a color CCD camera. Preferably, the identification indicators include visually sensible identification information. Additionally, the identification indicators may be dynamic

indicators and may provide indication as to various additional parameters relevant to the objects, such as temperature, humidity, tilt and G-shock histories. Visual indications as to other types of parameters may also be provided.

The camera outputs from one or multiple cameras are transmitted wirelessly or via a wired network to a central image processor which processes the images, inter alia to locate and decode the identification indicators in order to extract identification and parameter data. This data, preferably together with the original images showing not only the identification indicators, but also the objects, may be transmitted to one or more monitors, which provide a display of the images and of the decoded data.

It is appreciated that the system and method of the present invention enables real time or non-real time monitoring of objects and multiple locations which may be remote from the monitor and from the image processor.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of the various embodiments described hereinabove as well as modifications and additions thereto which would occur naturally to a person of skill in the art upon reading the foregoing description and which are not in the prior art.

## CLAIMS

1. A methodology for tracking objects comprising:  
affixing at least one imagable identifier onto each of a multiplicity of objects to be tracked;  
imaging at least a portion of at least one of the multiplicity of objects at a known location to provide an at least partial image of said at least one of said multiplicity of objects, containing said at least one imagable identifier; and  
employing said at least partial image of said object containing said at least one imagable identifier to provide an output indication of the location of said at least one of said multiplicity of objects.
2. A methodology for tracking objects according to claim 1 and also comprising communicating at least one of said at least partial image and said output indication to a remote location.
3. A methodology according to claim 1 and wherein said affixing includes adhesively attaching said at least one imagable identifier onto a surface of each of said multiplicity of objects.
4. A methodology according to claim 1 and wherein said affixing includes molding said at least one imagable identifier onto a surface of each of said multiplicity of objects.
5. A methodology according to claim 1 and wherein said affixing includes printing said at least one imagable identifier onto a surface of each of said multiplicity of objects.
6. A methodology according to claim 1 and wherein said at least one imagable identifier comprises a multi-color identifier.

7. A methodology according to claim 1 and wherein said at least one imagable identifier comprises a multi-segment, multi-color identifier.

8. A methodology according to claim 7 and wherein said multi-segment, multi-color identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = (n \times (n - 1)^{(p-2)} \times (n - 2))/p$$

where

n is the number of different colors and

p is the number of segments.

9. A methodology according to claim 7 and wherein said multi-segment, multi-color identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = n \times (n - 1)^{(p-2)} \times (n - 2)$$

where

n is the number of different colors and

p is the number of segments.

10. A methodology according to claim 9 and wherein said multi-segment, multi-color identifier has an inherent orientation.

11. A methodology according to claim 9 and wherein said imaging comprises photographing.

12. A methodology according to claim 1 and wherein said imaging comprises imaging a plurality of said objects together within a single image.

13. A methodology according to claim 1 and wherein said imaging comprises sequentially imaging a plurality of said objects passing a given imaging location.

14. A methodology according to claim 1 and wherein said at least one imagable identifier comprises a plurality of imagable identifiers arranged in at least predetermined propinquity to each other.

15. A methodology according to claim 9 and wherein said imaging comprises imaging a plurality of said objects together within a single image.

16. A methodology according to claim 1 and wherein employing said at least partial image of said object containing said at least one imagable identifier comprises extracting an identification code from said at least partial image.

17. A methodology according to claim 1 and wherein said identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = (n \times (n - 1)^{(p-2)} \times (n - 2))/p$$

where

n is the number of different colors and

p is the number of segments.

18. A methodology according to claim 1 and wherein said multi-segment, multi-color identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = n \times (n - 1)^{(p-2)} \times (n - 2)$$

where

n is the number of different colors and

p is the number of segments.

19. A methodology according to claim 1 and wherein said identifier has an inherent orientation.

20. A methodology according to claim 1 and wherein said imaging comprises photographing.

21. An object tracking system comprising:  
at least one imagable identifier affixed onto each of a multiplicity of objects to be tracked;  
an imager, imaging at least a portion of at least one of said multiplicity of objects at a known location to provide an at least partial image of said at least one of said multiplicity of objects, containing said at least one imagable identifier; and  
a processor employing said at least partial image of said object containing said at least one imagable identifier to provide an output indication of the location of said at least one of said multiplicity of objects.
22. An object tracking system according to claim 21 and also comprising a communicator, communicating at least one of said at least partial image and said output indication to a remote location.
23. An object tracking system according to claim 21 and wherein said affixing includes adhesively attaching said at least one imagable identifier onto a surface of each of said multiplicity of objects.
24. An object tracking system according to claim 21 and wherein said identifier is molded onto a surface of each of said multiplicity of objects.
25. An object tracking system according to claim 21 and wherein said identifier is printed onto a surface of each of said multiplicity of objects.
26. An object tracking system according to claim 21 and wherein said at least one imagable identifier comprises a multi-color identifier.
27. An object tracking system according to claim 21 and wherein said at least one imagable identifier comprises a multi-segment, multi-color identifier.

28. An object tracking system according to claim 27 and wherein said multi-segment, multi-color identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = (n \times (n - 1)^{(p-2)} \times (n - 2))/p$$

where

n is the number of different colors and

p is the number of segments.

29. An object tracking system according to claim 27 and wherein said multi-segment, multi-color identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = n \times (n - 1)^{(p-2)} \times (n - 2)$$

where

n is the number of different colors and

p is the number of segments.

30. An object tracking system according to claim 29 and wherein said multi-segment, multi-color identifier has an inherent orientation.

31. An object tracking system according to claim 29 and wherein said imaging comprises photographing.

32. An object tracking system according to claim 21 and wherein said imaging comprises imaging a plurality of said objects together within a single image.

33. An object tracking system according to claim 21 and wherein said imaging comprises sequentially imaging a plurality of said objects passing a given imaging location.

34. An object tracking system according to claim 21 and wherein said at least one imagable identifier comprises a plurality of imagable identifiers arranged in at least predetermined propinquity to each other.

35. An object tracking system according to claim 29 and wherein said imaging comprises imaging a plurality of said objects together within a single image.

36. An object tracking system according to claim 21 and wherein said processor is operative to extract an identification code from said at least partial image.

37. An object tracking system according to claim 21 and wherein said identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = (n \times (n - 1)^{(p-2)} \times (n - 2))/p$$

where

n is the number of different colors and

p is the number of segments.

38. An object tracking system according to claim 21 and wherein said multi-segment, multi-color identifier is capable of identifying and distinguishing a plurality of objects at least equal to approximately:

$$\text{Plurality of objects} = n \times (n - 1)^{(p-2)} \times (n - 2)$$

where

n is the number of different colors and

p is the number of segments.

39. An object tracking system according to claim 21 and wherein said identifier has an inherent orientation.

40. An object tracking system according to claim 21 and wherein said imaging comprises photographing.

41. An object tracking system according to claim 21 and wherein output from said imager can be stored for future retrieval.



42. An object tracking system according to claim 27 and wherein output from said imager can be stored for future retrieval.
43. An object tracking system according to claim 29 and wherein output from said imager can be stored for future retrieval.
44. A methodology according to claim 1 and wherein output of said imaging can be stored for future retrieval.
45. A methodology according to claim 7 and wherein output of said imaging can be stored for future retrieval.
46. A methodology according to claim 9 and wherein output of said imaging can be stored for future retrieval.
47. A system for tracking objects comprising:  
visually sensible indicators on objects being tracked;  
at least one imager capturing images of said objects being tracked which images also show said visually sensible indicators; and  
at least one image processor receiving outputs of said at least one imager and extracting from said outputs coded information indicated by said visually sensible indicators.
48. A system for tracking objects according to claim 47 and also comprising at least one monitor receiving and displaying said coded information from said image processor.
49. A system for tracking objects according to claim 48 and wherein said at least one monitor is also operative to display said images of said objects in conjunction with said coded information.

50. A system for tracking objects according to any of claims 47-49 and wherein said visually sensible indicator indicates object identity information.
51. A system according to claim 50 and wherein said visually sensible indicator also indicates at least one additional parameter relating to said object.
52. A system for tracking objects according to any of claims 47-51 and wherein said visually sensible indicator is a dynamic indicator.
53. A system for tracking objects according to any of claims 47-52 and wherein said visually sensible indicator provides non-alphanumeric indications of multiple parameters relating to an object onto which the indicator is mounted.
54. A system for tracking objects according to any of claims 47-53 and wherein said visually sensible indicator provides a coded indication of at least two of the following parameters: object location, object identity, object maximum temperature history; object maximum humidity history; object minimum temperature history; object minimum humidity history; object tilt history, object G-force history.
55. A system for tracking objects according to any of claims 47-54 and wherein said at least one imager comprises a plurality of imagers, which plurality is greater than the number of said at least one image processor.
56. A system for tracking objects according to any of claims 47-55 and wherein said at least one imager comprises at least one scanning imager.
57. A method for tracking objects comprising:  
associating visually sensible indicators with objects being tracked;  
capturing images of said objects being tracked which images also show said visually sensible indicators; and  
image processing outputs of said at least one imager and extracting from said outputs coded information indicated by said visually sensible indicators.

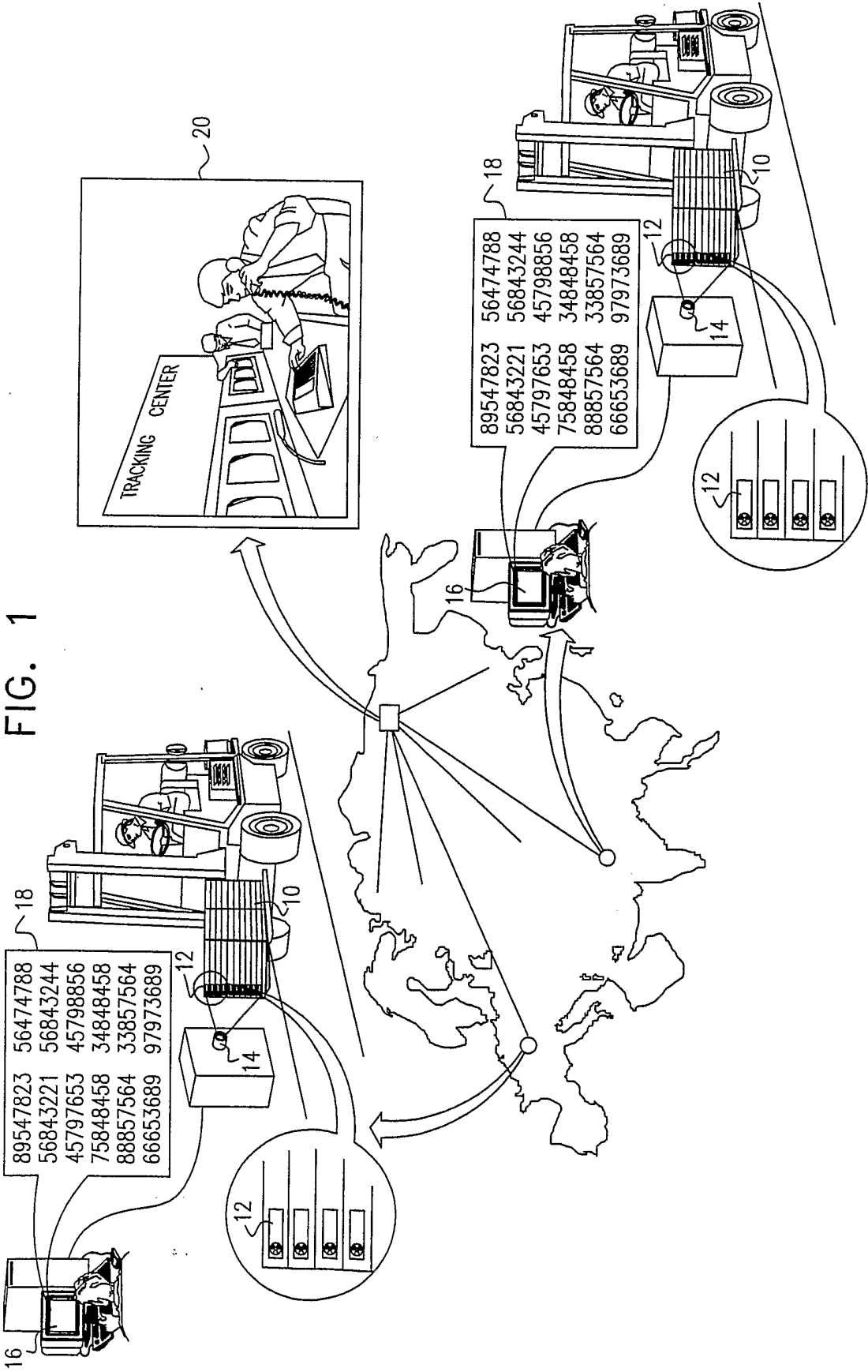
58. A method for tracking objects according to claim 57 and also comprising remotely receiving and displaying said coded information from said image processor.
59. A method for tracking objects according to claim 57 or claim 58 and also comprising displaying said images of said objects in conjunction with said coded information.
60. A method for tracking objects according to any of claims 57-59 and wherein said visually sensible indicator indicates object identity information.
61. A method according to claim 60 and wherein said visually sensible indicator also indicates at least one additional parameter relating to said object.
62. A method for tracking objects according to any of claims 57 - 61 and wherein said visually sensible indicator changes its visual display in real time in accordance with the parameters indicated thereby.
63. A method for tracking objects according to any of claims 57-62 and wherein said visually sensible indicator provides non-alphanumeric indications of multiple parameters relating to an object onto which the indicator is mounted.
64. A method for tracking objects according to any of claims 57-63 and wherein said visually sensible indicator provides a coded indication of at least two of the following parameters: object location, object identity, object maximum temperature history; object maximum humidity history; object minimum temperature history; object minimum humidity history; object tilt history, object G-force history.
65. A method for tracking objects according to any of claims 57-64 and wherein said image processor processes images captured at plural locations

66. A method for tracking objects according to any of claims 57-65 and wherein said capturing images employs at least one scanning imager.
67. A system for monitoring objects comprising:  
a plurality of sensors associated with objects being monitored;  
visually sensible indicators associated with each of said objects,  
receiving sensor outputs of said plurality of sensors and providing visually sensible indications of said sensor outputs;  
at least one imager capturing images of said visually sensible indicators;  
and  
at least one image processor receiving image outputs of said at least one imager and extracting from said image outputs coded information indicated by said visually sensible indicators.
68. A system for monitoring objects according to claim 67 and also comprising at least one monitor receiving and displaying said coded information from said image processor.
69. A system for monitoring objects according to claim 68 and wherein said at least one monitor is also operative to display said images of said objects in conjunction with said coded information.
70. A system for monitoring objects according to any of claims 67-69 and wherein said visually sensible indicators also indicate object identity information.
71. A system for monitoring objects according to claim 70 and wherein said at least one monitor is remotely located from said objects.
72. A system for monitoring objects according to any of claims 67-71 and wherein said visually sensible indicators are dynamic indicators.

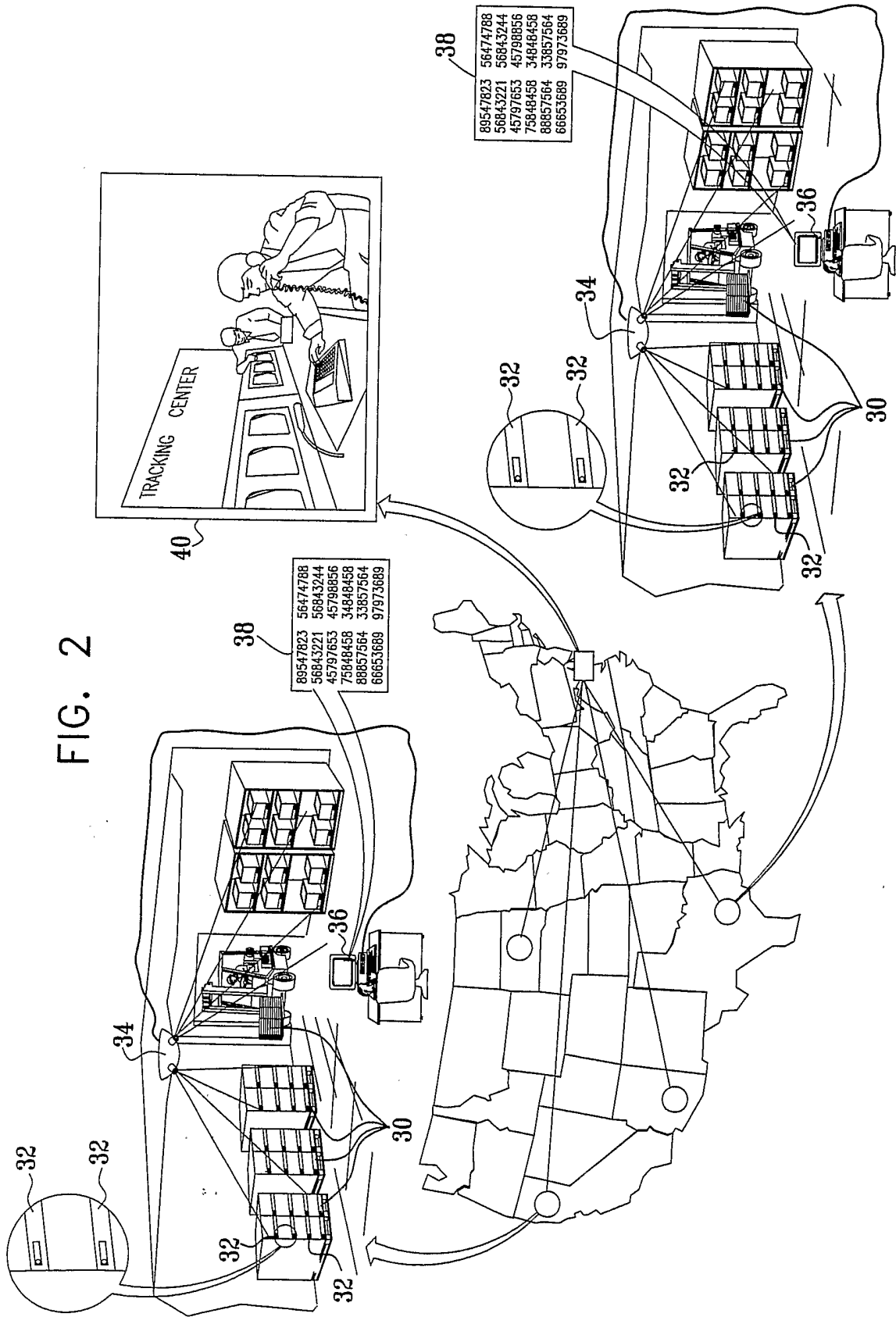
73. A system for monitoring objects according to any of claims 67-72 and wherein said visually sensible indicators provides non-alphanumeric indications of multiple parameters relating to an object onto which the indicator is mounted.
74. A system for monitoring objects according to any of claims 67-73 and wherein said visually sensible indicator provides a coded indication of at least two of the following parameters: object location, object identity, object maximum temperature history; object maximum humidity history; object minimum temperature history; object minimum humidity history; object tilt history, object G-force history.
75. A system for monitoring objects according to any of claims 67-74 and wherein said at least one imager comprises a plurality of imagers, which plurality is greater than the number of said at least one image processor.
76. A system for monitoring objects according to any of claims 67-75 and wherein said at least one imager comprises at least one scanning imager.
77. A method for monitoring objects comprising:  
associating a plurality of sensors with objects being monitored;  
associating visually sensible indicators with each of said objects;  
providing to said visually sensible indicators, sensor outputs of said plurality of sensors;  
operating said visually sensible indicators to provide visually sensible indications of said sensor outputs;  
employing at least one imager to capture images of said visually sensible indicators; and  
employing at least one image processor to receive image outputs of said at least one imager and extract from said image outputs coded information indicated by said visually sensible indicators.

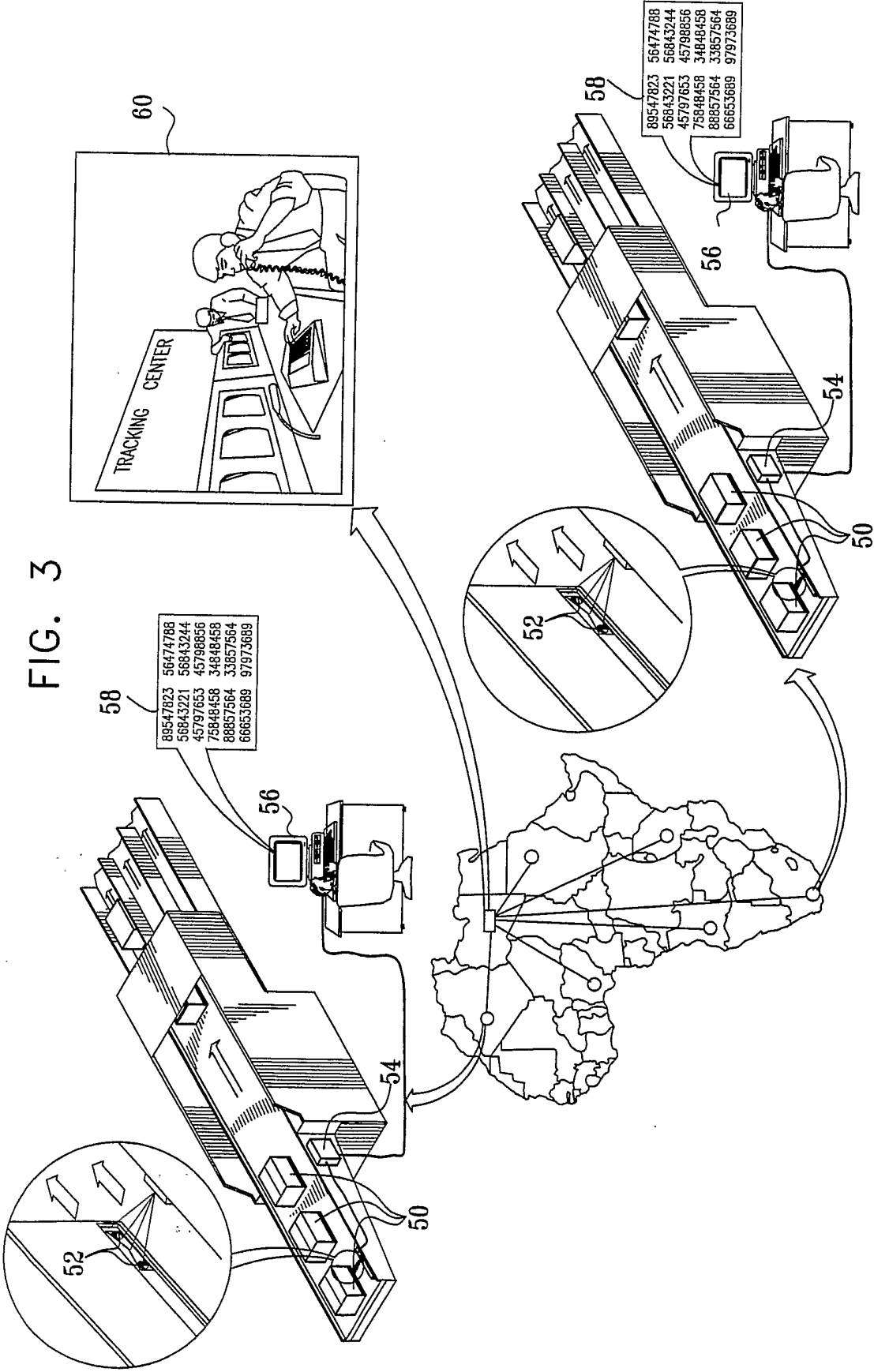
78. A method for monitoring objects according to claim 77 and also comprising remotely receiving and displaying said coded information from said image processor.
79. A method for monitoring objects according to claim 77 or claim 78 and also comprising displaying said images of said objects in conjunction with said coded information.
80. A method for monitoring objects according to any of claims 77 – 79 and also comprising indicating object identity information on said visually sensible indicators.
81. A method for monitoring objects according to claim 80 and also comprising indicating at least one additional parameter relating to said object on said visually sensible indicator.
82. A method for monitoring objects according to any of claims 77 - 81 and also comprising changing the visual display of said visually sensible indicator in real time in accordance with the parameters indicated thereby.
83. A method for monitoring objects according to any of claims 77-82 and also comprising providing non-alphanumeric indications of multiple parameters relating to an object onto which said visually sensible indicator is mounted.
84. A method for monitoring objects according to any of claims 77-83 and also comprising providing a coded indication on said visually sensible indicator of at least two of the following parameters: object location, object identity, object maximum temperature history; object maximum humidity history; object minimum temperature history; object minimum humidity history; object tilt history, object G-force history.
85. A method for monitoring objects according to any of claims 77-84 and also comprising processing images captured at plural locations.

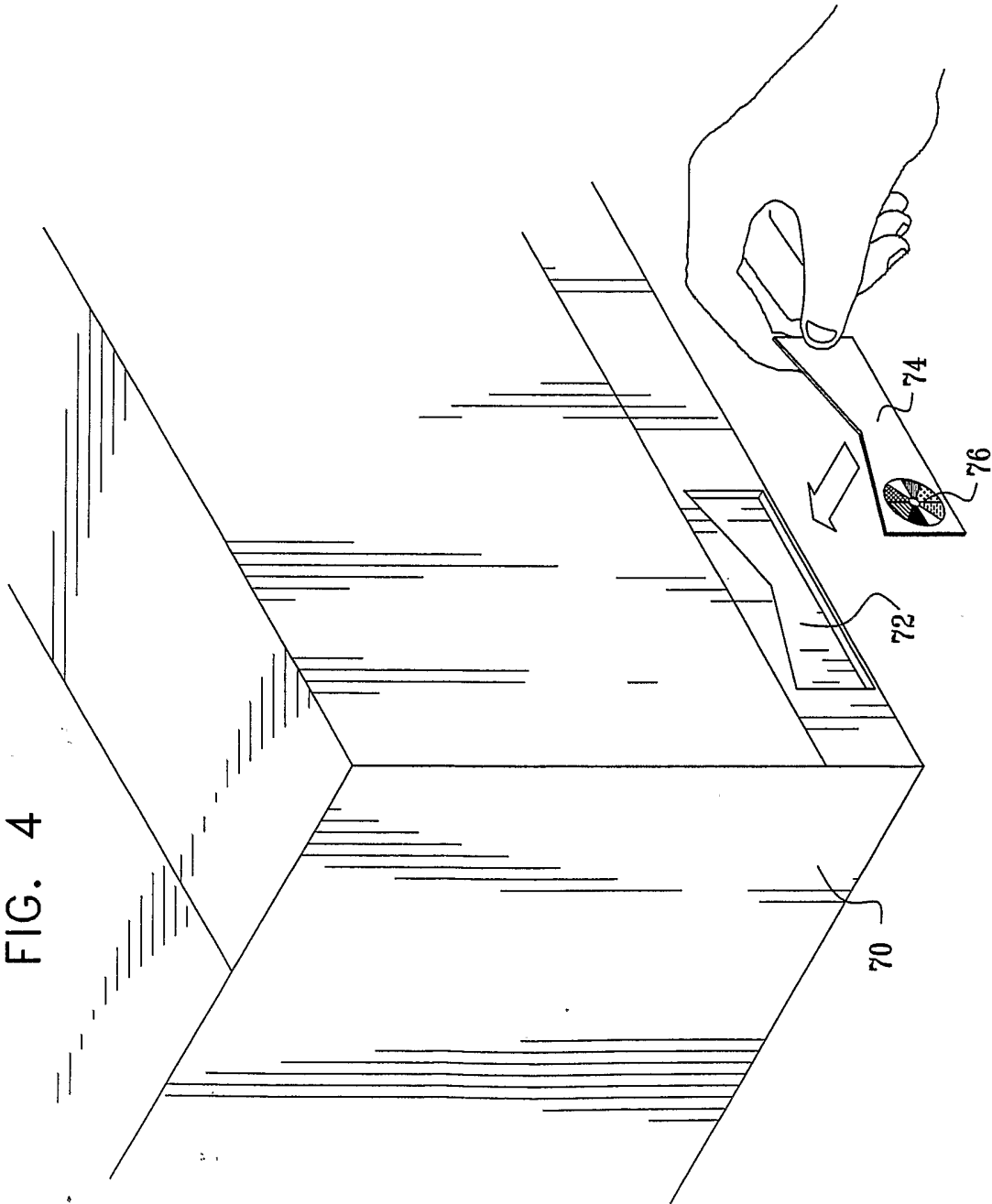
86. A method for monitoring objects according to any of claims 77-85 and wherein said capturing images employs at least one scanning imager.











5/13

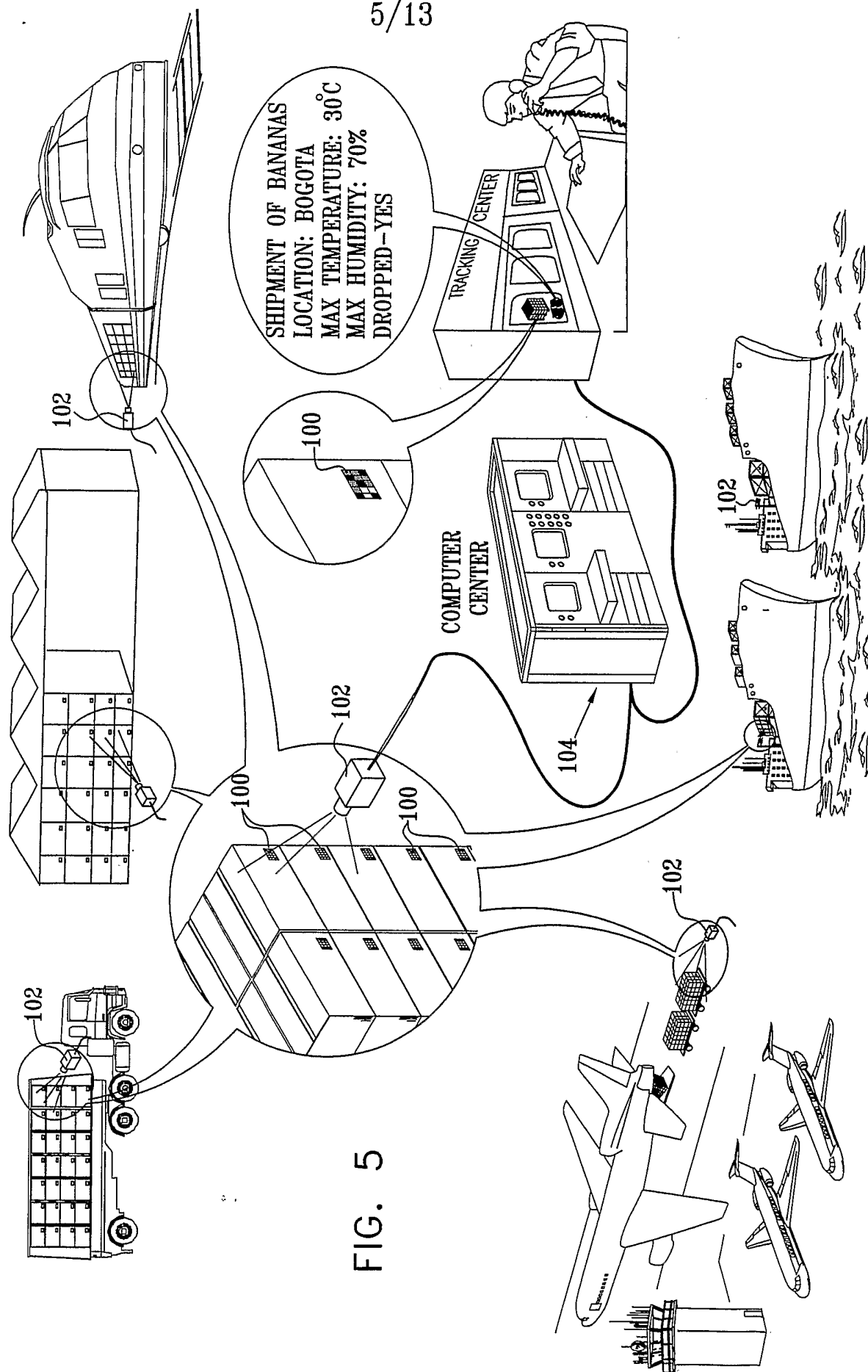
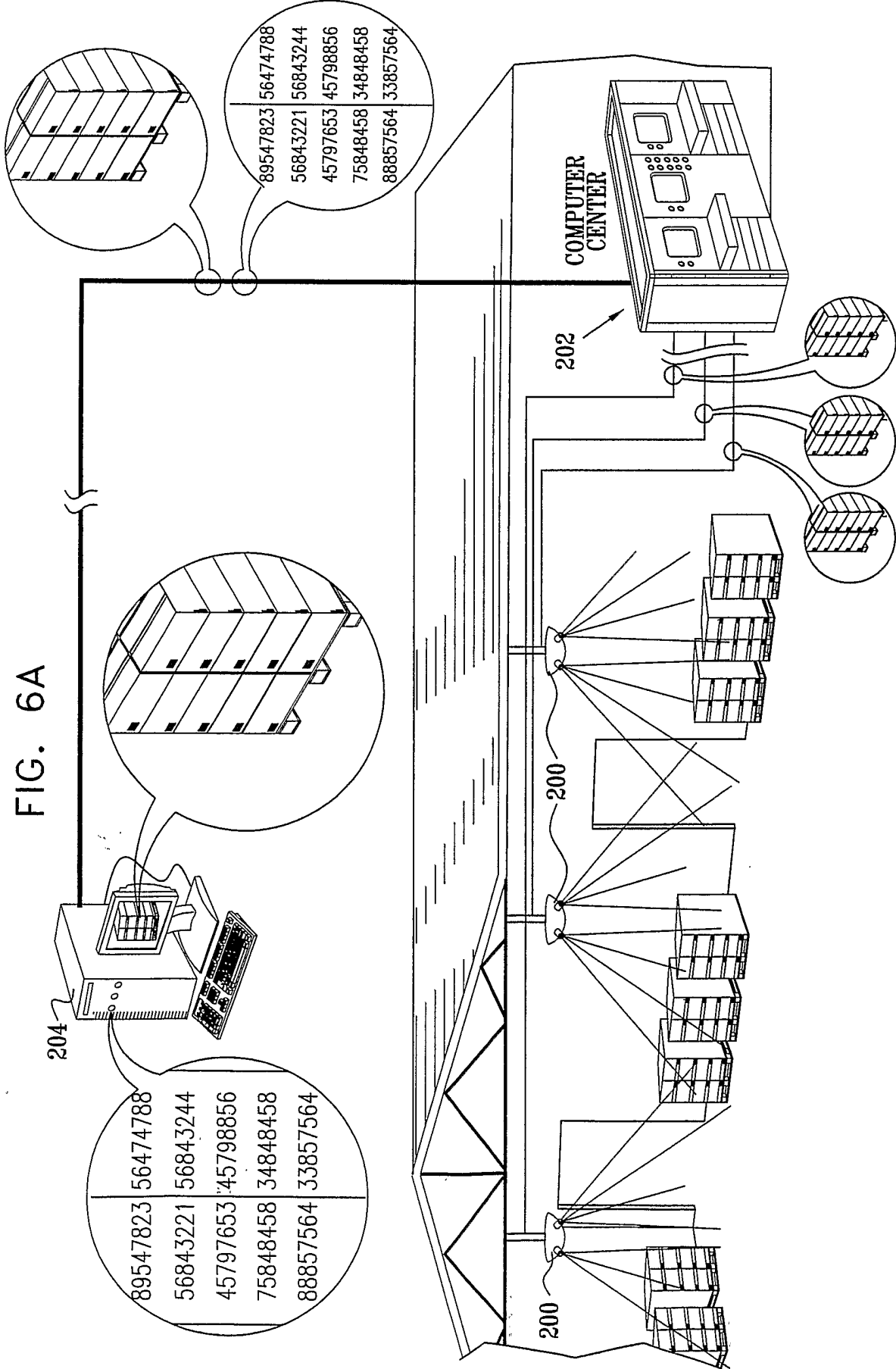


FIG. 5



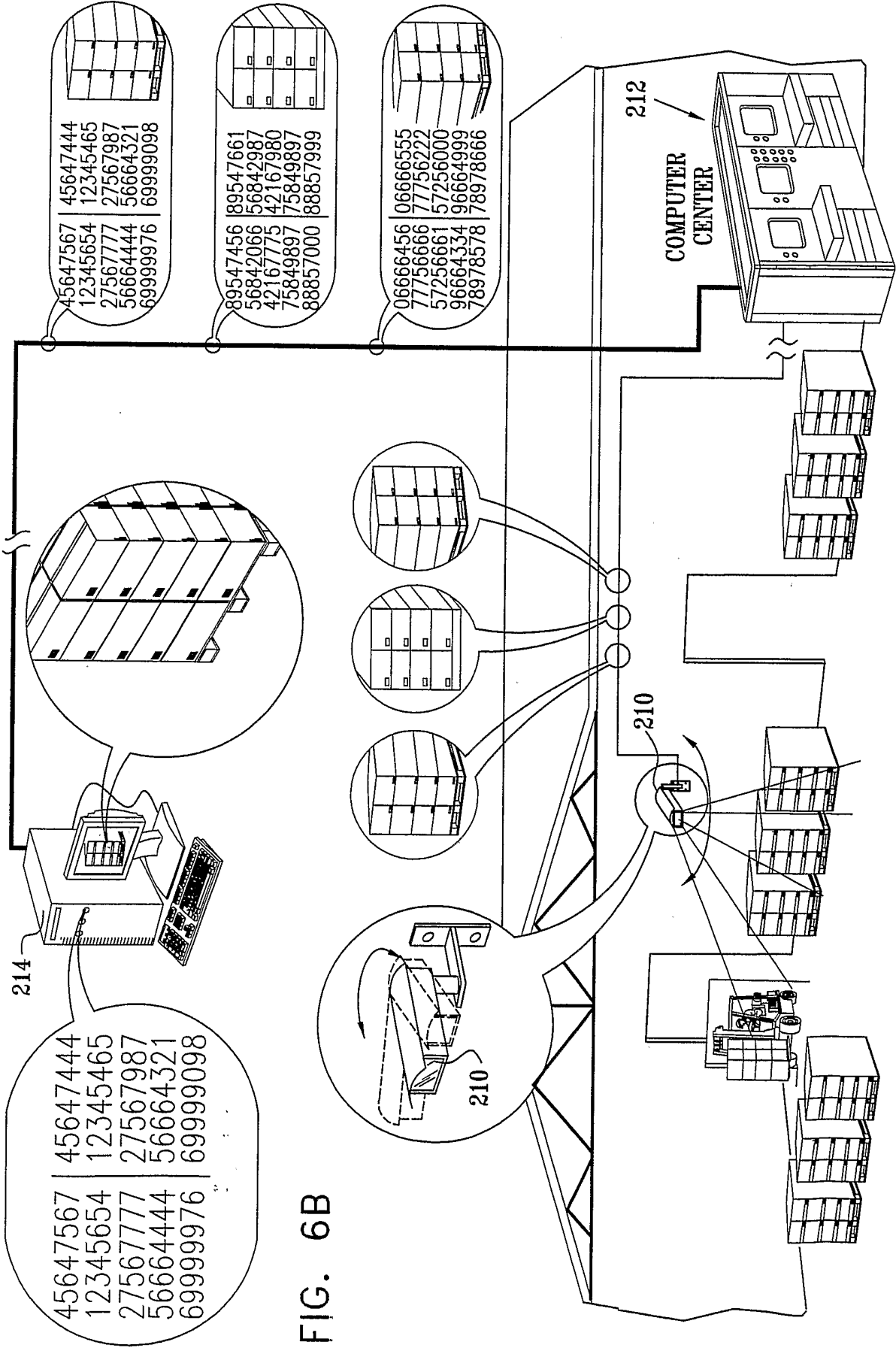
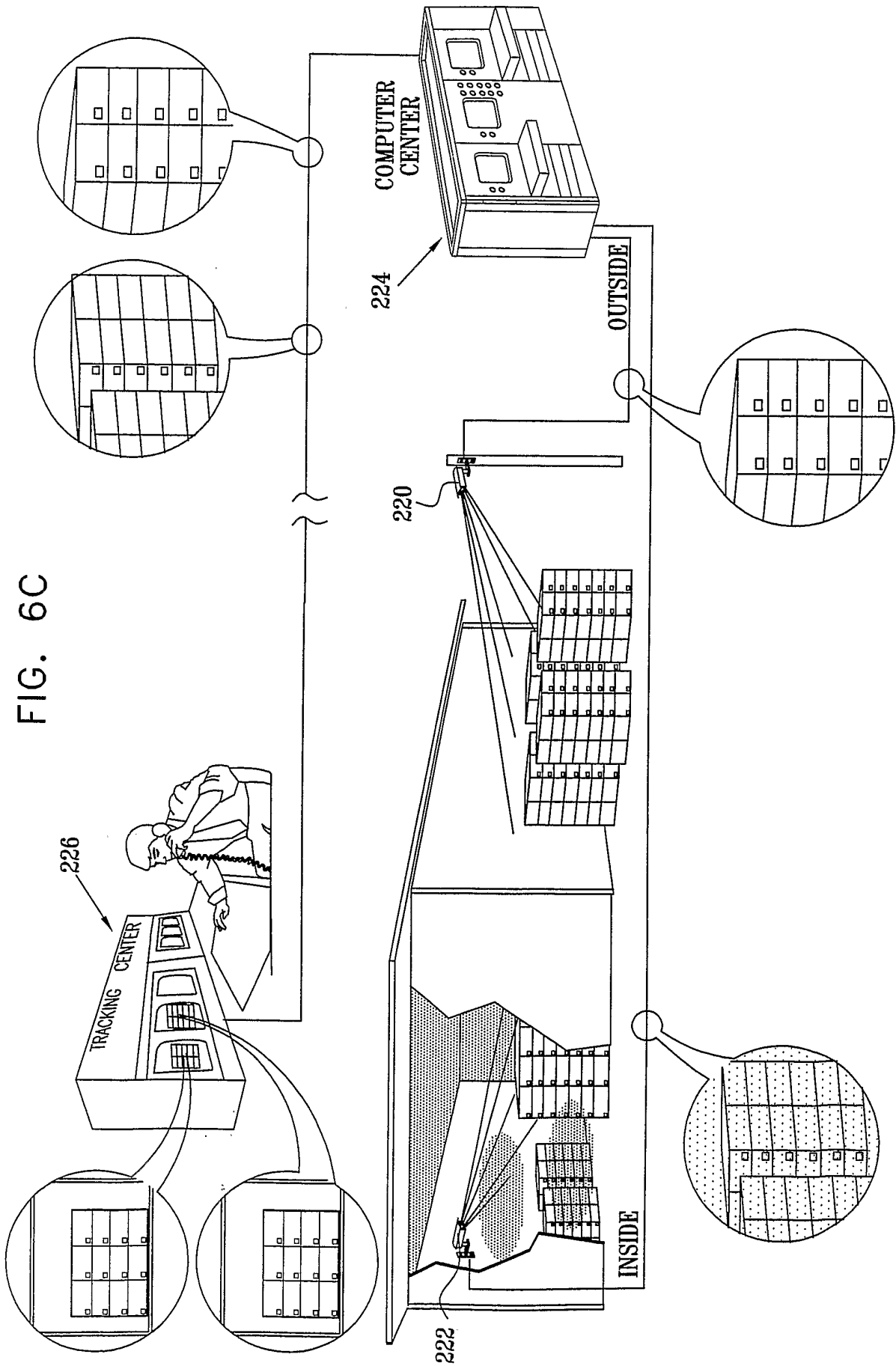
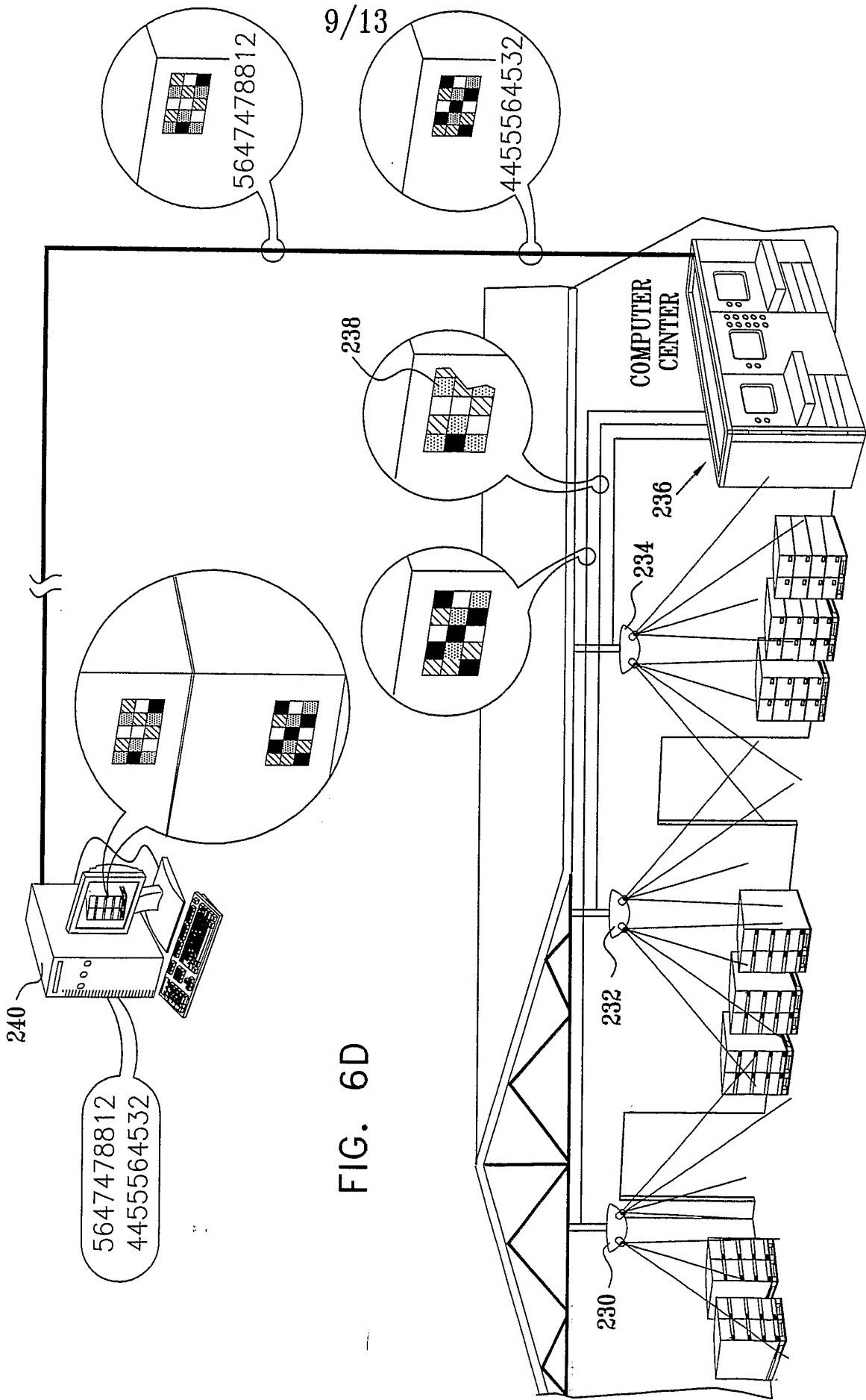


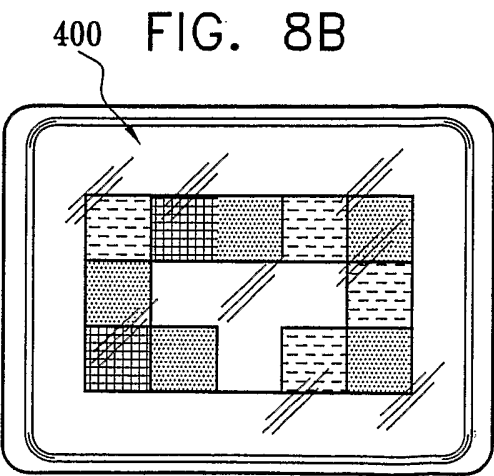
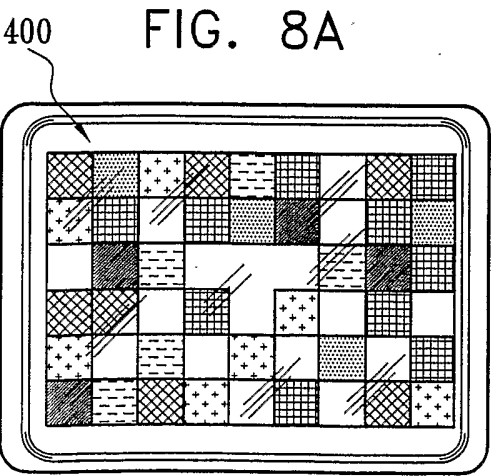
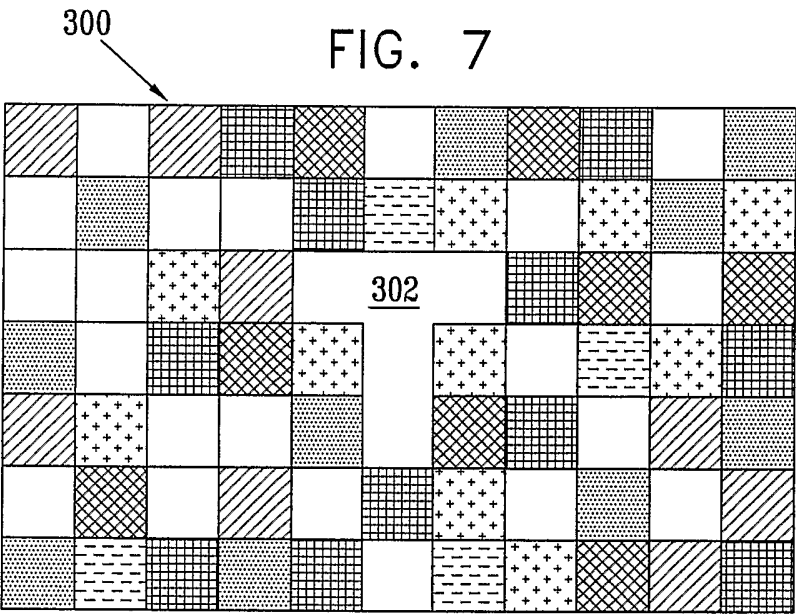
FIG. 6B

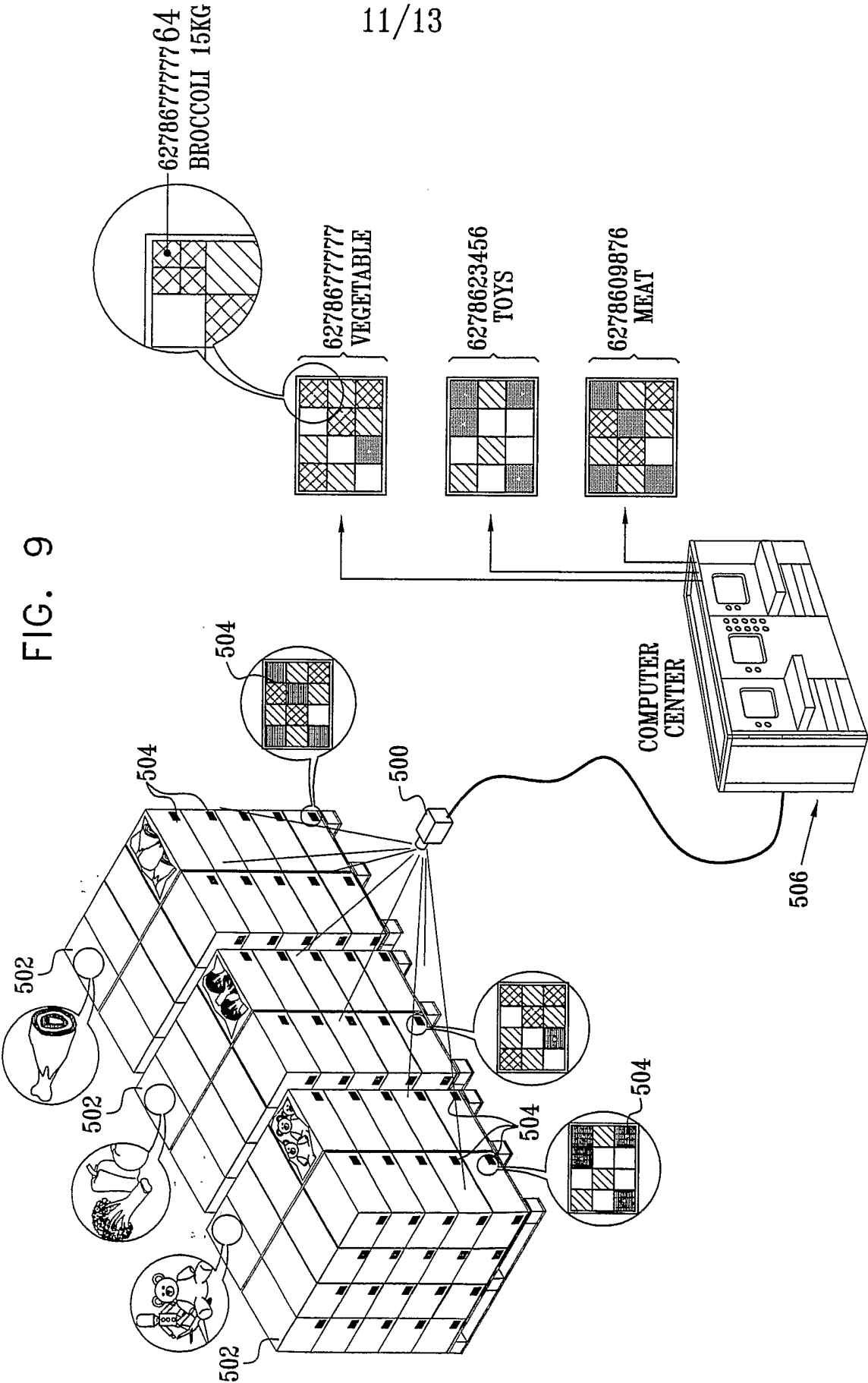
FIG. 6C

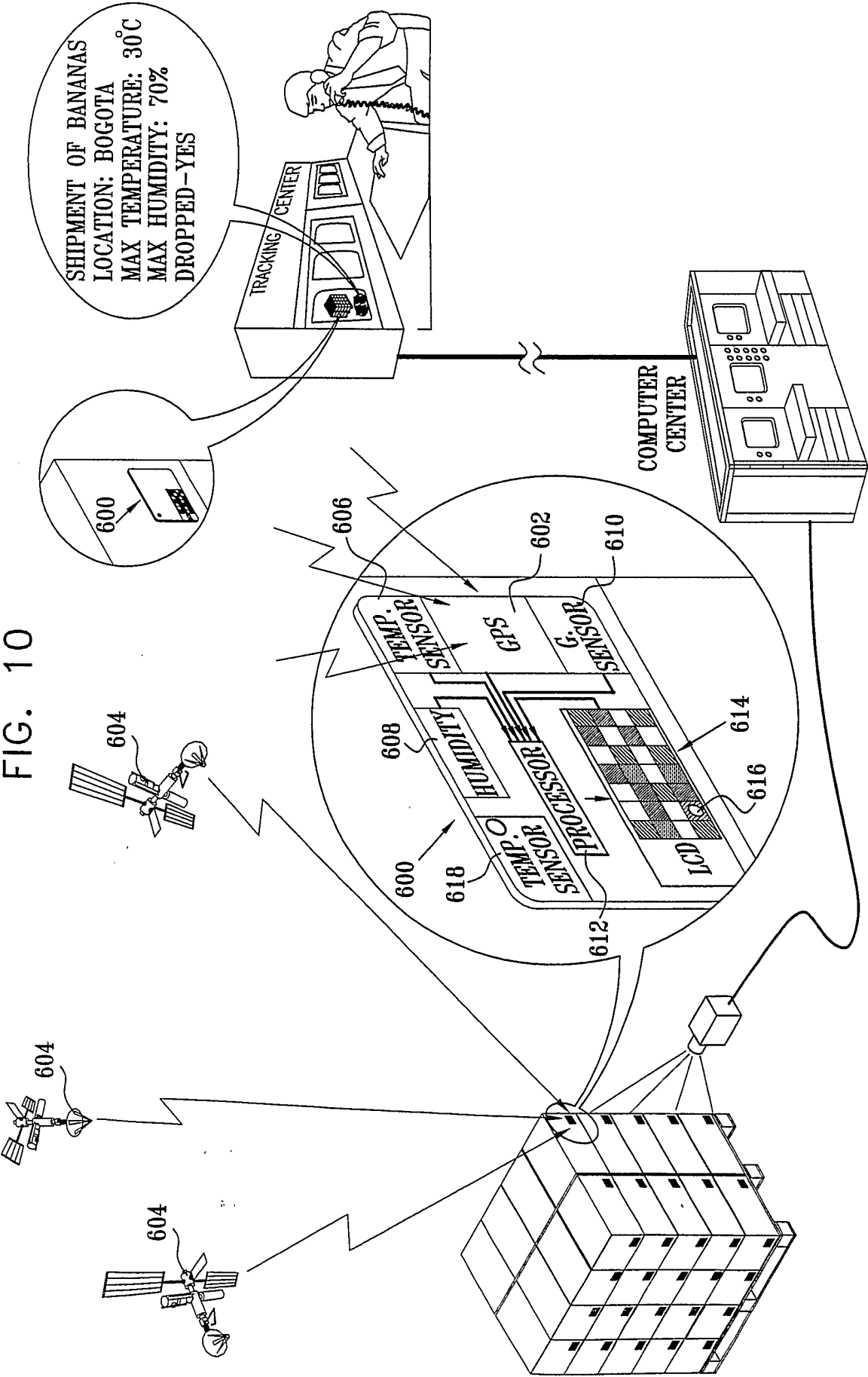












13/13

FIG. 11

