(12) STANDARD PATENT APPLICATION (11) Application No. **AU 2004233458 A1**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Analysing image data

(51)⁷ International Patent Classification(s)
G06T 007/20

(21) Application No: **2004233458** (22) Date of Filing: **2004.11.25**

(30) Priority Data

(31) Number	(32) Date	(33) Country
2003906681	**2003.12.03**	**AU**
04 07 268.2	**2004.03.31**	**GB**
04 07 263.3	**2004.03.31**	**GB**

(43) Publication Date: **2005.06.23**
(43) Publication Journal Date: **2005.06.23**

(71) Applicant(s)
Safehouse International Inc

(72) Inventor(s)
Henson, Michael Anthony; Van Den Bergen, Mark Adrian

(74) Agent / Attorney
Eagar & Buck, 21/36 Agnes Street, FORTITUDE VALLEY, QLD, 4006

Abstract of the Disclosure

Analysing Image Data

Image data is processed to track moving foreground objects thereby identifying tracked objects, and the movement of said foreground objects is tracked. A timeline is displayed, along with an indication of said tracked objects with reference to said timeline.

[Figure 45]

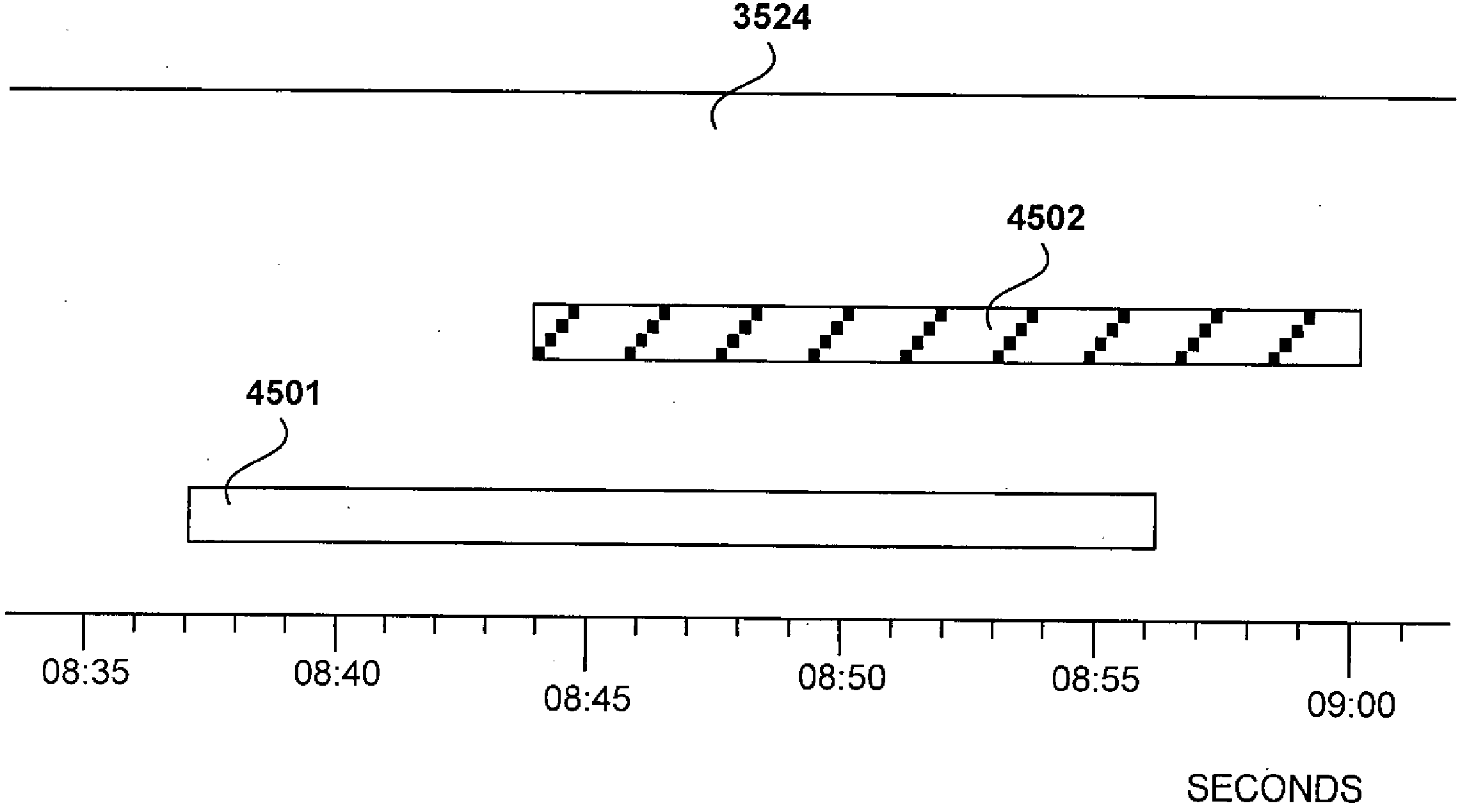


Fig. 45

2004233458 25 Nov 2004

P/00/011
Regulation 3.2

AUSTRALIA
PATENTS ACT 1990

Original Complete Specification

Standard Patent

Invention Title:

ANALYSING IMAGE DATA

The following statement is a full description of this invention, including the best method of performing known to me:

2004233458 25 Nov 2004

Analysing Image Data

Field of the Invention

The present invention relates to analysing image data in which foreground objects are present.

Description of the Related Art

Automated monitoring systems provide a plurality of cameras for monitoring one or more objects so as to detect predetermined characteristics and generate trigger signals. An event system receives events and determines whether an alarm condition exists and the system can be used to protect a number of objects, such as paintings and art works held in a number of locations, from theft or vandalism.

Figure 1

A plan view of an art gallery is shown in *Figure 1*, consisting of an entrance area **101**, a central area **102**, and a number of peripheral viewing galleries **103** to **111**. Monitoring may also be provided in a car park area **112** adjacent to the gallery.

Viewing galleries to **103** to **111** all contain expensive works of art and are therefore protected by a plurality of cameras, including cameras **115** and **116** in room **103** and cameras **117**, **118**, **119** and **120** in room **109**. A security guard sits in a security office **121** that includes many television monitors **122** configured to receive signals from the cameras, including cameras **115** to **120**.

The cameras of the prior art include self-regulating controls for brightness and contrast, so as to compensate automatically when changes occur to the ambient room lighting.

Figure 2

Gallery viewing room **109** is shown in detail in *Figure 2*. In this example, a vandal has attacked a painting **201** with a knife and the vandal's actions have been caught by camera **117**. However, there are a large number of cameras in the establishment, including camera **119** that is monitoring the activities of visitors viewing a second painting **202**.

Figure 3

A surveillance officer located in room **121** views the outputs from many video cameras, including cameras **118** to **120**, via a bank of video monitors **301**. The surveillance officer is presented with a large amount of visual data including an image of painting **201** being vandalised, on a monitor **302** and an image of visitors looking at painting **202** on a monitor **303**. In this example, the surveillance officer is looking at the output from monitor **303** at a time when the vandalism is taking place such that, although being displayed, the officer is not made aware of the vandalism being depicted on monitor **302**.

It is likely that the images displayed on monitor **302** will have been recorded on video tape, or similar media, such that it would be possible to take action after the event. However, it is far preferable to detect an event of interest (the vandalism of the picture say) at an early stage and preferably identify some other form of activity prior to the vandalism taking place which could allow the vandal to be apprehended before any damage is done.

It has been appreciated that there has been an increasing demand for security monitoring and surveillance operations to be conducted but the reliance on predominantly human activities often makes the task uneconomic. It would therefore be preferable to introduce technical solutions in order to provide technical monitoring with far less reliance on human observation.

Brief Summary of the Invention

According to an aspect of the present invention, there is provided a method of analysing image data, including the steps of processing image data to track moving foreground objects thereby identifying tracked objects, monitoring movement of said foreground objects, displaying a timeline, and displaying an indication of said tracked objects with reference to said timeline.

Brief Description of the Several Views of the Drawings

Figure 1 shows a plan view of an art gallery of the prior art;

Figure 2 shows a gallery viewing room of the prior art;

Figure 3 shows a security room of the prior art;

Figure 4 shows a plan view of an art gallery substantially similar to that shown in *Figure 1* but incorporating an embodiment of the present invention.

Figure 5 shows a control room similar to that shown in *Figure 3* but embodying the present invention;

Figure 6 shows a gallery viewing room incorporating an embodiment of the present invention;

Figure 7 shows an overview of monitoring apparatus;

Figure 8 details the processing systems shown in *Figure 7*;

Figure 9 shows the steps of installation, configuration and operation of the system;

Figure 10 shows a summary of the memory contents for each processing system shown in *Figure 7*;

Figure 11 shows the object interactions involved in operation of the system;

Figure 12 shows an overall functionality of the system illustrated in *Figure 11*;

Figure 13 shows a schematic representation of a digital monitoring camera shown in *Figure 4*;

Figure 14 details procedures performed by a microcontroller *in Figure 13;*

Figure 15 details procedures implemented by analysing objects as shown in *Figure 11*;

Figure 16 shows a schematic representation of background modelling and foreground classification;

Figure 17 shows the effect of the threshold for foreground/background classification being set too low;

Figure 18 shows the effect of the threshold for foreground/background classification being well adjusted;

Figure 19 details morphology processes;

Figure 20 shows the result of the morphology process shown in *Figure 19;*

Figure 21 shows several binary large objects being tracked in the same frame;

Figure 22 details the generation of multi-resolution images;

Figure 23 shows an image with foreground stored at high quality and background at reduced quality;

Figure 24 shows a schematic representation of the optimisation of images for storage;

Figure 25 shows the automatic generation of parameters;

Figure 26 shows a summary of parameters generated as shown in

Figure 25;

Figure 27 details procedures for creating minute-based summaries as shown in *Figure 25*;

Figure 28 details procedures for calculating optimised camera parameters as shown in *Figure 25*;

Figure 29 details the process of quality monitoring as shown in *Figure 25;*

Figure 30 details procedures for producing exemplar images as shown in *Figure 15*;

Figure 31 details the generation of exemplar images as shown in *Figure 30*;

Figure 32 shows a graph of activity against time in accordance with procedures shown in *Figure 31*;

Figure 33 details the redundant array of independent disks as shown in *Figure 8*;

Figure 34 details viewing, reporting and maintenance scheduling procedures shown in *Figure 12*;

Figure 35 shows an example of a graphical user interface in accordance with the present invention;

Figure 36 details procedures for displaying analysis results as shown in *Figure 34*;

Figure 37 details procedures for retrieving data using the multi-resolution database as shown in *Figure 36*;

Figure 38 details the recursive nature of filling the multi-resolution cache, as shown in *Figure 37*;

Figure 39 shows the storage of summary data at multi-resolution levels;

Figure 40 details procedures for calculating system quality as shown in

Figure 36;

Figure 41 details procedures for selecting cameras for display as shown in *Figure 36*;

Figure 42 details procedures for rendering the grid map as shown in *Figure 36*;

Figure 43 shows a plurality of grid maps which may be associated with a monitored installation;

Figure 44 details procedures for rendering the track path timeline as shown in *Figure 36*;

Figure 45 shows an expanded view of the track path shown in *Figure 35*;

Figure 46 details procedures for rendering the activity timeline with exemplar images as shown in *Figure 36*;

Figure 47 details procedures for tagging as shown in *Figure 34*;

Figure 48 shows an example of a tag;

Figure 49 details procedures for generating a maintenance schedule as shown in *Figure 34*;

Figure 50 details procedures for generating reports as shown in *Figure 34;*

Figure 51 details procedures for producing a daily single page report as shown in *Figure 50*;

Figure 52 shows an example of a daily report;

Figure 53 details procedures for producing a shift end report as shown in *Figure 50*; and

Figure 54 shows an example of a report.

The invention will now be described, by way of example only, with reference to the accompanying figures.

Written Description of the Best Mode for Carrying out the Invention

Figure 4

A plan view of the art gallery identified in *Figure 1*, is shown in *Figure 4* after modifications have been made to incorporate an embodiment of the present invention. . Detection devices are in this example provided by digital monitoring cameras, such as cameras **401** to **420**, that produce a digital video output signal for transmission over a data network. In addition, the cameras are also configured with digital input interfaces for receiving operational control signals.

It will be appreciated that the digital monitoring video cameras provide many advantages over traditional analogue video cameras. However, it will also be appreciated that many of the techniques described herein could also be applied to use of cameras of a more traditional design.

In surveillance office **121**, the bank of video monitors **122** has been replaced by a single monitor **431**. However, in an alternative embodiment, information may be processed locally and then transmitted to a remote site over a telecommunications link. The remote site could in theory be many miles away, possibly even in a different country. In addition, several environments such as the art gallery shown in *Figure 4* could be monitored using a shared facility.

Figure 5

The security office **121** shown in *Figure 4* is detailed in *Figure 5*. Monitor **431** is shown displaying images to the security officer (operator) such that said operator may make observations and then act upon these observations. The digital monitoring cameras shown in *Figure 4* (**115** to **120** etc) supply input image data to a processing environment (shown *in Figure 7*) such that the visual information is monitored by said processing environment. Thus, after performing a degree of technical monitoring, output image data is supplied to the monitor **431** for observations to be performed and actions to be taken by the operator. A local processing system is also configured to receive manual input data from the operator via a keyboard **501** and a mouse **502** or similar manually operable input devices.

The processing environment (possibly in the form of a plurality of networked computers) is configured to identify events of potential interest from an analysis of the image input data sources. The operator observes information displayed by monitor **431** but much of the monitoring exercise is performed by the system technology itself. Consequently, the amount of data displayed to the operator is reduced significantly but the information content is much higher. In this way, there is a greater likelihood of an event of interest being observed by the operator (thereby allowing it to be acted upon) while the degree of human effort and attention is significantly reduced.

Figure 6

With reference to the previously described scenario, the painting **201** is about to be attacked by a vandal. However, the activities of the vandal are now being captured by digital monitoring camera **417** and the resulting video images are being monitored by the processing system. In this way, it is possible for the monitoring system to identify unusual activities performed by the vandal, such as the vandal moving too close to the painting and raising an arm etc. Thus, these activities are detected by the monitoring system as being more likely to be of interest than the activities captured by camera **420**, say. Activities identified in this way by the monitoring system are described herein as events of potential interest. Activities identified by the monitoring processes would then be observed by an operator to determine whether they were of real interest.

Upon the vandal's activities being monitored and detected by the processing system, the image is brought to the attention of the operator shown in *Figure 5* by being displayed prominently on monitor **431**. The operator is then in a position to radio a colleague who can apprehend the vandal, as shown in *Figure 6*, prior to any actual damage taking place. It is also possible for information to be sent to patrolling guards via portable devices, such as radio enable hand-held computers. This could be instigated by an operator (after observing) or an image could be sent automatically by the monitoring system.

The sophistication of the digital monitoring cameras shown in *Figure 6*, in combination with the processing environment for monitoring input signals, allows a further degree of sophistication to be introduced. Thus, for example, it is desirable for the digital monitoring cameras to be appropriately maintained; so as to ensure the reception of optimum signals while at the same time avoiding unnecessary periods when the cameras are placed offline while avoiding the unnecessary expense of performing maintenance functions that are not actually required. Consequently, in a preferred embodiment, a servicing schedule for the cameras is generated by analysing background images to produce a background model. The background model data is processed in combination with the incoming data to ascertain an extent of degradation experienced by the cameras. The extents of degradation are reviewed automatically for a plurality of cameras so as to automatically generate a servicing schedule.

It is possible for other characteristics to be monitored over time that measure camera quality or health, from which it is possible to estimate future health in order to determine an optimum time for carrying out maintenance. Thus camera health could be considered with reference to degradation of focus and/or degradation of contrast, for example.

Furthermore, as previously described, the digital monitoring cameras include an input interface for receiving operational control signals. In this way, it is possible for input signals to be generated that alter the characteristics of the camera so as to optimise and further enhance monitoring functions of the processing environment. Thus, in this example, the operating characteristics of camera **417** have been adjusted in order to obtain better contrast and clarification of the image data that that includes the captured image of the vandal. This in turn facilitates the monitoring operation which determines whether activities of potential interest are being carried out. These activities of potential interest (detected by the monitoring system) are then presented to the operator allowing the operator to observe the activities directly and act upon them appropriately. Thus, in this scenario, the activities of potential interest have been observed and the human operator has then reached a decision to the effect that the activities are of real interest and must be acted upon.

Figure 7

The network of cameras illustrated in *Figure 4* in combination with the local processing environment shown in *Figure 5* forms part of an overall monitoring apparatus, as illustrated in *Figure 7*. Image data processing systems **701**, **702** and **703** communicate via a high speed ethernet network **704**. Processing system **701** receives input image data from digital monitoring cameras **417** to **420**. The processing system **701** may also receive other sensor input data from other types of detector, such as pressure detectors and infra-red detectors etc. Similarly, processing system **702** receives input image data from monitoring cameras **414** to **416** and processing system **703** receives input image data from monitoring cameras **411** to **414**.

At each processing system **701** to **703** image data processing is performed which results in decisions being made such as to whether particular input images are to be stored, processed more intensively and/or possibly used in order to adjust operating characteristics of the image capturing process.

Image processing system **705** provides a data store for images, along with other data generated by analytical processes or in response to inputs received from an operator.

In the environment shown in *Figure 4*, all of the digital monitoring cameras are interfaced to processing systems similar to processing system **701**. These additional processing systems are also connected to the ethemet network **704**, thereby allowing all image data produced within the environment to be analysed and stored to an extent considered appropriate by the monitoring system.

Data store processing system **705** communicates with a high capacity offline backup storage unit **706** to allow for image data to be duplicated onto removable data media, such as digital video tape, magnetic or optical disks etc.

Remote processing system **707** is available to provide remote analysis of incoming video data in situations where additional processing capacity is required or is considered desirable. In addition, remote processing system **707** also communicates with a plurality of output alarm generating devices **708** which, in response to potential activities of interest being monitored, will result in appropriate alarm triggers being generated such that appropriate action may be taken.

It is also possible for information to be transmitted to handheld radio devices, such as devices **709**, **710** and **711** taking the form of wireless equipped handheld computers or processing enabled mobile phones etc. Communication to these devices is provided by a wireless local area network server **712**, which in turn receives signals from the processing systems via the network **704**.

The local processing system or workstation described with reference to *Figure 5* is shown communicating with the network **704** via a processing system **713**. Operating instructions for the processing system **713** are, in an embodiment, loaded from an instruction-carrying medium such as a CD-ROM **714** receivable within a CD-ROM player. Alternatively, operating instructions may be received from a server via the network **704**. These possibilities and others exist for other processing systems within the overall apparatus.

The provision of a network connection to the local workstation enables the workstation to view analysis results generated from captured input data, thereby allowing monitored activities to be observed by the operator. In addition, the network connection also facilitates the replay and examination of recorded material, including images and results of analyses performed by the monitoring infrastructure. Recorded images may also be retrieved from the storage system **705/706**.

The operator's workstation also includes a printing device **715** configured to produce daily reports in eye-readable form, in addition to similar reports being generated electronically and possibly distributed over the network **704**. The printing device **715** is also available to produce hard copies of maintenance schedules that are generated in response to analysing the incoming video data and determining the extent to which degradation has taken place so that the maintenance activities may be scheduled to obtain optimised results at minimised cost.

Figure 8

The processing systems shown in *Figure 7* are all substantially similar, and are illustrated in *Figure 8*. In a preferred embodiment, each of the processing systems is based substantially upon a standard PC constructed from general purpose "off the shelf" components. However it will be appreciated that many other types of processing platform may be adopted in order to optimise price/performance considerations.

A processor is provided by a Pentium® 4 central processing unit **801** running at a clock speed of 3 gigahertz. Internal communication within the system occurs over a system bus **802** facilitating, for example, communication with two gigabytes of dynamic random access memory **803**, available for storing executable instructions, and pre-processed and post-processed data.

Non-volatile storage is provided by a hard disk drive **804**, for the storage of instructions and for the storage of large quantities of data. In some configurations, such as that for the data store, the hard disk drive **804** may take the form of a redundant array of independent disks (RAID) providing a total capacity in excess of one terabyte. In other processing systems a storage capacity of 90 gigabytes is generally available.

As previously described, program instructions are received from a CD-ROM **714** via a CD-ROM/DVD drive **805**. In a preferred embodiment, instructions are installed within the local system **713**, whereafter these instructions can be installed on other processing systems via the network such that, after installation, these processing systems may be configured remotely so as to perform their specialised operations.

System **713** also includes a universal serial bus (USB) input/output interface **806** for providing connectivity with the input devices **501** and **502** and with the output printing device **715**. The graphics card **807** receives rendering instructions and data from the processing unit **801** so as to display an interface and camera images to the display monitor **431**.

Processing systems **701** to **703** connected to digital monitoring cameras (as shown in *Figure 7*) may include video capture cards **808** to **811**, one for each of the video inputs. The video capture cards **808** to **811** receive real time digital video signals from the digital monitoring cameras to which they are connected. The cards in turn provide output data in the form of addressable image frames that can be accessed by the central processing unit to facilitate local analysis, transmission for remote analysis, real time monitoring or storage. Communication to the network **704** is facilitated by the provision of a network card **812**.

In an alternative embodiment (not shown), the digital monitoring cameras have their own digital interface with an internet protocol facility.

Figure 9

After constructing the apparatus as shown in *Figure 7*, installation, configuration and operation are performed as shown in *Figure 9*. At step **901** the security system is switched on. At step **902** a question is asked as to whether monitoring systems are already installed. If so, control is directed to step **908** whereupon the monitoring system is operated. Alternatively, control is directed to step **903**, where a question is asked as to whether installation should be performed from a CD-ROM/DVD disk or from a network. If the system is not configured to operate in this way, installation may be completed with reference to written instructions.

If installation is to be performed via a network, control is directed to step **904**, whereupon installation is performed via the network **704**, possibly via a secure connection to a site on the internet. Security instructions can also be installed from the CD-ROM disk **714**, as performed at step **905**. Thereafter control is directed to step **906**. Having installed monitoring instructions on processing system **713** shown in *Figure 8*, network installation to other processing systems may be performed at step **906** via the network **704**.

Similar or identical instructions may be installed on each of the processing systems, and the relevant functionality is activated in response to a configuration script running on the first processing system upon which the instructions were installed. This usually requires some input from a person overseeing the configuration process. At step **907** this configuration script is executed, resulting in configuration of the various processing modules upon the various processing systems. Thereafter, at step **908** the monitoring system instructions are activated.

Figure 10

A summary of the contents of main memory **803** for each processing system illustrated in *Figure 7* (when running the monitoring system as shown at step **908**) are illustrated in *Figure 10*. Each of the processing systems will store slightly different contents in memory and *Figure 10* illustrates the contents that will be found at least somewhere in the monitoring system in order to perform the various monitoring functions.

A Linux operating system **1001** provides basic functionality for each processing platform, including video for Linux instructions **1002** to facilitate video hardware device abstraction, thereby allowing the digital monitoring cameras to communicate with the video capture cards.

A suitable database server is provided at the data store **705** to facilitate non-linear data storage and retrieval of time based images and video analysis data. Monitoring instructions **1004** include alarm manager instructions **1005**, monitoring workstation instructions **1006**, analyser instructions **1007**, video server instructions **1008** and video capture instructions **1009**.

Video and data buffers are provided in several of the processing systems for facilitating various communication protocols, analyses and viewing. A multi-resolution data cache **1011** and grid view data **1012** are provided at the local workstation system **713**. Binary large objects (blobs) **1013** are used by analysis instructions **1007**. Background models and threshold parameters **1012** are also utilised by analysis instructions **1007**.

Figure 11

After system configuration at step **908**, each of the processing systems **701** etc is configured to execute a certain subset of the instructions **1003** to **1009**. This results in the instantiation of a number of objects (or modules) at various processing nodes on the system. In order to provide an understanding of the overall operation of the security system an illustration as to how these objects interact is provided in *Figure 11*.

Cameras, such as cameras **405** to **410**, are connected to video capture objects, such as video capture objects **1101** to **1106**. The video capture objects are created as a result of the execution of video capture instructions **1009**. Thereafter, each video capture object executes instructions for receiving and formatting images for a particular camera, such as camera **407**. For example, the capture process typically reduces the camera frame rate from standard transmission rates of 25 or 30 frames per second (50 or 60 fields per second) to a lower rate acceptable for monitoring purposes such as 10 frames per second. However, these frame rates may be adjusted either as part of a set up procedure or dynamically in response to activities of interest being captured. The video capture objects **1101** to **1106** also facilitate the dynamic configuration of camera parameters, again in response to capturing an activity of potential interest.

In response to the execution of analyser instructions **1007**, analyser objects **1107** to **1112** etc are created that in turn each receive video frames from a respective video capture object **1101** to **1106**.

Digital monitoring camera **407** supplies a digital video signal to capture object **1101**, that in turn supplies images to a first analyser **1107**. Capture object **1101** and analyser object **1107** are (in a preferred embodiment) located within the same processing system **701**. However, as an example of an alternative configuration, it is seen that capture object **1105** and analyser object **1111** are located on different processing systems and communicate via a network. In this example, an intervening video server **1113** is provided to enable the network to be used transparently. Video server objects are created as a result of executing video server instructions **1008**.

The analysers **1107** to **1112** generate image data and text data outputs that may be monitored in real time by an alarm manager object **1115** or a monitoring workstation object **1116**. These objects are created as a result of initially executing instructions **1005** and **1006** respectively. Outputs from the analysers are generally supplied to a data store object **1117**. The data store object **1117** also facilitates playback of recorded image data and text data by the monitoring workstation object **1116**. The data store object is created as a result of executing the database server instructions **1003**.

Hand held radio devices **709** to **711** may connect to any of the objects, and monitoring browser instructions executed on the hand-held devices may be used to view images directly, as supplied to the output of the video server. The hand-held devices may receive alarm notifications directly and may review recorded data. This is a typical use for the hand-held devices in this environment, given that current hand-held designs do not contain sufficient processing capabilities to perform more complex monitoring and analysis operations. However, in the future hand-held devices may be able to perform more complex tasks and so could play a greater role in future embodiments.

Camera **407** supplies image data to analyser **1107** and the analyser object **1107** performs sophisticated analyses of the image frames that it receives. Depending upon the contents of these images, received typically at a rate of 10 frames per second, the analyser may supply image data and parameters to the data store **1117** and/or to the monitoring workstation **1116** and/or to the alarm manager **1115.**

Figure 12

Overall functionality of the system illustrated in *Figure 11* is summarised in *Figure 12*. The structure of *Figure 12* shows the processes being executed serially although, in practice, it will be appreciated that these processes are interdependent and interact in complex ways. Furthermore, it should be appreciated that pipelining techniques may be invoked in order to achieve a high level of processing efficiency and the serial representation is presented as a means of gaining an appreciation of the available functionality.

At step **1201** video capture and serving is performed, this largely being a matter of moving and formatting data as performed by the video capture object **1101**. However, operations of the camera itself must also be considered as part of this overall video capture process.

At step **1202** an analysis of the captured video is performed and, where appropriate, analysed signals are also stored.

At step **1203** the benefits of performing the analysis techniques are obtained. These include processes of viewing, reporting and assisting with maintenance scheduling.

Figure 13

A schematic representation of digital monitoring camera **414** is illustrated in *Figure 13*. A lens **1301** focuses an image onto a CMOS imaging array **1302**. The imaging array **1302** generates an analogue signal that is processed by an analogue pre-processing circuit **1303**. Circuit **1303** modifies the offset and gain of the red green and blue colour signals generated for each pixel, thereby adjusting brightness and contrast. Subsequently, an analogue to digital converter **1304** digitises the resulting red, green and blue analogue signals.

The CMOS image array **1302**, the analogue pre-processing circuit **1303** and the analogue to digital converter **1304** each introduce a degree of uncorrelated pixel noise, that manifests itself in the form of pixel-size luminance variations in the resulting digital image. Measures may be taken in order to minimise the level of this noise but a level of noise is always present, even though it may not create visible degradation of the image to any noticeable degree.

A digital signal processor **1305** performs digital manipulation upon the red, green and blue pixel values and may include, for example, the use of look up tables to modify the gamma characteristic of the image signal. A CMOS image array has a particular set of characteristics that are different from film or other electronic sensors and these characteristics can be modified by the use of look up tables. Consequently, several lookup tables may be used, each programmed in advance in accordance with preferred operational characteristics.

Modification to image signals in the digital domain is limited due to the dynamic range of the analogue to digital converter **1304** which, in a preferred embodiment, provides 8 bits per pixel of colour. Digital post-processing circuit **1305** cannot improve the true brightness resolution and can only exaggerate existing pixel values. Analogue pre-processing can increase resolution but usually at the expense of saturating high or low brightness parts of an image.

An interface and power supply circuit **1306** connects the camera to its video capture card **808**, with the camera connecting cable also including a power connection. The complexity and power consumption of the camera **407** are minimised so as to reduce cabling costs while increasing reliability.

The microcontroller **1307** receives data from interface circuit **1306** that is used to determine the operations carried out by processor **1305** and pre-processing circuit **1303**. An electrically-erasable programmable read only memory device (EEPROM) **1308** stores microcontroller instructions. The digital to analogue converter **1309** converts digital parameters for offset and gain into analogue voltages, that are supplied to analogue pre-processing circuit **1303** to control the brightness and contrast of an image prior to its digitisation. This results in the available dynamic range of the analogue to digital converter **1304** being exploited to a higher degree when capturing images of potential interest.

Camera cable **1310** transmits and receives camera parameter data as well as image pixel data, thereby making the camera highly configurable. However, unlike many known monitoring and surveillance cameras, attempts to perform sophisticated gain adjustments automatically within the camera itself are avoided. Modifications of this type are controlled externally to the camera, elsewhere within the monitoring system.

Figure 14

Procedures performed by microcontroller **1307**, following instructions read from EEPROM device **1308**, so as to interface with analyser **1107** are shown in *Figure 14*. At step **1401** a question is asked as to whether new control data has been received from the video capture process **1101**. If no new control data has been received, the procedures jump to step **1404**, to await the next frame synchronisation signal. Alternatively, if new control data has been received the question asked at step **1401** is answered in the affirmative, resulting in control being directed to step **1402**.

At step **1402** received control data representing desired levels of brightness and/or contrast are translated into camera control parameters suitable for application to the digital to analogue converter **1309**.

At step **1403** the control parameters are placed into a control pipeline so as to ensure that any changes required take place during frame intervals and do not take place during the transmission of an actual frame.

At step **1404** the controller waits for the next frame-synchronisation signal, whereafter at step **1405** the next scan/convert/process/transmit cycle is initiated.

At step **1406** an update signal is supplied to the control pipeline, resulting in the digital to analogue converter **1309** generating a new pair of analogue outputs for the analogue pre-processing circuit **1303**, thereby affecting all pixels of the next image frame.

Figure 15

Procedures implemented by the analysing objects, such as object **1107** are detailed in *Figure 15*. The analysis step **1202** identified in *Figure 12* is performed by several analysers operating in parallel.

At step **1501** background modelling and foreground classification is performed. Frames of input image data, arriving at 10 frames per second, have their individual pixels classified as being foreground or background. Reference to background is not identical to its use in, say, a compositing environment. Pixels identified as being in the "background" are derived from areas of the image where the received pixels are substantially equivalent to expected values. Thus, they are considered to represent portions of the image that have not changed. As used herein, foreground refers to areas of the image in which pixels have unexpected values, often caused by the movement of a person for example. Furthermore, an activity level is derived by measuring the proportion of pixels that have been classified as belonging to the foreground.

At step **1502** a question is asked as to whether activity has been detected; that is to say, whether the measured level of activity has exceeded a predetermined threshold. If the activity has not exceeded this threshold control is directed to step **1506**, primarily to avoid making unnecessary use of the available processing facility.

If activity is detected at step **1502**, morphology is performed at step **1503** so as to remove noise from the image and thereby facilitating a pixel classification process.

At step **1504** procedures are implemented in order to identify binary large objects (blobs) and multi-object tracking. Blobs are identified in each new frame and the movement of blobs from frame to frame is tracked which is often considered to be representing information likely to be of interest.

At step **1505** multi-resolution images (differing levels of compression) are generated in which foreground objects are encoded with low compression (to retain definition) whereas their background, being of less interest but also necessary in order to put the images in context, is encoded with higher levels of compression.

At step **1506** a parameterisation process is performed in order to calculate various parameters that result from the main analyser processing, possibly to provide feedback to the camera or to make other adjustments to the analysing processors themselves.

At step **1507** event data is generated including the creation of warnings and alarms. Each analyser **1107** to **1112** makes an assessment as to whether what it sees represents significant activity and possibly an event that is likely to be of interest.

Having detected activity and events that may be of interest, step **1508** generates an exemplar image that is subsequently stored and facilitates the identification of events of interest.

At step **1509** image data and other non-image data (such as alpha-numeric data) is supplied to the data store, monitoring workstation, the alarm manager and the video capture process.

Figure 16

Procedures performed at step **1501** for background modelling and foreground classification are illustrated schematically in *Figure 16*. In background modelling process **1601** a current image frame **1602** has been supplied to an integrating process **1603**. The integrating process combines the current image frame with data from a large number of previous frames and updates a background model **1604**. The background model **1604** includes a set of colour statistics for each pixel in the frame. Thus "background modelling" is also known as "background maintenance" and several sophisticated techniques have been developed to represent complex moving images (such as leaves and branches of trees) as part of a background model.

A comparison process **1605** compares the background model **1604** with the current image frame **1602** and generates a difference value for each pixel. The difference value for a pixel is in the range of zero to one and if the difference is large there is a higher probability that the pixel should be classified as belonging to the foreground, as previously described. Thus, a signal in the range of zero to one must be compared against a threshold value to determine whether (when the level exceeds this threshold) the pixel value should be classified as foreground. However, analysis has shown that it is preferable to adjust this threshold value in response to various phenomena, including systemic noise and global lighting variation.

It is known that providing a fixed threshold value produces results that are far from optimum. However, effecting procedures to adjust the threshold value automatically requires complex techniques. Thus, such known methods as histogram co-ordinate cornering and median statistics etc require an expensive processing overhead while producing results that tend to fall below theoretical optimums.

A classifier **1606** performs classification to determine whether a pixel belongs to the foreground or to the background. The output of the classifier **1606** is a binary pixel image map where each pixel has a value of either one or zero depending upon whether it is considered to be foreground or background respectively. Foreground pixels contain activity and the level of activity in an image is quantified by an activity measuring process **1607**. The total number of foreground pixels is counted and this is expressed as a proportion of the total number of pixels in the image. This value **1608** is supplied to several subsequent stages of analyser processing and is also used in the monitoring workstation.

The output of the classifier **1606** is also used as an input to the noise measuring process **1609** in which the number of isolated foreground pixels is counted and then expressed as a percentage of the total number of background pixels. As previously stated, an isolated foreground pixel will tend to have been produced due to noise present within the camera circuitry, typically from the image array, the analogue pre-processing circuit or the analogue to digital converter.

The noise comparison process **1610** compares the proportion of isolated foreground pixels with a configurable target value of around 0.2%. If the proportion of isolated foreground pixels (due to noise) is below this target, the comparison process generates a negative output, thus lowering the threshold supplied to the classification process **1606**. This results in a probable increase in the number of isolated foreground pixels when the next image frame is processed. If, alternatively, the proportion of isolated foreground pixels is higher than the configured target (around 0.2%) the threshold is increased, thereby reducing the number of isolated foreground pixels that are found in the next frame.

A filter **1611** provides strong low-pass filtering of the threshold value when the output of the comparison process fluctuates wildly. Preferably, the filter characteristic changes over time (it has a temporal characteristic) and a Kalman type filter may be adopted. Once the process converges to a stable value, the filter **1611** registers an increase in confidence in its input and reduces the level of filtering appropriately. The output of filter **1612** is used as the input to the classifier **1606**. Thus, the threshold value supplied to the classifier **1606** is derived via a degree of adaptive filtering. This results in an improved foreground/background classification frame **1613** which is in turn supplied as an input to subsequent analysis processing.

Figure 17

The effect of threshold value **1612** being too low is illustrated in *Figure 17*. A binary pixel image map **1613** is shown, in which a main foreground image **1701** bleeds outwards from the moving shape it is supposed to encompass. In addition, other regions **1702, 1703** and **1704** are incorrectly classified as foreground, possibly generated due to the presence of shadows or other lighting effects.

A background area is highlighted at **1705**. As can be seen, this background area shows a high proportion of isolated foreground pixels, such as pixels **1706** and **1707**.

Figure 18

Contrasting with *Figure 17*, the effects of a well-adjusted threshold are illustrated in *Figure 18*. In this example, a main foreground region **1801** provides a good representation of the moving object (the vandal attempting to damage the painting) viewed by camera **417**. Although some incorrectly classified regions still exist, such as regions **1802**, **1803** and **1804**, these are much smaller in size and can therefore be dealt with by subsequent processing measures as described with respect to *Figure 19*. Furthermore, a highlight **1805** on the background shows a much smaller proportion of isolated foreground pixels.

Figure 19

Morphology processes identified at step **1503** are detailed in *Figure 19*. Morphology is carried out in order to remove noise from the binary pixel image map **1613**.

Morphology identifies groups of adjacent foreground pixels and performs operations upon them. The two most important operations performed upon the foreground pixels are those of erosion and dilation. These steps are performed repeatedly in an open technique to remove noise from an image. During erosion, step **1901**, the outline of a group of foreground pixels is shrunk by a selected number of pixels, typically five. This is followed by process **1902** of dilation. During the dilation process, the former process is reversed; thus, pixels are added to the outer boundary of the foreground object. The effects of repeating these processes of erosion and dilation is to erode and then restore large group of foreground pixels but to shrink small groups of foreground pixels down to nothing such that, on the next stage, there is nothing to be restored by the dilation process. Thus, erosion and dilation continue at steps **1903** and **1904** for a pre-determined number of cycles.

In addition to removing isolated noise pixels, the processes of erosion and dilation will also have the effect of smoothing the outline of the foreground shape. Thus, isolated foreground pixels **1805** and the small foreground regions **1802**, **1803** and **1804** shown in *Figure 4* are removed by morphology processing as illustrated in *Figure 20.*

Figure 20

As stated above, *Figure 20* shows the results of performing the background modelling process to distinguish foreground pixels from background pixels, classifying the foreground pixels so as to produce a binary pixel image map and then performing morphology in order to remove noise components from the binary pixel image map.

A further morphology technique is known as a close, in which a dilation is followed by an erosion. This technique is deployed to close up gaps in objects. Changing the size of these techniques can also be used to good effect. Thus, in a preferred embodiment an “open small” technique is applied to remove noise. This is followed by a “close medium” technique to remove gaps. This is then followed by an “open large” technique to remove spurious small objects.

Figure 21

As described with reference to *Figure 15*, step **1504** consists of finding and identifying connected foreground pixels and then performing operations to track the position of these connected pixels on a frame by frame basis.

Clearly defined groups of foreground pixels are recorded in memory region **1013** of *Figure 10*. An object of this type may include definitions of its centroid, defined by Cartesian co-ordinates and a bounding box in a way that is useful in subsequent processing operations. In order to track a plurality of objects (multi-object tracking) it is desirable to resolve ambiguity and match objects to observations. An object previously recognised may become unmatched because no relevant detection has been made in the next frame. Similarly a new observation may become unmatched if nothing in the preceding frame matches it. Thus tracks are established that are derived from a model of expected behaviour, which is updated from observation. In this way objects may continue to be tracked even when observations do not support their existence, such as when two objects overlap (in three space) which will be perceived as a collision in two space.

Subsequent processing of these tracks may make assumptions such that, for example, small incremental movements are very likely to be generated by movement of a single object rather than the sudden appearance of a completely different object of a similar size and location. Thus, conditions of this type allow it to be possible to track several groups of connected foreground pixels in the same image, as illustrated in *Figure 21*.

In many situations, the group of connected foreground pixels identified may be generated by the presence of people within a viewed scene. Thus, by tracking objects in this way, it is possible to track the position of a plurality of people as they move through an environment. This is particularly useful for counting the number of people entering and leaving a room and from these totals it is possible to derive a figure for the number of people in a room at any particular time. Thus, by ensuring that all doors etc are within the field of view of at least one digital monitoring camera it is possible to count the number of people that have entered the environment and then subsequently left the environment. To facilitate the process of identifying the movement of people into and out of an environment, the monitoring system is preferably configured with guard regions in images where a doorway exists. Consequently, any binary large object identified that may be considered as being person-sized moving across this guard region results in that person being counted. Furthermore, the direction of movement across the guard region may also provide information as to whether the person is moving into the environment or out of the environment.

The tracking of a group of connected foreground pixels may also be used to determine a number of significant parameters that identify unusual behaviour. One such type of unusual behaviour is referred to as "upstreaming" which may be expressed as walking the wrong way down a gangway where flow is expected to occur in a certain direction. Fast movements such as running may also be unusual in many environments and again this may be identified by calculating the velocity of the tracked group as it moves on a frame by frame basis.

Figure 22

Process **1505** for the generation of multi-resolution images is detailed in *Figure 22*. At step **2201** the question is asked as to whether a binary large object is present and if this is answered in the negative no action is taken in order to generate multi-resolution images. In this way, the available processing resource is not wasted when there is nothing of interest being observed.

If an object is present and the question asked at step **2201** is answered in the affirmative a low quality compressed image of the entire image frame is created using a high data-compression ratio. In an embodiment, JPEG (Joint Picture Expert Group) compression is invoked although other compression types may be deployed where appropriate.

At step **2203** the first object is selected and at step **2204** a rectangle bounding the object identified at step **2203** is identified.

At step **2205** a distinction is made between foreground pixels in the bounding rectangle and background pixels within the bounding rectangle. Furthermore, background pixels in the bounding rectangle are set to zero value such that, if viewed, these background pixels would be seen as black.

At step **2206** high quality image data of the area within the rectangle is created. Thus, the area of interest containing the object will have been generated to a high quality at step **2206**. The remainder of the image, thereby placing the area of interest in context, will only have been recorded at low quality (high data compression) at step **2202**. In this way, the total amount of data required to record the frame is minimised while at the same time the area of interest is retained at high spatial definition.

In an alternative embodiment, no background image is stored when activity is detected. A composite is then produced consisted of the detected foreground against a recently recorded background. Thus in order to implement this approach, it may be desirable to record empty background images on a regular basis. Thus the foreground activity could be composited against a low quality contemporaneous background, or against a previously recorded temporal (multi-frame) or still background at low or high quality.

At step **2207** a question is asked as to whether another object is present and if answered in the affirmative the next object is selected at step **2203**. Consequently, all of the objects present are processed as described above until the question asked at step **2207** is answered in the negative.

Complex images will tend not to result in the loop consisting of processes **2203** to **2206** being executed many times. When such conditions exist, such as that provided by a crowded room for example, it is likely that much of the crowded scene will be processed as a single object. Consequently, all areas where activity is occurring will tend to be recorded at high definition with the background areas being recorded at lower definition. Upon re-playing the recorded images from a data store the high quality foreground images are composited against the low quality background images. Each foreground image will be placed upon top of the background image, the latter being the lower quality recorded JPEG. After decoding the JPEG images, the zero RGB pixels contained within the foreground are replaced by the background image pixels occupying similar positions. In this way, it is possible to combine pixel values of the foreground and the background without using a separate keying or alpha channel.

Figure 23

An image frame **2301** in shown in *Figure 23* in which an object has been detected and high quality image data has been recorded.

An object has been detected due to the activities of the vandal as illustrated in *Figure 6*. Following step **2202** low quality high JPEG compression image data for the whole frame is generated, shown schematically as **2302**. At step **2204** a bounding rectangle **2303** has been placed around the object and at step **2205** background pixels in the rectangle **2304** are replaced with zero value pixels. Thereafter, at step **2206** a high quality (lightly compressed) image is created for all pixels within the rectangle **2303** (including those that have been set to zero) resulting in image data **2305** of the vandal being recorded at high quality as illustrated by high quality low JPEG compression image data **2306**.

It can be appreciated from the illustration shown in *Figure 23* that the bounding rectangle **2303** represents a relatively small portion of the overall frame **2301**. Consequently, it is possible for the image frame to be stored and remotely viewed, by being retrieved from the data store, without using unnecessary bandwidth.

In an alternative embodiment, only pixels in the area of a detected group are recorded at high definition, thereby reducing storage requirements further, where an appropriate compression technique, possibly using run length encoding, is adopted.

Figure 24

As previously described, it is possible for a region of interest within a recorded frame to be stored at a higher spatial definition (with less compression) than the remaining background where very little of interest is occurring. It is also possible for the foreground group of pixels to be recorded at a higher frame rate than their associated background, given that most of the movement will be occurring in the foreground. It is therefore quite apparent that the background region is of little interest compared to the foreground area where the activity is occurring.

Conventional video recording cameras are known that include circuitry for enhancing the quality of images produced by the camera. In general, the camera will have automatic brightness and contrast controls so as to ensure that appropriate levels have been selected so as to give the best quality of picture overall. However, in accordance with the present embodiment, it has been appreciated that it would be preferable to adjust the camera controls in order to enhance the quality of regions of interest, such as region **2304,** possibly at the expense of the background region. Consequently, in the preferred embodiment, the digital monitoring cameras do not include circuitry for making these modifications locally. In the preferred embodiment the input data signal is analysed to identify potential events of interest. Furthermore, upon detecting a potential event of interest, an output control signal is generated so as to modify a characteristic of the input data signal.

In the preferred embodiment, the digital monitoring cameras, such as camera **407**, are physically connected to the processing environment via a network connection. However, logically, this network connection facilitates communication both of output video signals and of input control signals.

Referring to *Figure 24*, the camera **407** will initially view an area in a condition where it is unknown as to whether an area of interest exists. Consequently, as illustrated by **2401** contrast and brightness settings for the camera are adjusted so as to provide an output video signal that is optimal for the entire image.

As previously described, the output video signal from camera **407** is processed by processor **701** such that the analysis and activities result in the determination being made as to whether a potential area of interest exists. If such an area is identified, it is possible to provide a feedback signal **2402** to the camera **407** so as to improve the contrast and brightness levels not for the image as a whole but for the particular area that has been identified as being of potential interest.

Considering the techniques that have previously been described, it can be appreciated that, having optimised the response of camera **407**, the subsequent processing techniques will provide further enhancement of the area of potential interest; such that foreground area **2403** is recorded at enhanced quality at the expense of a background area **2404**. In this way, images of improved quality are recorded on the data store **704** and are made available to the observing workstation **401**.

Figure 25

Process **1506** for the automatic generation of parameters is detailed in *Figure 25*. Parameters relating to aspects of identified activity are generated when activity is detected. Consequently, a question is asked at step **2501** as to whether there is any activity and if this question is answered in the affirmative, activity-related parameters for the current frame are calculated at step **2502**. If the question asked at step **2501** is answered in the negative, step **2502** is bypassed.

After one minute of time has elapsed the question asked at **2503** is answered in the affirmative resulting in minute-based summaries being calculated of activity related parameters at step **2504**. Thus, step **2504** results in one-minute summaries being generated for each of the parameters considered at step **2502.**

At step **2505** a question is asked as to whether camera optimisation is required. If answered in the affirmative, camera parameters are calculated at step **2506** to enhance foreground properties. Thereafter, at step **2507** the background model input compensation data is updated via the pipeline delay. Step **2507** is required because if changes continue to be made to the contrast and brightness at the camera, the background modelling process needs to be compensated. Based upon the modifications required at the camera, it is possible to perform a division followed by a subtraction on all pixel values before they enter the background modelling process. It is then possible for the foreground/background classification to continue working as normal, with the image data in the areas of interest being enhanced. Given that pipeline delays exist, it is necessary to equalise these delays so as to ensure that only frames affected by the new camera brightness and/or contrast settings get compensated on their way to contribute towards the background model.

After step **2507**, following a response to the question asked at step **2505** being answered in the negative, quality monitoring is performed at step **2508**. In particular, information obtained as a result of analyser processing is used to identify the quality and/or performance of the individual digital monitoring cameras.

Figure 26

A summary of the parameters calculated, at step **2502,** are presented in tabular form in *Figure 26*. In the table, parameters are defined in column **2601**, a range of values are specified in column **2602** and the summarisation method is defined in column **2603**.

In this example, the particular parameters of concern or activity **2604**, high speed movement of an object **2605**, the detection of stationary objects **2606**, the detection of upstreaming **2607**, the detection of a face **2608** and a people count **2609**. Parameters **2604** to **2608** all have a continuous numerical range (as shown in column **2602**) of zero to one and are summarised by choosing the maximum value from the data set. The face value is effectively logical and provides a measure as to whether a face has been detected or not. People count **2409** takes an integer value from zero upwards and it counts the number of people going past a pre-defined position, such as a doorway or an entrance. It is summarised by adding all of the data observations together.

*Figure **27***

Process **2504** for calculating minute-based summaries of activity related parameters detailed in *Figure 27*. The procedure effectively takes each of the parameters shown in *Figure 26* and generates a summary for each minute during which activity is detected. In the preferred embodiment, data is generated at a rate of 10 frames per second and therefore a typical minute will consist of 600 frames, although this frame rate may be modified, possibly under automatic control, in response to data generated by the analyser.

At step **2701** the first parameter is selected to be summarised and therefore the value is initially set to zero.

At step **2702** the first frame is selected and at step **2703** a question is asked as to whether the parameter was calculated for the frame selected at step **2702**.

If the question asked at step **2703** is answered in the negative, the zero value is entered for the frame's value at step **2704**. Alternatively, if the question asked at step **2703** is answered in the affirmative, the value is accrued at step **2705** using the method specified in column **2603**.

At step **2706** a question is asked as to whether another frame is to be considered and when answered in the affirmative control is returned to step **2702**, where the next frame is selected, and so on until all of the frames have been considered.

When the question asked at step **2706** is answered in the negative, a question is asked at step **2707** as to whether another parameter is to be considered. Consequently, when answered in the affirmative, control is returned to step **2701** and the next parameter is selected. Thus, all of the frames are then considered for the next parameter and so on until all of the parameters have been considered and the question asked at step **2707** is answered in the negative.

Figure 28

Process **2506** for calculating enhanced camera parameters is detailed in *Figure 28.* At step **2801** statistics are generated to identify the brightness range of the foreground pixels. At step **2802** an offset value is identified that is required to reduce the dimmest foreground pixel as near as possible to black. Thereafter, at step **2803** a gain value is identified which is required to set the brightness foreground pixels as near as possible to white; it is, however, appreciated that the image may already include white and that a degree of clipping may have occurred. Thus the combination of steps **2801** to **2803** concentrate on the region of pixels defining the detected object. Their purpose is to best modify the brightness and contrast of the identified pixels of the foreground image so as to enhance the visibility of this region of the image. Upon doing this, they are in a position to calculate the correction in terms of a gain and offset that, once applied to the camera in analogue form by circuit **1309**, will result in image data of an improved quality, in terms of the level of visible detail (dynamic range) in the area of the object of potential interest.

It is appreciated that the values calculated by steps **2801** to **2803** may lie outside realistic limits therefore at step **2804** the values are considered so as to limit the offset gain values to within realistic limits.

At step **2805** corresponding offset and gain values are calculated as required for the background model so as to ensure that the background model calculation may carry on without seeing any significant change to the image as a whole.

Figure **29**

Step **2508** was identified in *Figure 25* as identifying the process of quality monitoring. Quality monitoring relates to the process of generating a servicing schedule for cameras used in the monitoring environment. Background images are analysed to produce a background model as previously described. It is then possible to process the background model in combination with new incoming data.

At step **2901** brightness and colour histograms for the background model are calculated. Thus, this results in a production of a histogram **2902** for brightness, a histogram **2903** for red, a histogram **2904** for green and a histogram **2905** for blue. Each histogram provides a probability density function that characterises the kind of data that is being captured.

Experimentation has shown that a dysfunctional camera, possibly due to dust on the lens for example, will result in a probability density function that peaks more than would be expected at a certain point. This suggests that pixels of the same value are being seen more frequently than normal and are therefore due to an artefact rather than captured image data. Other problems of this type also reveal themselves in probability density functions. Thus, for example, if a camera loses sensitivity with respect to a particular colour (red for example) the probability density function for red will become depressed and eventually will become a straight vertical line at zero. Similarly, large specks of foreign material present on the lens would also show up, as would numerous other sorts of problems associated with the processing circuit.

In order to provide something for the power density functions to be compared against, it is necessary to create and store histograms for a healthy camera, preferably shortly after a camera has been installed or serviced. Thus, at step **2906** the histograms produced at step **2901** are compared with the stored histograms. Thus, the histograms generated at step **2901** are derived from the background model **1601** that is effectively fed from a live camera, such as camera **407**, for which a health check is to be performed. At step **2906** these histograms are compared with the stored histograms, effectively being similar to that produced when the camera was known to be healthy. Thus, the actual brightness histogram **2902** is compared against an ideal histogram for brightness **2907**. The actual histogram for red **2903** is compared against an ideal histogram for red **2908**. An actual histogram for green **2904** is compared against an ideal histogram for green **2909** and, similarly, the actual histogram for blue **2905** is compared against the ideal health histogram for blue **2910**.

At step **2911** a camera health value between zero and one is quantified. This is achieved by combining the results of the linear correlations between the histogram pairs (**2902/2907** etc) and taking the average. This provides a value between zero and one, where one would be obtained if the histograms of a live camera matched those of a healthy camera completely; with the value reducing below one as degradation takes place. In this sense, degradation should be understood to represent anything that results in quality reduction of the output image. Thus the degradation could be due to a misalignment of some sort, not necessarily due to camera ageing. Furthermore, other characteristics for detecting degradation could be used, such as defocus detection derived from performed edge detection upon observed objects.

A measurement of camera health provides an ingredient for measuring the overall system quality. Furthermore, camera health calculations also allow maintenance schedules to be defined such that maintenance and servicing is performed upon the cameras at optimal times, thereby ensuring that good-quality image capturing continues while at the same time reducing costs that would be incurred with unnecessary servicing activities. Similarly, it is possible to ensure that a plurality of cameras are serviced as part of a combined activity rather than having individual call out operations being performed that would be expensive. Thus, by maintaining the cameras on an ongoing basis, expensive one-off costs for repair and servicing are reduced.

In order to identify an optimised point in the future for servicing a camera, linear regression, linear extrapolation or other predicting techniques may be used to predict the future health of the camera related signals.

Figure 30

Procedures **1508** for generating an exemplar image are detailed in *Figure 30*. At step **3001** a question is asked as to whether there has been a high level of activity for several frames. If answered in the negative, a question is asked at step **3002** as to whether the activity level is presently high. If this is answered in the negative a question is asked at step **3003** as to whether the activity level has been low for several frames. If this question is answered in the affirmative an exemplar image for the previous period of high activity is generated at step **3004**.

Each period of activity identified in this way is recorded uniquely. Thus, in this way, having generated an exemplar image for the period of activity, the system is effectively reset awaiting the next period of activity. Thus, the effect is to wait until a substantially continuous period of high activity has occurred, that is, a period of activity composed of a plurality of substantially consecutive images having a high level of activity is identified. If within this period a frame or two occur without activity these are effectively ignored. Likewise, if there is a single isolated frame of activity this is also ignored.

Figure 31

Process **3004** for the generation of an exemplar image is detailed in *Figure 31*. At step **3101** the start and end of an object track is identified. This represents a frame where the tracking process started and a frame where the tracking process ended, both of which may be considered as points in time.

At step **3102** the block or clip of frames recorded throughout the tracking process is considered. From this collection of frames, an image frame substantially half way along the collection may be identified. Alternatively, an image may be selected from the position of peak activity.

In terms of storing an exemplar image it is possible to select a single frame (a freeze frame) or it is possible to blur a plurality of selected frames. Consequently, at step **3103** a question is asked as to whether a blur or a freeze frame operation is to be selected. If freeze frame is selected the mid-track or peak image frame is selected as the exemplar image at step **3104**.

Alternatively, if blur is selected at step **3103** image pixels from a plurality of images are combined, preferably with a weighted average, so as to emphasise the image or images that are substantially mid-way between the start and the end of the tracked positions, at step **3105**.

At step **3106** the exemplar image frame is cropped so as to remove background pixels such that a rectangular box containing the foreground remains. Thereafter, at step **3107** a high quality compressed image (such as JPEG) is generated and stored as the exemplar image.

When a blurring operation is performed at step **3105** image pixels may be combined from all of the activity frames, in a weighted average, so as to emphasise the image or images mid-way between the start and end of the track positions. Other methods are possible for selecting an exemplar or the kernel image in the case of a blurring process for the generation of the exemplar. For example, it would be possible to find the single frame that has the most difference between the frames just before and just after the activity sequence.

When detecting activities of potential interest, a likely scenario is for a person to walk past a digital monitoring camera such that, at the start of the period of activity, only part of the person's body is in view. Similarly, at the end of the activity a similar position may exist to the effect that only part of the person's body is visible. Consequently, it is only around the middle of the activity that the person will tend to be fully in shot and this is why the exemplar image may be selected as described above. Experimentation has shown that many activities of interest exhibit a similar recordal signature, such as passing cars, criminal activities and disturbances of many types.

Figure 32

The procedures described with respect to *Figure 31* allow a single image to be recorded during what should be the most important part of an activity. Thus, this results in a single snapshot frame that is an exemplar of the activity as a whole and may therefore be referred to as an activity snapshot.

A graph is shown in *Figure 32* in which activity level **3201** is plotted against time **3202** for a plurality of cameras. A first camera has a period of activity **3203** resulting in a snapshot **3204** being recorded. Similarly, a second camera has a period of activity **3205** resulting in a second snapshot **3206** being recorded. A third snapshot **3207** is recorded in response to a period of activity **3208** being detected in signals processed from a third camera.

Selected (freeze frame) images or generated (blurred) images are established by different analysers at different times. Exemplar images can be shown without their surrounding low quality images because it is the foreground area that is of most interest. In a preferred embodiment, the full frame will have been recorded and the exemplar images are primarily intended for the identification and categorisation of stored image frames. Furthermore, when presenting exemplar images on a timeline, such as that presented on monitor **431**, space is limited. Consequently, it is preferable for only the foreground regions to be displayed, preferably scaled so as to be presented with a fixed height in the available space for the presentation of the timeline. Consequently, with height values being adjusted so as to fit the available space, it is possible for the images to have varying widths.

Figure 33

At the data store **705**, the hard disk drive **804** takes the form of a redundant array of independent disks **803**, as shown in *Figure 33*. Many different types of data are stored on this data store, originating from many different sources within the system. A Linux operating system **3301** is stored in combination with instructions for a database server, thereby providing the main functionality of the data store system. The data store object **1117** shown in *Figure 11* exists as a result of executing the database instructions **3302** in combination with configuration data **3303.** Other data includes various configuration and dynamic data that are stored on the array **803** by the instructions derived from **3301** and **3302.**

Maintenance schedules **3305** are generated as a result of combining camera health parameters, as described below.

Reports **3306**, tags **3307**, events, warnings and alarms **3308** are generated in response to system operation. These collectively represent time-based data records describing the status of the camera sensors or the system as a whole at particular points in time.

2004233458 25 Nov 2004

Within the data store, sufficient storage is provided to enable the output from multiple cameras to be recorded over several months, particularly given that only significant activity is recorded. Furthermore, in a preferred embodiment, when significant activity is recorded only the foreground parts of each image frame are recorded at high quality.

Multi-resolution parameters **3309** include frame-based values **3311** generated at step **3502** and minute-based values **3310** generated at step **2504.** The multi-resolution images themselves include foreground images **3313**, entire images (at low quality) **3314**, and exemplar images **3315**.

Figure 34

The viewing, reporting and maintenance scheduling procedures **1203** identified in *Figure 12* are detailed in *Figure 34*. These procedures are performed at the local workstation systems **713** or, in the functional representation shown in *Figure 11*, via the workstation object **1116.**

At step **3401** current analysis results are received. It should be appreciated that the data store receives a large volume of data all of the time, creating a record of images captured by the digital monitoring cameras (at relatively low quality). However, whenever there is significant activity detected by a analyser, the monitoring workstation receives data that has been selected as representing an event that is likely to be of interest. Thus, the analyser objects **1107** etc are configured to request attention to be given by the monitoring workstation to their output, resulting in the images processed by the analyser being displayed automatically. Thus, the monitoring workstation object **1116** receives current analysis results on a selected basis as part of the overall monitoring process.

At step **3402** analysis results are displayed in accordance with user defined preferences. In the preferred embodiment, view configurations are possible, representing timelines using different styles, different numbers of priority images, different numbers of large images and so on, determined either exclusively in accordance with personal preferences or in accordance with a preferred configuration for a particular application. However, irrespective of the chosen layout, the processes involved for rendering the images in a viewable manner are substantially similar only with minor variations.

At step **3403** a question is asked as to whether user input has been received. If there is no user input, control is directed to step **3406**. If user input has been received, tag processing is effected at step **3404** in response to the user entering a request to tag. At step **3405** a response is made to any updates to view the configuration and at step **3406** updates are processed in response to requests to change the analyser configuration.

It is possible that the user may have operated mouse **502** in order to, for example, zoom in on a displayed timeline or performed some other operation that changes the display in some way. Such an operation changes the view configurations accordingly and in a preferred embodiment these steps are multi-threaded and executed at least partially in parallel, rather than being executed in the sequential manner shown in *Figure 4* for illustrative purposes only.

Referring again to step **3406**, user input or an automated process may result in analyser parameters being changed for one or more of the analyser objects present within the system. For example, a group of analysers may be instructed to send exemplar images to the monitoring workstation **1116** as and when they are created and the particular group that has been selected may be changed interactively by the user. At step **3407** a maintenance schedule is generated using camera health parameters (as described with respect to *Figure 29*) to generate a maintenance schedule.

At step **3408** reports are generated, preferably from a plurality of different sources, including activity levels and tags, to generate various types of report. Thus, reports may be made available in electronic form or printed locally using printing device **715**.

Figure 35

During monitoring operations, information is presented to the operator in the form of a graphical user interface displayed on monitor **431**. A typical example of such an interface is illustrated in *Figure 35* although it should be appreciated that, as previously discussed, the actual layout of this interface may be modified to some extent in accordance with user preferences. An example of a graphical user interface displayed to an operator (via monitor **431**) is shown in *Figure 35*. It should be appreciated that this represents an example of a possible graphical user interface and many alternative arrangements will be possible while providing substantially similar functionality.

A menu bar is presented at the top of the interface and includes menu items "help" **3501**, "reports" **3502**, "schedule" **3503** and "settings" **2304**. To the right of the top of the screen there is also a display region **3505** that displays the measure of system quality. This represents general operational quality of the monitoring system derived primarily from an accumulation of camera health values and possibly incorporating measures of any other devices that suffer degradation and require servicing.

As is well known in the art, the help menu **3501** opens a help system to guide the operator in an interactive way. Report menu **3502** is used to generate one of several types of report or to configure the system to generate reports automatically. Thus, in this way, it is possible to generate a daily report both in paper form and for distribution in electronic form, possibly as an HTML document.

Schedule menu **3503** is used to select operations associated with a generation of a maintenance schedule. Thus, enquiries may be made as to whether it would be appropriate to schedule maintenance or estimates may be provided as to when a maintenance operation would be appropriate. Furthermore, it is possible for maintenance schedules to be printed and thereafter acted upon by maintenance operatives. Similarly, the setting menu **3504** is used to modify various possible configurations of the monitoring workstation including amendments to the user interface itself.

The priority sensors area **3506** includes (in this example) five small image display areas **3507** to **3511**. An output from any of the digital monitoring cameras may be directed towards any of the small image display areas and in each image display area **3507** to **3511** a reference is included at its lower portion identifying the source from which the images are taken. A scroll bar may be included to facilitate a selection of particular outputs for the small image display areas. It is usually intended that the selected images should be derived from camera outputs that are considered to be of a high priority, either selected by an operator or by processing procedures (possibly forms of artificial intelligence) included within the monitoring system itself. During operation, images captured in real time are supplied to the allocated small image display areas. It is also possible for an exemplar image to be shown in the priority sensors display panel.

A situation may arise in which there are more camera outputs that are considered to be of a high priority than there are small image areas available for these priority outputs to be displayed. Under these circumstances, it is possible to cycle through all of the priority outputs (at a selected speed) so that they may be periodically reviewed in the priority sensor area **3506.** Furthermore, it is possible for procedures to be included that give weightings to the priority levels such that outputs considered to be of highest priority are shown to a greater extent within area **3506** compared to outputs that are considered to be of a lower priority. Thus, for example, cameras that have captured high degrees of activity (as determined by a respective analyser) may be considered as being of a high priority and are therefore given more prominence in the displayed interface.

A main viewer **3512** allows a single large image to be displayed, usually by coming from the camera considered to produce outputs of the highest priority or from the camera where the most recent event likely to be of interest has been detected through the monitoring process. This represents a first default mode operation in which images are being acquired directly as they are being captured. In a second mode of operation the main viewer presents the most recent events and only updates the display when a new event is added or detected. In a third mode of operation it is possible to review previously recorded images and control of the display is achieved using conventional video navigation controls **3513**. Consequently, the navigation controls **3513** allow the video images that have been stored to be played forward and backward at any speed, were also allowing the user to select and go to a next or previous event. Furthermore, as an alternative to using control **3513**, navigation of stored video may also be achieved by using gestural movements of a user-input device, such as mouse **502**. Thus, in this way, forward play may be instructed by clicking and dragging to the right and backward play may be selected by clicking and dragging to the left. Replay speed may be adjusted by performing similar actions but by dragging repeatedly in the same direction. For example, if the current speed is four times normal play speed, dragging to the left may make it three times the current speed where dragging to the right may make it five times normal speed. Furthermore, a tapping action may allow a jogging operation to be affected, either one frame forwards or one frame backwards.

Facilities are also included for cropping and zooming so as to select specific regions while reducing the amount of data that is necessary to transport over the network **704**.

A first timeline **3514** displays an activity graph **3515**, of the type described with reference to *Figure 32*.

Furthermore, in addition to elements **3515** showing analysed activity, the timeline **3514** also includes exemplar images **3516** and tag markers **3517.**

An events snap control allows the user to navigate timeline **3514** by operation of a first button **3518** or a second button **3519**. Operation of button **3518** enables the user to navigate to a previous exemplar image while operation of button **3519** allows the user to navigate to the next exemplar image.

A second timeline **3520** displays tracking information from several monitoring cameras. Track path control buttons **3521** and **3522** provide for navigation in a backward direction **(3521)** and in a forward direction **(3522).** The track patch includes a plurality of substantially horizontal lines **3523** each representing an object that has been tracked over the duration represented by the length of the line. In preferred embodiments, it is possible to provide further encoding to the nature of the line. Thus, on detecting certain conditions, a line **3523** may be displayed as a thicker line compared to lines for which this condition has not been detected. Alternative representations may also be included, such as colour coding. In a preferred embodiment, different colours are selected to represent other attributes of the tracking process, such as the velocity of the object being tracked. Thus, for example, relatively slow objects may be colour coded blue with relatively fast objects being colour coded red. Depending on the particular monitoring application, slow movement or fast movement may be considered as unusual and therefore may represent an event likely to be of interest.

A timeline navigation bar **3524** enables a user to define start and end times for the timeline and it is possible for a duration specified in this way to vary from, say, minutes to years etc. In this way, it is possible to identify an event if it is known that the event occurred within a particular period. Thus, for example, it may be known that an event occurred in a particular year or in a particular month. Having selected this duration, events are displayed in the first timeline **3514** which significantly assists in terms of identifying the specific event of interest. In this way, the system is made substantially more useful given that it should be possible to identify events of interest relatively rapidly without, for example, spooling through many hours of recorded video tape.

Main viewer area **3512** includes a tag icon **3525.** Selection of this icon (by means of a mouse click for example) provides a record to the effect that a particular image has been tagged. Furthermore, the tag may also include information, including information generated automatically (such as an indication of an event likely to be of interest or an alarm condition) and may also include alpha-numeric text manually entered by the operator via keyboard **501**. A user may also enter graphical information via a mouse a touch tablet or a hand held device.

A recent warning area **3526** provides a summary of recent warnings that have been generated. These will generally include alarm events and events of a serious nature that require immediate action to be taken. Similarly, a sensor events area **3527** provides a summary of events that have been detected by the monitoring system and considered to be likely to be of interest.

The interface also includes a grid map area **3528**. The grid map **3528** provides an interface for viewing the status of monitoring cameras and other sensors connected to the system. It allows cameras to be grouped such that each group is shown in a grid lay out.

A configuration mode enables cameras to be assigned to a topological or logical group. Initially, the grid has all cells available and is therefore represented as a complete grid. The grid map may be used to create layouts by clicking on cells or dragging over a range of cells to either deselect them and turn them off or to map cameras to the cell, thereby creating a layout or map of a group of cameras.

When cameras are placed in a topological or logical group, they are considered to be mapped, where as unmapped cameras are shown below the selected map, being those that have not been assigned to a group. The mapped cameras are each illustrated positioned relative to the positions of other cameras in the group, by means of a square cell. An example of a topological grouping is "level 1, zone 2", which would be all of the cameras on the first floor in one section of a monitored environment. Logical groupings are also possible thus, for example, a map may display a logical grouping of exits, this being the group of all of the cameras (and possibly other sensors) that are in a position to record information about the exits of an environment.

In monitoring mode, the digital monitoring cameras may be selected within the map using an input device such as mouse **502**. In a preferred embodiment, a selected sensor is displayed using a different colour, or by means of an alternative graphical representation (possibly where colour is not available).

The grid map may also include a camera list for sensor selection, thereby allowing the quick designation of the grouping being displayed and the camera output selected. The main viewer **3512** is preferably configured to display video images of a selected (in focus) camera output.

The state of cameras in the group may be quickly assessed from the grid map interface given that a white square within a sensor cell indicates activity based on the measurements determined by a respective analyser. Thus, for a high level of activity a large white square is displayed within the cell for the sensor. Similarly, when a significant event or an alarm condition occurs it is possible for its associated cell to flash red and white. In the configuration, a cell may or may not have a camera output associated there too and this condition is displayed by representing the cell using a brighter colour than a camera output has been allocated.

Figure 36

Procedure **3402** for displaying analysis results is detailed in *Figure 36*. At step **3601** data is retrieved using the multi-resolution database. The reading of data from the database involves the use of a hierarchical cache so as to retrieve the data necessary to construct the activity timeline **3514.** A problem arises in that if the time window is too wide, the number of frames that need to be accessed in order to build up the timeline becomes very large.

At step **3602** a numerical value for system quality is calculated, so as to be displayed at **3505**. At step **3603** camera outputs for display are selected, resulting in images being rendered for display. These operations are performed both for the priority areas **3507** to **3511** and for the main viewer **3512**. At step **3604** the grid map **3528** is rendered for display.

At step **3605** the tracking timeline **3520** is rendered and at step **3606** the activity timeline **3514** with exemplar images is rendered.

At step **3607** tag icons **3517** are rendered where after, at step **3608**, any other components required to complete the graphical user interface are rendered. This includes a rendering of the system quality value calculated at step **3602**.

Figure **37**

Procedures **3601** for retrieving data using the multi-resolution database are detailed in *Figure 37.* At step **3701** the resolution of the timeline is identified as being representative of frames, minutes, ten minute intervals, one-hour intervals, four-hour intervals or days. The timeline is drawn in pixels and therefore in order to plot an activity graph **3514** there must be at least one frame value per pixel. If the timeline covers a substantial period of time, activity values generated from many frames will be represented at the single pixel position.

At step **3702** a first data item is requested for rendering on the timeline. Thereafter, at step **3703** a question is asked as to whether items exist in a multi-resolution cache.

If the question asked at step **3703** is answered in the negative, the multi-resolution cache is recursively filled at step **3704** in order to satisfy the data requirement. Thereafter, at step **3705** a question is asked as to whether more data is required in the cache and if answered in the affirmative control is returned to step **3702.** Thus, upon executing step **3702** again, the next data items are requested resulting in further data being written to the cache at step **3704.** If requested data items are already in cache, resulting in the question asked at step **3703** being answered in the affirmative, step **3704** is by passed.

Eventually, sufficient data will have been written to cache resulting in the question asked at step **3705** being answered in the negative.

Figure 38

The recursive nature of step **3704** is detailed in *Figure 38.* In step **3801** data items are identified that are required to calculate metadata at a current level of time resolution.

At step **3802** a data item is selected and at step **3803** a question is asked as to whether the data items are available. If this question is answered in the negative, the whole process illustrated in *Figure 38* is recursively repeated. If the question asked at step **3803** is answered in the affirmative, then upon the completion of step **3804** data items are included in the summarisation of step **3805**. Thereafter, at step **3806** a question is asked as to whether another data item is to be selected.

Step **3805** invokes a summarisation method from the list of methods shown in *Figure 26.* In the present example, activity level is being graphed therefore the summarisation method selected is that of "choose maximum". Previously, this was done for the minute summaries but now a similar process is performed at every level of resolution, thereby filling the hierarchical cache up to the level where a value is required.

Figure 39

An illustration of the way in which the summarisation data is stored at multi-resolution levels is illustrated in *Figure 39.* At its lowest level, individual frames **3901** are stored each consisting of actual compressed image data and possibly having descriptive data associated therewith as previously described. Thus, the frame **3901** effectively divides the recorded time into a plurality of intervals (frames) that are stored in the database over the period of time under consideration.

The period of time is divided into a set of sub periods which, at its lowest level, consists of dividing the period of time into one-minute intervals **3902**. The data recorded on an interval by interval (frame by frame basis) is analysed to produce first level metadata for each of these individual one-minute frame groups **3902.** Furthermore, a plurality of the first level groups (minutes) are combined to produce second level groups (representing ten minute intervals in the example) **3903.** Consequently, the metadata of the first level one-minute intervals is then combined to produce second level metadata. Thus, each ten-minute group **3903** includes the metadata derived from each of its ten one-minute components **3902.**

This process is repeated for a one-hour interval **3904,** clearly containing data derived from six ten-minute intervals **3903**. Again, this process is repeated to produce a four-hour interval **3905** by grouping the metadata derived from four one-hour intervals **3904**. Finally, in this example, at its highest level, a one-day interval **3906** is considered in which metadata is combined from four-hour groups **3905**.

Figure 40

Procedures **3602** for calculating system quality are detailed in *Figure 40*. At step **4001** a quality parameter is initially set to zero whereafter, at step **4002** a first camera is selected.

At step **4003** the health value HC (in the range zero to one) for the camera selected at step **4002** is added to the quality parameter.

At step **4004** a question is asked as to whether another camera is to be considered and when answered in the affirmative the next camera is selected at step **4002.** Thus, the health value for the next selected camera is added to the running total for Q and so on until all off the cameras have been considered.

Step **4005** calculates system quality (as a percentage) by multiplying the accumulated Q value by 100 and then dividing by the number of cameras considered.

As previously stated, more sophisticated procedures may be adopted for calculating system quality and other types of devices may be included. It is also likely that system health functions may change to accommodate other constraints, such as giving more weighting to very sick cameras.

Figure 41

Process **3603** for selecting cameras for display is detailed in *Figure 41*. As previously described, the outputs from a plurality of cameras are displayable to an operator, and therefore it is not usually possible for all of the outputs to be displayed at the same time and a degree of prioritisation is required. Consequently, the data received from the cameras is processed in order to identify events of interest. Thereafter the output from a selected camera or cameras is displayed to an operator prominently after detecting an event of interest by the processing of data received from that selected camera. Thus, having captured video data and performed an analysis upon it (as part of the overall monitoring procedures) images will be displayed prominently if an event of interest has been detected.

At step **4101** a display area is identified to which the next new camera event will be assigned. This may be identified as the main area **3512** or one of the smaller priority areas **3507** to **3511**.

At step **4102** a question is asked as to whether a new event likely to be of interest has been detected. In response to an affirmative answer, a question is asked at step **4103** as to whether the output from the camera is already on view. In response to this question being answered in the negative the camera output is assigned to the display area identified at step **4101**, at step **4104**. In response to the question at step **4102** being answered in the negative or in response to the question asked at **4103** being answered in the affirmative, step **4104 is** bypassed.

Figure 42

Procedures **3604** for rendering the grid map **3528** are detailed in *Figure 42*. At step **4201** a predefined grid map is identified and at step **4202** a first square of the identified grid map is selected.

At step **4203** a question is asked as to whether the square selected at step **4202** is associated with an active monitoring camera. If the question asked at step **4203** is answered in the affirmative, the square selected at step **4202** is filled in accordance with the activity analysed from the selected camera.

At step **4205** the activity square is drawn and at step **4206** a question is asked as to whether another grid map square is to be considered. Thus, when the question asked at step **4206** is answered in the affirmative control is returned to step **4202** and the next grid map square is selected.

If a selected square is not associated with a camera, resulting in the question asked at step **4203** being answered in the negative, step **4204** is bypassed and the selected square is drawn without an activity related infill. Eventually, all of the squares in the grid map will have been considered and the question asked at step **4206** will be answered in the negative.

Figure 43

A monitored installation may have a plurality of grid maps associated therewith, as illustrated in *Figure 43*. In this example, grid map **4301** represents a first floor of a gallery, grid map **4302** represents a main entrance with exit areas and grid map **4303** represents the basement area, where it is possible that access is limited.

In this example, square **4304** represents a situation where a camera has not been assigned. Square **4305** represents an area where a camera has been assigned but very little activity is occurring. Square **4306** represents a situation where a camera has been assigned and there is substantial activity being detected by an analysis process of the monitoring system.

Figure 44

The procedure **3605** for rendering the track path timeline **3520**, and in particular the individual tracks **3523**, is detailed in *Figure 44*.

At step **4401** a first event is selected and at step **4402** event records are examined from tracks that fall within the timeline **3520** (*Figure 35*).

At step **4403** it is possible to identify additional tracking information such as velocity so that this may have an effect on the appearance of the timeline. Thus, as previously described, it is possible for slow velocities to be shown in a first colour (such as blue) with velocities that exceed a predetermined threshold being displayed in an alternative colour such as red.

At step **4404** a vertically offset horizontal line **3523** is drawn to mark the start and end of each track on the timeline. Thus, each horizontal line (offset from its neighbours in a vertical direction) represents the duration over which an individual binary large object has been tracked.

At step **4405** a question is asked as to whether another event is to be considered and when answered in the affirmative control is returned to step **4401** whereupon the next camera is selected.

Thus, the processes repeat for each track until all of the cameras have been considered and the question asked at step **4405** is answered in the negative.

Each track start point and end point is stored in the data store as an event itself. Consequently, it is not necessary to access all of the records at the frame level in order to generate the horizontal track **3523** (*Figure 35).*

Figure 45

An expanded view of track path **3524** generated by the procedures shown in *Figure 44* is illustrated in *Figure 45.*

The portion of the track path shown represents a period from 8 minutes 35 seconds to 9 seconds. An event has been detected that started at 8.37 and terminated at 8.56. These start and end points have been identified resulting in a tracked line **4501** being displayed. Similarly, a second event has been recorded as starting at 8.44 and then finishing at 9.00. This has resulted in a second track line **4502** being displayed. In this example, the first event occurred at a lower velocity with the second event occurring at a higher velocity. Consequently, track line **4501** is displayed in blue (represented as being without shading) where as track line **4502** is displayed in red, represented by the shading.

Figure 46

Procedures for rendering the activity timeline with exemplar images **3606** are detailed in *Figure 46.*

At step **4601** a question is asked as to whether real time monitoring is occurring or whether images are being viewed from storage. Here it can be appreciated that when receiving images from storage, when in playback mode, there are more options for controlling the timeline. Thus, if the question asked at step **4601** is answered in the negative, (to the effect that a play-back is occurring) the timeline start and end points are modified in response to user input, such as forward or backward scrolling or zooming at step **4602.**

At step **4603** a question is asked as to whether a snap event has occurred to the previous or next activity period, by operation of buttons **3518/3519**. If this question is answered in the affirmative, the playback time is changed to the previous or next activity period at step **4604.**

At completion of step **4604** or after the question at step **4601** has been answered in the affirmative, results in the activity graph being plotted at step **4605.**

At step **4606** exemplar images are drawn at reduced size at appropriate positions along the timeline.

Figure 47

Procedures **3404** for tagging are detailed in *Figure 47*. In an embodiment, an operator uses mouse **502** to activate tag icon **3525.** Thus, at step **4701** a question is asked as to whether the tag icon **3525** has been clicked.

Upon detecting a click (the question at step **4701** being answered in the affirmative) a question is asked at step **4702** as to whether a single click has occurred or whether a double click has occurred.

In response to detecting a single click at step **4702** a tag is created at step **4703.** A tag of this type contains details of the current time with a default attribute including the name of the operator. Thus, the creation of a tag of this type is straightforward and no further measures are taken within process **3404.**

In response to a double click being detected at step **4702** a tag is created at step **4704** identifying the current time, the operator's name and creating a blank text field.

At step **4705** a dialog box is opened for the operator thereby inviting the operator to type via keyboard **501**, text describing the tagged event.

At step **4706** text is received via user input and the dialog box is then closed. Subsequently, at step **4707** the contents of the tag are updated.

Once a tag has been created using the **3407** processes, it will be rendered at step **3607** the next time a rendering operation is performed, usually initiated by the next frame synchronisation pulse for the monitor **431.**

Figure 48

An example of a tag created by step **4707** is shown in *Figure 48*. The tag is stored at the data store as a file **4801** associated with an image frame.

The tag includes a tag time and date **4802** and a camera number **4803.** The tag also identifies the operator **4804** who has created the tag and an alert level **4805**. The description of the event, entered via keyboard **501** is recorded at **4806.**

Figure 49

Procedures **3407** for generating a maintenance schedule are detailed in *Figure 49*. Each camera's health records HC are extrapolated thereby enabling a prediction to be made as to whether the camera will fall below a health threshold of, say, ninety percent in the next month. Where the prediction is made to the effect that the health of the camera will fall below the ninety percent threshold, the camera is considered to be unhealthy and is therefore scheduled for maintenance to be carried out.

At step **4901** a question is asked as to whether a maintenance schedule is to be created and when answered in the affirmative a first camera is selected at step **4902**.

At step **4903** the last three months of camera health ratings are accessed and at step **4904** camera health is extrapolated for the next month.

At step **4905** a question is asked as to whether it is expected that the camera health will go below the target threshold of ninety percent and when answered in the affirmative, a maintenance request is generated for that camera at step **4906**.

At step **4907** a question is asked as to whether another camera is to be considered and when answered in the affirmative control is returned to step **4902** resulting in the next camera being selected.

When all of the cameras have been considered, maintenance requests are sorted so as to produce a list of cameras that require maintenance by the end of the month at step **4908**. Thereafter, the schedule is printed at step **4909.**

The maintenance schedule may identify degrees of urgency for the cameras or give specific dates by which it is expected that their health values are predicted to fall below ninety percent. This could also be extended to include predictions for eighty percent (very important) and even seventy-percent (urgent) etc.

Figure 50

Process **3408** for generating reports is detailed in *Figure 50.*

At step **5001** a selection is made as to whether a report is required and, if so, it is possible to select a report type.

As illustrated at **5002** it is possible to produce a daily single page report showing, on a single page, the most important events that have occurred that day.

Similarly, as indicated at **5003**, it is possible to produce a shift end report for a particular operator. In this way, it is possible for the operator to make a quick check to the effect that the day as recorded is consistent with his recollection of it. In particular, the report would indicate that tags have been recorded thereby providing confirmation to the effect that the operator's actions had been responded to as desired.

As indicated at step **5004** it is possible to produce a weekly summary and as indicated at **5005** other types of report may be produced in response to specific demands.

Figure 51

Procedures **5002** for producing a daily single page report are detailed in *Figure 51*. The day of interest is split up into twelve two-hour periods that are printed out on a single sheet of preferably A4 paper in landscape mode. Each period is represented by a block and an exemplar image is placed in each block, resulting in six exemplar images in each of two rows being printed.

At step **5101** the first two-hour period is selected and at step **5102** activity graphs are examined for all cameras over the period selected at step **5101**.

At step **5103** a most valuable activity period is selected, possibly determined by an identification of the highest level of activity detected by a camera of highest priority.

At step **5104** an exemplar image is generated by the freeze frame process or the blur process previously described. Thereafter, at step **5105** a question is asked as to whether all of the two-hour periods have been considered. When answered in the negative, control is returned to step **5101** and the next two hour period is selected.

When all of the periods have been considered, the question asked at step **5105** is answered in the affirmative and at step **5106** the exemplar images are arranged in two rows of six in landscape format. Thereafter, at step **5107** the exemplar images are generated.

It will be appreciated that, for this process, all of the cameras are used as input so there is a significant degree of activity to choose from. This contrasts with the activity snap shot described previously that is generated by analysers individually. In terms of generating the report, a selection is made from all of the stored outputs of all of the analysers available within the monitoring system. Preferably, the printing process is automated and produced at a selected time during each day.

Figure 52

An example of a daily report produced by this process shown in *Figure 51* is detailed in *Figure 52*. Images **5201** to **5206** are presented in a first row of six two-hour periods. Thus, an exemplar image **5201** is selected for the period of midnight to 2am. Similarly, exemplar image **5202** is selected for the period 2am to 4am.

A second row of exemplar images **5207** to **5212** represents the second twelve-hour period. Thus, image **5207** is an exemplar image derived from the period 12 midday to 2pm and so on. Consequently, twelve exemplar images are printed selected from their respective two-hour slots. In addition, the date of the report is also printed at **5213**.

Figure 53

Procedures **5003** for producing a shift end report are detailed in *Figure 53*. It is suggested that each operator would work for a shift consisting of a few, say three, hours during which it is expected that several tags will have been created. Each operator logs onto the monitoring system at the start of their shift such that the tags generated by a particular operator over their shift are uniquely identifiable. Thus, from this information, it is possible to produce a useful report consisting of the list of tags (some with comments and some without). In particular, this provides a useful mechanism for showing what has been going on during a shift when one operator hands over to the next operator.

As shown in *Figure 48*, the time and date **4802** when a tag is created is stored within the tag. Thus, from this information, it is possible to look up the image at that time and date so that the image itself can be included in the report.

At step **5301** a first tag is selected from the operators shift. From the time and date data as previously described, image data is selected. As previously described, it is possible that the foreground and background part of the image will be recorded at different definitions therefore the high quality foreground is composited against the poor quality background at step **5302.**

At step **5303** the tag time and text is prepared for printing with the selected image.

At step **5304** a question is asked as to whether another tag is to be processed and when answered in the affirmative control is returned to step **5301** whereupon the next tag is selected for the operators shift.

Eventually, all of the tags will have been considered resulting in the question asked at step **5304** being answered in the negative. Subsequently, a report is printed at step **5305.**

Figure 54

An example of a report printed at step **5305** is illustrated in *Figure 54.* Each tagged event is recorded in a specific block and, in this example, it is possible to contain four blocks within a single page. Consequently, sufficient pages are printed in order to represent all of the tags recorded for a particular shift, one such page being shown in *Figure 54.*

For each entry (representing a tag) a time is shown at **5401.** In addition, if present, textual matter is shown at **5402** and the composited image is shown at **5403.**

Thus, this arrangement is repeated for a second tag at time **5404**, with text **5405** and an image **5406.** The next tag is displayed at time **5407** with text **5408** and an image **5409.** Finally, at time **5410** a tag is displayed with text **5411** and image **5412.**

Claims

1. A method of analysing image data, including the steps of

processing image data to track moving foreground objects thereby identifying tracked objects;

monitoring movement of said foreground objects;

displaying a timeline; and

displaying an indication of a said tracked objects with reference to said timeline.

2. A method according to claim **1**, wherein said indication is displayed as a horizontal line for each tracked event.

3. A method according to claim **2**, wherein a plurality of said horizontal lines occupy different vertical positions.

4. A method according to any of claims **1** to **3**, wherein said processing step includes establishing a background model and analysing incoming frames with respect to said background model to identify foreground objects.

5. A method according to claim **4**, wherein said analysing step includes comparing difference values against a dynamically varying threshold value.

6. A method according to claim **5**, wherein said threshold value is varied in response to a count of isolated foreground pixels.

7. A method according to claim **1**, wherein said processing step includes representing a foreground object as a binary object and applying processes of erosion and dilation upon said binary object.

8. A method according to claim **1**, wherein foreground objects are tracked by identifying a centroid for each object on a frame-by-frame basis.

9. A method according to claim **1**, wherein a velocity for a moving object is calculated.

10. A method according to claim **9**, wherein differently coloured displayed indications identify different object velocities.

11. A computer-readable medium having computer-readable instructions executable by a computer or by a network of computers such that when executing said instructions said computer(s) will perform a method as defined by claim **1**.

12. Image processing apparatus, including a data store, a processor, a display monitor and an input, wherein said processing means is configured to:

receive first image data via said input;

track moving foreground objects;

monitor movement of said foreground objects; and

output, to said display monitor, second image data representing a timeline and an indication of said tracked foreground objects with reference to said timeline.

13. A method of observing monitored image data generated by a plurality of cameras, wherein

camera images are selected by a monitoring process and displayed to an operator;

said operator observes said displayed images in combination with a displayed time line; and

upon observation by said operator of an action considered of interest, said monitoring system:

(a) responds to manual input from said operator; and

(b) provides a visual indication on said timeline to show when manual input was made.

14. A method according to claim **13**, wherein said manual input includes text.

15. A method according to claim **13**, wherein said visual indication is shown on a time line that also includes an indication of detected activity and/or exemplar images.

16. A method according to claim **13**, wherein said manual input involves selecting a displayed icon.

17. A method according to claim **16**, wherein said displayed icon is displayed over a displayed image and not at the position of said displayed time line.

2004233458 25 Nov 2004

18. A method according to claim **16,** wherein said visual indication and said displayed icon have a substantially similar configuration.

19. Apparatus configured to carry out a method according to claim **13.**

20. A computer-readable medium having computer-readable instructions executable by a computer or by a network of computers such that when executing said instructions said computer(s) will perform a method as defined by claim **13.**

Dated this 25th Day of November 2004

SAFEHOUSE INTERNATIONAL INC.

By my attorneys

Eagar & Buck Patent and Trade Mark Attorneys

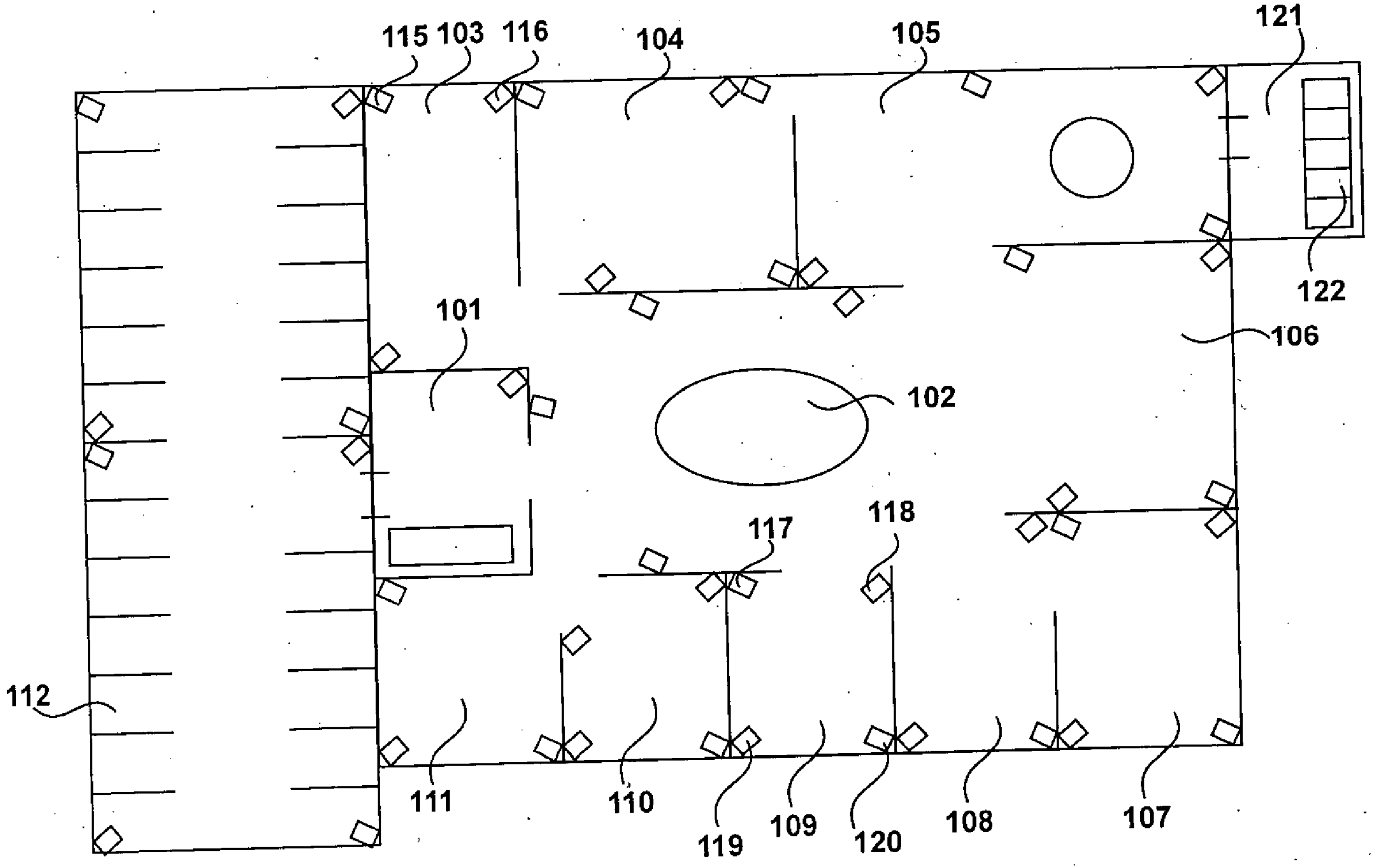

115
103
116
104
105
121
101
122
106
102
117
118
112
111
110
119
109
120
108
107

Fig. 1

Fig. 2

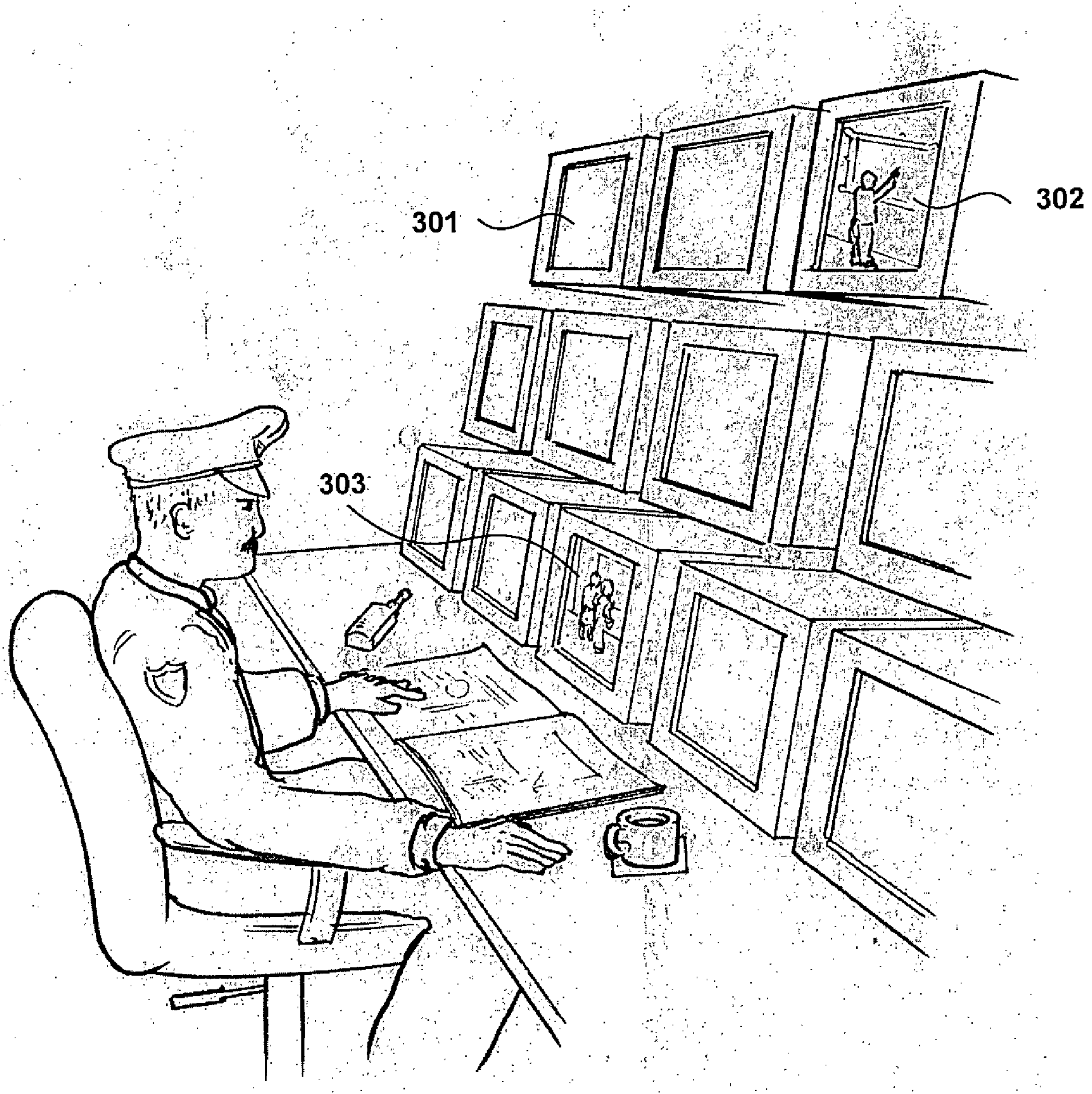


Fig. 3

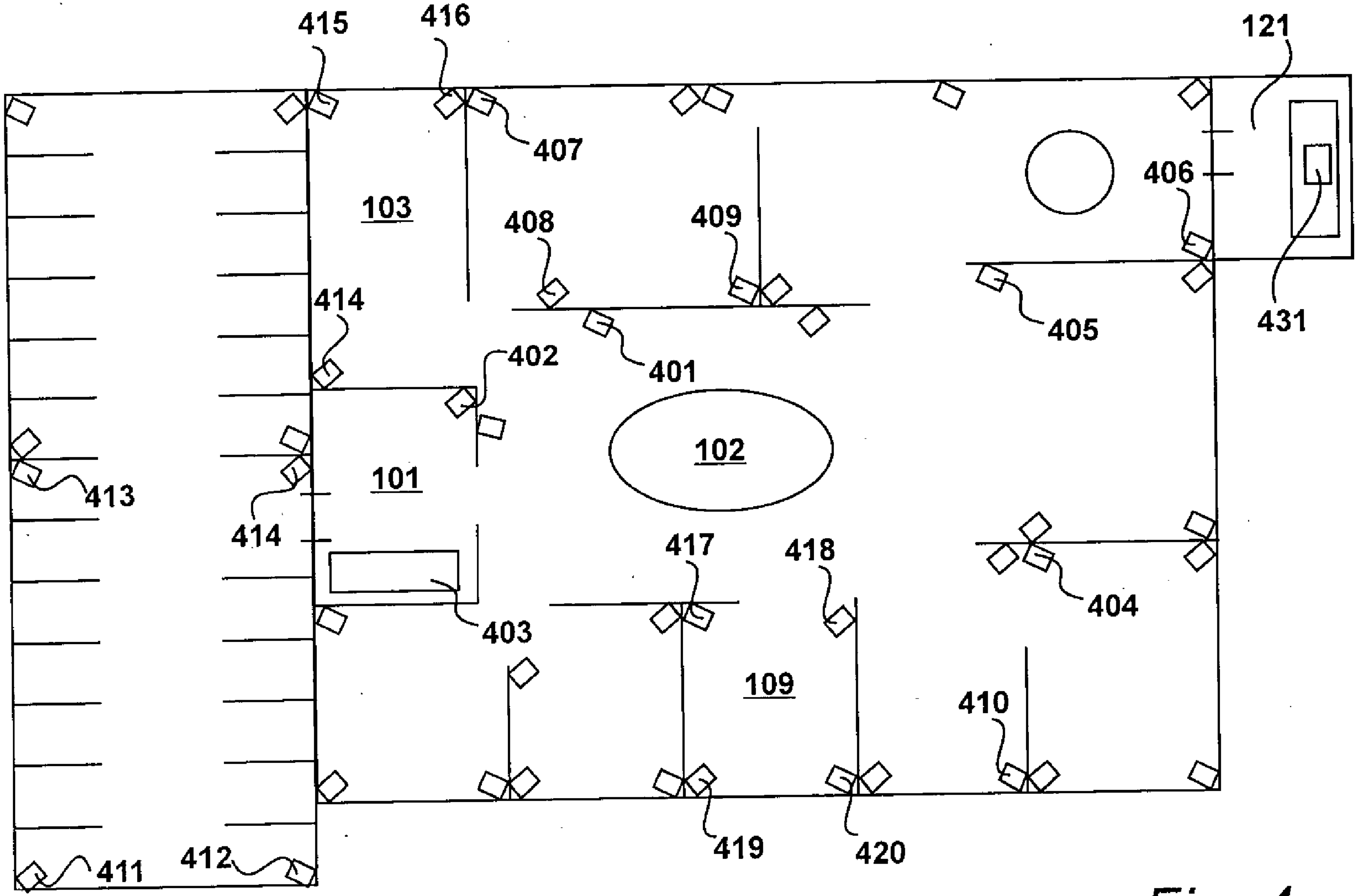

415
416
121
407
103
408
409
406
431
405
414
402
401
102
101
413
414
417
418
404
403
109
410
411
412
419
420

Fig. 4

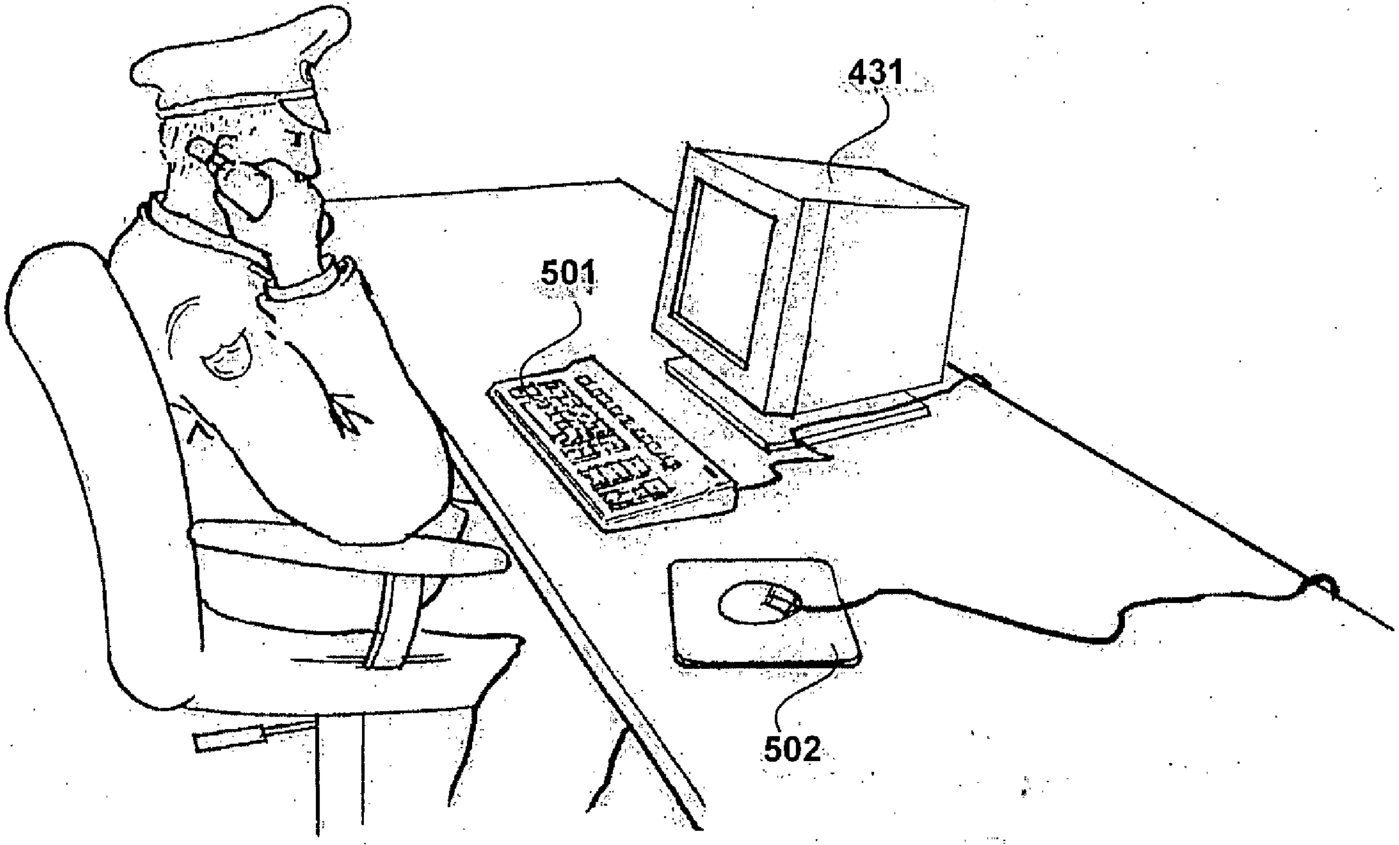


Fig. 5

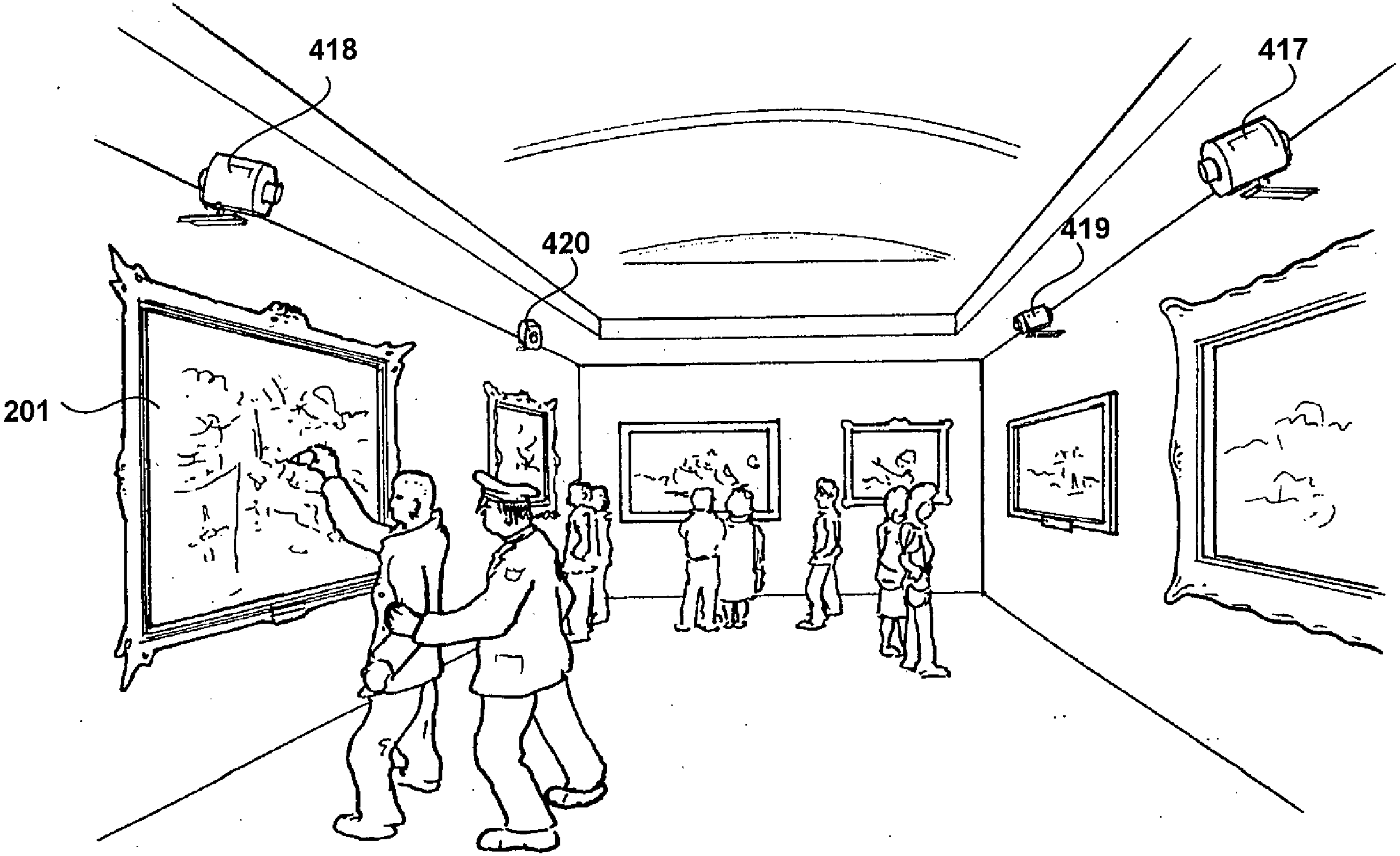


Fig. 6

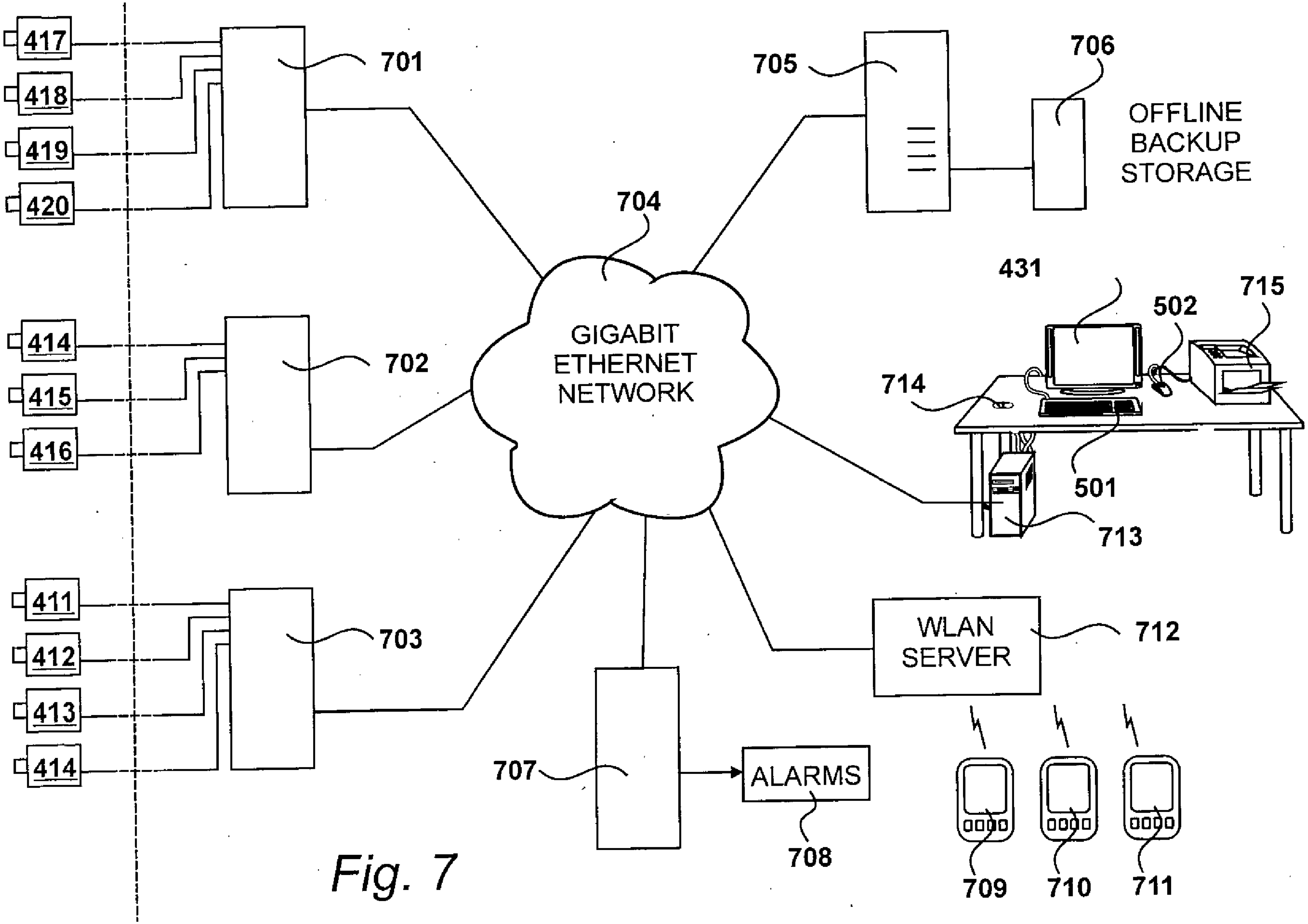

417
418
419
420
701
414
415
416
702
411
412
413
414
703
704
GIGABIT ETHERNET NETWORK
705
706
OFFLINE BACKUP STORAGE
431
502
715
714
501
713
WLAN SERVER
712
707
ALARMS
708
709
710
711

Fig. 7

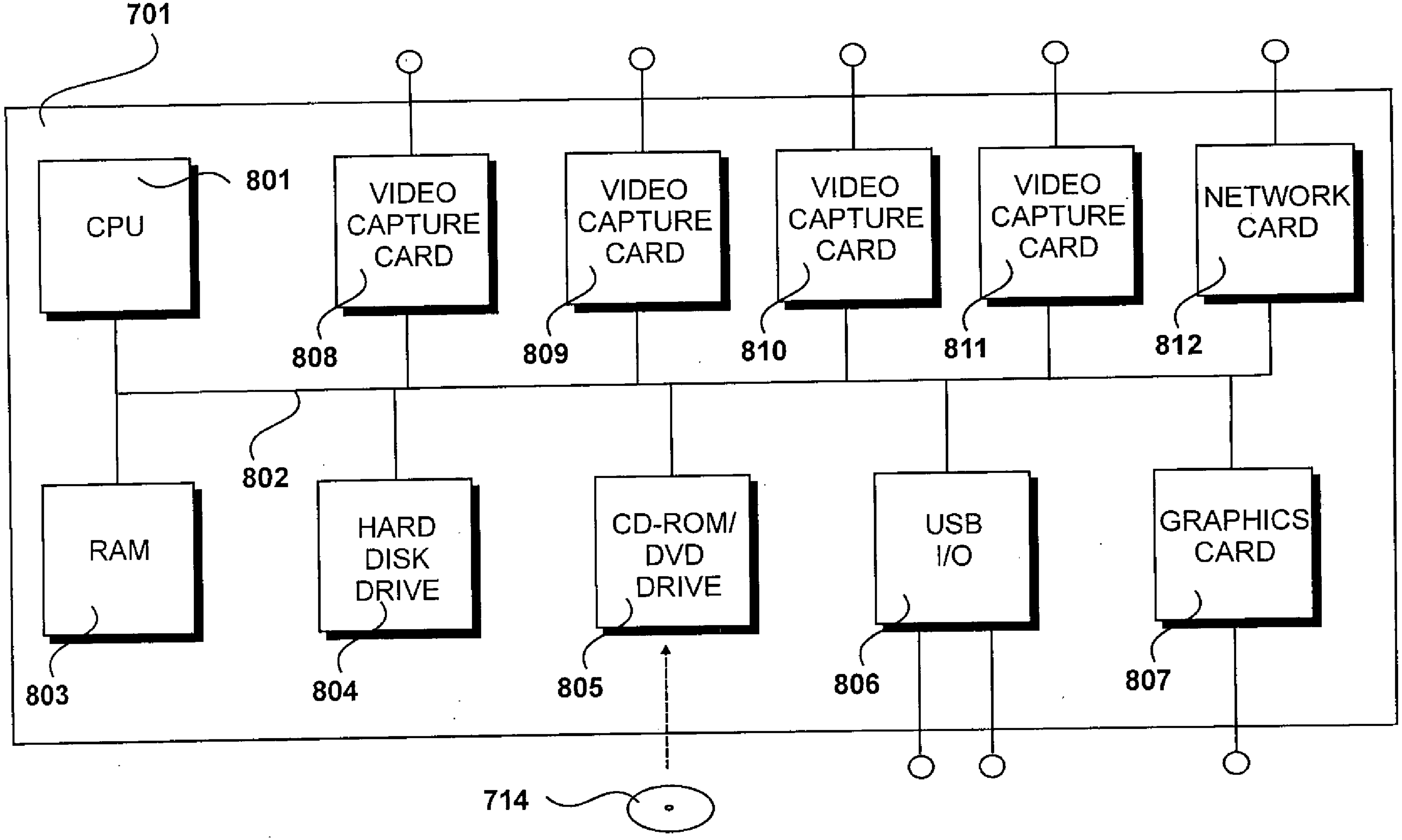

701
CPU
801
VIDEO CAPTURE CARD
VIDEO CAPTURE CARD
VIDEO CAPTURE CARD
VIDEO CAPTURE CARD
NETWORK CARD
808
809
810
811
812
802
RAM
HARD DISK DRIVE
CD-ROM/ DVD DRIVE
USB I/O
GRAPHICS CARD
803
804
805
806
807
714

Fig. 8

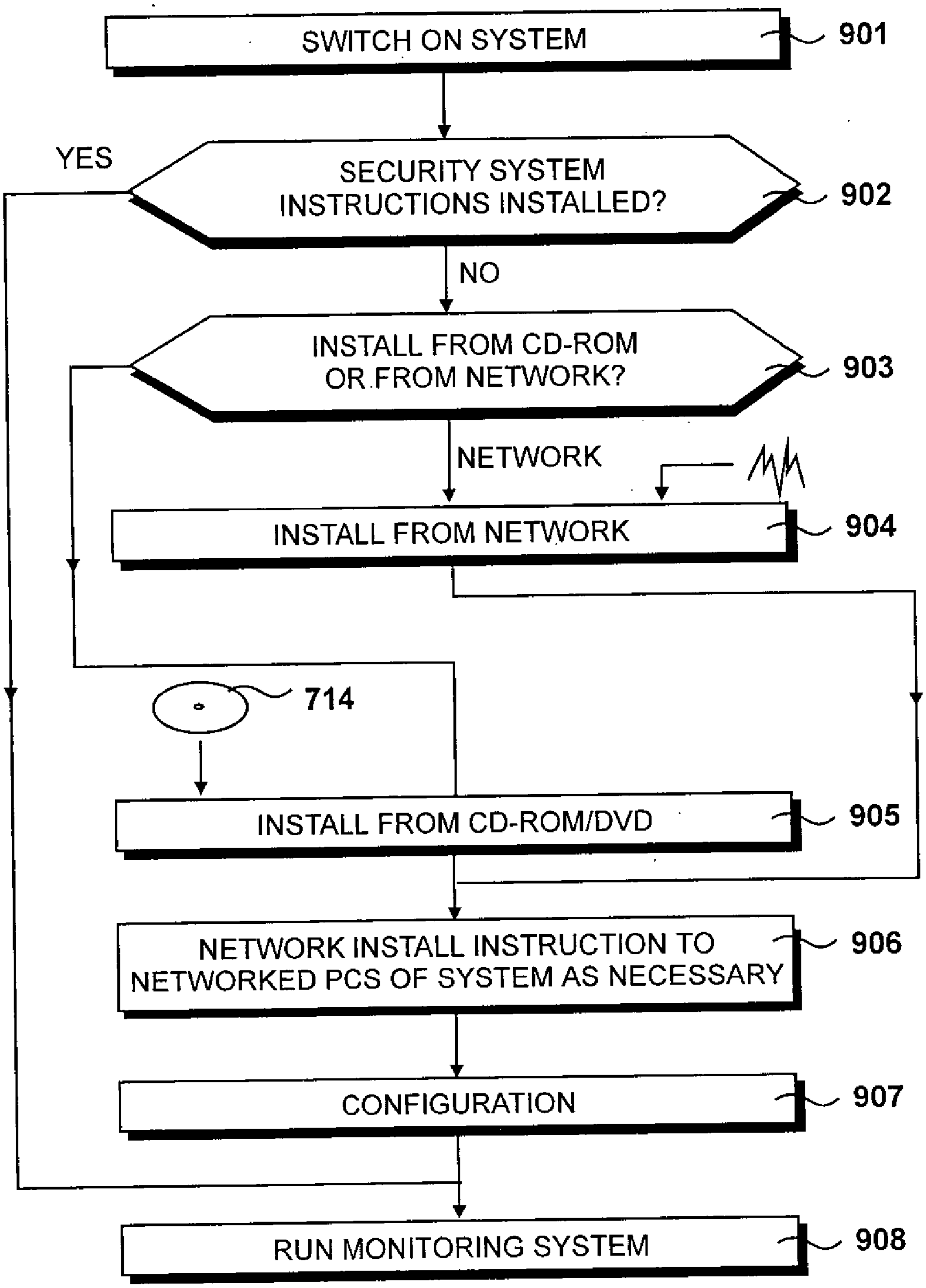

SWITCH ON SYSTEM
901
YES
SECURITY SYSTEM INSTRUCTIONS INSTALLED?
902
NO
INSTALL FROM CD-ROM OR FROM NETWORK?
903
NETWORK
INSTALL FROM NETWORK
904
714
INSTALL FROM CD-ROM/DVD
905
NETWORK INSTALL INSTRUCTION TO NETWORKED PCS OF SYSTEM AS NECESSARY
906
CONFIGURATION
907
RUN MONITORING SYSTEM
908

Fig. 9

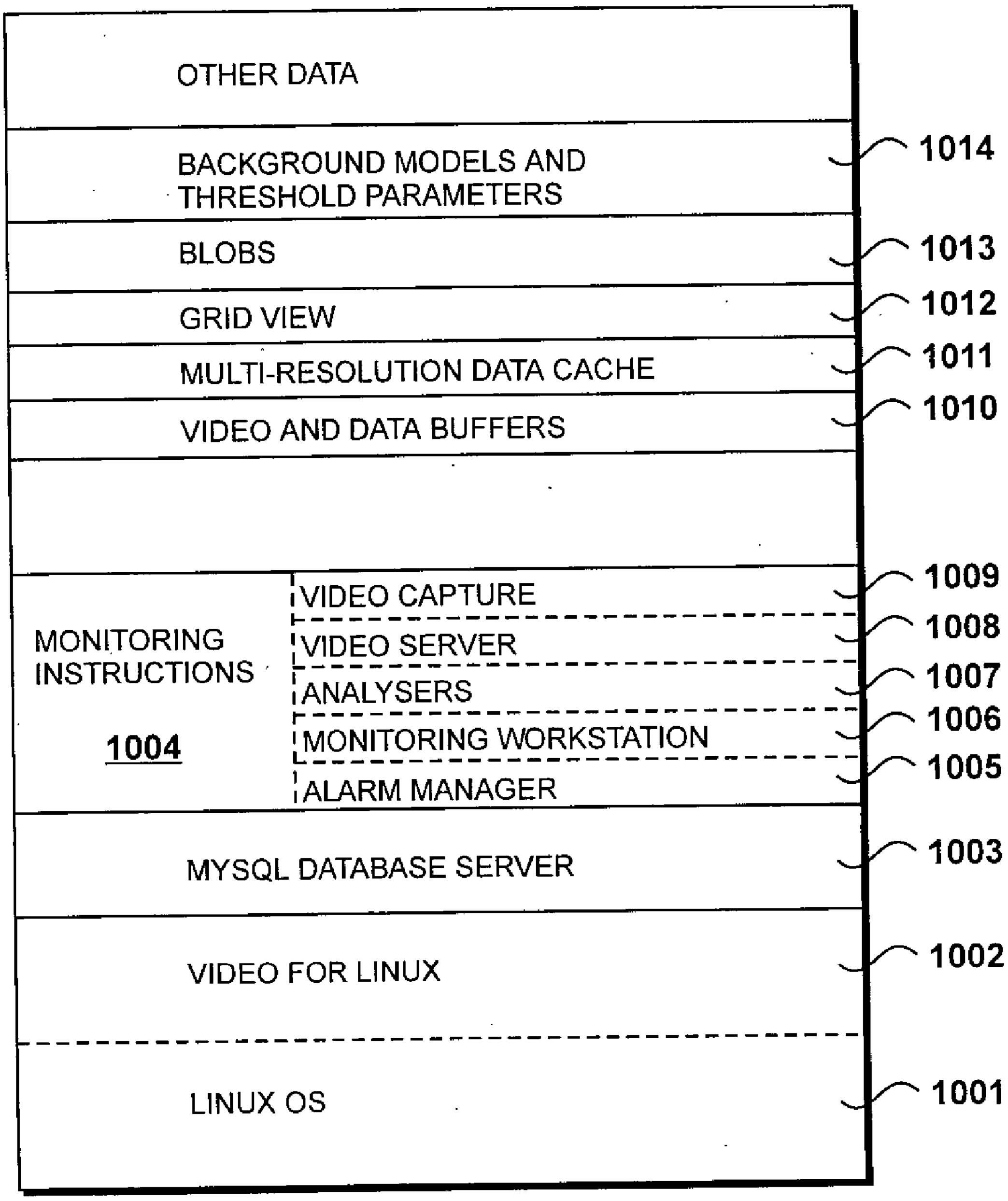

OTHER DATA
BACKGROUND MODELS AND THRESHOLD PARAMETERS
1014
BLOBS
1013
GRID VIEW
1012
MULTI-RESOLUTION DATA CACHE
1011
VIDEO AND DATA BUFFERS
1010
MONITORING INSTRUCTIONS
1004
VIDEO CAPTURE
1009
VIDEO SERVER
1008
ANALYSERS
1007
MONITORING WORKSTATION
1006
ALARM MANAGER
1005
MYSQL DATABASE SERVER
1003
VIDEO FOR LINUX
1002
LINUX OS
1001

Fig. 10

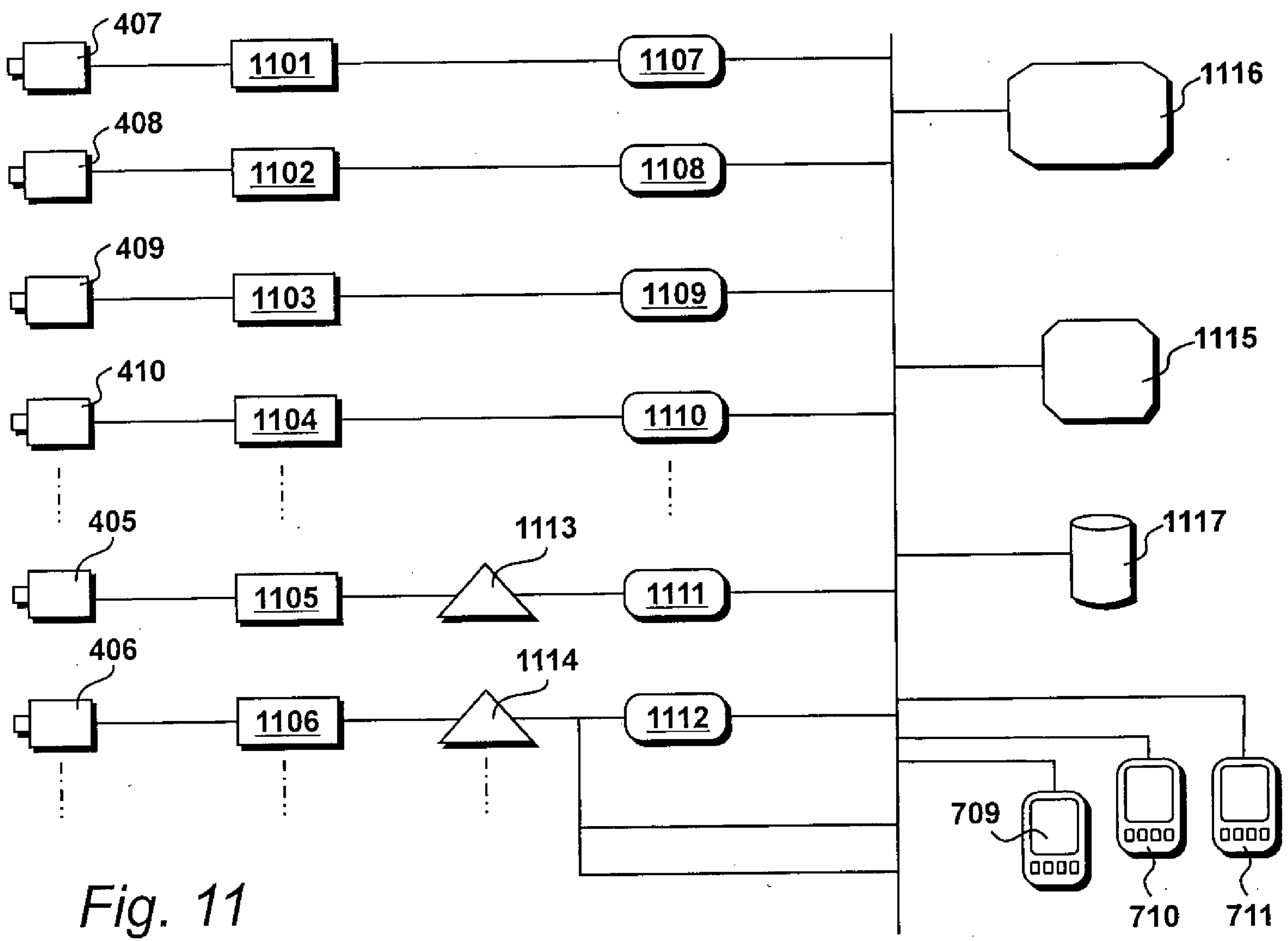

407
408
409
410
405
406
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1116
1115
1117
709
710
711

Fig. 11

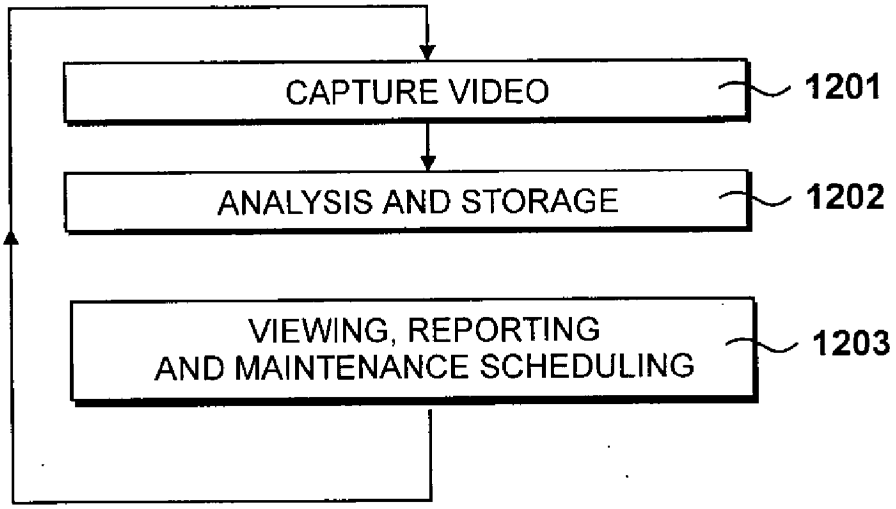

CAPTURE VIDEO
1201
ANALYSIS AND STORAGE
1202
VIEWING, REPORTING AND MAINTENANCE SCHEDULING
1203

Fig. 12

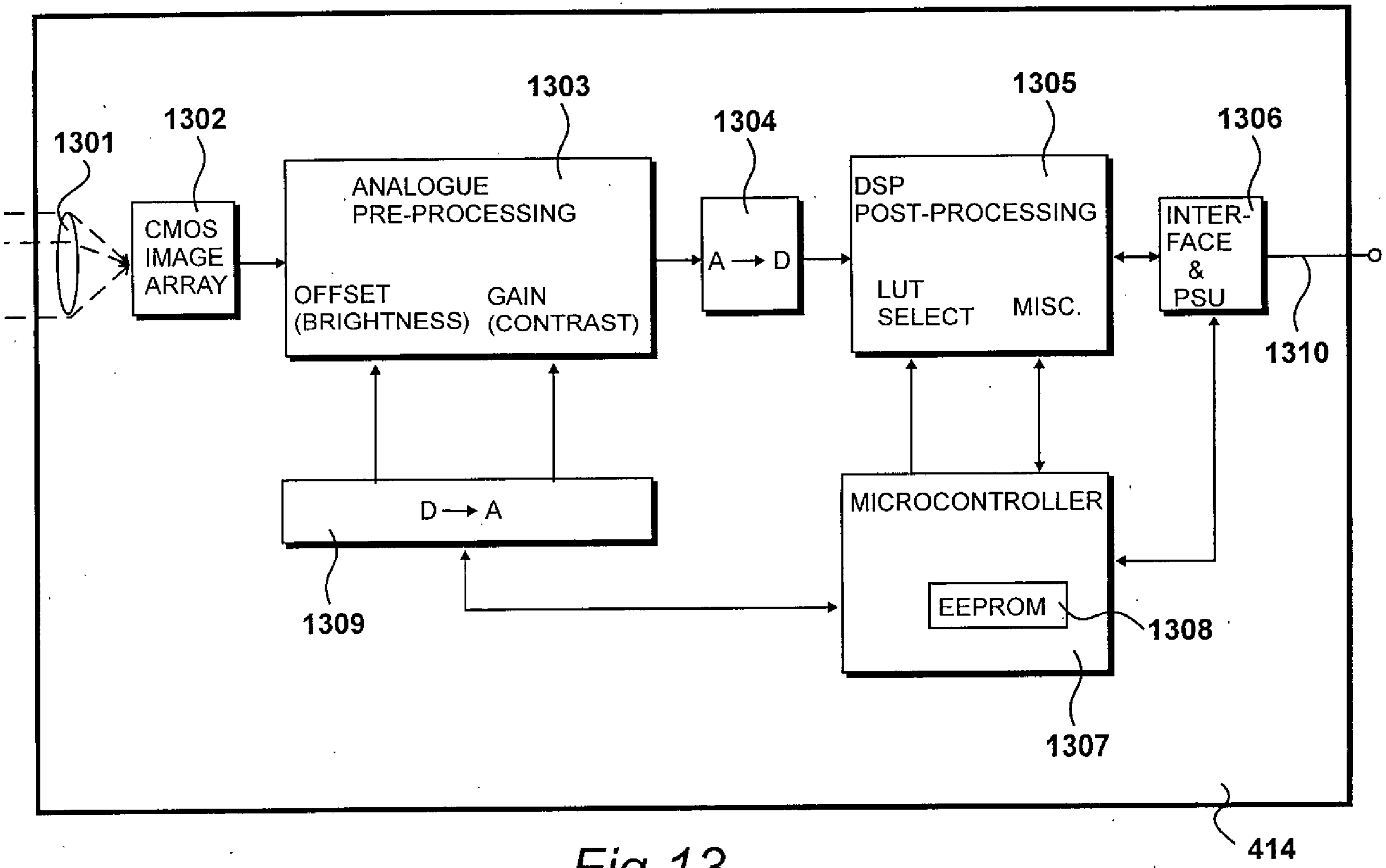

1301
1302
1303
1304
1305
1306
CMOS IMAGE ARRAY
ANALOGUE PRE-PROCESSING
OFFSET (BRIGHTNESS)
GAIN (CONTRAST)
A → D
DSP POST-PROCESSING
LUT SELECT
MISC.
INTER-FACE & PSU
1310
D → A
1309
MICROCONTROLLER
EEPROM
1308
1307
414

Fig.13

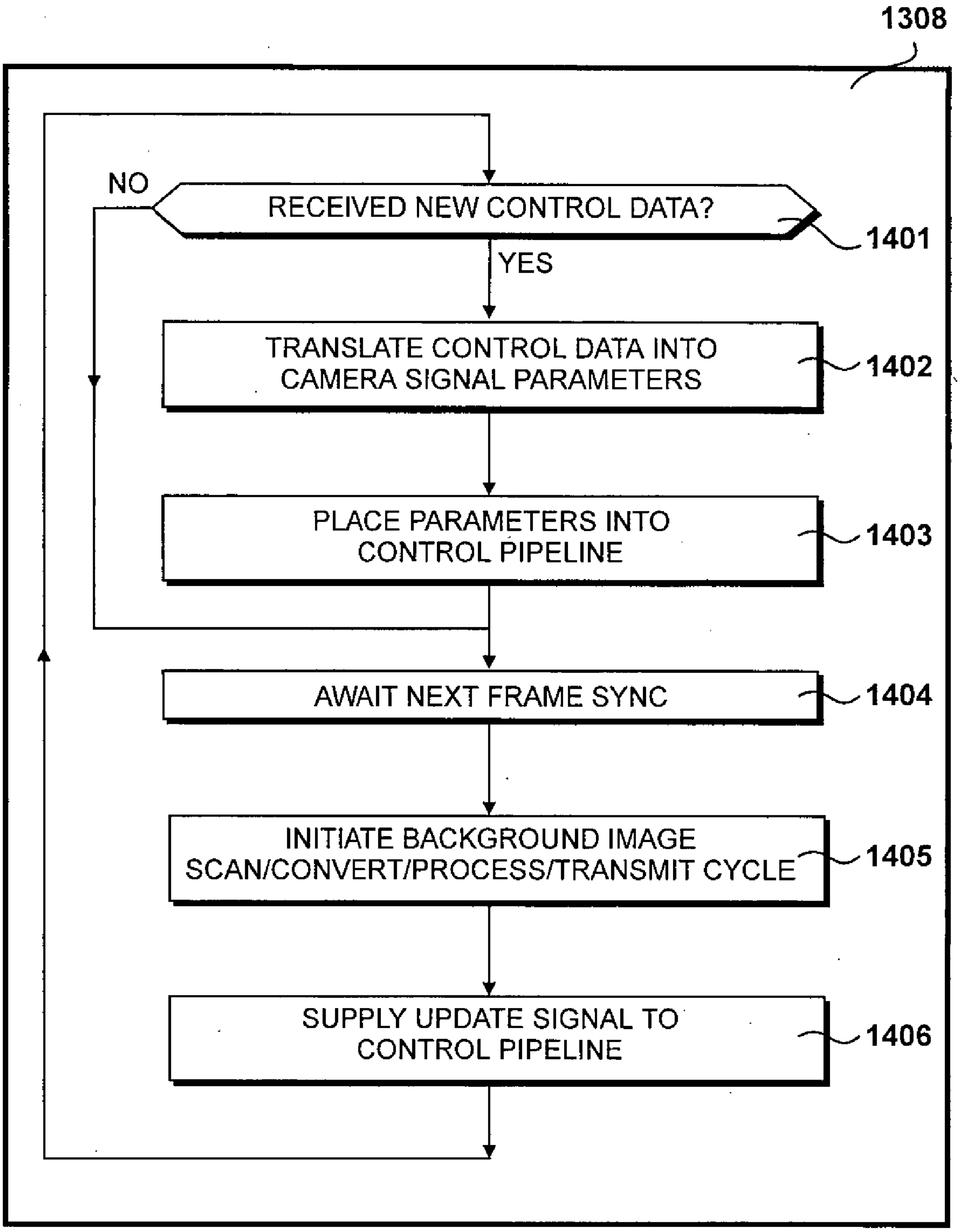

1308
NO
RECEIVED NEW CONTROL DATA?
1401
YES
TRANSLATE CONTROL DATA INTO CAMERA SIGNAL PARAMETERS
1402
PLACE PARAMETERS INTO CONTROL PIPELINE
1403
AWAIT NEXT FRAME SYNC
1404
INITIATE BACKGROUND IMAGE SCAN/CONVERT/PROCESS/TRANSMIT CYCLE
1405
SUPPLY UPDATE SIGNAL TO CONTROL PIPELINE
1406

Fig. 14

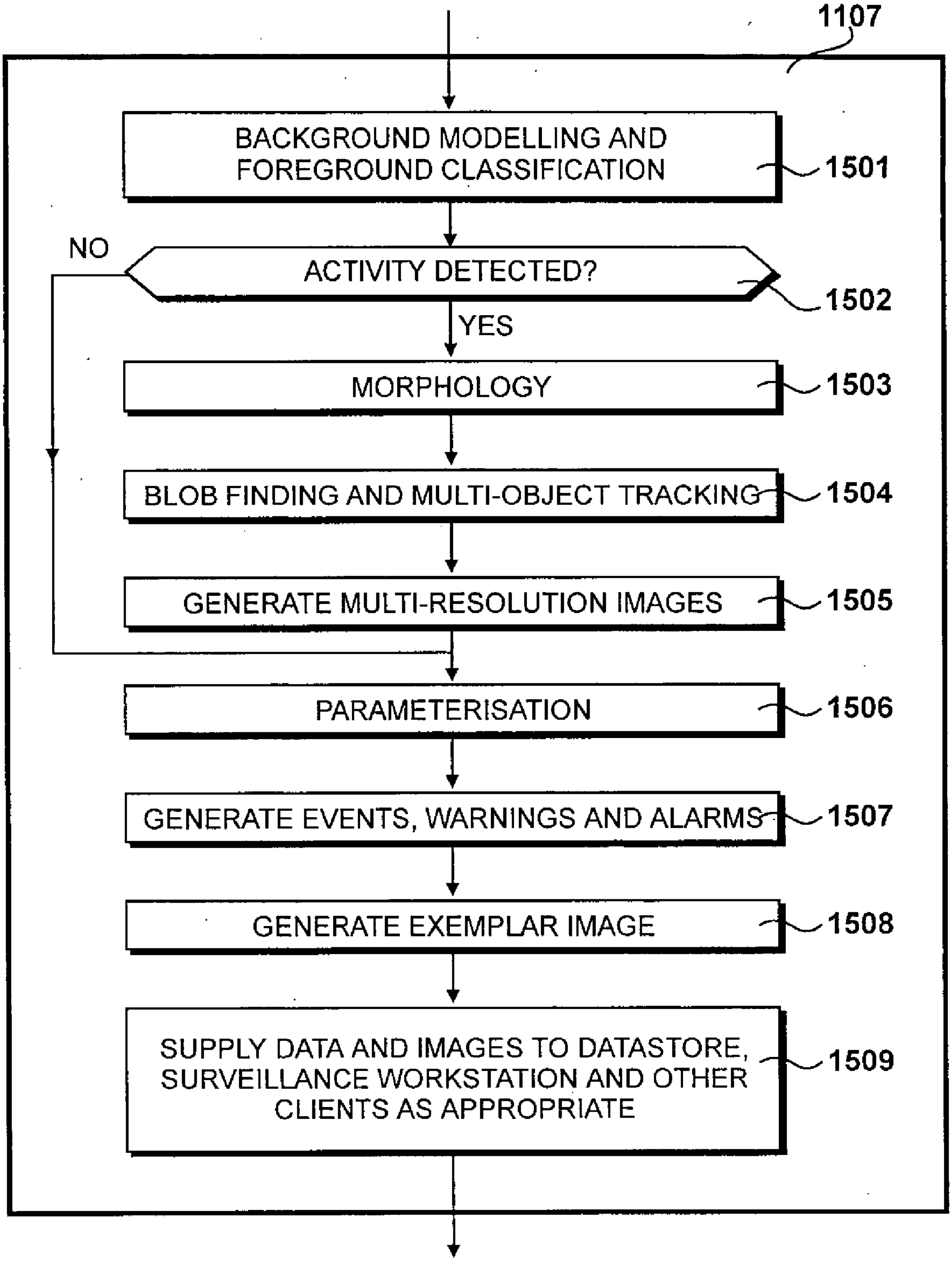

1107
BACKGROUND MODELLING AND FOREGROUND CLASSIFICATION
1501
NO
ACTIVITY DETECTED?
1502
YES
MORPHOLOGY
1503
BLOB FINDING AND MULTI-OBJECT TRACKING
1504
GENERATE MULTI-RESOLUTION IMAGES
1505
PARAMETERISATION
1506
GENERATE EVENTS, WARNINGS AND ALARMS
1507
GENERATE EXEMPLAR IMAGE
1508
SUPPLY DATA AND IMAGES TO DATASTORE, SURVEILLANCE WORKSTATION AND OTHER CLIENTS AS APPROPRIATE
1509

Fig. 15

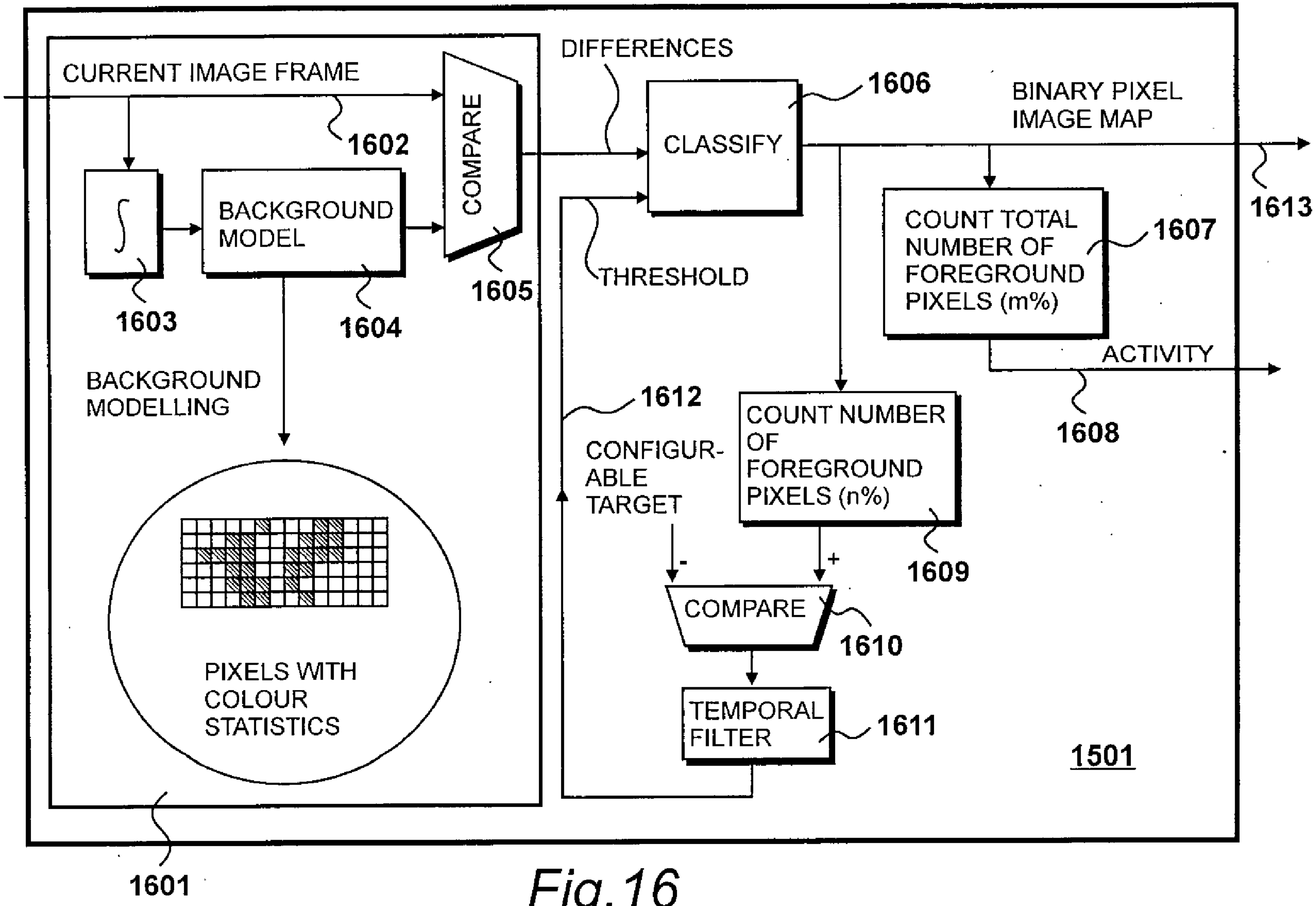

CURRENT IMAGE FRAME
1602
COMPARE
DIFFERENCES
CLASSIFY
1606
BINARY PIXEL IMAGE MAP
1613
BACKGROUND MODEL
1603
1604
1605
THRESHOLD
COUNT TOTAL NUMBER OF FOREGROUND PIXELS (m%)
1607
ACTIVITY
1608
BACKGROUND MODELLING
1612
CONFIGUR-ABLE TARGET
COUNT NUMBER OF FOREGROUND PIXELS (n%)
1609
-
+
COMPARE
1610
PIXELS WITH COLOUR STATISTICS
TEMPORAL FILTER
1611
1501
1601

Fig.16

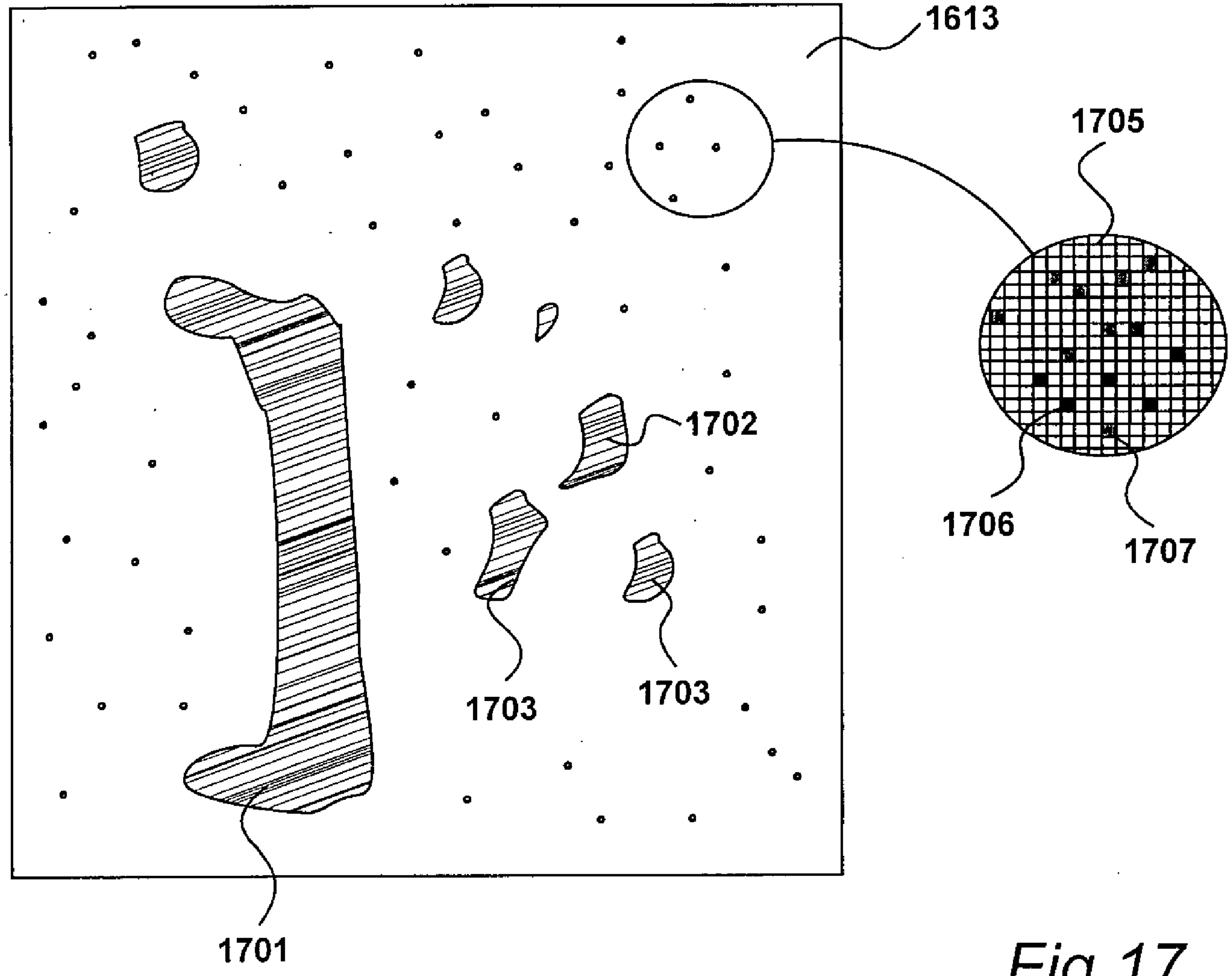


Fig.17

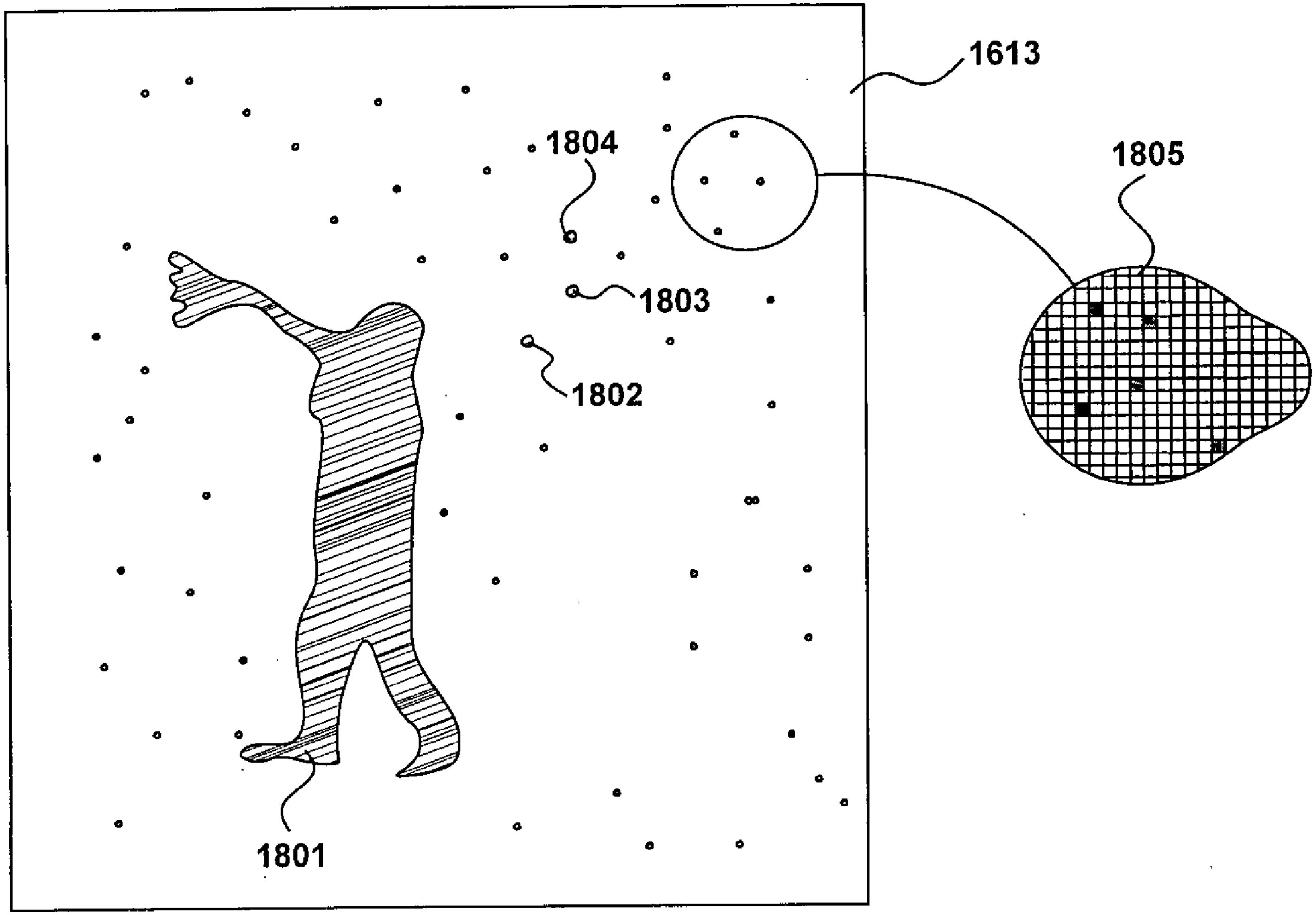


Fig.18

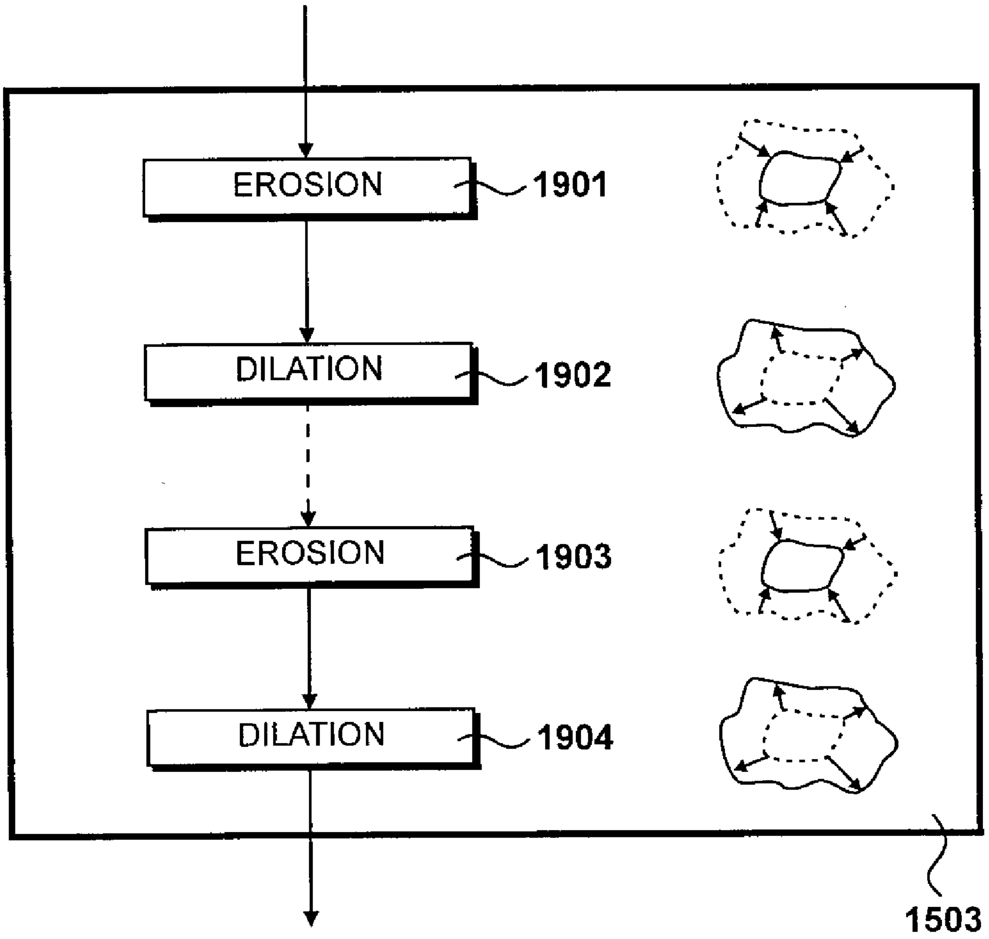

EROSION
1901
DILATION
1902
EROSION
1903
DILATION
1904
1503

Fig. 19

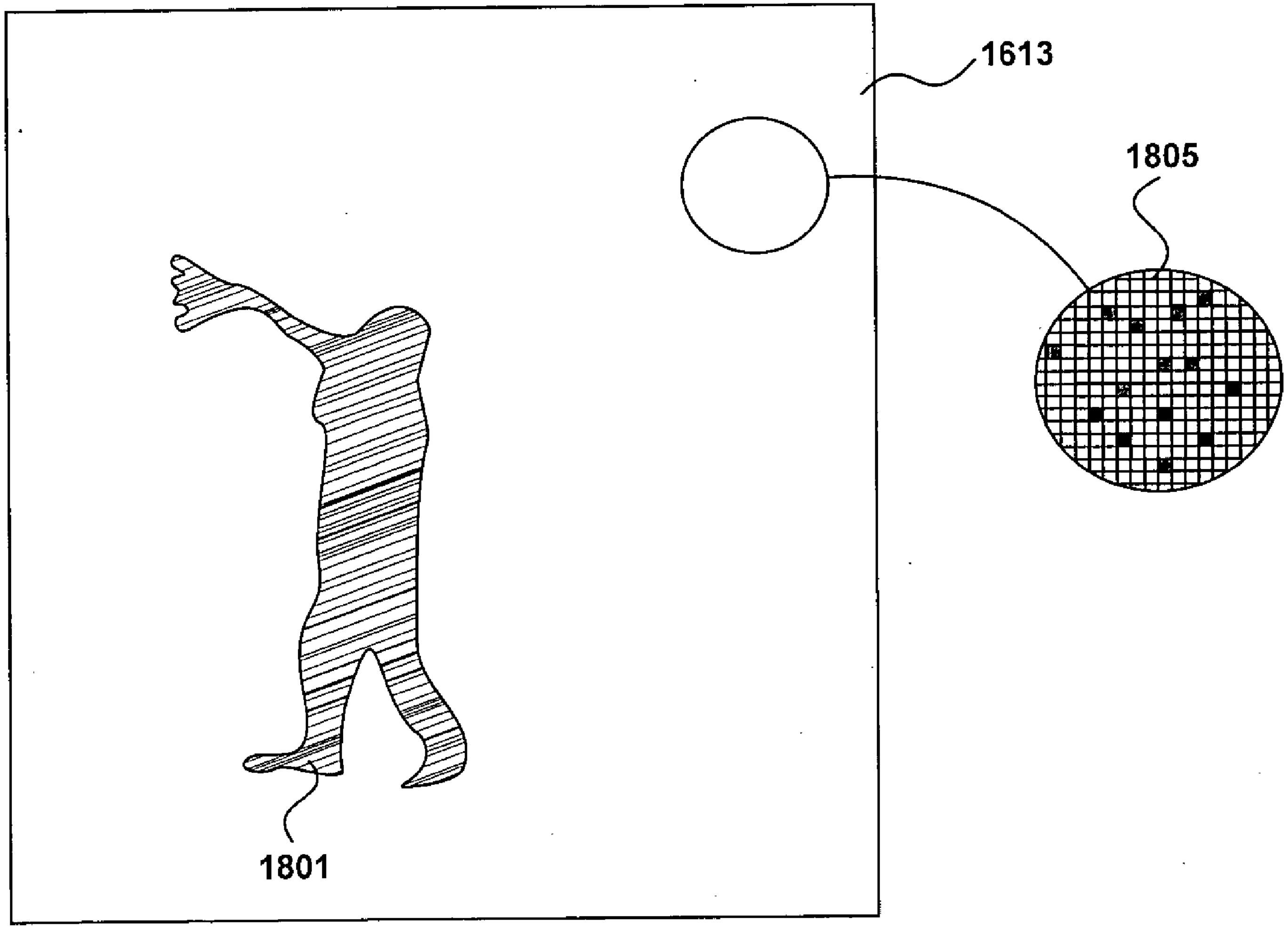


Fig.20

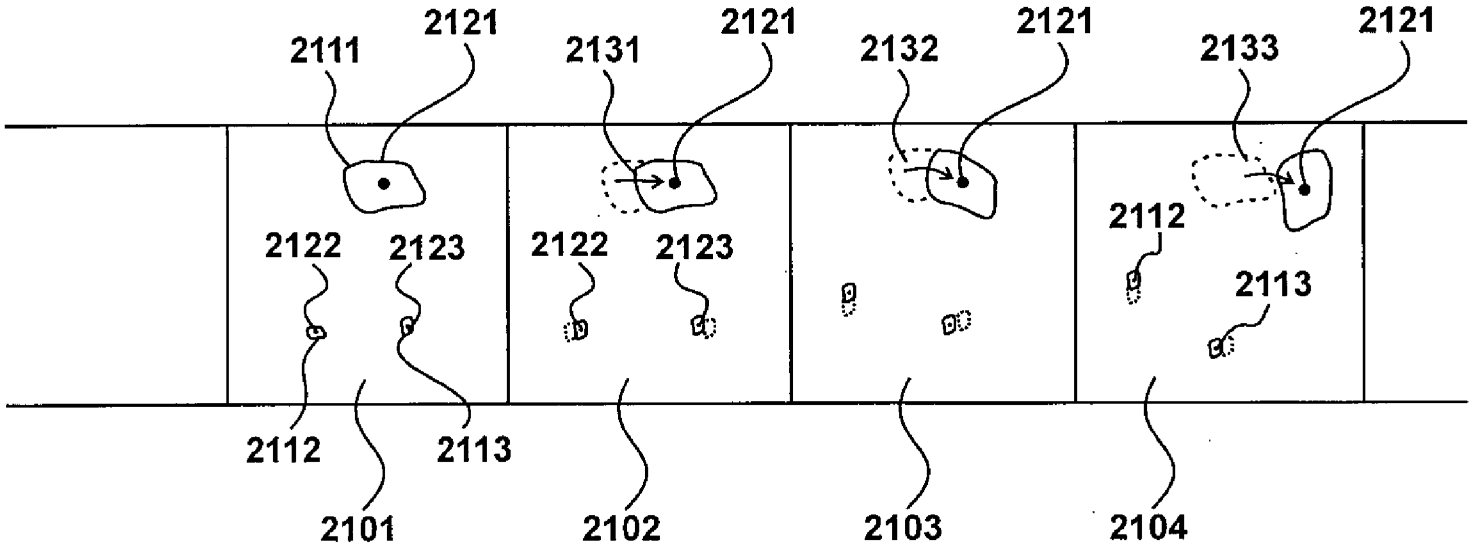

2111
2121
2131
2121
2132
2121
2133
2121
2122
2123
2122
2123
2112
2113
2112
2113
2101
2102
2103
2104

Fig.21

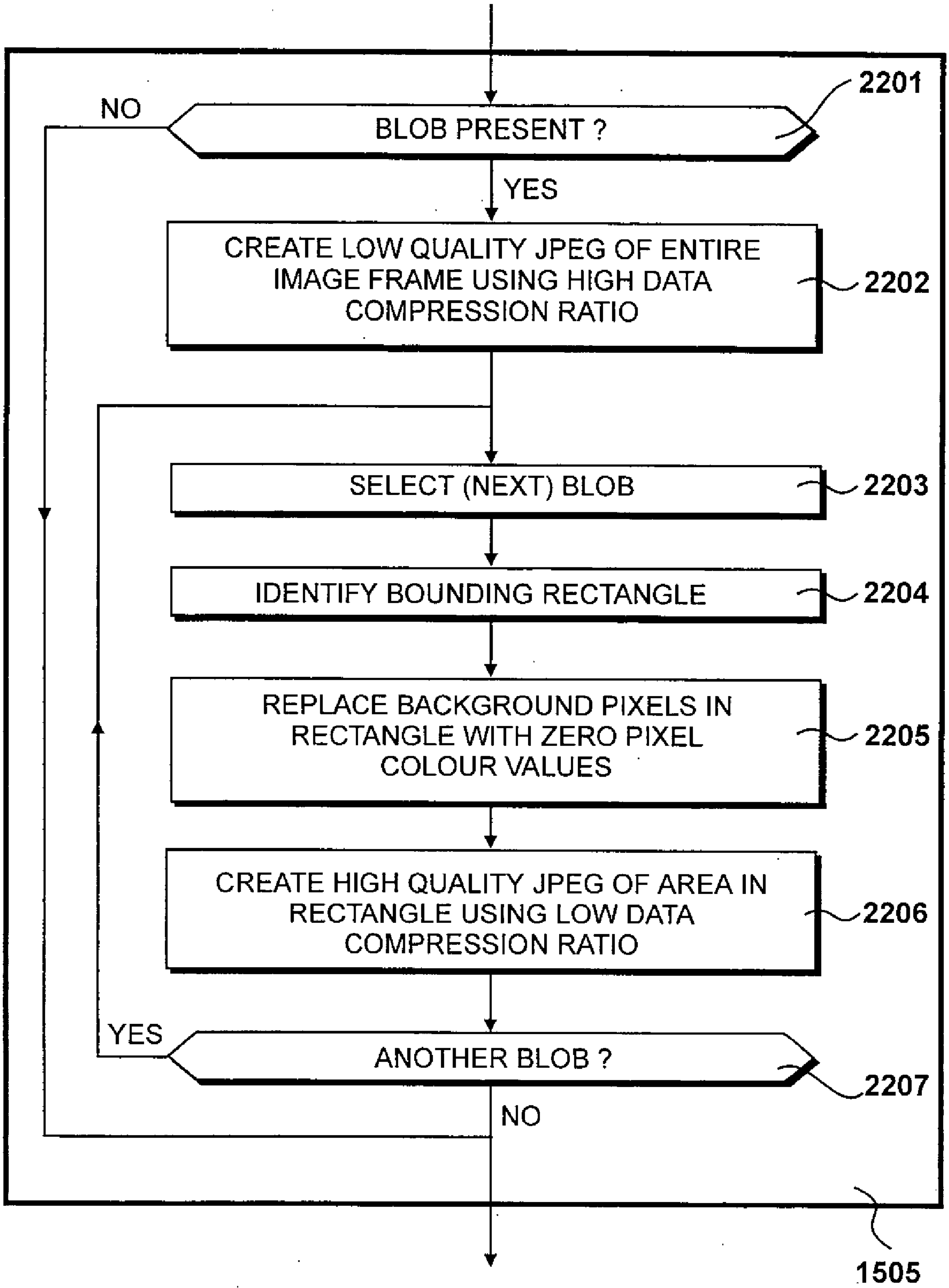

BLOB PRESENT ?
NO
YES
2201
CREATE LOW QUALITY JPEG OF ENTIRE IMAGE FRAME USING HIGH DATA COMPRESSION RATIO
2202
SELECT (NEXT) BLOB
2203
IDENTIFY BOUNDING RECTANGLE
2204
REPLACE BACKGROUND PIXELS IN RECTANGLE WITH ZERO PIXEL COLOUR VALUES
2205
CREATE HIGH QUALITY JPEG OF AREA IN RECTANGLE USING LOW DATA COMPRESSION RATIO
2206
YES
ANOTHER BLOB ?
2207
NO
1505

Fig. 22

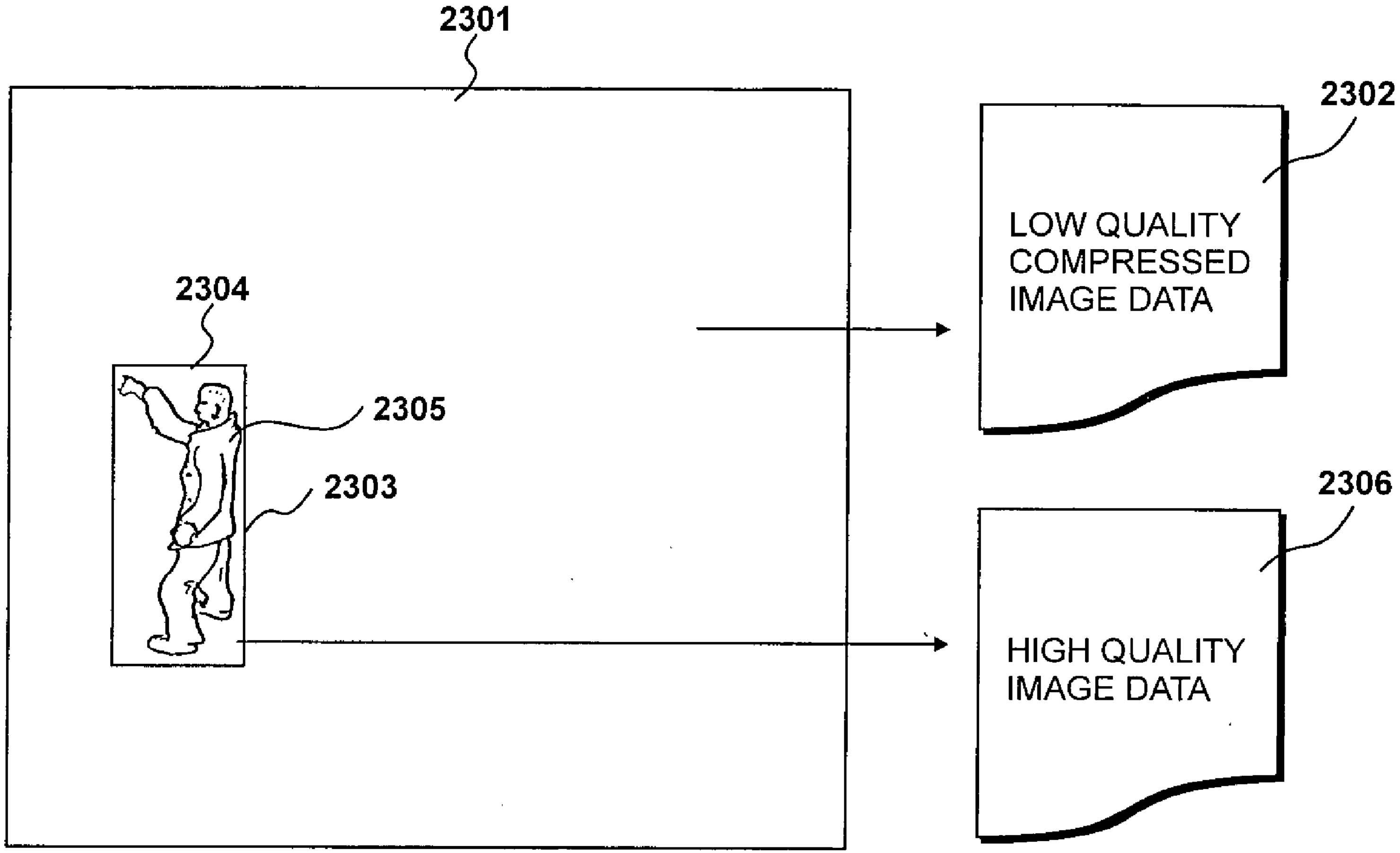

2301
2302
LOW QUALITY
COMPRESSED
IMAGE DATA
2304
2305
2303
2306
HIGH QUALITY
IMAGE DATA

Fig.23

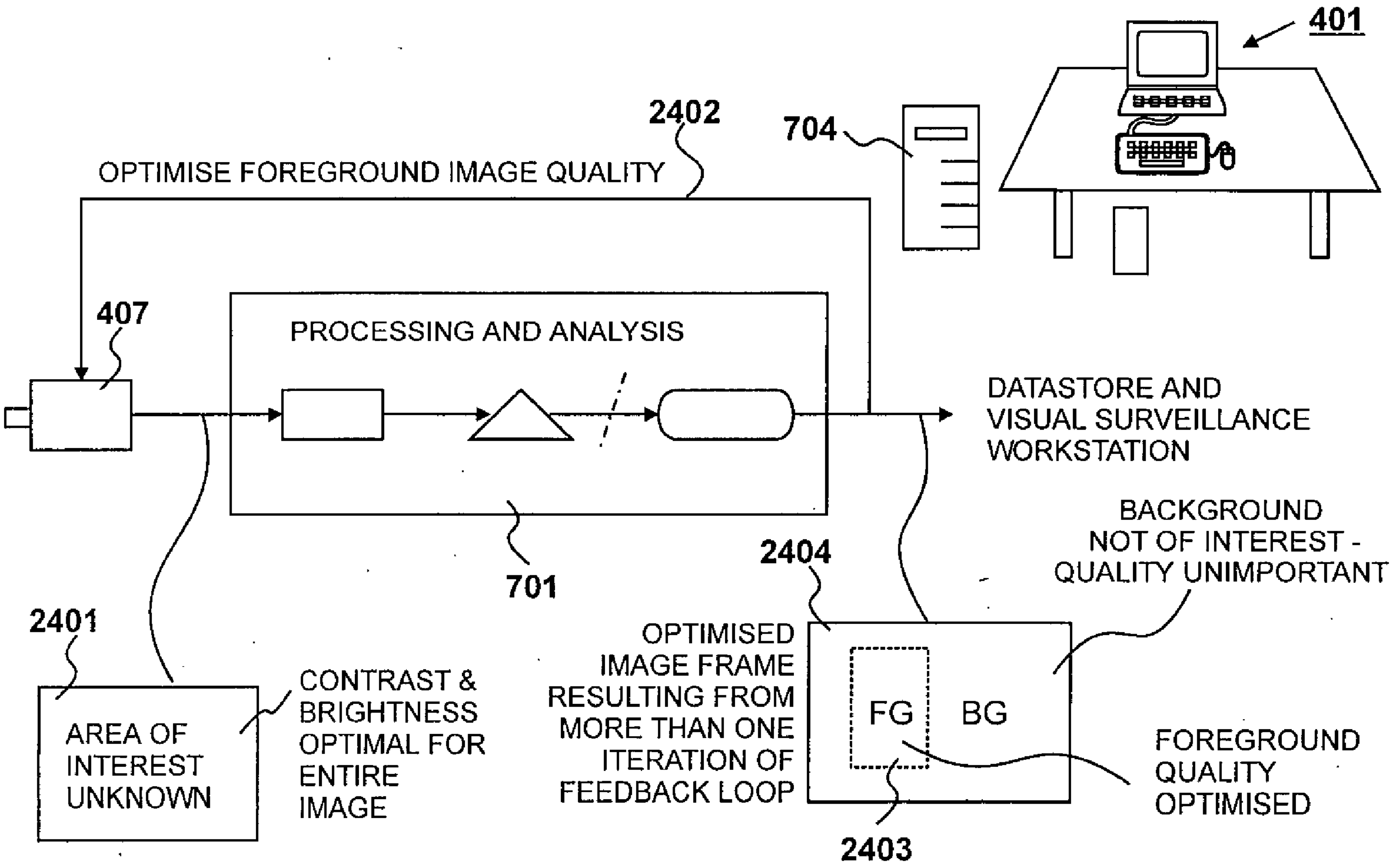

401
704
2402
OPTIMISE FOREGROUND IMAGE QUALITY
407
PROCESSING AND ANALYSIS
DATASTORE AND VISUAL SURVEILLANCE WORKSTATION
701
2404
BACKGROUND NOT OF INTEREST - QUALITY UNIMPORTANT
2401
AREA OF INTEREST UNKNOWN
CONTRAST & BRIGHTNESS OPTIMAL FOR ENTIRE IMAGE
OPTIMISED IMAGE FRAME RESULTING FROM MORE THAN ONE ITERATION OF FEEDBACK LOOP
FG
BG
FOREGROUND QUALITY OPTIMISED
2403

Fig.24

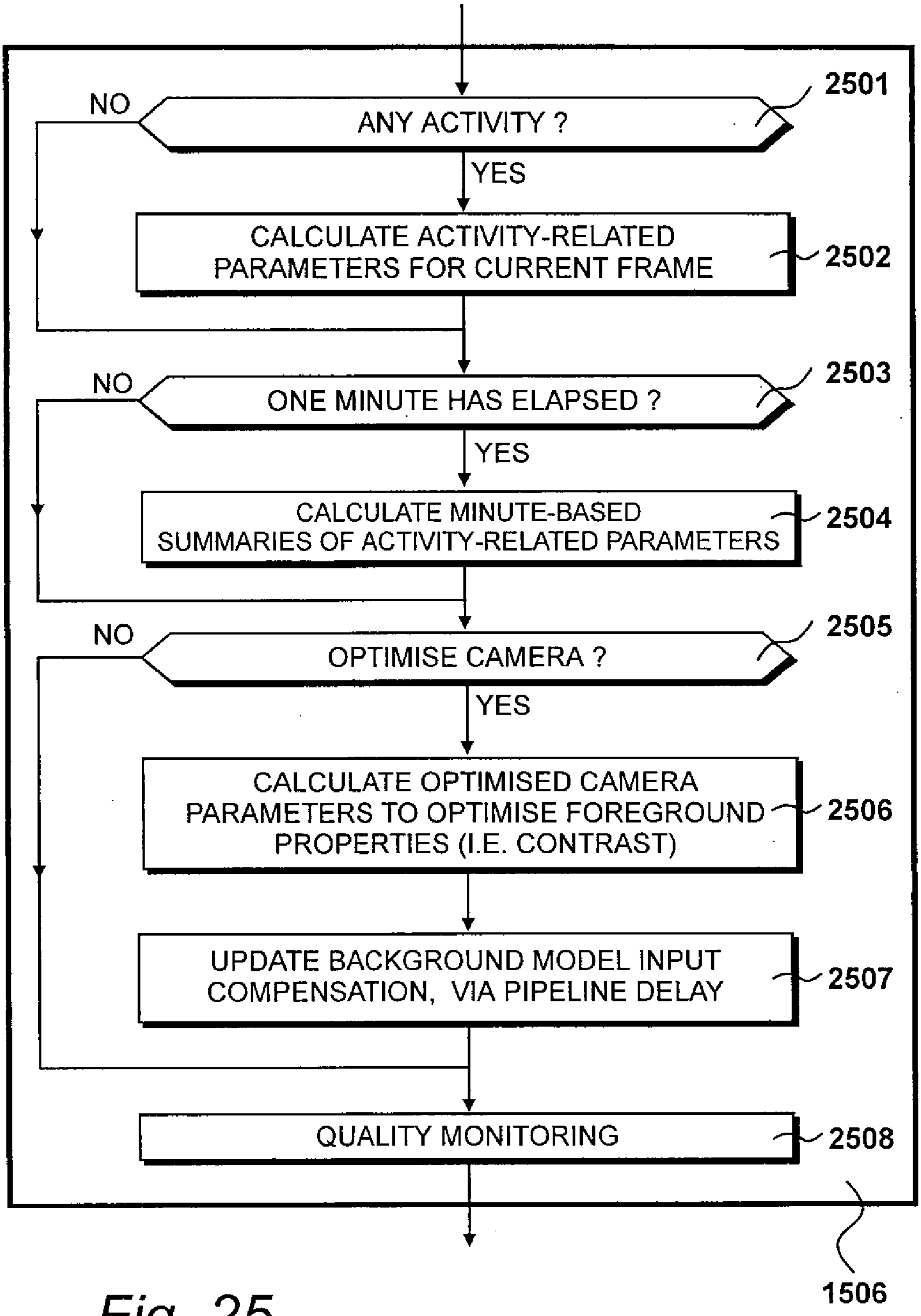
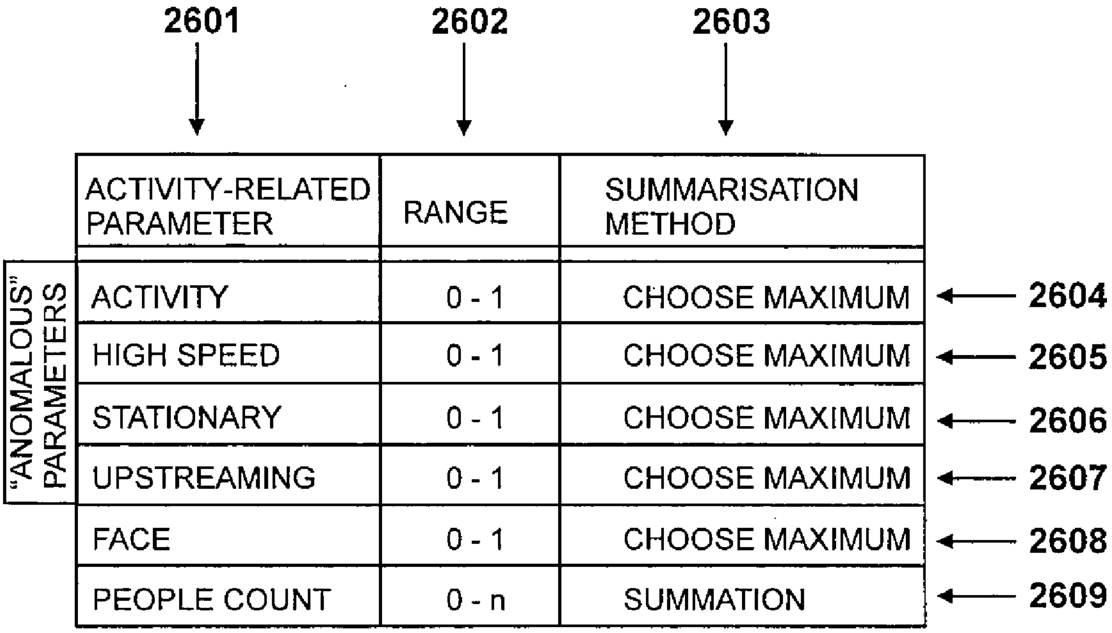

ANY ACTIVITY ?
NO
YES
2501
CALCULATE ACTIVITY-RELATED PARAMETERS FOR CURRENT FRAME
2502
ONE MINUTE HAS ELAPSED ?
NO
YES
2503
CALCULATE MINUTE-BASED SUMMARIES OF ACTIVITY-RELATED PARAMETERS
2504
OPTIMISE CAMERA ?
NO
YES
2505
CALCULATE OPTIMISED CAMERA PARAMETERS TO OPTIMISE FOREGROUND PROPERTIES (I.E. CONTRAST)
2506
UPDATE BACKGROUND MODEL INPUT COMPENSATION, VIA PIPELINE DELAY
2507
QUALITY MONITORING
2508
1506

Fig. 25



	ACTIVITY-RELATED PARAMETER	RANGE	SUMMARISATION METHOD
"ANOMALOUS" PARAMETERS	ACTIVITY	0 - 1	CHOOSE MAXIMUM
	HIGH SPEED	0 - 1	CHOOSE MAXIMUM
	STATIONARY	0 - 1	CHOOSE MAXIMUM
	UPSTREAMING	0 - 1	CHOOSE MAXIMUM
	FACE	0 - 1	CHOOSE MAXIMUM
	PEOPLE COUNT	0 - n	SUMMATION

Fig. 26

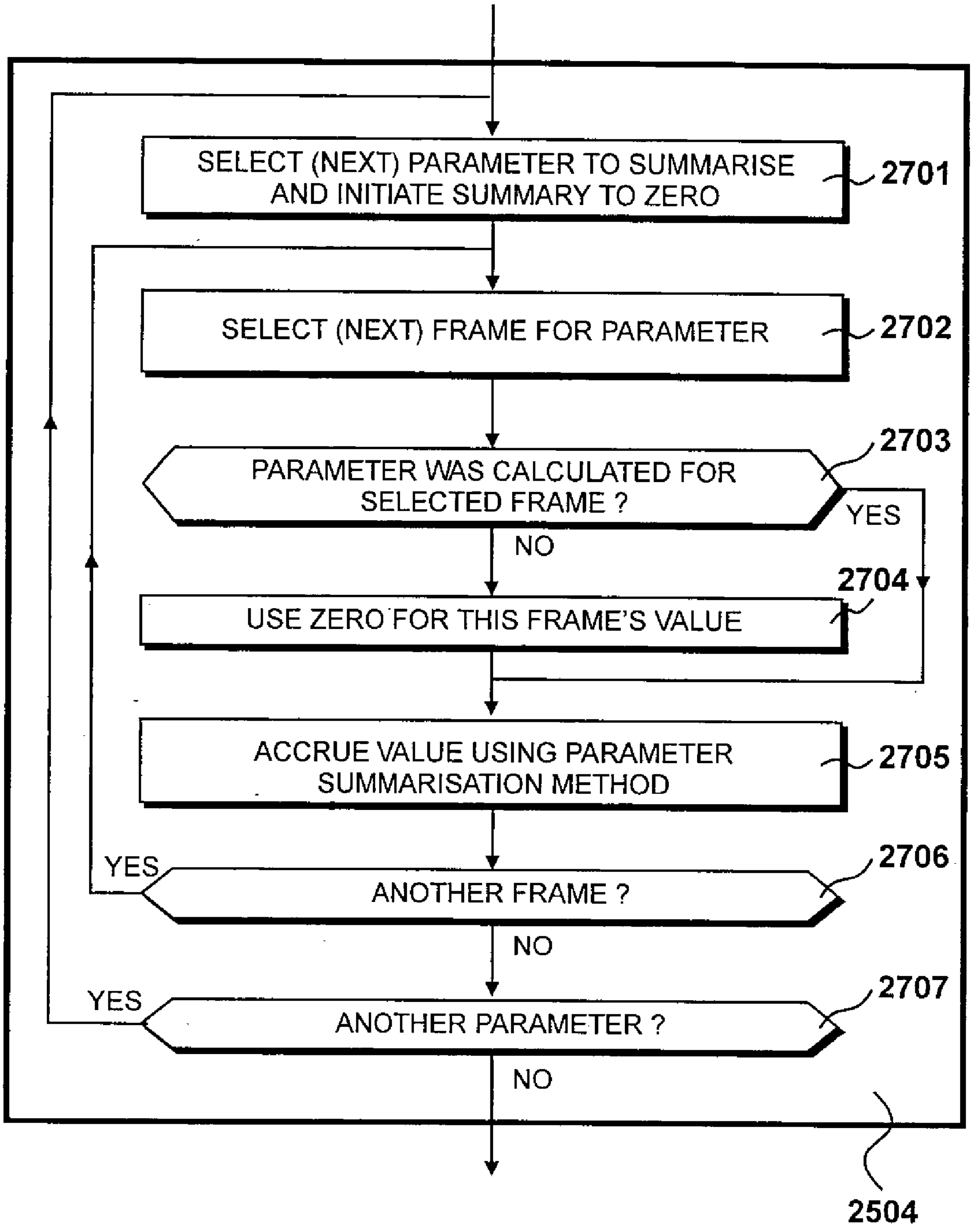

SELECT (NEXT) PARAMETER TO SUMMARISE AND INITIATE SUMMARY TO ZERO
2701
SELECT (NEXT) FRAME FOR PARAMETER
2702
PARAMETER WAS CALCULATED FOR SELECTED FRAME ?
2703
YES
NO
2704
USE ZERO FOR THIS FRAME'S VALUE
ACCRUE VALUE USING PARAMETER SUMMARISATION METHOD
2705
YES
ANOTHER FRAME ?
2706
NO
YES
ANOTHER PARAMETER ?
2707
NO
2504

Fig. 27

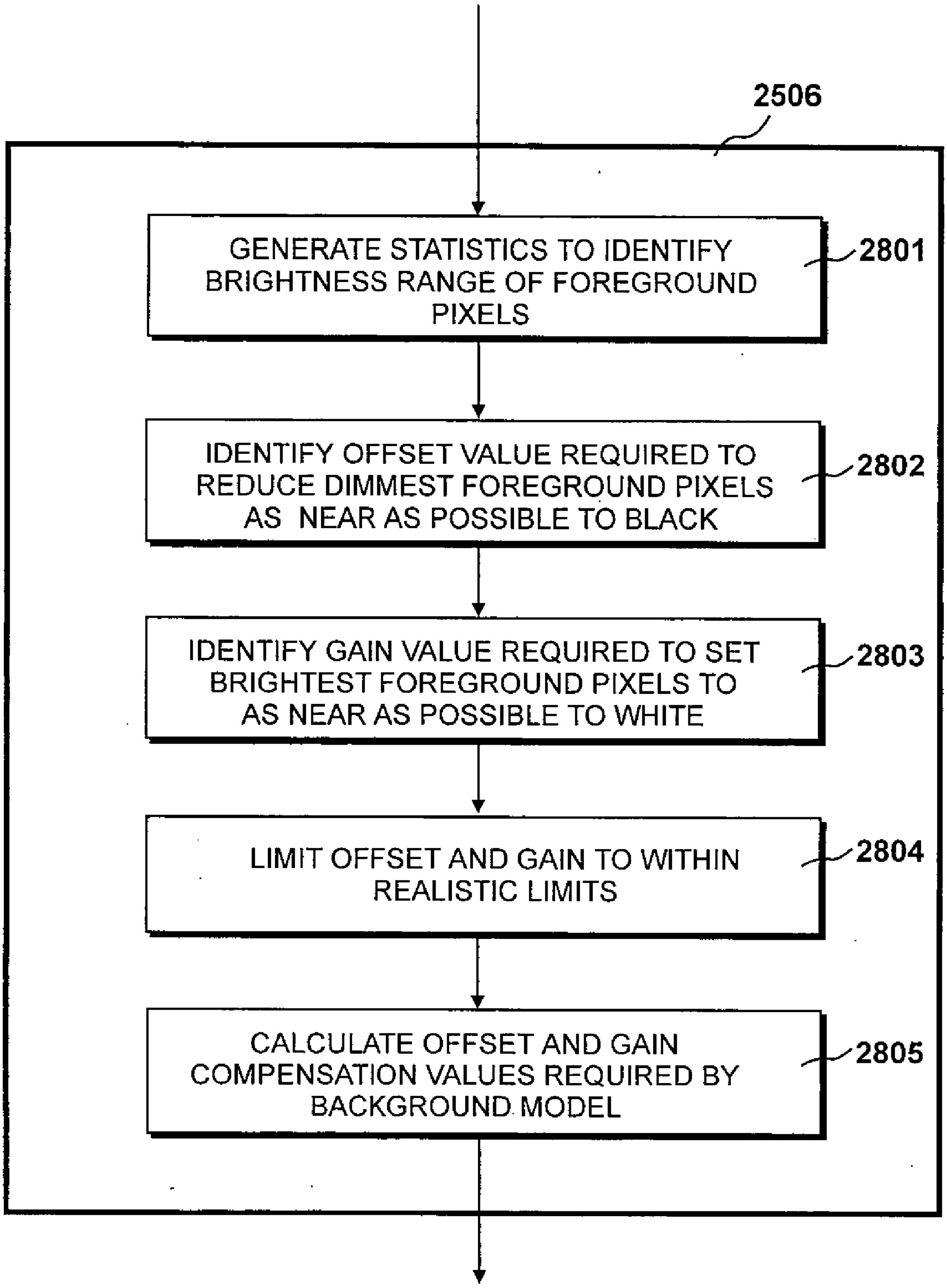

2506
GENERATE STATISTICS TO IDENTIFY BRIGHTNESS RANGE OF FOREGROUND PIXELS
2801
IDENTIFY OFFSET VALUE REQUIRED TO REDUCE DIMMEST FOREGROUND PIXELS AS NEAR AS POSSIBLE TO BLACK
2802
IDENTIFY GAIN VALUE REQUIRED TO SET BRIGHTEST FOREGROUND PIXELS TO AS NEAR AS POSSIBLE TO WHITE
2803
LIMIT OFFSET AND GAIN TO WITHIN REALISTIC LIMITS
2804
CALCULATE OFFSET AND GAIN COMPENSATION VALUES REQUIRED BY BACKGROUND MODEL
2805

Fig. 28

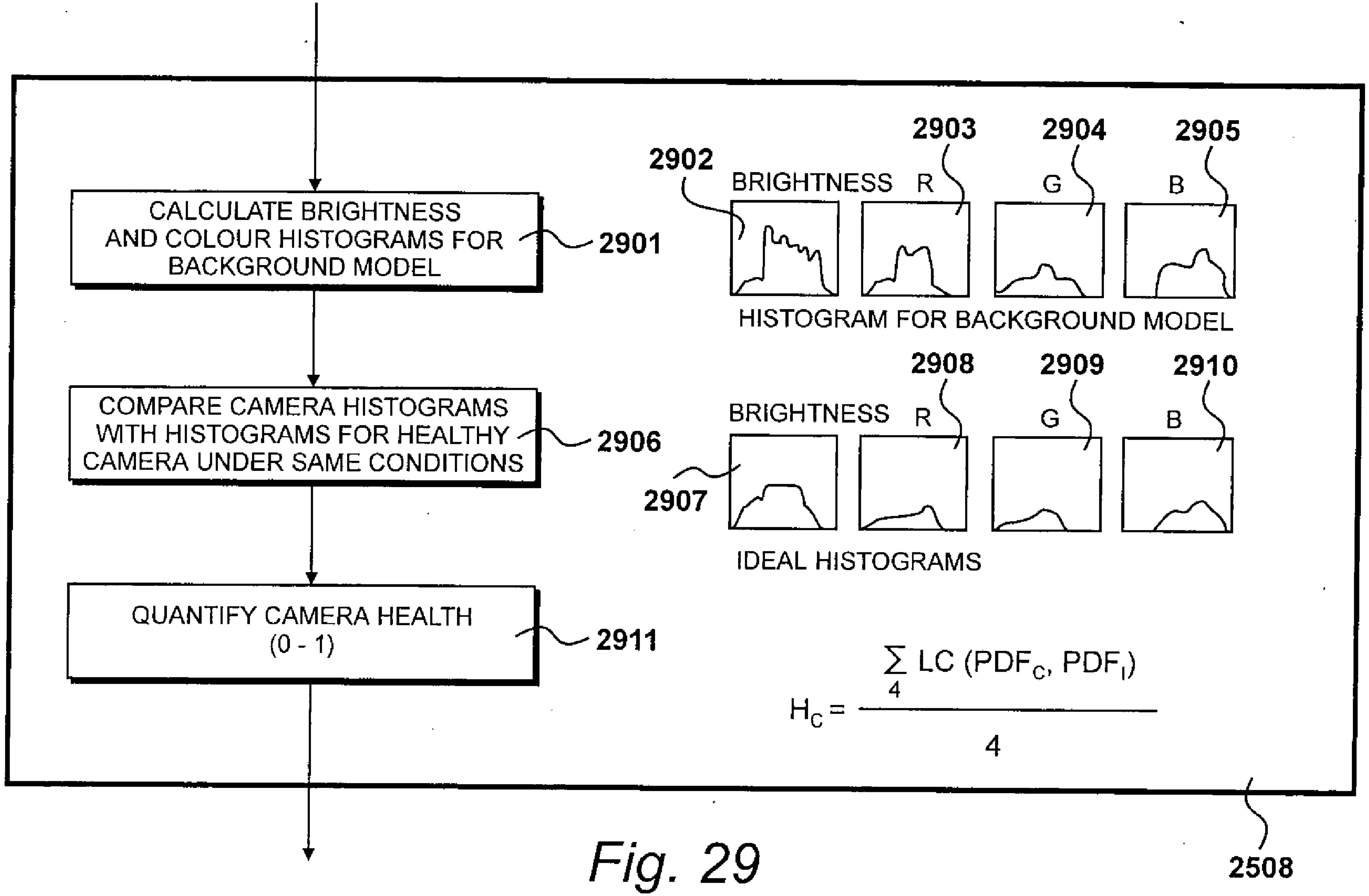

CALCULATE BRIGHTNESS AND COLOUR HISTOGRAMS FOR BACKGROUND MODEL
2901
COMPARE CAMERA HISTOGRAMS WITH HISTOGRAMS FOR HEALTHY CAMERA UNDER SAME CONDITIONS
2906
QUANTIFY CAMERA HEALTH (0 - 1)
2911
2902
2903
2904
2905
BRIGHTNESS
R
G
B
HISTOGRAM FOR BACKGROUND MODEL
2907
2908
2909
2910
BRIGHTNESS
R
G
B
IDEAL HISTOGRAMS
$H_C = \frac{\sum_4 LC(PDF_C, PDF_I)}{4}$
2508

Fig. 29

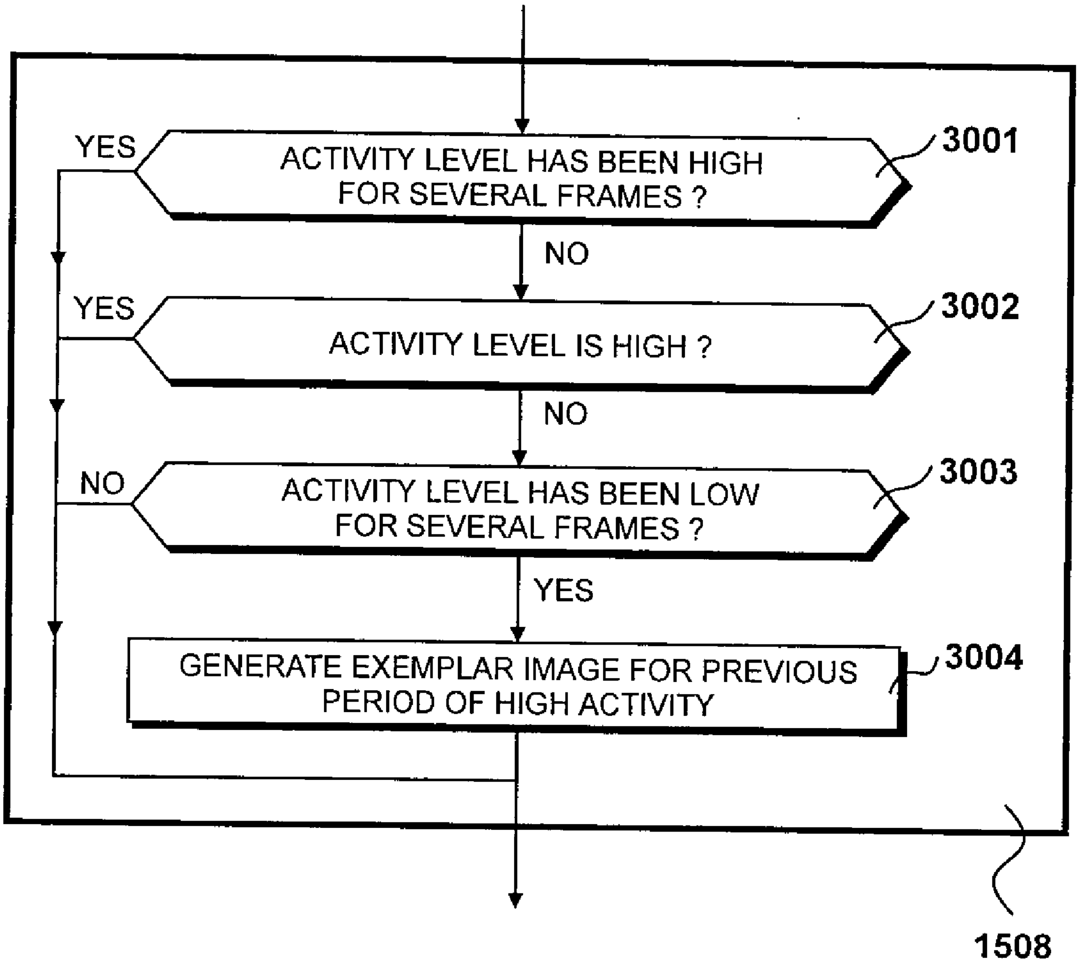

ACTIVITY LEVEL HAS BEEN HIGH FOR SEVERAL FRAMES ?
3001
YES
NO
ACTIVITY LEVEL IS HIGH ?
3002
YES
NO
ACTIVITY LEVEL HAS BEEN LOW FOR SEVERAL FRAMES ?
3003
NO
YES
GENERATE EXEMPLAR IMAGE FOR PREVIOUS PERIOD OF HIGH ACTIVITY
3004
1508

Fig. 30

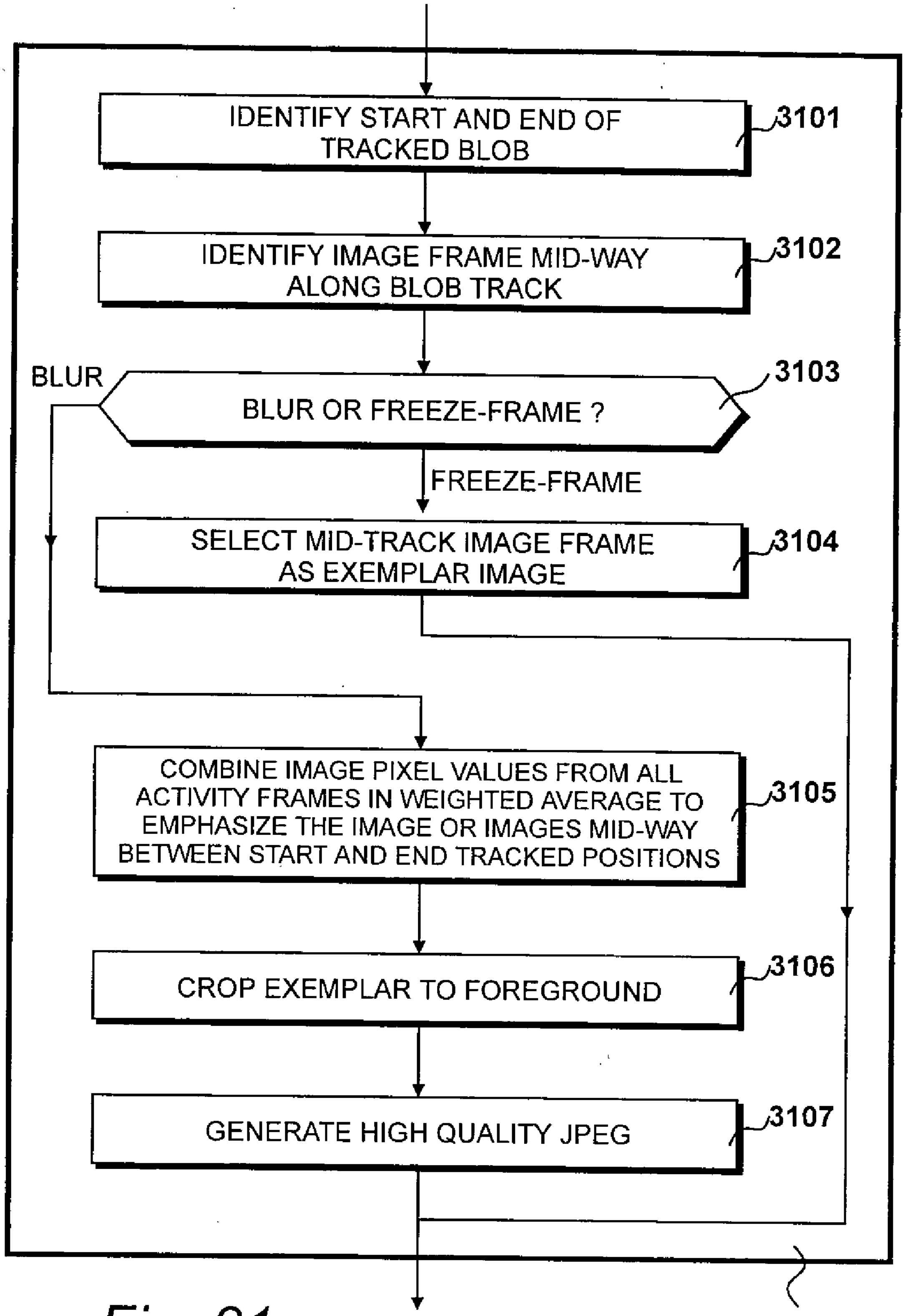

IDENTIFY START AND END OF TRACKED BLOB
3101
IDENTIFY IMAGE FRAME MID-WAY ALONG BLOB TRACK
3102
BLUR
BLUR OR FREEZE-FRAME ?
3103
FREEZE-FRAME
SELECT MID-TRACK IMAGE FRAME AS EXEMPLAR IMAGE
3104
COMBINE IMAGE PIXEL VALUES FROM ALL ACTIVITY FRAMES IN WEIGHTED AVERAGE TO EMPHASIZE THE IMAGE OR IMAGES MID-WAY BETWEEN START AND END TRACKED POSITIONS
3105
CROP EXEMPLAR TO FOREGROUND
3106
GENERATE HIGH QUALITY JPEG
3107
3004

Fig. 31

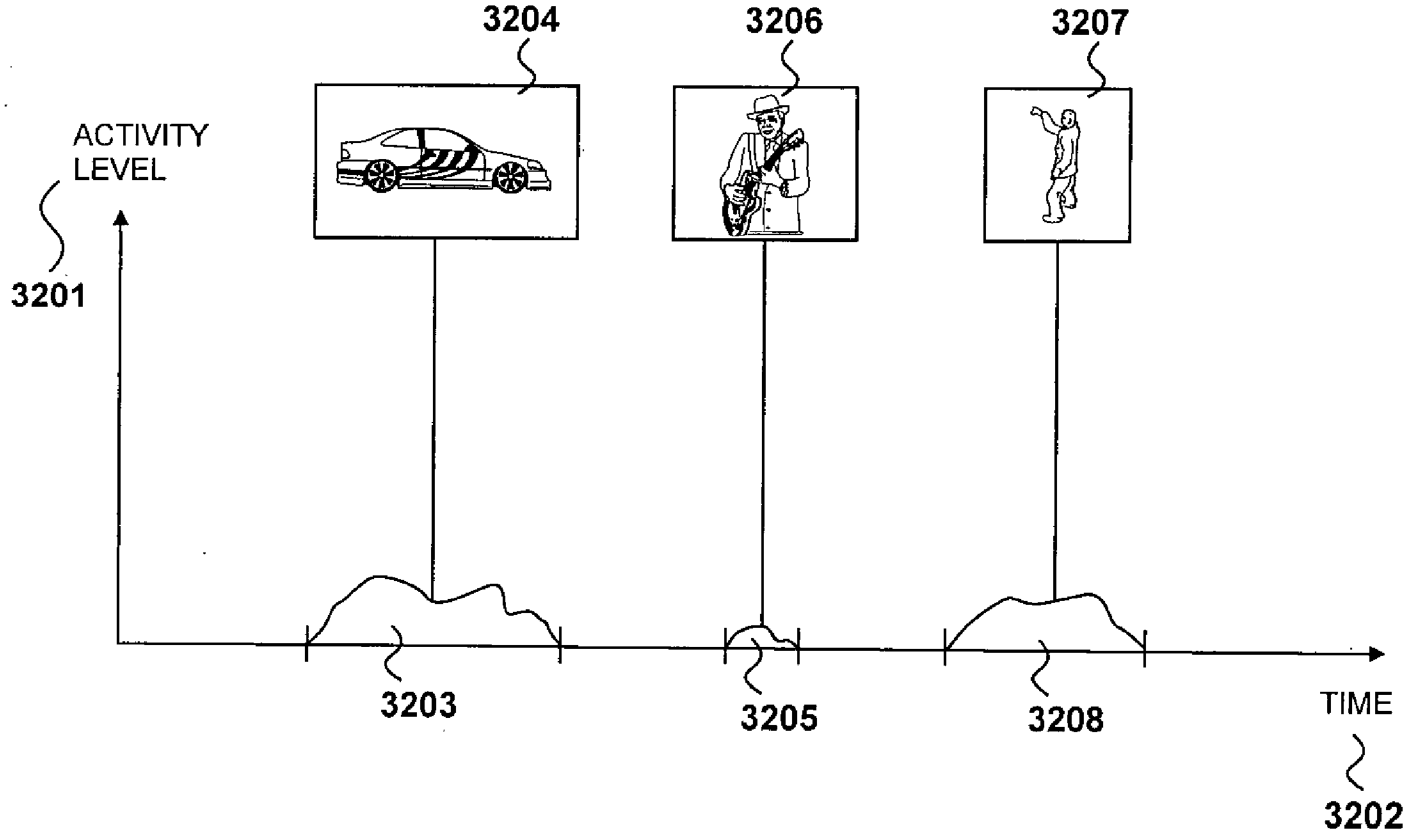


Fig.32

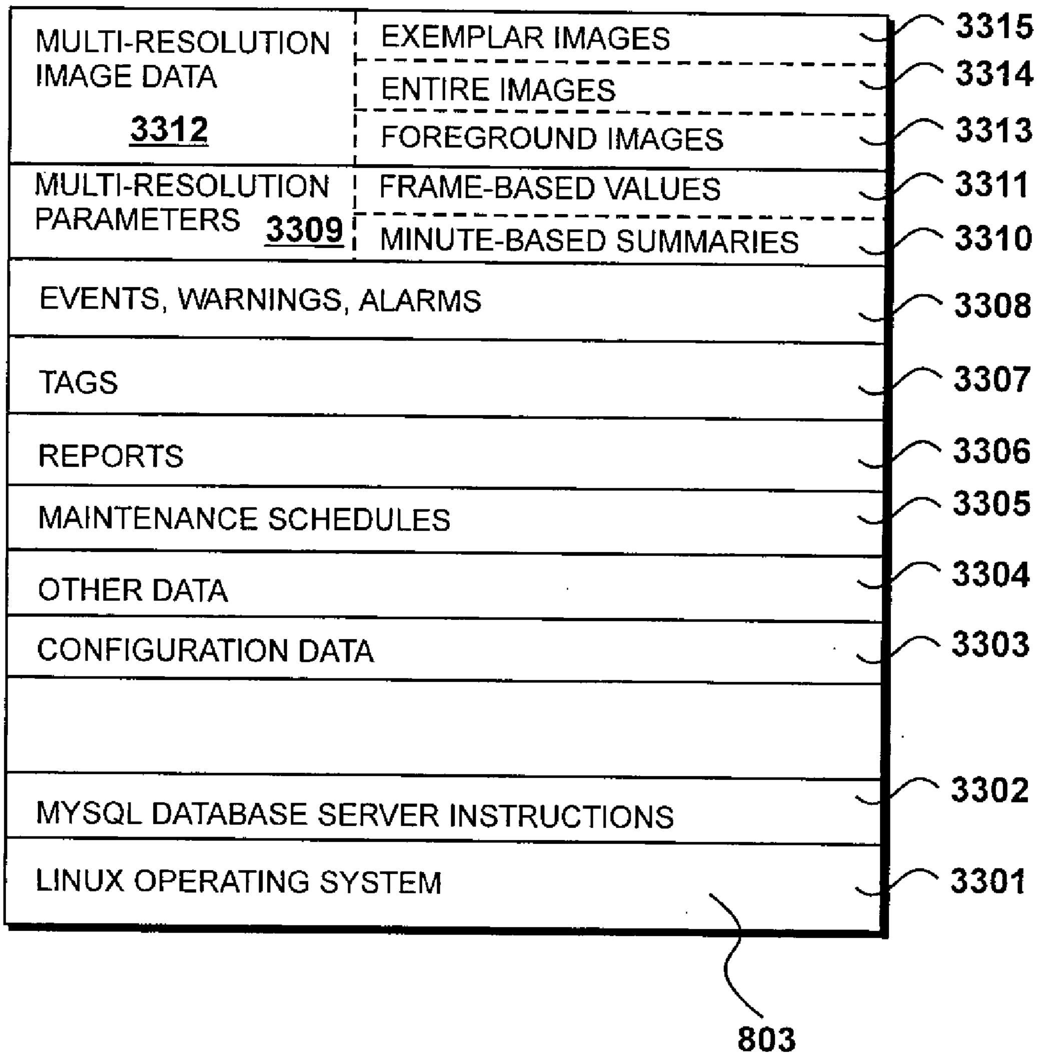

MULTI-RESOLUTION IMAGE DATA
3312
EXEMPLAR IMAGES
ENTIRE IMAGES
FOREGROUND IMAGES
MULTI-RESOLUTION PARAMETERS 3309
FRAME-BASED VALUES
MINUTE-BASED SUMMARIES
EVENTS, WARNINGS, ALARMS
TAGS
REPORTS
MAINTENANCE SCHEDULES
OTHER DATA
CONFIGURATION DATA
MYSQL DATABASE SERVER INSTRUCTIONS
LINUX OPERATING SYSTEM
3315
3314
3313
3311
3310
3308
3307
3306
3305
3304
3303
3302
3301
803

Fig. 33

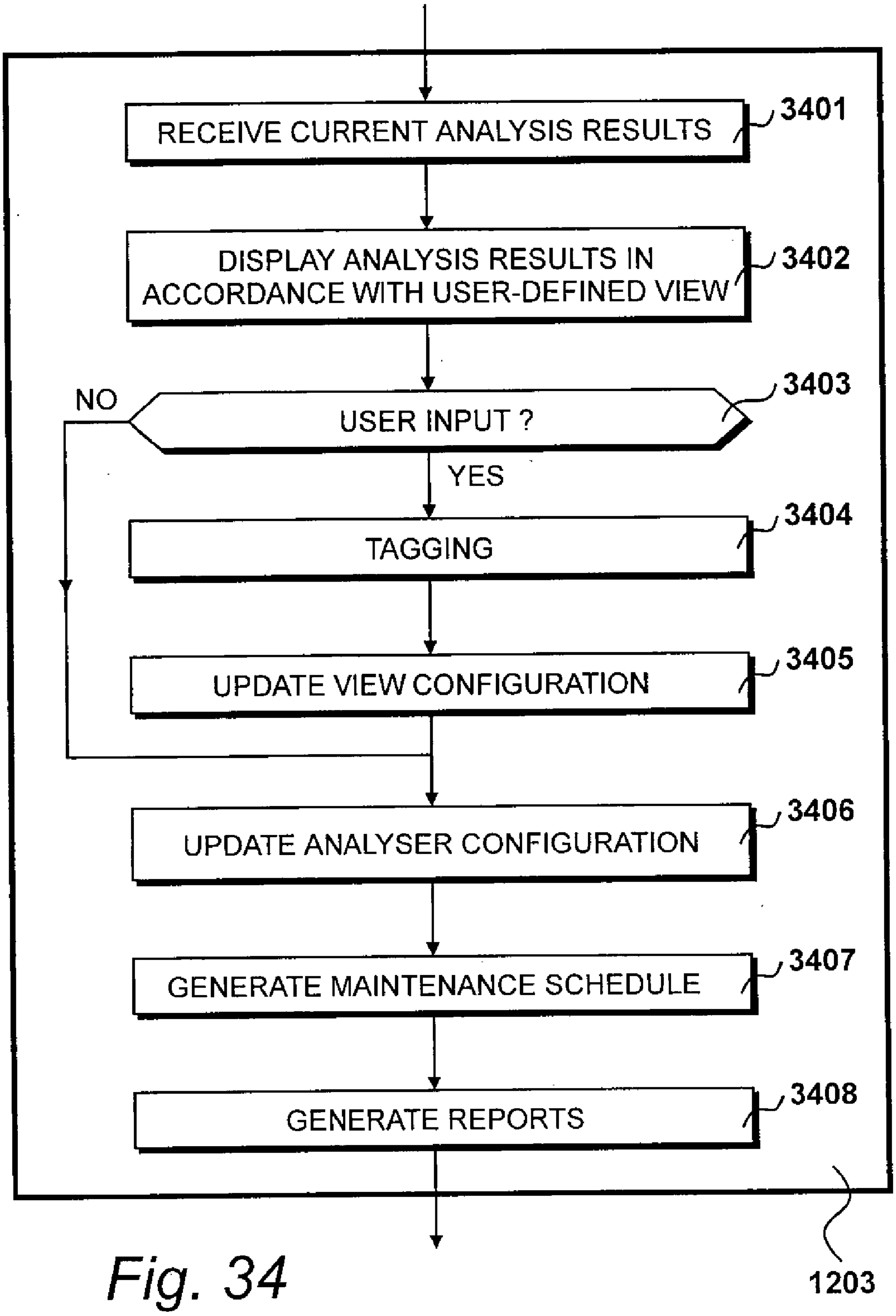
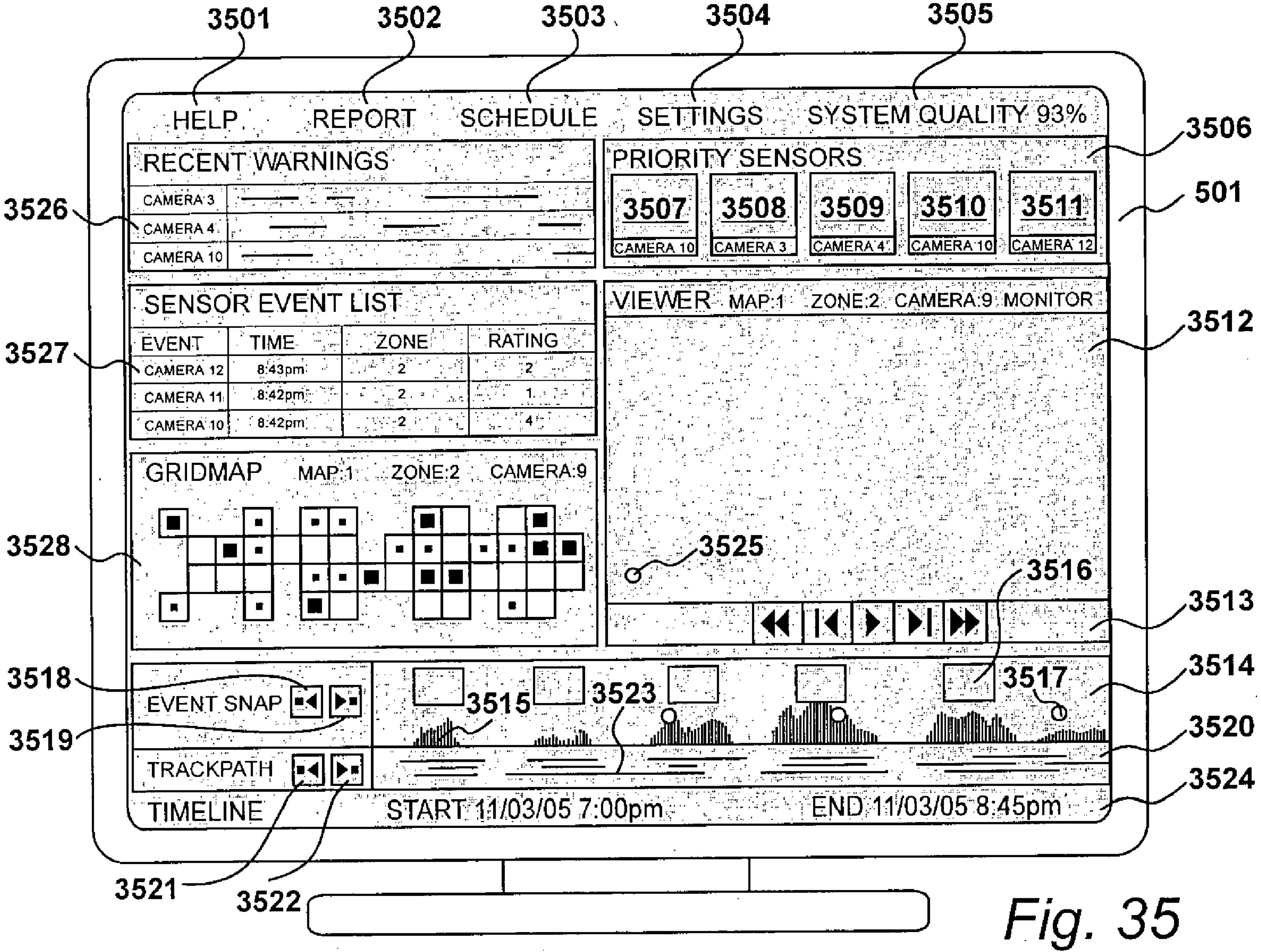

RECEIVE CURRENT ANALYSIS RESULTS
3401
DISPLAY ANALYSIS RESULTS IN ACCORDANCE WITH USER-DEFINED VIEW
3402
NO
USER INPUT ?
3403
YES
TAGGING
3404
UPDATE VIEW CONFIGURATION
3405
UPDATE ANALYSER CONFIGURATION
3406
GENERATE MAINTENANCE SCHEDULE
3407
GENERATE REPORTS
3408
1203

Fig. 34



EVENT	TIME	ZONE	RATING
CAMERA 12	8:43pm	2	2
CAMERA 11	8:42pm	2	1
CAMERA 10	8:42pm	2	4

Fig. 35

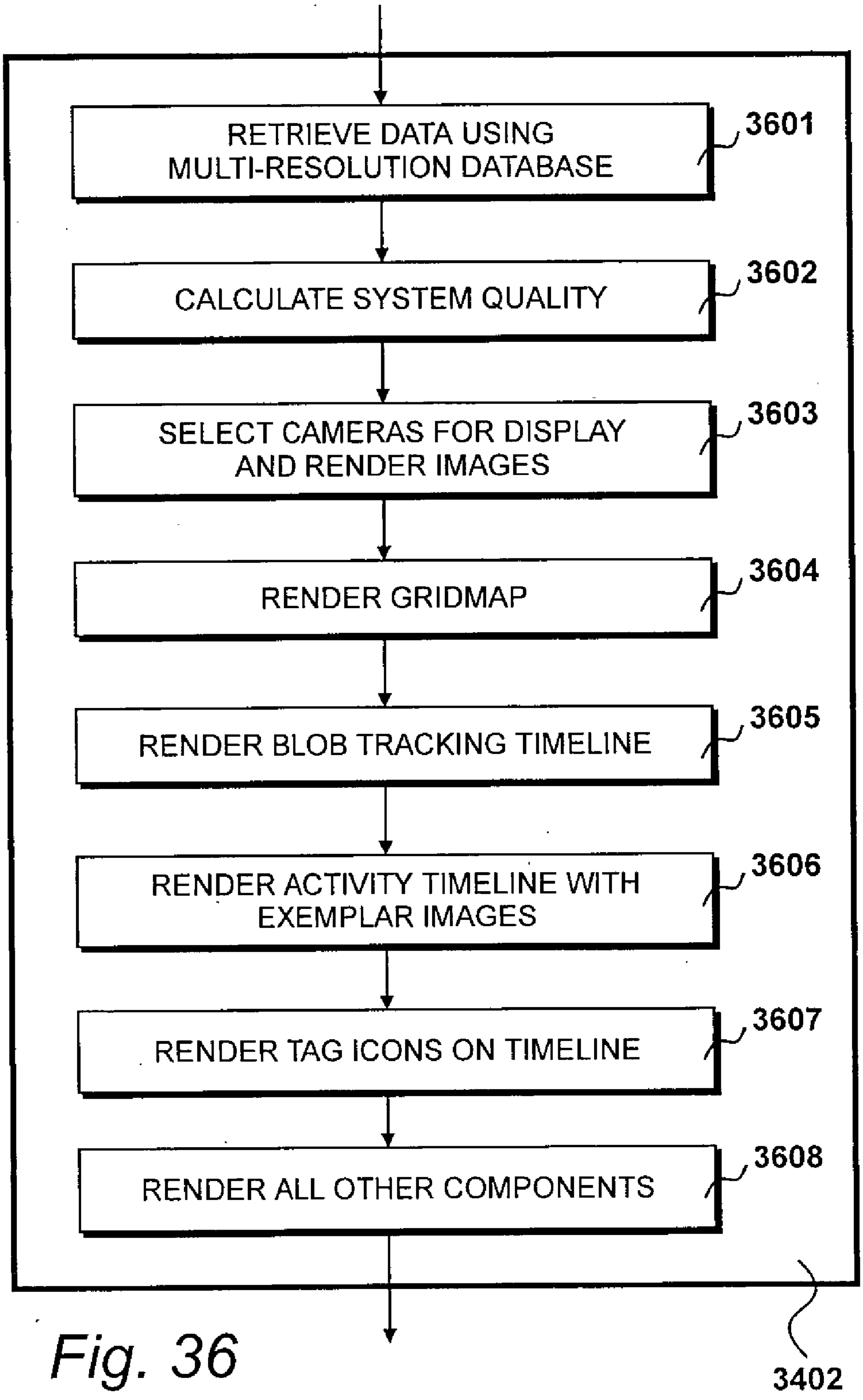

RETRIEVE DATA USING MULTI-RESOLUTION DATABASE
3601
CALCULATE SYSTEM QUALITY
3602
SELECT CAMERAS FOR DISPLAY AND RENDER IMAGES
3603
RENDER GRIDMAP
3604
RENDER BLOB TRACKING TIMELINE
3605
RENDER ACTIVITY TIMELINE WITH EXEMPLAR IMAGES
3606
RENDER TAG ICONS ON TIMELINE
3607
RENDER ALL OTHER COMPONENTS
3608
3402

Fig. 36

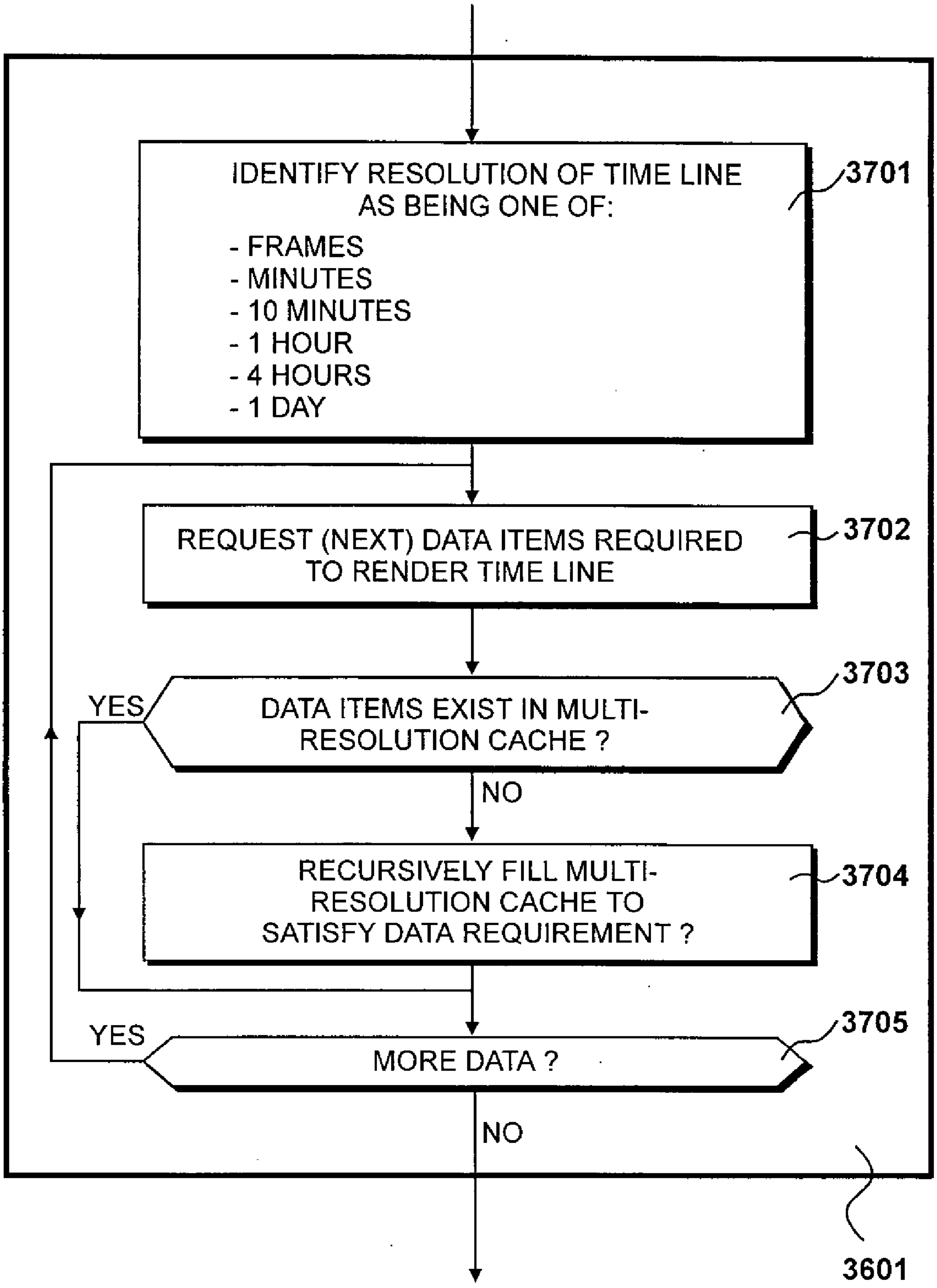

IDENTIFY RESOLUTION OF TIME LINE AS BEING ONE OF:
- FRAMES
- MINUTES
- 10 MINUTES
- 1 HOUR
- 4 HOURS
- 1 DAY
3701
REQUEST (NEXT) DATA ITEMS REQUIRED TO RENDER TIME LINE
3702
DATA ITEMS EXIST IN MULTI-RESOLUTION CACHE ?
3703
YES
NO
RECURSIVELY FILL MULTI-RESOLUTION CACHE TO SATISFY DATA REQUIREMENT ?
3704
MORE DATA ?
3705
YES
NO
3601

Fig. 37

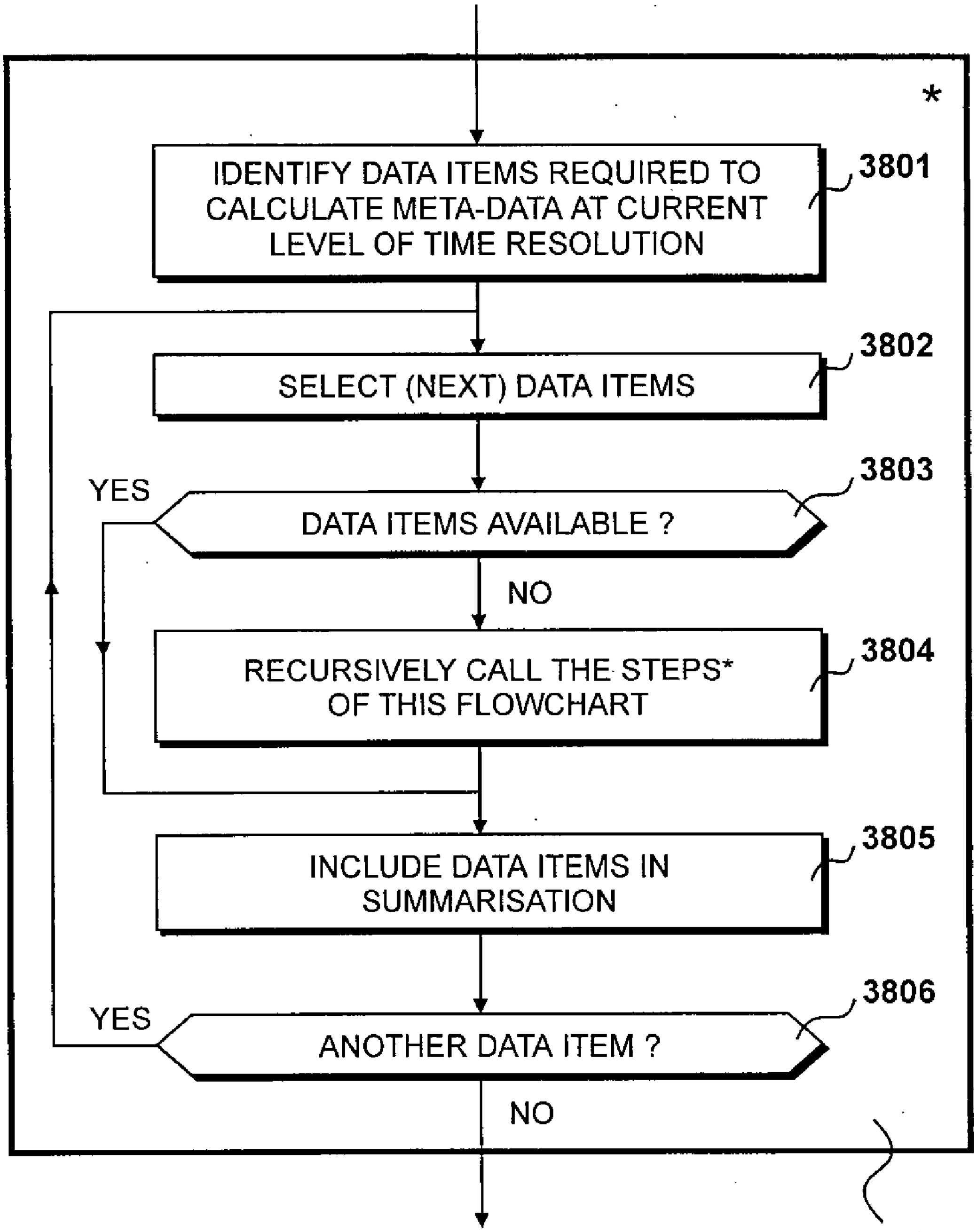

*
IDENTIFY DATA ITEMS REQUIRED TO CALCULATE META-DATA AT CURRENT LEVEL OF TIME RESOLUTION
3801
SELECT (NEXT) DATA ITEMS
3802
YES
DATA ITEMS AVAILABLE ?
3803
NO
RECURSIVELY CALL THE STEPS* OF THIS FLOWCHART
3804
INCLUDE DATA ITEMS IN SUMMARISATION
3805
YES
ANOTHER DATA ITEM ?
3806
NO
3704, 3804

Fig. 38

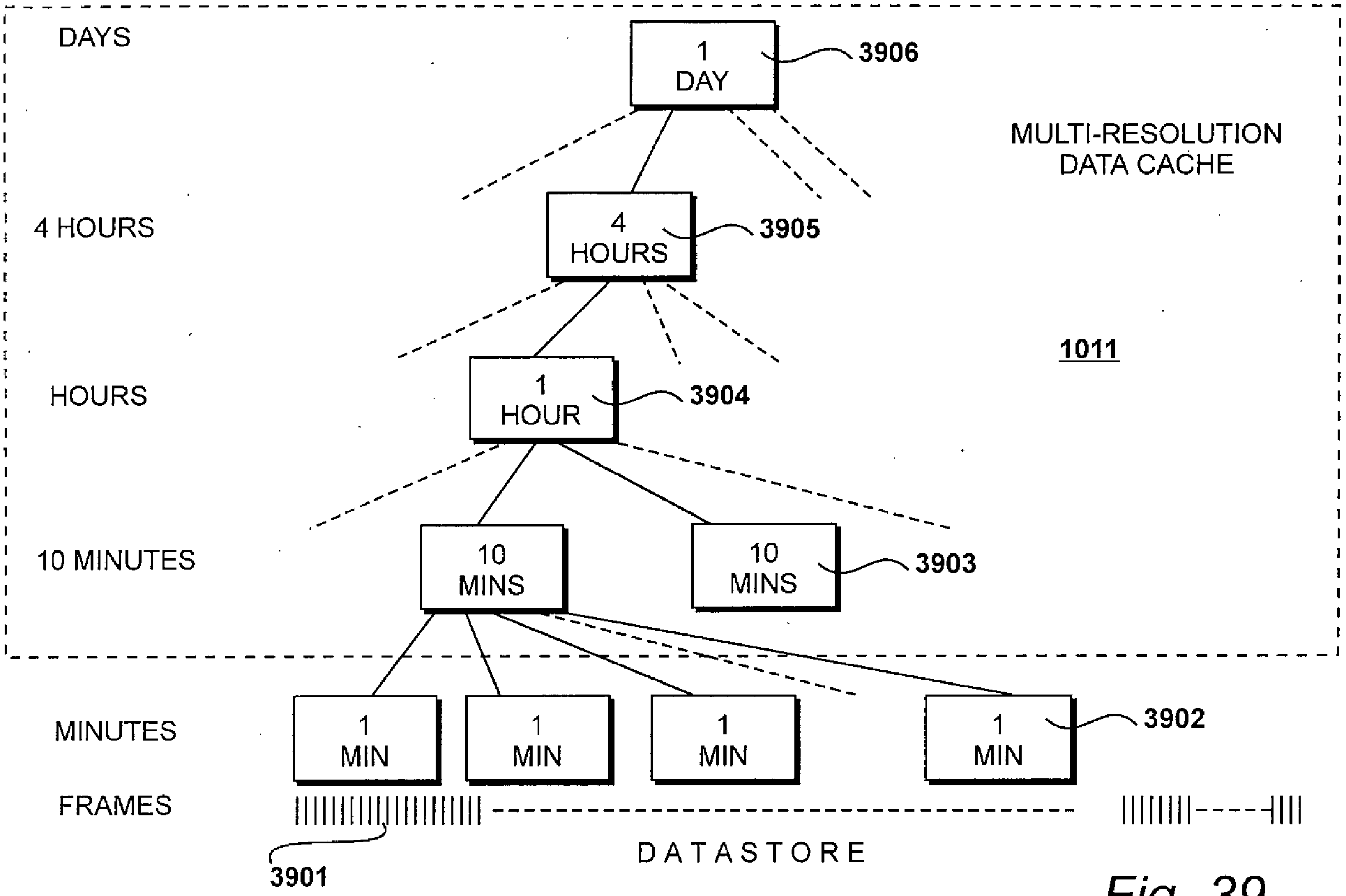

DAYS
1 DAY
3906
MULTI-RESOLUTION DATA CACHE
4 HOURS
4 HOURS
3905
1011
HOURS
1 HOUR
3904
10 MINUTES
10 MINS
10 MINS
3903
MINUTES
1 MIN
1 MIN
1 MIN
1 MIN
3902
FRAMES
DATASTORE
3901

Fig. 39

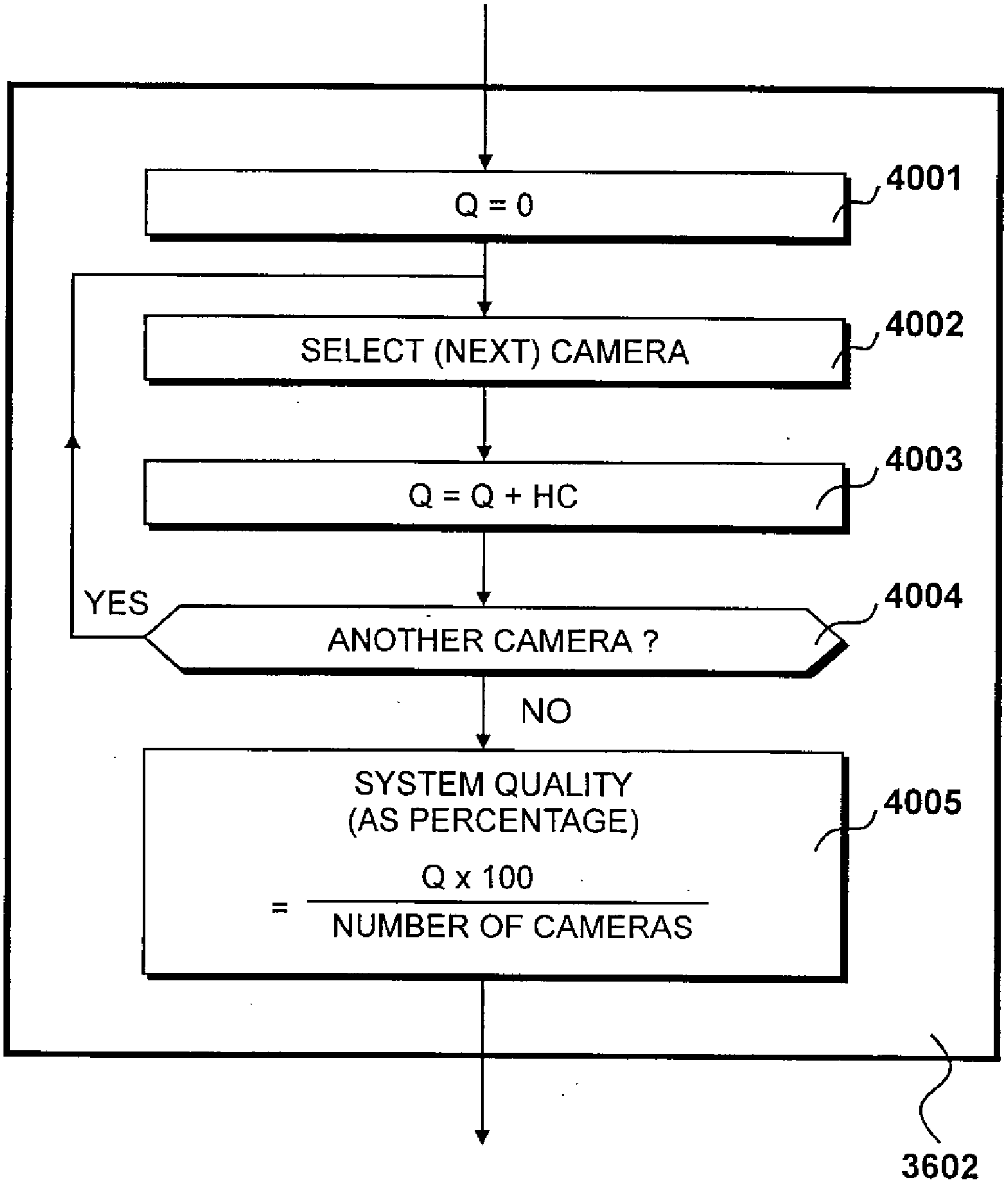

Q = 0
4001
SELECT (NEXT) CAMERA
4002
Q = Q + HC
4003
YES
ANOTHER CAMERA ?
4004
NO
SYSTEM QUALITY
(AS PERCENTAGE)
= Q x 100 / NUMBER OF CAMERAS
4005
3602

Fig. 40

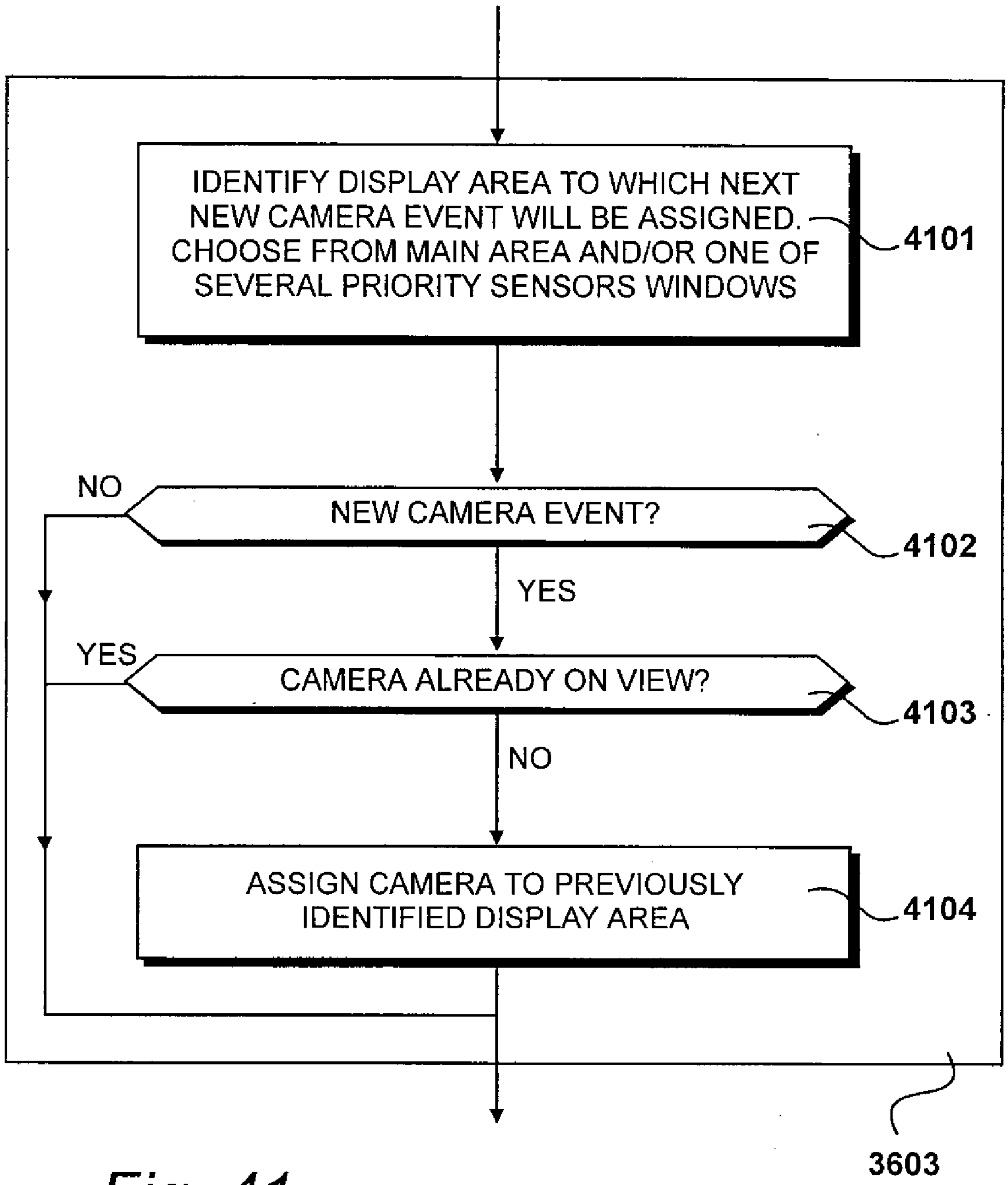

IDENTIFY DISPLAY AREA TO WHICH NEXT NEW CAMERA EVENT WILL BE ASSIGNED. CHOOSE FROM MAIN AREA AND/OR ONE OF SEVERAL PRIORITY SENSORS WINDOWS
4101
NO
NEW CAMERA EVENT?
4102
YES
YES
CAMERA ALREADY ON VIEW?
4103
NO
ASSIGN CAMERA TO PREVIOUSLY IDENTIFIED DISPLAY AREA
4104
3603

Fig. 41

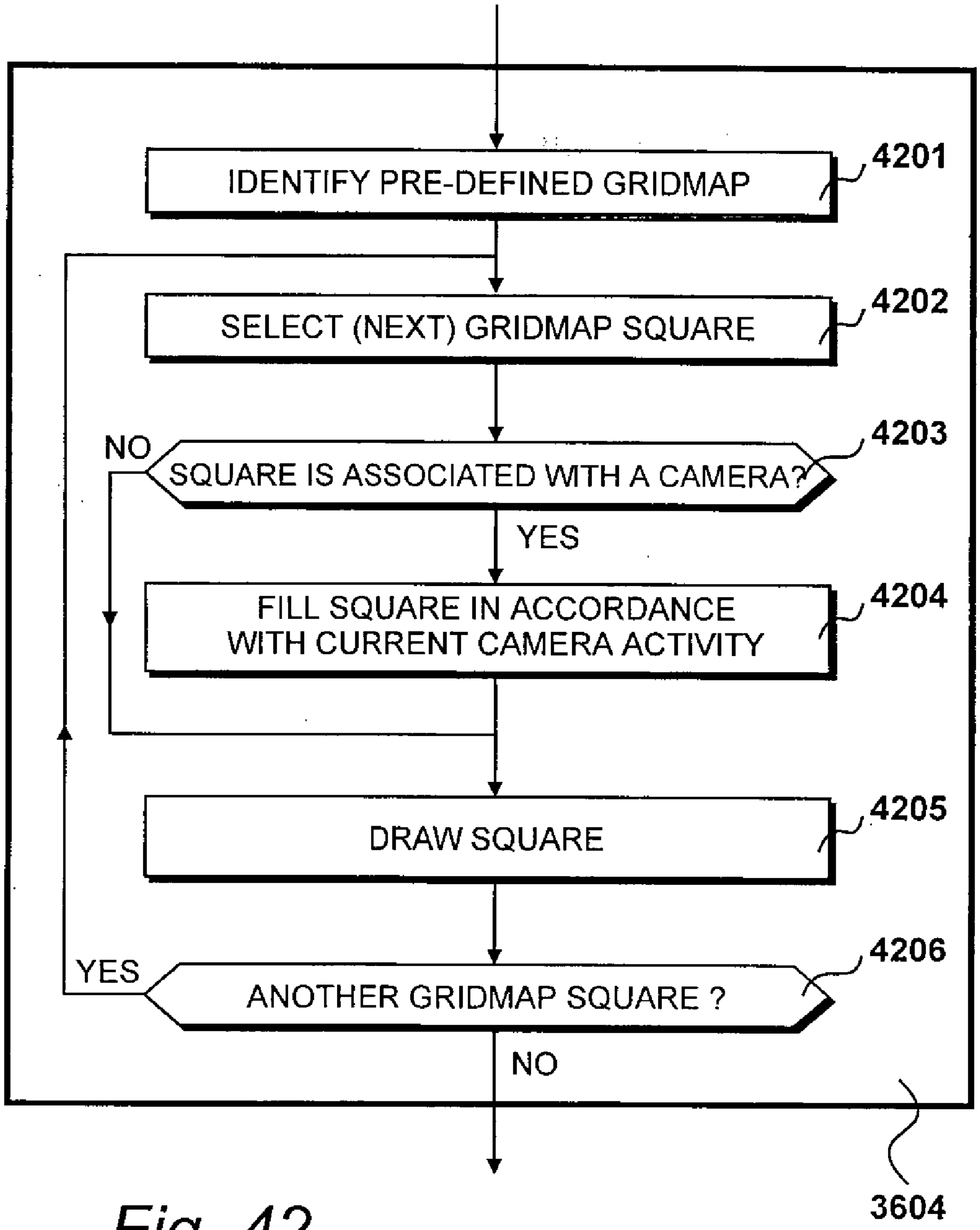

IDENTIFY PRE-DEFINED GRIDMAP
4201
SELECT (NEXT) GRIDMAP SQUARE
4202
NO
SQUARE IS ASSOCIATED WITH A CAMERA?
4203
YES
FILL SQUARE IN ACCORDANCE WITH CURRENT CAMERA ACTIVITY
4204
DRAW SQUARE
4205
YES
ANOTHER GRIDMAP SQUARE ?
4206
NO
3604

Fig. 42

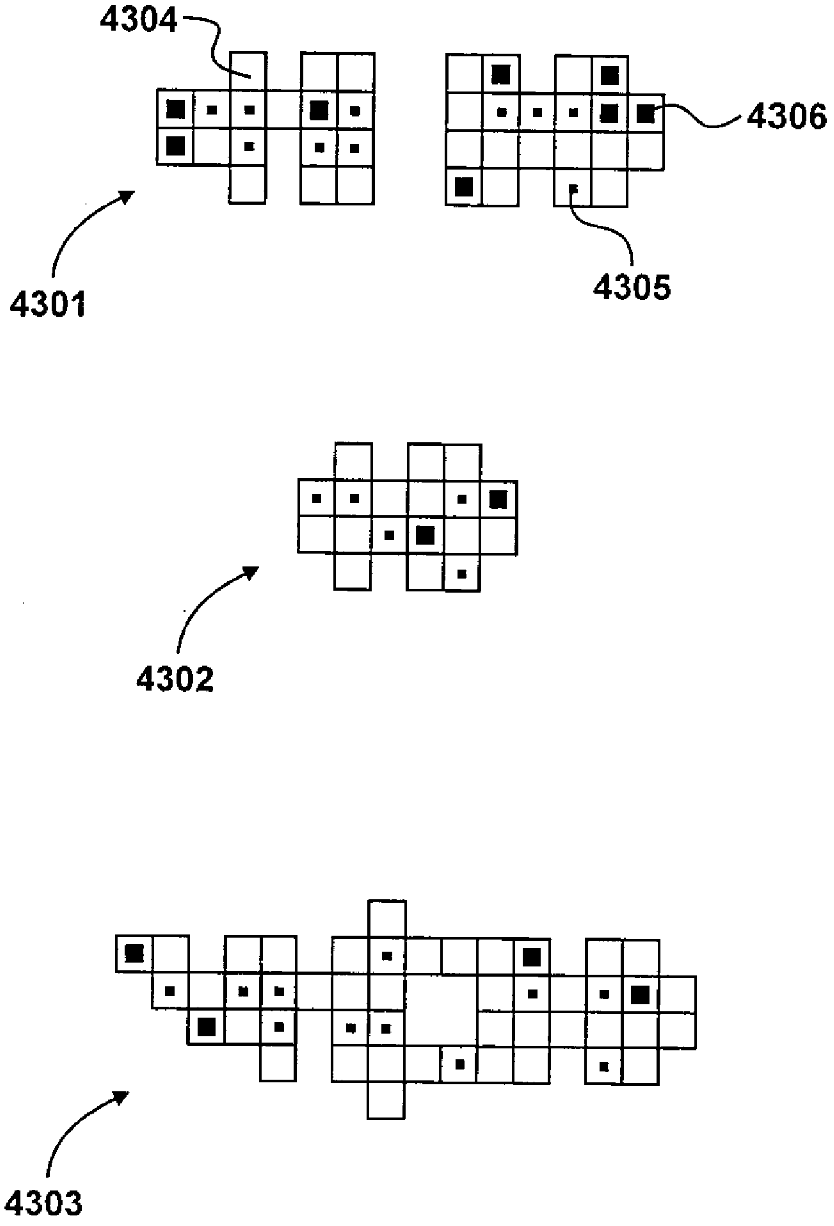


Fig. 43

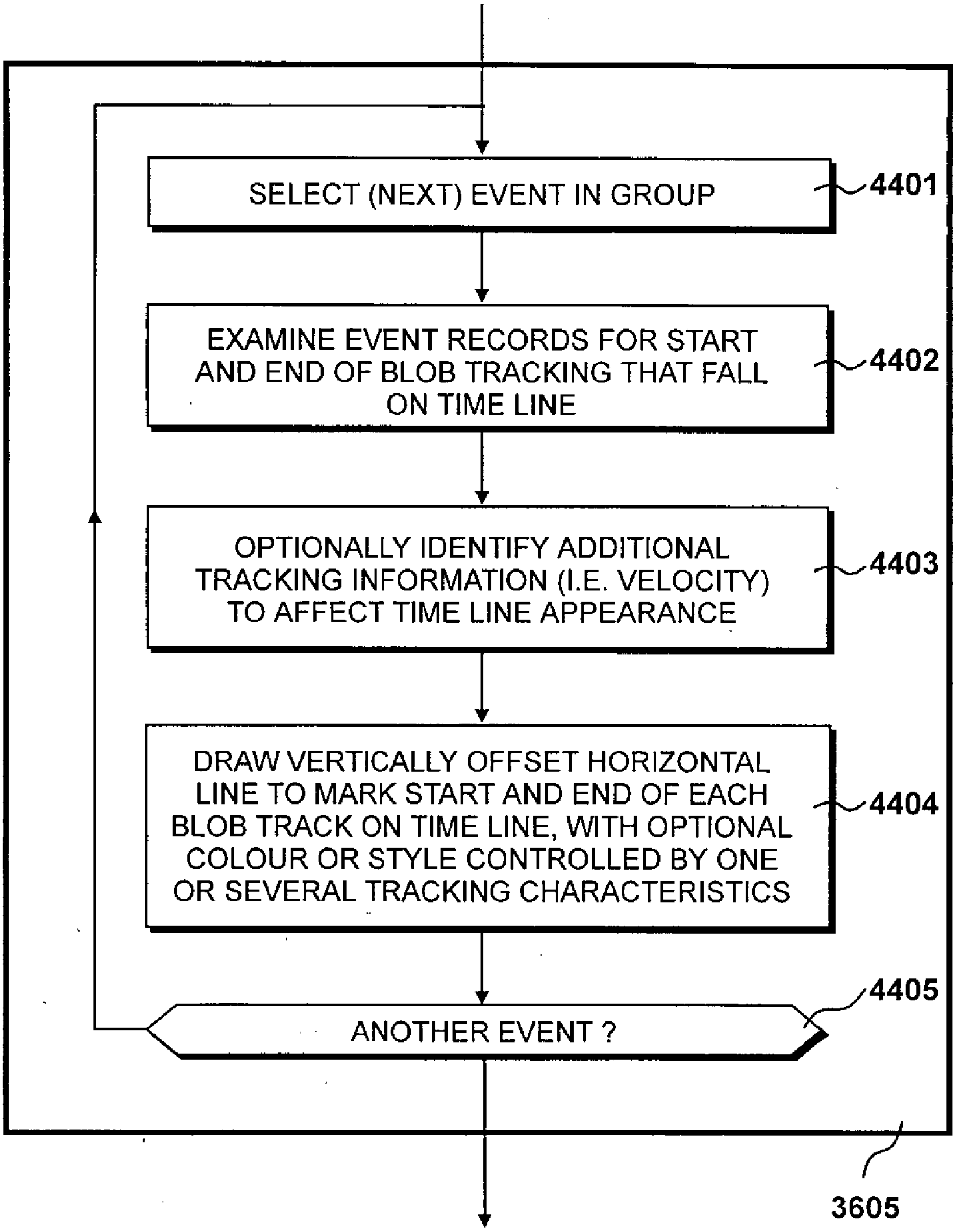

SELECT (NEXT) EVENT IN GROUP
4401
EXAMINE EVENT RECORDS FOR START AND END OF BLOB TRACKING THAT FALL ON TIME LINE
4402
OPTIONALLY IDENTIFY ADDITIONAL TRACKING INFORMATION (I.E. VELOCITY) TO AFFECT TIME LINE APPEARANCE
4403
DRAW VERTICALLY OFFSET HORIZONTAL LINE TO MARK START AND END OF EACH BLOB TRACK ON TIME LINE, WITH OPTIONAL COLOUR OR STYLE CONTROLLED BY ONE OR SEVERAL TRACKING CHARACTERISTICS
4404
ANOTHER EVENT ?
4405
3605

Fig. 44

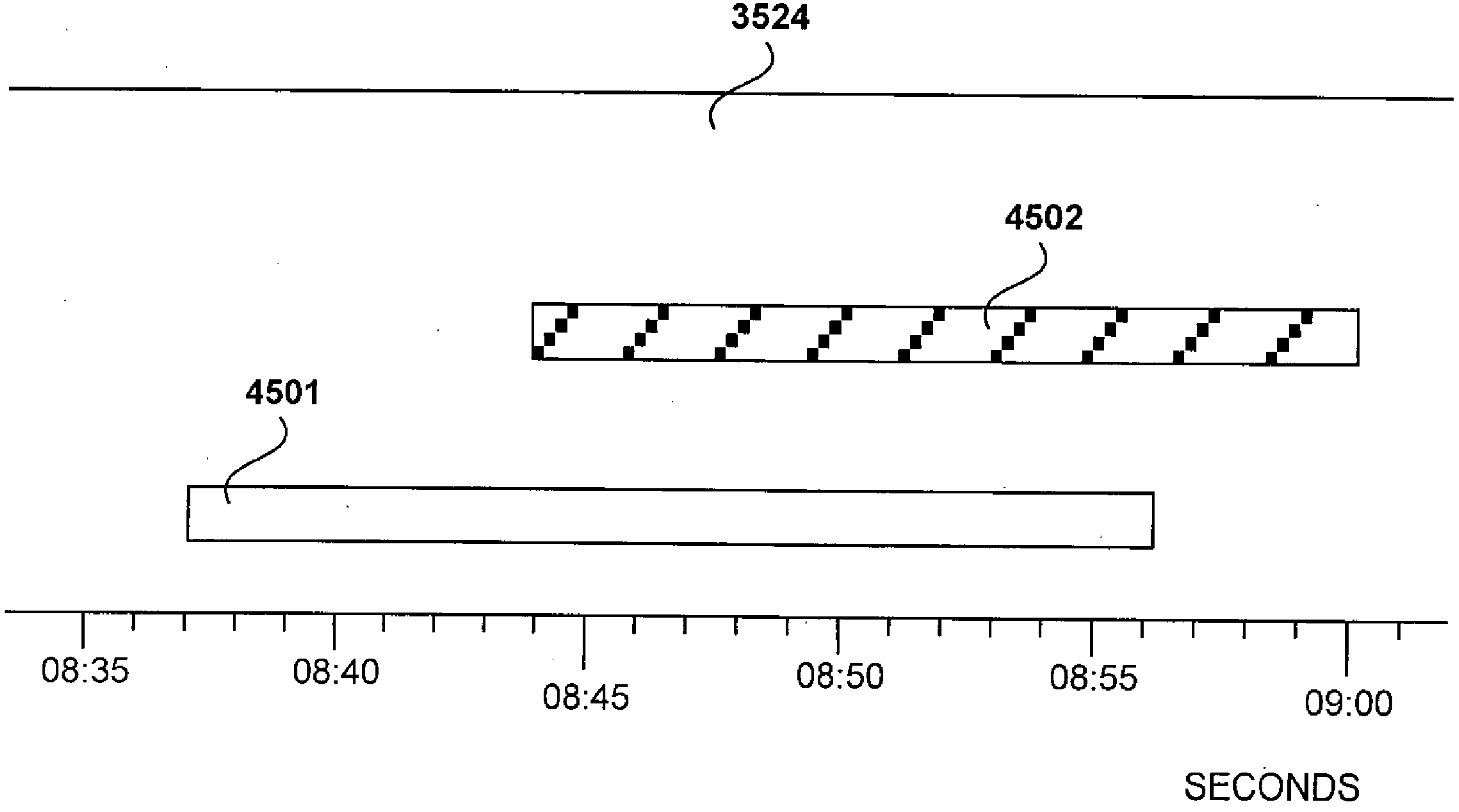


Fig. 45

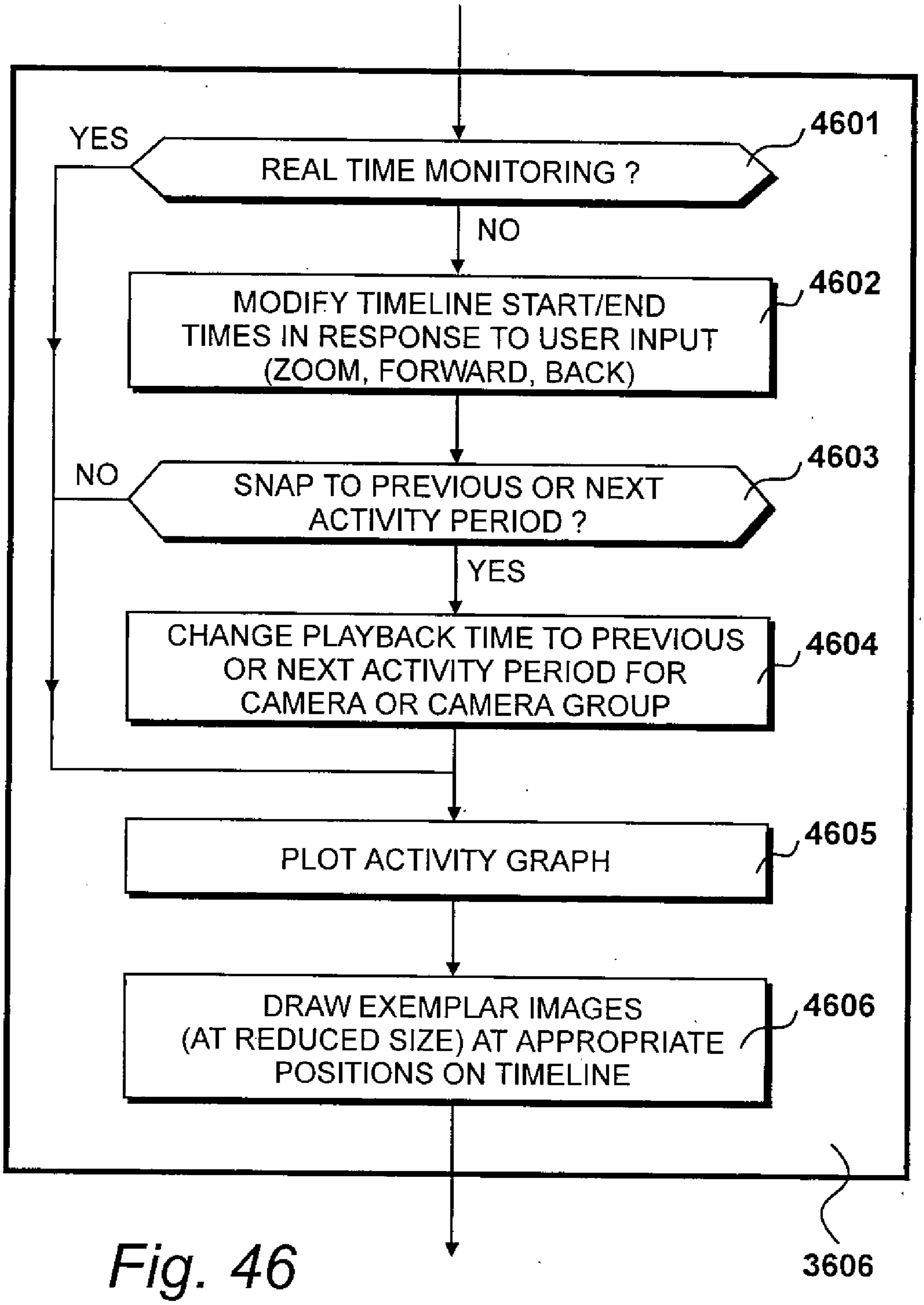

REAL TIME MONITORING ?
YES
NO
4601
MODIFY TIMELINE START/END TIMES IN RESPONSE TO USER INPUT (ZOOM, FORWARD, BACK)
4602
SNAP TO PREVIOUS OR NEXT ACTIVITY PERIOD ?
NO
YES
4603
CHANGE PLAYBACK TIME TO PREVIOUS OR NEXT ACTIVITY PERIOD FOR CAMERA OR CAMERA GROUP
4604
PLOT ACTIVITY GRAPH
4605
DRAW EXEMPLAR IMAGES (AT REDUCED SIZE) AT APPROPRIATE POSITIONS ON TIMELINE
4606
3606

Fig. 46

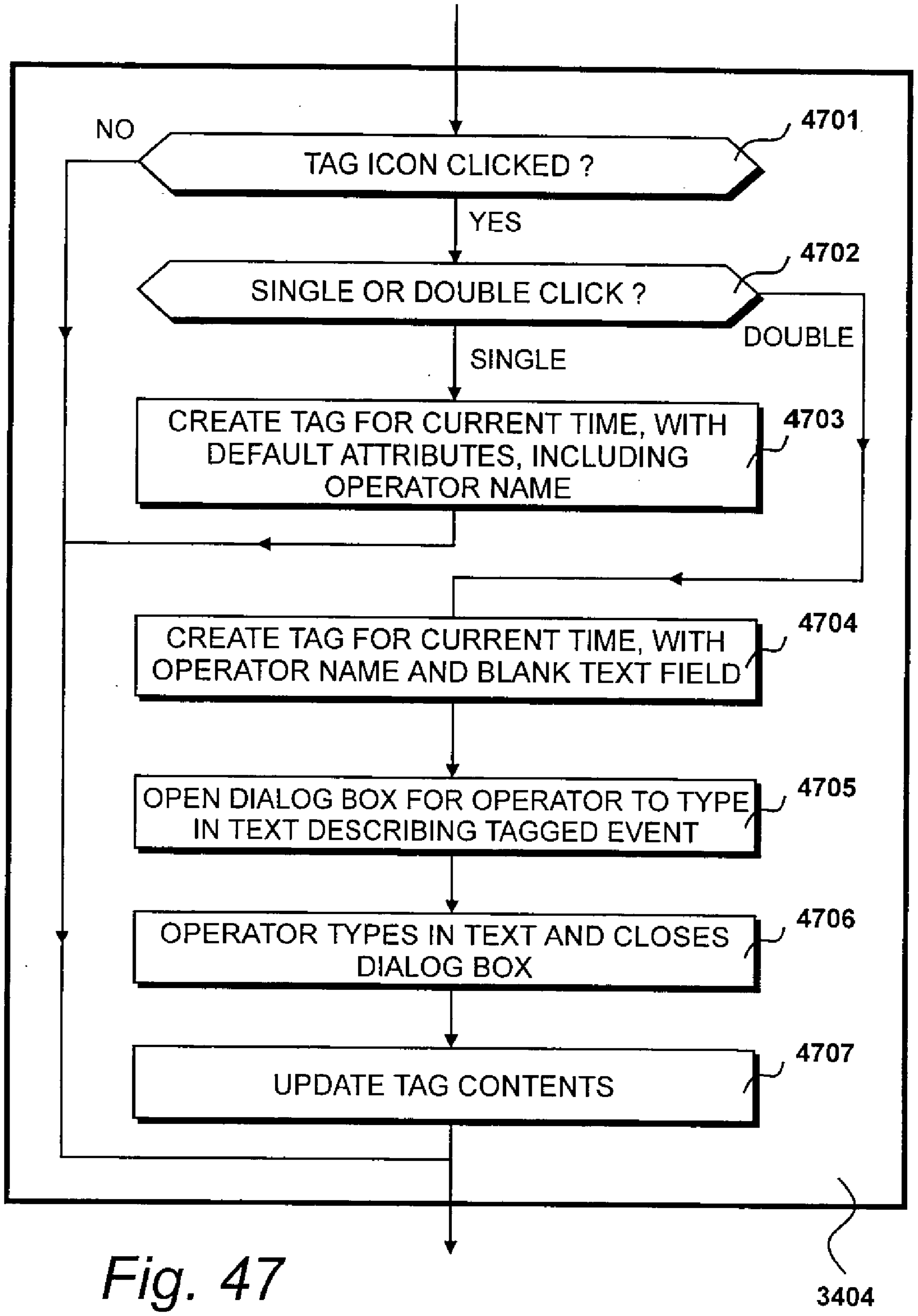

NO
TAG ICON CLICKED ?
4701
YES
SINGLE OR DOUBLE CLICK ?
4702
DOUBLE
SINGLE
CREATE TAG FOR CURRENT TIME, WITH DEFAULT ATTRIBUTES, INCLUDING OPERATOR NAME
4703
CREATE TAG FOR CURRENT TIME, WITH OPERATOR NAME AND BLANK TEXT FIELD
4704
OPEN DIALOG BOX FOR OPERATOR TO TYPE IN TEXT DESCRIBING TAGGED EVENT
4705
OPERATOR TYPES IN TEXT AND CLOSES DIALOG BOX
4706
UPDATE TAG CONTENTS
4707
3404

Fig. 47

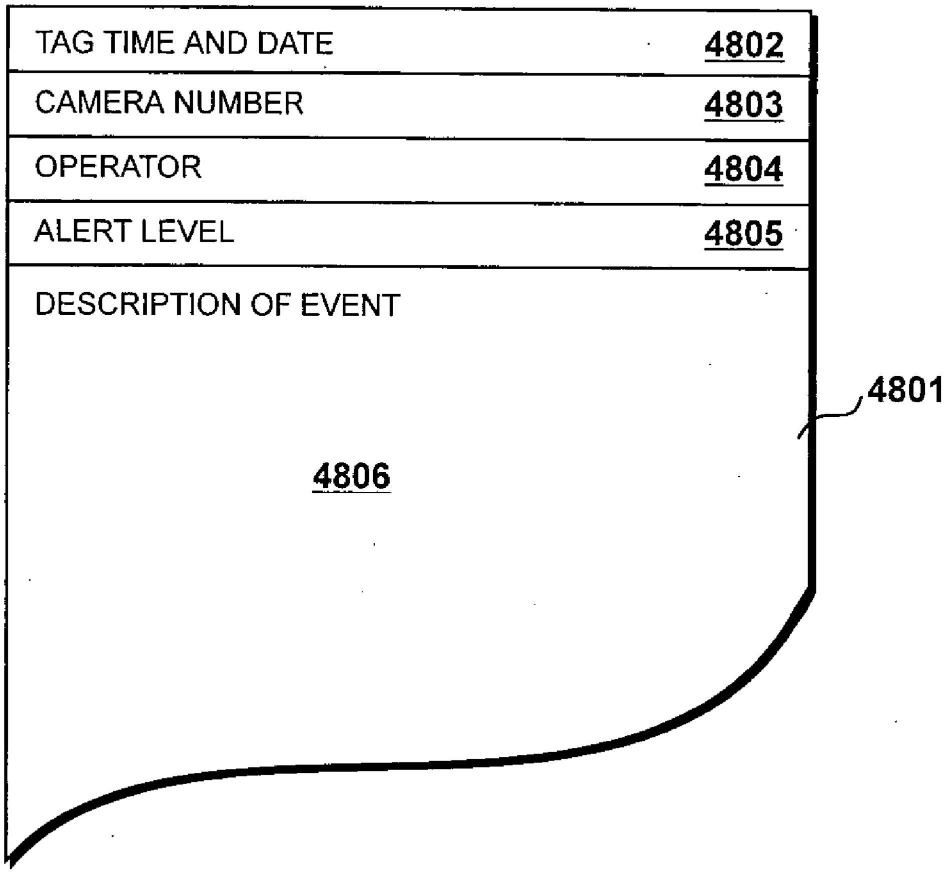

TAG TIME AND DATE
4802
CAMERA NUMBER
4803
OPERATOR
4804
ALERT LEVEL
4805
DESCRIPTION OF EVENT
4806
4801

Fig. 48

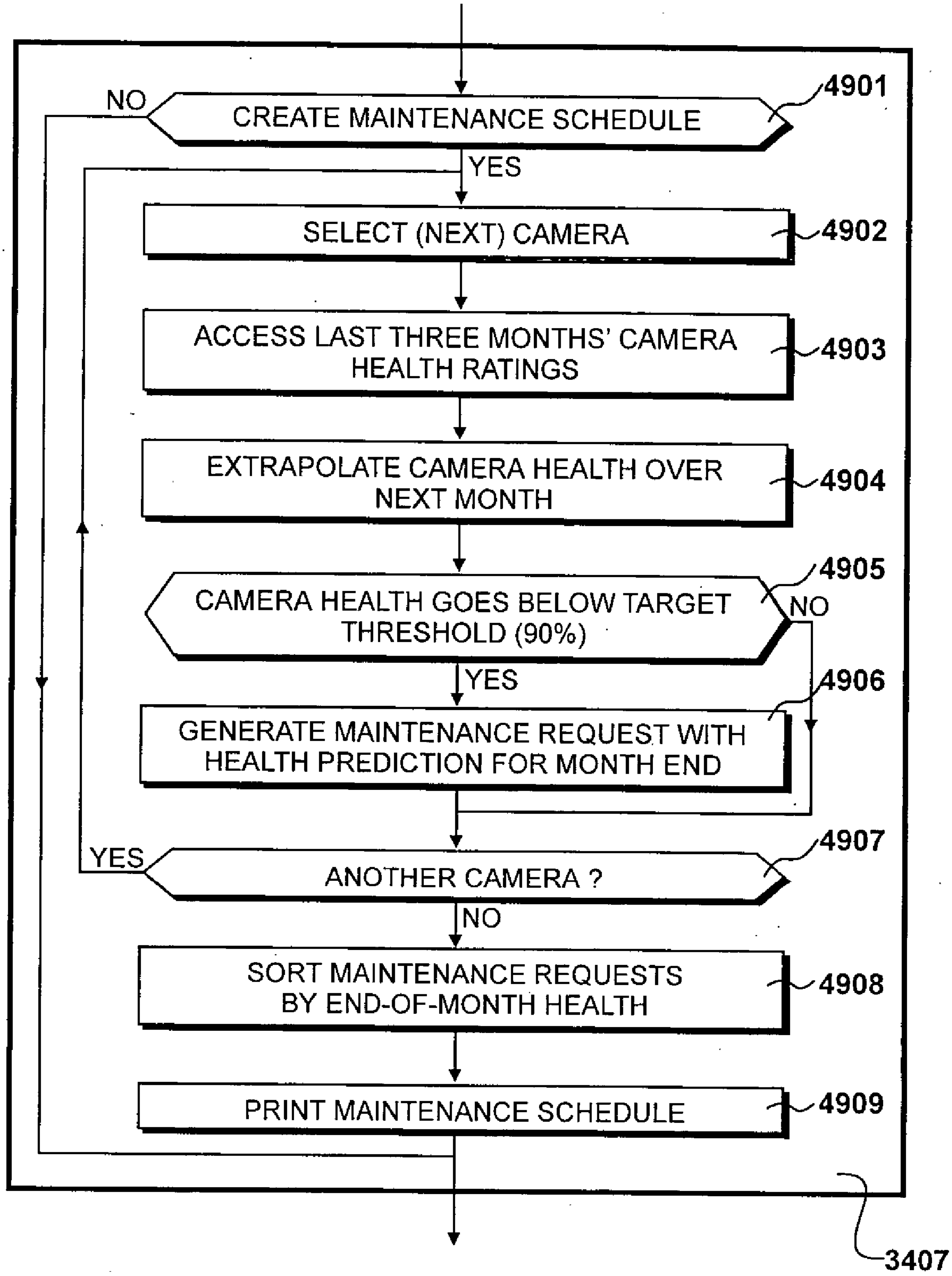

CREATE MAINTENANCE SCHEDULE
4901
NO
YES
SELECT (NEXT) CAMERA
4902
ACCESS LAST THREE MONTHS' CAMERA HEALTH RATINGS
4903
EXTRAPOLATE CAMERA HEALTH OVER NEXT MONTH
4904
CAMERA HEALTH GOES BELOW TARGET THRESHOLD (90%)
4905
NO
YES
GENERATE MAINTENANCE REQUEST WITH HEALTH PREDICTION FOR MONTH END
4906
YES
ANOTHER CAMERA ?
4907
NO
SORT MAINTENANCE REQUESTS BY END-OF-MONTH HEALTH
4908
PRINT MAINTENANCE SCHEDULE
4909
3407

Fig. 49

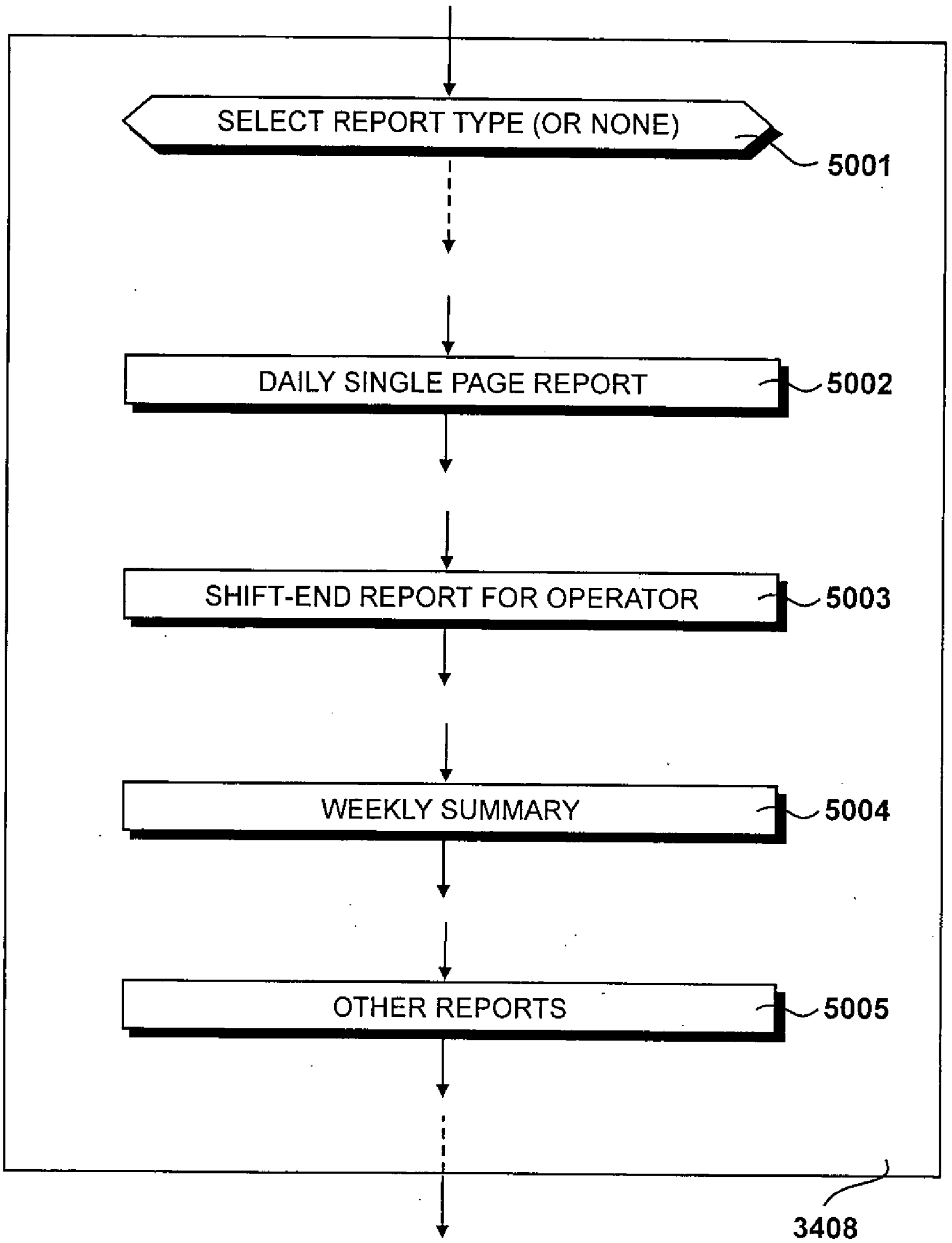

SELECT REPORT TYPE (OR NONE)
5001
DAILY SINGLE PAGE REPORT
5002
SHIFT-END REPORT FOR OPERATOR
5003
WEEKLY SUMMARY
5004
OTHER REPORTS
5005
3408

Fig. 50

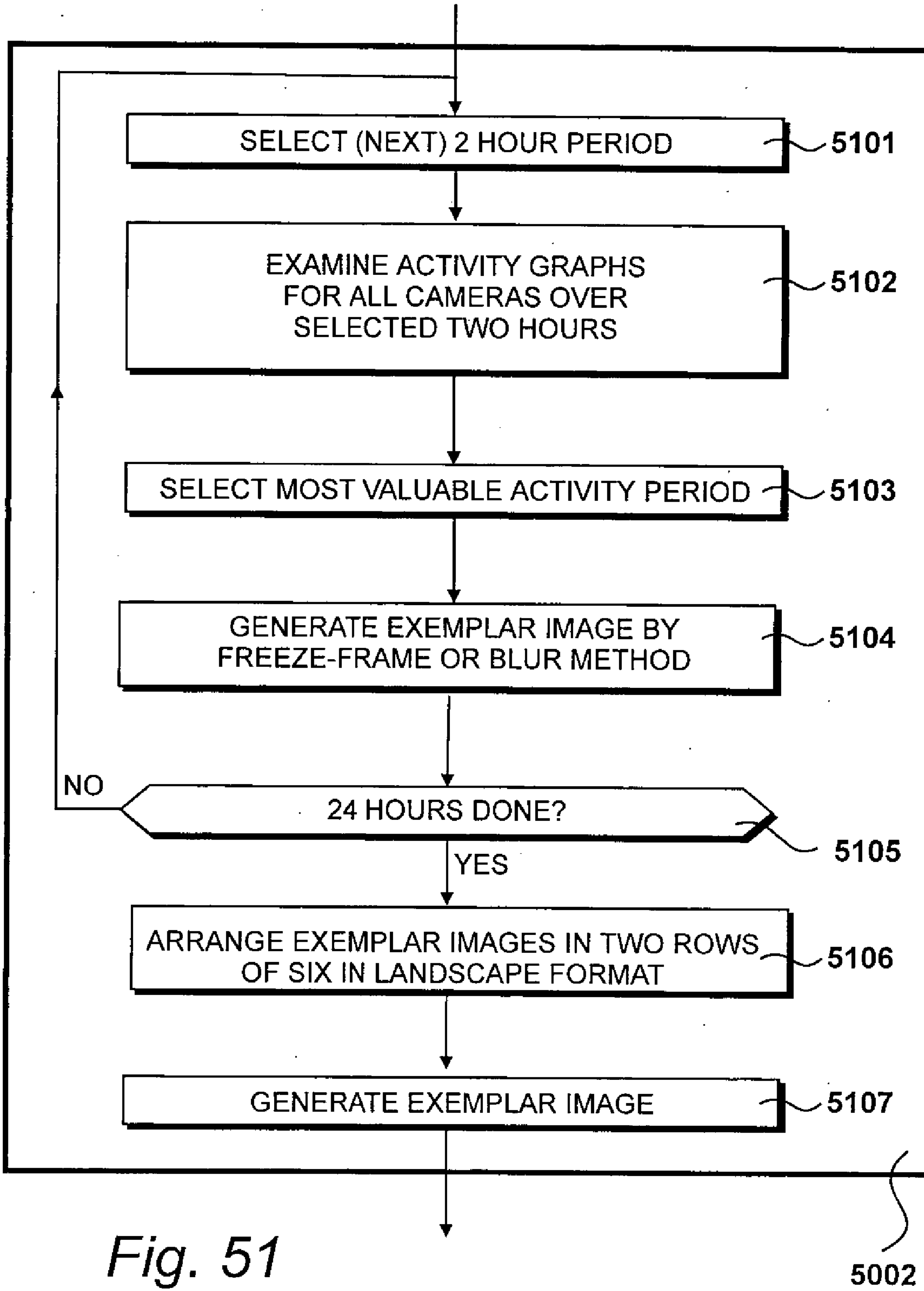

SELECT (NEXT) 2 HOUR PERIOD
5101
EXAMINE ACTIVITY GRAPHS FOR ALL CAMERAS OVER SELECTED TWO HOURS
5102
SELECT MOST VALUABLE ACTIVITY PERIOD
5103
GENERATE EXEMPLAR IMAGE BY FREEZE-FRAME OR BLUR METHOD
5104
NO
24 HOURS DONE?
5105
YES
ARRANGE EXEMPLAR IMAGES IN TWO ROWS OF SIX IN LANDSCAPE FORMAT
5106
GENERATE EXEMPLAR IMAGE
5107
5002

Fig. 51

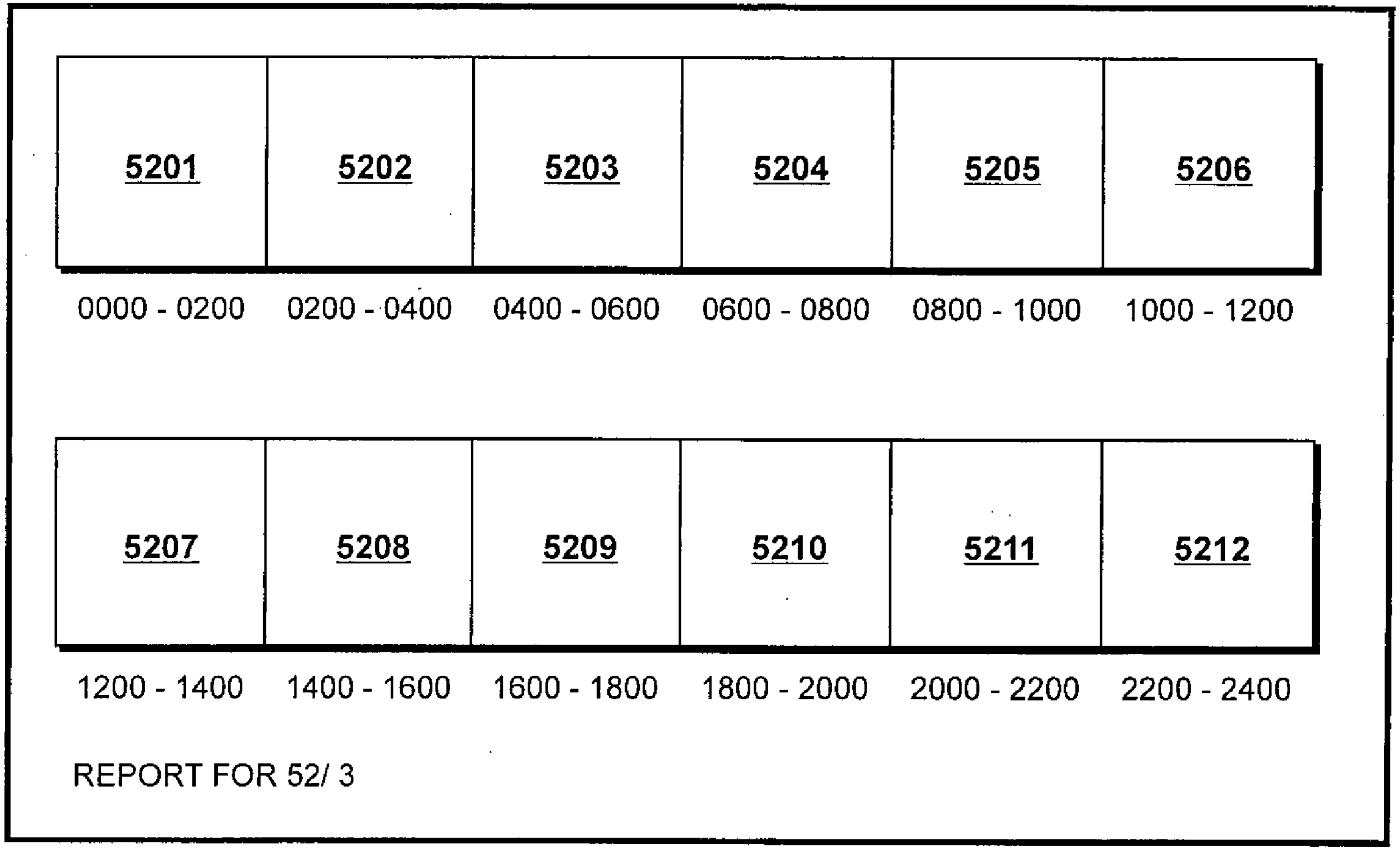

5201
5202
5203
5204
5205
5206
0000 - 0200
0200 - 0400
0400 - 0600
0600 - 0800
0800 - 1000
1000 - 1200
5207
5208
5209
5210
5211
5212
1200 - 1400
1400 - 1600
1600 - 1800
1800 - 2000
2000 - 2200
2200 - 2400
REPORT FOR 52/ 3

Fig. 52

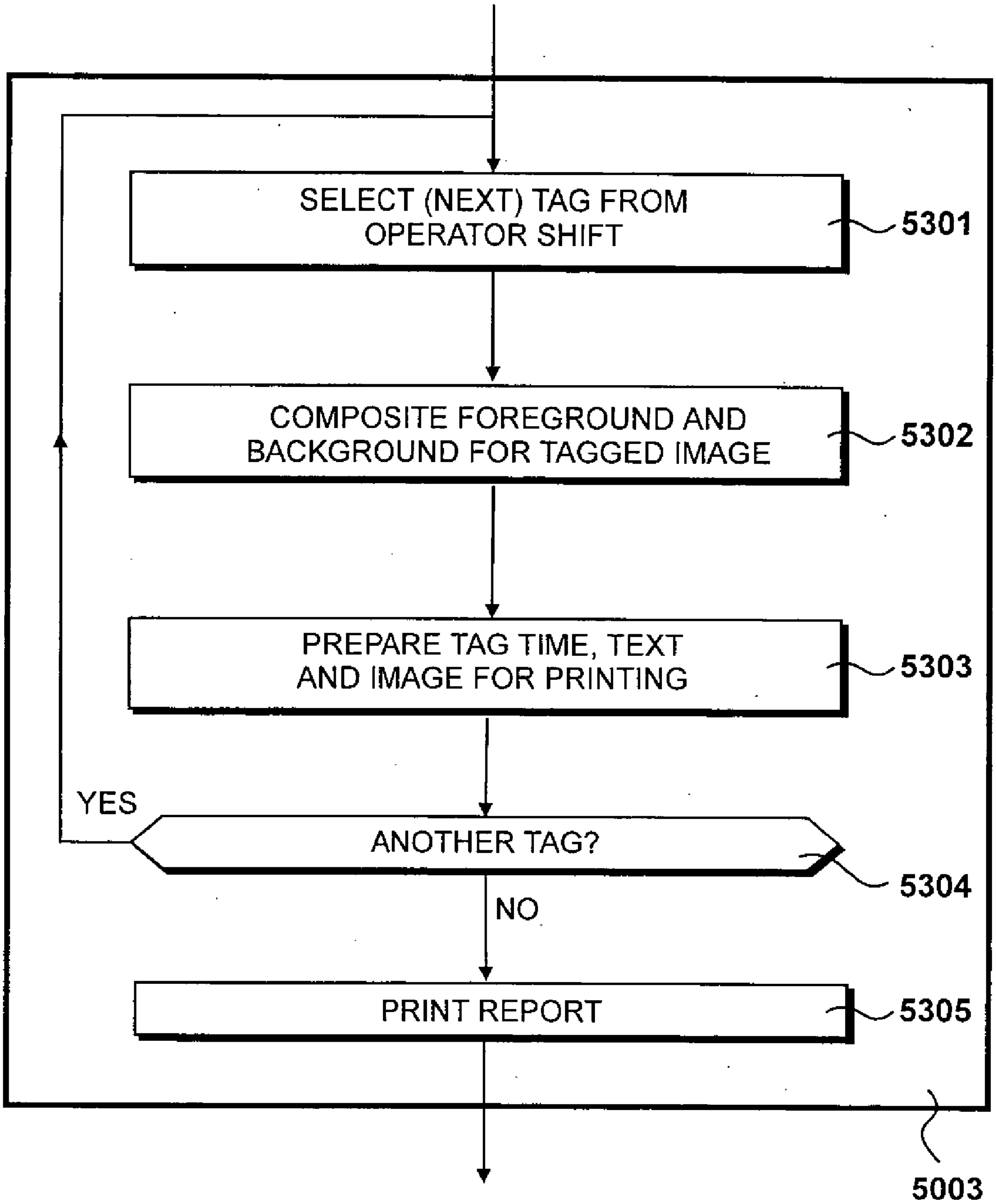

SELECT (NEXT) TAG FROM OPERATOR SHIFT
5301
COMPOSITE FOREGROUND AND BACKGROUND FOR TAGGED IMAGE
5302
PREPARE TAG TIME, TEXT AND IMAGE FOR PRINTING
5303
YES
ANOTHER TAG?
5304
NO
PRINT REPORT
5305
5003

Fig. 53

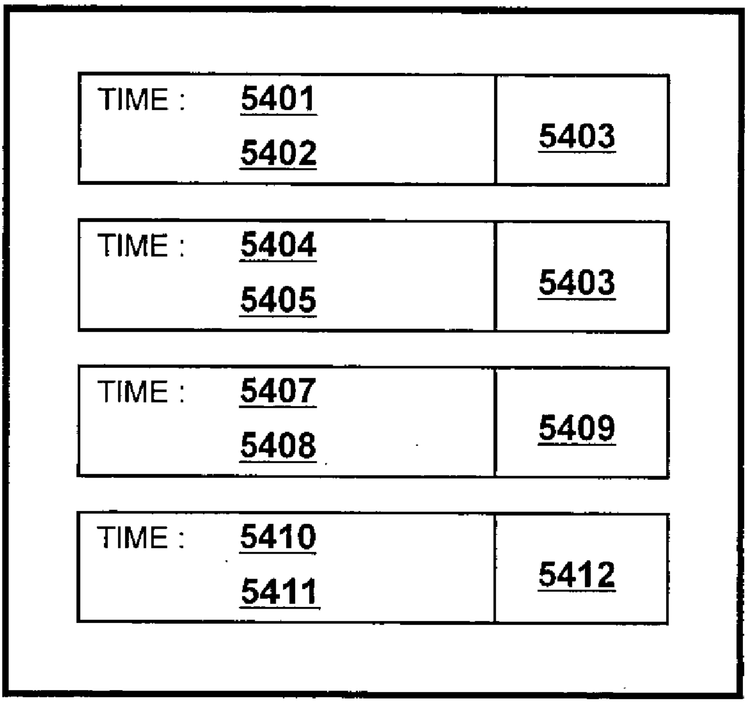

TIME :
5401
5402
5403
TIME :
5404
5405
5403
TIME :
5407
5408
5409
TIME :
5410
5411
5412

Fig. 54