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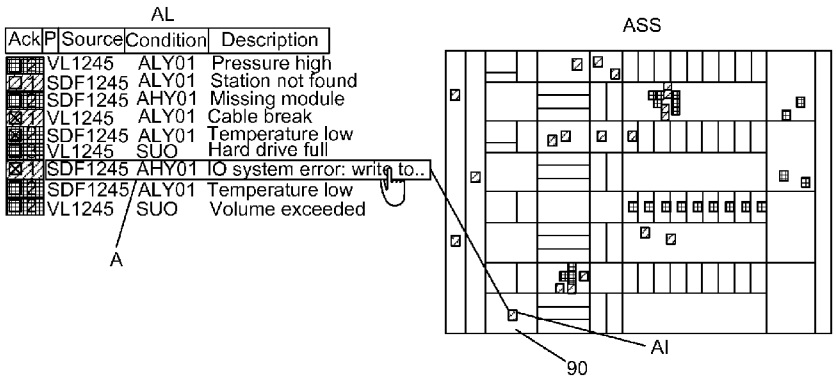

Fig. 4

(57) Abstract: An alarm handling arrangement provides an alarm summary screen (ASS) comprising a number of display objects (90), each display object represents a process control entity and comprises alarm indicators (AI), each assigned to a specific position in the display object, having an off state and able to occupy an on-state if triggered by a corresponding alarm, where the alarms of at least some of the process control entities have a causal dependency on each other, thereby providing an alarm flow through these process control entities forming at least one process control entity chain of linked process control entities, wherein the display objects associated with the process control entities of the process control entity chain are organized on the alarm summary screen in a display object chain with display objects that border each other, the order of which follows the process control entity order in the process control entity chain.

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HANDLING OF ALARMS HAVING A CAUSAL DEPENDENCY

FIELD OF THE INVENTION

The present invention generally relates to process control systems. More particularly the present invention relates to an alarm handling arrangement, a method and a computer program product for handling alarms in a process control system as well as to an alarm summary screen generating device.

BACKGROUND

A process control system may be provided in an industrial plant. Such a system normally comprises a number of process control devices involved in the control of the process. The operation of these devices is typically monitored by plant operators via operator terminals of the system.

In such monitoring process control systems alarms are frequently generated whenever there is a malfunction of some sort or when a malfunction is likely to occur.

Alarms may then be displayed to the operator in an alarm list or table. Alarms are typically presented on lines in the table, where colour may be used to indicate the severity. For a physical property being monitored there may for instance exist a warning limit and a critical limit. For instance, if a pressure level surpasses a warning limit, an alarm may be triggered through a yellow line “Pressure HI” appearing. If the pressure level grows further and surpasses the critical limit, another alarm may be triggered where a red line “Pressure HIHI” may appear for instance together with the playing of a disturbing sound. When an alarm is triggered, the operator has to acknowledge it. When the problem is fixed, the alarm line may then disappear.

In computerised process control systems, the configuring and deployment of alarms is simple. An alarm may as an example be implemented through typing in a location, a measurement value to alarm on and then setting the alarm to an active state. This has led to a situation that in many cases is undesirable in that too many alarms may have been set. Initial installers may have routinely set an alarm at 80% and 20% of the operating range of any variable. In such a situation alarms may be generated all over the process control system. Thereby incidents could accrue as a combination of too much data collided with too little useful information. Meaningless to operator at their majority, alarms occur just because someone has configured them. Because of such misconfiguration and a number of other reasons, operators often ignore the alarm system as a whole. This may be problematic in some situations, such as when there is an “alarm flood”.

An “alarm flood” is a case, when there are a great number of alarms, such as hundreds of alarms, occurring as a consequence of one or a few root alarms. In this case only the root one is meaningful, but it may be hard to locate it, because it may be directly pushed far down in the list by less relevant alarms. This may lead to the operator being distracted, stressed and not being able to act properly. This multitude of alarms may make it harder to identify the root cause and consequently also make it harder to implement appropriate countermeasures.

Because of this attempts have been made to optimize the alarm system, so that (ideally) every alarm would be meaningful for the operator. Alarm Management has for instance emerged as a response to poor alarm systems design. In Alarm Management the focus lies on reducing the number of alarms, which is of course one but not the only solution to the problem of information overload. When reducing alarms there is also always the risk that an alarm that fills an important function is deleted.

There have been made some interesting developments in relation to how alarms are displayed in order to obtain a better alarm overview.

US 7646294 does for instance describe the display of alarms in an alarm summary screen, where individual alarms are represented by corresponding rectangles with luminance and parts organized onto categories forming logical alarm clusters, typically placed in a box. The size and layout of a rectangle here defines its priority and precedence. Furthermore, each box may represent one or more alarm clusters of different failure situations in a process. One box can thus be seen as comprising a number of alarms according to a category. Furthermore through this clustering an operator is said to be able to determine the status of the alarms by looking at the color, luminance and pattern of the bounding boxes as well as being allowed to use pattern recognition to determine a cause of groups of alarms.

WO 2008/124677 is in turn related to the field of monitoring faults in a computer network. The document describes that a rectangle may be used to represent an IO terminal, which is grouped into a box representing a plant, which in turn is a part of a higher level element in the form of a controller. In WO 2008/124677 there is thus a hierarchical alarm structure.

It would in view of what has been stated above be of interest to improve on the situation through providing an improved alarm handling.

SUMMARY OF THE INVENTION

The present invention addresses the problem of providing improved alarm handling.

This object is according to a first aspect of the invention solved through an alarm handling arrangement in a process control system, the arrangement comprising:

- at least one alarm generating device configured to generate alarms based on sensor measurements in the process control system,
- an alarm summary screen generating device comprising a control unit configured to
  - provide an alarm summary screen comprising a number of display objects, each display object representing a process control entity and comprising a number of alarm indicators, each alarm indicator being assigned a specific position in the display object, having an off state and being able to occupy at least one on-state if triggered by a corresponding alarm generated for the process control entity by at least one alarm generating device, where the alarms of at least some of the process control entities have a causal dependency on each other, thereby providing an alarm flow through these process control entities forming at least one process control entity chain of linked process control entities,
  - wherein the display objects associated with the process control entities of said process control entity chain are organized on the alarm summary screen in a display object chain with display objects that border each other, where the order of the display objects in the display object chain follows the order of the process control entities in the process control entity chain.

This object is according to a second aspect of the invention solved through a method for handling alarms in a process control system, the method being performed by an alarm handling arrangement and comprising the step of:

- providing an alarm summary screen comprising a number of display objects, each display object representing a process control entity and comprising a number of alarm indicators, each alarm indicator being assigned a specific position in the display object, having an off state and being able to occupy at least one on-state if triggered by a corresponding alarm generated for the process control entity by at least one alarm generating device of the process control system, where the

alarms of at least some of the process control entities have a causal dependency on each other, thereby providing an alarm flow through these process control entities forming at least one process control entity chain of linked process control entities,

wherein the display objects associated with the process control entities of said process control entity chain are organized on the alarm summary screen in a display object chain with display objects that border each other, where the order of the display objects in the display object chain follows the order of the process control entities in the process control entity chain.

This object is according to a third aspect of the invention solved through an alarm summary screen generating device for generating an alarm summary screen in a process control system, the device comprising:

- a control unit configured to
  - provide an alarm summary screen comprising a number of display objects, each display object representing a process control entity and comprising a number of alarm indicators, each alarm indicator being assigned a specific position in the display object, having an off state and being able to occupy at least one on-state if triggered by a corresponding alarm generated for the process control entity by at least one alarm generating device of the process control system, where the alarms of at least some of the process control entities have a causal dependency on each other, thereby providing an alarm flow through these process control entities forming at least one process control entity chain of linked process control entities,

wherein the display objects associated with the process control entities of said process control entity chain are organized on the alarm summary screen in a display object chain with display objects that border each other, where the order of the display objects in the display object chain follows the order of the process control entities in the process control entity chain.

This object is according to a fourth aspect of the invention solved through a computer program product for handling alarms in a process control system, said computer program product being provided on a data carrier comprising computer program code configured to cause an alarm handling arrangement to, when said computer program code is loaded into said alarm handling arrangement,

- provide an alarm summary screen comprising a number of display objects, each display object representing a process control entity and comprising a number of alarm indicators, each alarm indicator being assigned a specific position in the display object, having an off state and being able to occupy at least one on-state if triggered by a corresponding alarm generated for the process control entity by at least one alarm generating device of the process control system, where the alarms of at least some of the process control entities have a causal dependency on each other, thereby providing an alarm flow through these process control entities forming at least one process control entity chain of linked process control entities,

wherein the display objects associated with the process control entities of said process control entity chain are organized on the alarm summary screen in a display object chain with display objects that border each other, where the order of the display objects in the display object chain follows the order of the process control entities in the process control entity chain.

The present invention has a number of advantages. It provides improved overview without reducing the number of alarms. The overview may also be obtained in a simple, fast and effortless way. The visualization makes scrolling unnecessary. The operator may thus perceive a complete alarm picture all at once, which increases situational awareness. The design also allows meaningful relationships between alarms to be shown such as similarities and clusters. Through the provided overview the operator performance may also be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will in the following be described with reference being made to the accompanying drawings, where

Fig. 1 schematically shows an industrial plant with a process control system operating an industrial process using process control devices,
Fig. 2 schematically shows a process flow through a number of the process control devices,
Fig. 3 schematically shows an alarm list together with an alarm summary screen comprising display objects representing the process control devices in fig. 2,
Fig. 4 shows the alarm list and alarm summary screen as a few alarms are being generated,
Fig. 5 shows the alarm list and alarm summary screen when there is an alarm flood,
Fig. 6 schematically shows the obtaining of additional information in relation to an alarm indicator in the alarm summary screen
Fig. 7 schematically shows an alarm summary screen generating device for providing the alarm summary screen,
Fig. 8 schematically shows a flow chart of a number of method steps in a method of providing the alarm summary screen being performed by the alarm summary screen generating device,
Fig. 9 schematically shows a flow chart of a number of method steps for operating the alarm summary screen, and
Fig. 10 shows a data carrier with computer program code, in the form of a CD-ROM disc, for performing the steps of the method.

DETAILED DESCRIPTION OF THE INVENTION

In the following, a detailed description of preferred embodiments of an alarm handling arrangement, a method and a computer program product

for handling alarms as well as an alarm summary screen generating device will be given.

Fig. 1 schematically shows a process control system 10, which may be provided in an industrial plant. The process control system 10 is a computerized process control system for controlling an industrial process P. Examples of industrial processes that may be controlled are electrical power generation, transmission and distribution processes as well as water purification and distribution processes, oil and gas production and distribution processes, petrochemical, chemical, pharmaceutical and food processes, and pulp and paper production processes. These are just some examples of processes where the system can be applied. There exist countless other industrial processes. The processes may also be other types of industrial processes such as the manufacturing of goods. A process may be monitored through one or more process monitoring computers, which communicate with a computer or server handling monitoring and control of the process.

In fig. 1 the process control system 10 therefore includes a number of process monitoring computers 12 and 14. These computers may here also be considered to form operator terminals and are connected to a first data bus B1. Between this first data bus B1 and a second data bus B2 there is connected a first control computer 16, a second control computer 18 and a database 20.

To the second data bus B2 there is furthermore connected a number of further devices 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52 and 54. These further devices 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52 and 54 are field devices, which are devices that are interfaces to a process P being controlled. There is in this case a first 22, second 24, third 26, fourth 28, fifth 30, sixth 32, seventh 34, eighth 36, ninth 38, tenth 40, eleventh 42, twelfth 44, thirteenth 46, fourteenth 48, fifteenth 50, sixteenth 52 and seventeenth 54 field device. A field device is typically

an interface via which measurements of the process are being made and to which control commands are given. A field device may as an example be a tank and another as an example a centrifuge. The first computer 16 may be involved in controlling the process P based on inputs from field devices, such as from sensors of field devices, and actuating the same or other field devices, such as valves, based on the inputs. The field devices and computers are all examples of process control devices. Furthermore, the field devices may also be used by the second computer 18 for protecting the system. The various process control devices may also be set to generate alarms based on sensor measurements. A field device that generates alarms may therefore also be an alarm generating device. However, also other devices, such as computers, like the first and the second computer or the operator terminals, may be alarm generating devices. An alarm generating device may therefore also generate alarms based on inputs from process control devices. Generated alarms may then be displayed to an operator and may therefore also be submitted from alarm generating devices to alarm subscribing devices like the operator terminals. Alarm generating devices may also be used for triggering on-states of alarm indicators, which will be described in more detail later. Generated alarms may also be stored in the database 20.

The control being performed, for instance by the first computer 16, may furthermore follow a process flow PF, which is an order in which a number of process control devices operate on the process. Thereby the process control devices are also connected in the process in a process flow order, i.e. in an order in which the process flow passes them. Fig. 2 shows one example of a process flow PF employing the field devices in fig. 1. In the example given here only field devices are considered as a part of the process flow PF. It should however be realized that also control devices such as the first computer 16, the second computer 18 and possible controllers in the system may be considered to be a part of the process flow.

In the example process flow PF of fig 2, the flow PF starts at a first process control device, which is implemented through the first field device 22. This is followed by a second process control device 32, which as an example is the second field device 34. Thereafter the process flow splits into three subflows, a first subflow leading to a third process control device implemented via the third field device 26, a second subflow to a fourth process control device implemented through the fourth field device 28 and a third subflow to a fifth process control device in the form of the fifth field device 30. The subflows are then joined at a sixth process control device in the form of the sixth field device 32. After the sixth process control device the reunified flow continues to a seventh process control device in the form of the seventh field device 34 that in turn leads the flow to an eighth process control device in the form of the eighth field device 36.

The process flow from the eight field device 36 is finally divided into nine further subflows, where a first further subflow leads to a ninth process control device in the form of the ninth field device 38, a second further subflow leads to a tenth process control device in the form of the tenth field device 40, a third further subflow leads to an eleventh process control device in the form of the eleventh field device 42, a fourth further subflow leads to a twelfth process control device in the form of the twelfth field device 44, a fifth further subflow leads to a thirteenth process control device in the form of the thirteenth field device 46, a sixth further subflow leads to a fourteenth process control device in the form of the fourteenth field device 48, a seventh further subflow leads to a fifteenth process control device in the form of the fifteenth field device 50, an eighth further subflow leads to a sixteenth process control device in the form of the sixteenth field device 52 and a ninth further subflow leads to a seventeenth process control device in the form of the seventeenth field device 54.

The above given situation is somewhat simplified in that a field device that provides a sensor measurement or that influences the process P is considered as being a process control device. A process control device

acting as process interface may more particularly be a physical device where one or more properties of the process are sensed. It is furthermore possible that process control is performed via such a process control device. The process control device acting as a process interface may therefore also or instead perform one or more types of influences on the process P.

As an example for describing the process flow PF, the first field device 22 may be a tank comprising a sensor sensing one or more properties of the process P, such as a pressure, which is submitted to the first computer 16. The first computer 16 may in turn operate the second field device 24, which may be a valve in a conduit being placed downstream from the first process control device, which operation may be based on one or more sensed properties. The second field device 24 may then be connected via a manifold to the third, fourth and fifth field devices 26, 28, 30, which may be mixers. From these the three subflows may be joined at sixth field device 32, which may be another tank, at which one or more properties may be measured, such as temperature, and submitted to a control computer or controller, such as the first computer 16, which may in turn provide some control of the seventh field device 34, which may for instance be a further valve. This field device is in turn connected to the eighth field device 36 from which the flow is divided into the nine further subflows leading to the ninth – seventeenth field devices 38 – 52.

It can be seen in fig. 2 that there is a process control entity chain of linked process control entities. In the example in fig. 2, a process control entity is a process control device and a link is a physical connection between process control devices, where furthermore the connection points may form interfaces between the process control devices.

It should be realized that the above mentioned process flow PF passing the field devices 22 – 54 is merely exemplifying. It should therefore be realized that a field device is not necessary followed by a field device in the process

flow. As a control computer influences the process, it is also possible to consider a control or protection computer or controller to be a part of a process flow. It can therefore be seen that it is just as well possible that a field device is followed by a controller or computer. It is also possible that a controller or computer is followed by another controller or computer in the process flow. It is furthermore possible that the process flow may pass a process control device more than once.

In computerised process control systems, the configuring and deployment of alarms is simple. An alarm may as an example be implemented through typing in a location, a measurement value to alarm on and then setting the alarm to an active state. This has led to a situation that in many cases is undesirable in that too many alarms may have been set. Initial installers may have routinely set an alarm at 80% and 20% of the operating range of any variable. In such a situation alarms may be generated all over the process control system. This may lead to an excessive number of possible alarms being present in the process control system.
Traditionally alarms have been provided in an alarm list presented for operators on their operator terminals. An alarm may be a list of sequential alarms according to the point in time when they occur. Examples of alarms are shown in an alarm list AL on the left hand side of fig. 4. The alarm list has a visible section, which is the part of the alarm list that is visible to an operator, for instance when being displayed on an operator terminal.

As can be seen there, alarms are presented in a table, where the lines are coloured by the alarm severity. If for instance a pressure level surpasses a warning limit, an alarm is triggered and a yellow line appears, perhaps also comprising text indicating that the warning limit has been exceeded. If the pressure level grows further and surpasses a critical limit, another alarm may be triggered and a red line appear, perhaps also comprising text indicating the crossing of the critical limit. It is additionally possible to use sound as a warning.

The operator may then act on an alarm in order to make the process return to a normal or stationary state. This may be an efficient way to handle alarms when the processes is essentially running smoothly and the number of alarms are fairly low and perhaps occurring infrequently. However, there is a problem in that the system may include too many alarms. A lot of the alarms may be unnecessary or only a guidance to the operator and thereby not really requiring any action. This may not be a problem if the system is running smoothly, when the number of alarms may be fairly low.

However, some alarms may be more important than other and may need to be addressed. Furthermore, when there are many superfluous alarms, it is possible that one or a few important alarms cause a so-called "Alarm flood". This means that for example hundreds of alarms may occur as a consequence of one or a few root alarms. In this case only the root one is meaningful, but is hard to identify because of the multitude of other alarms. The situation is made even more critical through the root alarm being pushed far down in the list AL. If there are many alarms, the root alarm may even be pushed out of the visible area of the alarm list. Therefore, if the alarms are merely provided in an alarm list, it may be hard and sometimes almost impossible for the operator to identify the root cause of an alarm, which is especially the case if there are many alarms being generated. The operator may thus fail to obtain an overview of the alarms and may in some cases even not see the root alarm and could therefore take the wrong action, which may lead to a standstill of the process P or even to dangerous or hazardous situations.

Alarms having the same root cause are typically linked to each other according to a logical alarm flow. They do thus have a causal dependency on each other in that one alarm is generated after another based on the occurrence of a root cause alarm that forms an alarm flow through the process control devices. This alarm flow is often also related to the above described process flow through the process control devices. This means

that the alarms may follow the previously described process flow through the process control devices.

If the alarms are displayed linked to the process flow, then it may possible to identify such details as in which process control device the fault occurs, how the fault influences other process control devices and how serious the consequences are. It may also be possible to assess how long time there is left to perform corrective action before a permanent fault occurs.

How a better visualization of alarms may be achieved will now be described with reference being made to fig. 3 – 5 which show the previously mentioned alarm list AL together with an alarm summary screen ASS displayed on an operator terminal, such as the first operator terminal 12, when there is no alarm (fig. 3), when there are a limited number of alarms (fig. 4) and when there is an alarm flood (fig. 5).

In order to allow a better understanding of how a serious situation, which is indicated through the use of different alarms, may spread through process control entities of the process control system, such as through process control devices, the structure in fig. 3 is provided.

On the left hand side of fig. 3 an exemplifying (empty) alarm list AL is shown and to the right of this alarm list an exemplary alarm summary screen ASS is shown.

The alarm list AL and alarm summary screen ASS may be shown on one or more operator terminals or operator control room screens.

In the alarm list AL there is a column “ACK” for acknowledgements to be made by the control room operator, a column “P” where the priority of the alarm is indicated, a column “Source”, where an indication of from or for which process control device the alarm is generated, a column “Condition”

which is an indication of alarm type and finally a column “Description” that comprises a short description of the alarm.

In the example of fig. 3 – 5, the alarm summary screen is provided as an alarm array that may feature 6144 alarms.

In the alarm summary screen ASS there are a number of display objects, each associated with a corresponding process control entity. A process control entity may, as was described above, be a single process control device. However, it may also be a higher level element of the process control system, such as a process control section comprising a number of process control devices generating alarms. It is also possible with display objects that are a combination of display objects representing higher and lower level elements in the same alarm summary screen.

A process control entity for which alarms are generated is thus represented by a display object. The display objects correspond respectively to a defined area of the alarm summary screen. The display objects may as an example have four sides and each side of at least one display object may face one or more neighbouring display objects. Each display object furthermore comprises one or more alarm indicators, where one alarm indicator is associated with a corresponding alarm which may be triggered for the corresponding process control entity. The alarm indicators indicate the state of the corresponding alarms. Depending on how many alarms there are in or for a process control entity and on how many process control entities there are, the corresponding display object may be a vector of serially provided alarm indicators or a two-dimensional array with alarm indicators.

It can be seen in fig. 3 that there are a great number of display objects in the alarm summary screen ASS, which display objects in this example are formed as rectangles of varying size. The first process control device, i.e. the process control entity exemplified by the first field device 22, is here

represented by a first display object 56 having four sides, only two of which borders other display objects. It has a left side adjacent to and bordering one other display object and a right side, adjacent to and bordering no less than twelve display objects, where a sixth object from the top is a second display object 58 corresponding to the second process control device exemplified by the second field device 24. The second display object 58 also has four sides, where a left side borders the first display object 56. There is also an upper side bordering two display objects and a lower side bordering another two display objects. There is finally a right side that borders a third, fourth and fifth display object 60, 62 and 64 representing the third, fourth and fifth process control devices which in the given example are the third, fourth and fifth field devices 26, 28 and 30. All these three display objects 60, 62 and 64 have a left side bordering the second display object 58 and a right side, which borders a sixth display object 66 representing the sixth process control object, which in the example in fig. 2 was the sixth field device 32.

Furthermore, the third display object 60 has an upper side that borders another display object and a lower side that borders the upper side of the fourth display object 62. The lower side of the fourth display object 62 borders an upper side of the fifth display object 64 and a lower side of the fifth display object 64 borders another display object. The left side of the sixth display object 66 thus borders each of the third, fourth and fifth display objects 60, 62 and 64, while the right side of the sixth display object 66 borders a left side of a seventh display object 68 representing the seventh process control device, which in this case is the seventh field device 34. The upper and lower sides of the sixth and seventh display objects 66 and 68 each border a display object which is the same for them. The right side of the seventh display object 68 borders a left side of an eighth display object 70 representing the eighth process control device, which was exemplified by the eighth field device 36. The right side of the eighth display object 70 borders one display object, while each of the upper and lower sides border to no less than nine different display objects. The

upper side of the eighth display object 70 more particularly borders a ninth, tenth, eleventh, twelfth, thirteenth, fourteenth, fifteenth, sixteenth and seventeenth display object 72, 74, 76, 78, 80, 82, 84, 86 and 88, each representing a corresponding of the ninth to seventeenth field devices 38 – 54. Also an eighteenth display object 90 is indicated separately from the first to seventeenth display objects 56 - 88.

As can be seen there are number of further display objects in the alarm summary screen ASS. These will not be described in any detail in order not to confuse the understanding of variations of the invention. Furthermore, it should be realized that the shown structure is only exemplifying in order to describe some principles behind the way display objects and alarm indicators are organized. The layout is thus merely an example. It is furthermore possible that some display objects border each other without being linked to each other in the process flow.

It can be seen that the first to seventeenth display objects 56 – 88 are linked to each other in the order in which the corresponding process control devices appear in the process flow. They are thus interconnected in the order in which the process control devices are connected to each other in the process flow. Thereby they are organized in a display object chain that is similar to the process control entity chain with display objects that border each other. It can furthermore be seen that display objects in the display object chain follow the order of the process control entities in the process control entity chain. This organization may be obtained beforehand, i.e. before the system is put into operation, based on knowledge about the process flow PF. However it is also possible that the dependency may be determined based on an analysis of actual alarms being generated in or for the process control devices, i.e. based on alarms that are generated for the process control entities. The generation of alarms may thus provide information about the logical connection or causal dependency of the display objects to each other and hence the order in which they should be provided in the alarm summary screen ASS.

Each alarm indicator has at least two states: an off-state which indicates that the alarm with which the alarm indicator is associated is not triggered, and one or more on-states indicating that the alarm with which the alarm indicator is associated is triggered. If the alarm with which an alarm indicator is associated may be triggered at different levels such as "high level" and "critically high level" corresponding to different degrees of severity of the alarm, then the alarm indicator may have different on-states for reflecting such different degrees of severity. The different states of the alarm indicators may be indicated by different colours or patterns and may be triggered by the generation of the corresponding alarm. In the example embodiments illustrated in Figs. 4-6, alarm indicators which are in the off-state are configured to blend with the background. As can be seen in fig. 3 there are no triggered alarms yet and therefore no alarms can be seen in the alarm list AL. Consequently the alarm indicators are in the off-state in the alarm summary screen ASS.

As can be seen in fig. 4, the triggered alarms will appear as lines in the alarm list AL. At the same time indicators AI of the alarms will appear in the on-state in the display objects in the alarm summary screen ASS. An alarm indicator AI may thus be arranged as a little point or a group of elements inside a 2D graphical array forming the display object representing the process control entity in or for which the alarm is generated. The group of elements forming an alarm indicator may have a shape adapted to the shape of the display object, so that the display object may be completely filled with alarm indicators. The alarm indicator may as an example have rectangular or even quadratic shape. A certain position in a display object may thus be assigned to a specific alarm. An alarm indicator may thus be assigned a specific position in a display object. One colour may here represent one on-state and another colour may represent another on-state. The off-state may be represented by yet another colour, which e.g. may transparent or the same as the background colour of the display. The alarm indicators may additionally have the same size. This

means that it is possible that one factor influencing the size and shape of a display object is the number of alarms generated in or for it. Another factor that influences the size and shape is the number of other display objects it needs to have interfaces to. This also means that neither the size of an alarm indicator nor the size of a display object is in any way related to the severity or importance of the alarm. The size and shape of both the alarm indicator and the display object may thus be independent of the alarm severity or process control object importance.

As alarms are generated by the alarm generating devices, it is then possible for an operator to know what the alarm is and in or for which process control device it is generated by merely looking at the corresponding display object and the position therein assigned to the alarm.

It is furthermore possible to obtain information of the alarm in the alarm list through for instance selecting an alarm indicator in a display object of the alarm summary screen ASS, where the selection may be done through clicking or perhaps hovering on an alarm indicator e.g. by means of a pointer such as a mouse pointer. It can be seen that by marking an alarm indicator AI in the eighteenth display object 90, a corresponding alarm A in the alarm list is emphasized by being marked or highlighted. Furthermore in case the alarm at the time of selection is not in the visible section of the alarm list, the list may be automatically scrolled so that the alarm enters the visible section. This allows a quick identification of an alarm in the alarm list even when the number of alarms is so great that they cannot all be seen simultaneously. The operator may then easily proceed to quickly acknowledge the identified alarm and initiate an appropriate control action in response to the identified alarm.
The alarms in a process control device may furthermore be generated in respect of different parts of the process control device. A certain process control device may, in the process flow, have a first interface to a first neighbouring process control device and a second interface to a second neighbouring process control device, where the first neighbour may be a

preceding process control device in the alarm or process flow and the second neighbour may be a following process control device in the alarm or process flow. An alarm in respect of the process control device may also have differently close relationships to the first interface and to the second interface. The alarms of the alarm flow may thereby also have an order of flow within a certain process control device from a link or first interface to a first neighbouring process control device to a link or second interface to a second neighbouring process control device. According to variations of the invention, if an alarm of said certain process control device is more closely related to the first neighbouring process control device than the second neighbouring process control device in the alarm flow or process flow, i.e. has a closer relationship or stronger connection to the first interface than to the second interface, then the corresponding alarm indicator is provided closer to the first border than the second border. It can thereby be seen that the alarm indicators are assigned positions within the display object from the first border to the second border according to the relative relationships of the corresponding alarms to the first and second process control object interfaces. Thus the location of an individual alarm indicator within the display object and the order of the alarm indicators within the display object may reflect the relationships of the corresponding alarms to the interfaces of neighbouring display objects. In the example of fig. 3, it can for instance be assumed that an alarm in or for the seventh field device 34 closer to a connection point to the sixth field device 32 than to a connection point to the eighth field device 36, will be signalled through an alarm indicator in the seventh display object 68 that is provided closer to the border to the sixth display object 66 than the border to the eighth display object 70. If the alarm is generated at the physical interface between the process control devices then the position of the alarm indicator may also be provided at the border or interface between the two display objects representing the process control devices.

Put differently, the process control object and the alarm indicators in them are placed in the alarm summary screen ASS based on knowledge of the

process architecture and how the process control objects are organized in the system as well as where in the process control object alarms are generated. Such knowledge can be used to automatically arrange all the possible alarm indicators in the display objects, so that neighbouring or adjacent alarm indicators within one display object would represent elements in the process control device that can produce alarms and that have similar relationship to one or more process control device interfaces. This means that the location of an alarm in a process control device can be easily recognized and identified. It is also possible to visually identify clusters of alarms stretching between neighbouring process control devices in the process flow.

This type of mapping can be used with great advantage, in such a way that visual patterns which are formed of alarms become meaningful. It is thereby possible to identify alarm indicator clusters, which may be used to identify alarms having the same origin. It is also possible to identify similarities in different display objects, such as a row of 9 alarm indicators, see fig. 4 and the nine neighbouring display objects at the lower side of the eighth display object 70.

Another important advantage of the mapping of display objects as well as the alarm indicators in them is that it is possible to visualize the relationships between alarms in case there is an alarm flood along the process flow. It is thus possible to turn an alarm flood into an understandable situation.

This is exemplified in fig. 5. Here it can be seen that there is a pattern of alarm indicators from the first display object 56, via the second display object 58, in parallel via the third to fifth display objects 60 - 64, through the sixth, seventh and eighth display objects 66, 68 and 70 and through the fourteenth display object 82. However, it can also be seen that the alarm indicators in the ninth – thirteenth display objects 72 – 80 are very few, while none are present in the fifteenth to seventeenth display objects

84 – 88. The path of the alarm flood through the corresponding process control devices can thereby readily be visualized. Thereby it is also easier for the control room operator to determine the root cause of the alarm flood and perform the appropriate corrective action.

When the information is properly organized-visualized in the above described way, the wealth of alarms becomes useful. There is no need for reducing the number of alarms. It can in fact be argued that a reduction in the amount of alarms would harm the obtaining of the detailed picture of the situation. Thus, instead of reducing the amount of alarm information it is here proposed that the existing alarm information is organized with the help of visualization.

This has a number of advantages. The alarm flood overview may be obtained without the need for computational intense data mining. The alarm flood overview may thus be obtained in a simple, fast and effortless way. No active interaction is required. It may also be possible to see how the alarm flood changes over time.

As can be seen in fig. 6, the operator may also obtain further information about alarms in the alarm summary screen ASS through selecting a certain alarm indicator, which may be done through hovering over or marking the alarm indicator. In such further information more data about the alarm and alarm flow as well as the time stamp of the alarm may be obtained, which may further simplify for the operator in making the correct decision. The operator may thus hover over an alarm indicator to bring up a tooltip 91 with an alarm description. The operator may then also see where the alarm takes place in an “alarm rate over time” graph 92. It is thus possible to obtain an alarm flow history, i.e. statistics of previous alarm flows through the process control entity chain, comprising alarms of one or more previous alarm flows, which previous alarm flows include alarm floods, compare the investigated alarm and current alarm flow through the process control entity chain with the same alarm(s) and alarm flow(s) of

the alarm flow history in order to determine the position of the investigated alarm in the current alarm flow through the process control entity chain. It is also possible to predict the future progress of the current alarm flow based on said current and historic alarm flows and display the location of the selected alarm in the total alarm flow, which total alarm flow is made up of the current alarm flow up to a current point in time and a predicted remaining part.

Another possible use of statistics is to compare a current alarm flow with historic alarm floods and if the current alarm flow is found to correspond to a historic alarm flood, then a root cause alarm of the current alarm flow may be identified as an alarm in the current alarm flow that corresponds to a known root cause alarm in the historic alarm flood.

This can be used for early indication of an alarm flood and allows correct counter-measures to be performed faster.

The above-described alarm summary screen ASS has a number of further advantages.

The increased data density of the 2D visualization makes scrolling unnecessary. The operator may thus perceive the complete alarm picture all at once, which increases situational awareness. The visualization of the alarm summary screen provides overview first, then details may be obtained on demand, which is how the visualizations are supposed to be designed. The design of the alarm summary screen is based on pre-attentive capabilities of human perception, rather than attentive capabilities (reading), which also speeds up the transfer of information.

The design allows meaningful relationships between the triggered alarms to be shown. Anomalies, similarities, clusters and parent-child relations become evident, things that would otherwise require computation-heavy

machine learning algorithms. The use of such algorithms is furthermore undesirable in the timeframe of the control room operations.

Below some further advantages are listed:

☐ Increased usability of the control room

☐ Increased productivity of the control room operators.

☐ Increased situational awareness of the operators and as a result, safety of the industrial plant

☐ Decreased error rate of the operators, connected to reading the table lines in a stressed environment

☐ In the end, less accidents, less equipment and material losses, which occur as the result of inappropriate or ineffective alarming

The provision of the alarm summary screen ASS is made using an alarm summary screen generating device. One example of such a device is schematically shown in fig. 7. The device 93 comprises a control unit 96 and optionally also a user interface 94. The control unit 96 is with advantage implemented through a processor 98 with accompanying computer program memory 100 comprising computer program code which provides the alarm summary screen ASS and possibly also the alarm list for display on a display of the user interface 94. The control unit 96 may be implemented in a computer of the process control system such as the first or the second computer. As an alternative it may also be provided through an operator terminal or a central control room computer. The user interface 94 is with advantage a user interface of an operator terminal. Hence the optional inclusion in the alarm summary screen generating device, when it is not an operator terminal. The alarm summary screen generating device may more particularly form an alarm handling arrangement together with one or more alarm generating devices of the process control system. The alarm handling arrangement may furthermore

also comprise the process control devices for which the alarms are generated.

Fig. 8 shows a flow chart of a number of method steps in a corresponding method of generating an alarm summary screen and being performed by the control unit 96 of the alarm summary screen generating device 93.

The method may start with the optional step of collecting alarm data, step 102. The alarm data may be collected from alarm generating devices, where, as was described earlier, an alarm generating device may be a field device, a control or protection computer or an operator terminal. However the alarm data from an alarm generating device may also be stored in the database 20. Therefore the control unit 96 of the alarm summary screen generating device 93 may collect the alarm data from the database 20 instead.

Once the alarm data has been collected, the control unit may then optionally analyse the alarm data with regard to source and causal dependencies in order to determine an alarm flow, step 104, where an alarm source may be a process control device. This may be done through analysing which alarms from which alarm sources cause alarms in other sources as well as which alarm in some sources causes alarms at other location within the same source. A causal dependency or statistical dependency may be determined to exist if an alarm in one point of an alarm source is consistently followed closely in time by an alarm at another point of the same or a different source.

The results of the analysis are then used in a number of different ways by the control unit 96. Based on the process control entity division that the operator uses or desires to use, the control unit 96 determines the links between process control entities and thereby forms at least one process control entity chain, step 106. The control unit 96 also determines the

alarm flow within the process control entities based on the analysis, step 108.

As an alternative the causal dependency may be known in advance based on knowledge of the process flow and the behaviour of the process control devices in it. In this case the links between the process control entities and the alarm flow within them may already be known or considered as known. It is also possible that a combination of process flow knowledge and alarm data analysis is used.

Thereafter the control unit 96 determines the bordering between the display objects, step 110. It thus uses the knowledge of links between process control entities in order to decide which display objects are to be placed next to each other. It also determines the alarm indicator placing within the display objects, step 112, which may be done using the knowledge of alarm flow within the process control entities. Thereafter the control unit 96 forms display objects and links them to each other based on the determined bordering, step 114, i.e. places the objects adjacent each other on the alarm summary screen according to the determined bordering. A process control entity may, as was previously mentioned, be a process control device or a higher linked element, such as an industrial plant section with a number of process control devices. It is here also possible that the sections may operate completely separate subprocesses for which no causal dependency is known to exist beforehand.

Thereafter the control unit 94 forms the alarm indicators within each process control entity and links them to each other according to the determined alarm indicator placing, step 116, i.e. places the alarm indicators adjacent each other in the display object according to the determined alarm indicator placing. The alarms that may occur closer to the interfaces of process control devices at neighbouring process control entities may here furthermore be placed close to the border between the display objects.

Once this has been done the control unit 96 provides the alarm summary screen ASS with the linked display objects comprising the placed alarm indicators, step 118. The providing may be performed through displaying the alarm summary screen ASS on the display 94, with advantage together with an alarm list AL. The providing of the alarm summary screen may more particularly also comprise placing alarm indicators within a certain display object in the display object chain from a border with a first neighbouring display object to a border with a second neighbouring display object in the order of flow of the corresponding alarms in the process control entity chain from a link of the corresponding control entity to a first neighbouring control entity to a link of the control entity to a second neighbouring control entity.

The control unit 96 may also monitor the generation of alarms that an operator subscribes to and display the alarms in the alarm list and the corresponding alarm indicators when these alarms occurs in the process control system.

One example of how this may be done is shown in a flow chart in fig. 9, which shows a number of method steps of operating the alarm summary screen.

The control unit 96 receives alarms from the alarm generating devices, step 120. It causes the alarm indicators to occupy on-states corresponding to the alarms, step 122. For a specific alarm this may involve causing the corresponding alarm indicator to occupy an on-state corresponding to the type of alarm, which may be done through displaying the alarm indicator using a dedicated on-state colour or pattern. Thereby the on-state is also triggered by the alarm. The control unit 96 also displays the alarms in the alarm list AL, step 124. The control unit 96 may also monitor any inputs of the operator via the operator interface with regard to an alarm indicator. When the control unit 96 detects a selection of a specific alarm indicator,

step 126, it investigates if the corresponding alarm is in the visible section of the alarm list AL. If it is not, step 128, the control unit 96 scrolls the alarm list AL so that the alarm enters the visible section, step 130, and when the alarm is in the visible section or if it was there all the time, the alarm is emphasized, step 132, such as through being highlighted.

This is an important feature, especially in the case of alarm floods. The operator may in this case identify the root alarm in the alarm flood in the alarm summary screen through looking at the pattern of the alarm flow. By selecting the alarm indicator of the root alarm, the alarm is moved into the visible section of the alarm list and then emphasized.

Thereby the operator may directly understand the root cause of the alarm flood and implement the correct counter measure in a fast and efficient way.

In case of an alarm flow being a possible alarm flood, the control unit may also determine the actual progress of the current alarm flow, predict the future progress of the current alarm flow and show to the current location of an alarm corresponding to a second alarm indicator in the progress of the total alarm flow. This may be done by showing the position of the alarm corresponding to the operator selected alarm indicator in the curve of the alarm flow over time.

Another possible variation is that the control unit may identify a root cause alarm in a current alarm flow.

This may be done in the following way.

The operator may look at the alarm summary screen and notice that there seems to be a flow of alarms that is a potential alarm flood. He or she may then select an alarm flood detecting function.

The control unit may in this case receive the user selection of alarm flood detection. It then compares the current alarm flow with historic alarm floods. It may more particularly compare the pattern of alarms in the current alarm flow with the patterns of one or more historic alarm floods. If no match is found, the control unit then informs the user. However, if a match is found, i.e. if the current alarm flow is found to be an alarm flood, the control unit then identifies a root cause alarm in the current alarm flow.

The control unit may identify the root cause alarm as an alarm in the current alarm flow that corresponds to a known root cause alarm in the historic alarm flood.

Thereafter the control unit informs the user about the root cause alarm. This may with advantage be done through indicating the alarm in alarm summary screen, for instance with a special colour. It may additionally involve indicating the root cause alarm in the alarm list, where scrolling may be performed in case the root cause alarm is not present in the visible section.

Thereby the operator can directly see which alarm is a root cause alarm and may perform the necessary counter-measures.

The control unit of the alarm summary screen generating device may, as was previously mentioned, be provided in the form of one or more processors together with computer program memory including computer program code for performing its functions. As an alternative it may be provided in the form of an Application Specific Integrated Circuit (ASIC) or a Field-Programmable Gate Array (FPGA). This computer program code may also be provided on one or more data carriers which perform the functionality of the control unit when the program code is being loaded into a computer forming the summary screen generating device. One such data carrier 134 with computer program code 136, in the form of a CD

ROM disc, is schematically shown in fig. 10. Such computer program may as an alternative be provided on another server and downloaded therefrom into the summary screen generating device.

5

CLAIMS

1. An alarm handling arrangement in a process control system (10), the arrangement comprising:

- at least one alarm generating device configured to generate alarms based on sensor measurements in the process control system,
- an alarm summary screen generating device (93) comprising a control unit (96) configured to
  - provide an alarm summary screen (ASS) comprising a number of display objects (56 – 90), each display object representing a process control entity (22 – 54) and comprising a number of alarm indicators (AI), each alarm indicator being assigned a specific position in the display object, having an off state and being able to occupy at least one on-state if triggered by a corresponding alarm generated for the process control entity by the at least one alarm generating device, where the alarms of at least some of the process control entities (22 – 54) have a causal dependency on each other, thereby providing an alarm flow through these process control entities forming at least one process control entity chain of linked process control entities,
  - wherein the display objects (56 – 88) associated with the process control entities (22 – 54) of said process control entity chain are organized on the alarm summary screen in a display object chain with display objects that border each other, where the order of the display objects in the display object chain follows the order of the process control entities in the process control entity chain.

2. The alarm handling arrangement according to claim 1, wherein at least one display object in the display object chain has a first border with a first neighboring display object and a second border with a second neighboring display object, where the first border represents a first interface between a corresponding process control entity and a first

neighboring process control entity and the second border represents a second interface between said corresponding process control entity and a second neighboring entity, where the alarms of said process control entity in said alarm flow have differently close relationships to the first and second interfaces and the alarm indicators are assigned locations within the display object from the first border to the second border, which locations reflect the relative relationships of the corresponding alarms to the first and second interfaces.

3. The alarm handling arrangement according to claim 1 or 2, wherein the control unit (96) is configured to analyse a number of alarms, determine links of the at least one process control entity chain based on the analysis, determine the bordering between the display objects of the corresponding display object chain based on the process control entity chain and arrange the display objects in the alarm summary screen according to said determined bordering of the display object chain.

4. The alarm handling arrangement according to any previous claim, wherein the process control entities are connected in the process in a process flow order and the order of the process control entities in the process control entity chain is the process flow order.

5. The alarm handling arrangement according to claim 4, wherein the process control entities of said process control entity chain are process control devices involved in the process physically connected with each other and the borders between the display objects of the corresponding display object chain correspond to interfaces between said process control devices of said process control entity chain.

6. The alarm handling arrangement according to any of claims 1 – 4, wherein the process control entities comprise industrial plant sections, each comprising process control devices involved in the process.

7. The alarm handling arrangement according to any of claims 1 – 6, wherein the control unit (96) is configured to receive an alarm generated by the alarm generating device and cause the corresponding alarm indicator to occupy the on-state.

8. The alarm handling arrangement according to claim 7, the control unit (96) being further configured to display said alarm (A) in an alarm list (AL) and emphasise said alarm (A) based on a user selection of the corresponding alarm indicator (AI).

9. The alarm handling arrangement according to claim 8, wherein the alarm list has a visible section and if the alarm corresponding to the selected alarm indicator is outside of the visible section, the control unit (96) is further configured to scroll the alarm list so that said alarm enters the visible section.

10. The alarm handling arrangement according to any of claims 7 - 9, wherein the alarm generating device is configured to generate several alarms in a current alarm flow through the process control entity chain and the control unit (96) is configured to receive said alarms, determine a progress of the current alarm flow based on the received alarms, predict the future progress of the alarm flow based on the alarms of the current alarm flow and statistics of previous alarm flows, receive an operator selection of an alarm indicator and display the location of the alarm corresponding to the selected alarm indicator in the progress of the total current alarm flow.

11. The alarm handling arrangement according to any of claims 7 – 10, wherein the alarm generating device is configured to generate several alarms in a current alarm flow through the process control entity chain and the control unit (96) is configured to receive said alarms, compare the current alarm flow with at least one historic alarm flood, and identify, if the current alarm flow is found to correspond to a historic alarm flood, an

alarm of the current alarm flow that corresponds to a known root cause alarm in the historic alarm flood to be a root cause alarm.

12. A method for handling alarms in a process control system (10), the method being performed by an alarm handling arrangement in the process control system and comprising the step of:

- providing (118) an alarm summary screen (ASS) comprising a number of display objects (56 – 90), each display object representing a process control entity (22 – 54) and comprising a number of alarm indicators (AI), each alarm indicator being assigned a specific position in the display object, having an off state and being able to occupy at least one on-state if triggered by a corresponding alarm generated for the process control entity by at least one alarm generating device of the process control system, where the alarms of at least some of the process control entities (22 – 54) have a causal dependency on each other, thereby providing an alarm flow through these process control entities forming at least one process control entity chain of linked process control entities,
- wherein the display objects (56 – 88) associated with the process control entities (22 – 54) of said process control entity chain are organized on the alarm summary screen in a display object chain with display objects that border each other, where the order of the display objects in the display object chain follows the order of the process control entities in the process control entity chain.

13. The method according to claim 12, wherein at least one display object in the display object chain has a first border with a first neighboring display object and a second border with a second neighboring display object, where the first border represents a first interface between a corresponding process control entity and a first neighboring process control entity and the second border represents a second interface between said corresponding process control entity and a second neighboring entity, where the alarms of said process control entity in said alarm flow have

differently close relationships to the first and second interfaces and the alarm indicators are assigned locations within the display object from the first border to the second border, which locations reflect the relative relationships of the corresponding alarms to the first and second interfaces.

14. The method according to claim 12 or 13, further comprising analysing (104) a number of alarms, determining (106) links of the at least one process control entity chain based on the analysis, determining (110) the bordering between the display objects of the corresponding display object chain based on the process control entity chain and arranging (114) the display objects in the alarm summary screen (ASS) according to said determined bordering of the display object chain.

15. The method according to any of claims 12- 14, wherein the process control entities are connected in the process in a process flow order and the order of the process control entities in the process control entity chain is the process flow order.

16. The method according to claim 15, wherein the process control entities of said process control entity chain are process control devices involved in the process physically connected with each other and the borders between the display objects of the corresponding display object chain correspond to interfaces between said process control devices of said process control entity chain.

17. The method according to any of claims 12 - 15, wherein the process control entities comprise industrial plant sections, each comprising process control devices involved in the process.

18. The method according to any of claims 12 – 17, further comprising receiving (120) an alarm generated by an alarm generating

device and causing (122) the corresponding alarm indicator to occupy the on-state.

19. The method according to claim 18, further comprising displaying (124) said alarm (A) of the process control entity in an alarm list (AL) and emphasising (132) said alarm (A) based on a user selection (126) of the corresponding alarm indicator (AI).

20. The method according to claim 19, wherein the alarm list has a visible section and further comprising scrolling (130) the alarm list if the alarm corresponding to the selected alarm indicator is initially outside of the visible section so that said alarm enters the visible section.

21. The method according to any of claims 18 - 20, wherein the receiving of alarms comprises receiving several alarms in a current alarm flow and further comprising the steps of determining a progress of the current alarm flow through the process control entity chain based on the received alarms, predicting the future progress of the alarm flow based on the received alarms and statistics of previous alarm flows, receiving an operator selection of an alarm indicator and displaying the location of the alarm corresponding to the selected alarm indicator in the progress of the total current alarm flow.

22. The method according to any of claims 18 – 21, wherein the receiving of alarms comprises receiving several alarms in a current alarm flow and further comprising the steps of comparing the current alarm flow with at least one historic alarm flood, and identifying, if the current alarm flow is found to correspond to a historic alarm flood, an alarm of the current alarm flow that corresponds to a known root cause alarm in the historic alarm flood to be a root cause alarm.

23. An alarm summary screen generating device (93) for generating an alarm summary screen (ASS) in a process control system (10), the device (93) comprising:

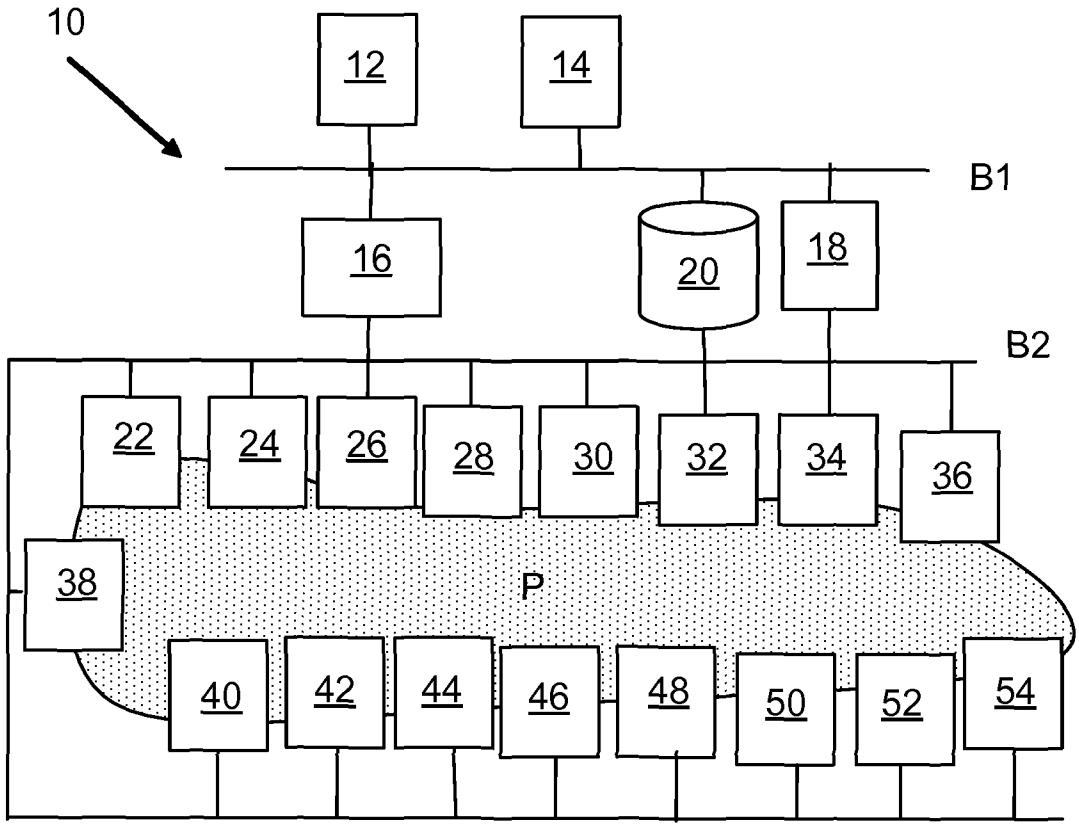
- a control unit (96) configured to
  - provide an alarm summary screen (ASS) comprising a number of display objects (56 – 90), each display object representing a process control entity (22 – 54) and comprising a number of alarm indicators (AI), each alarm indicator being assigned a specific position in the display object, having an off state and being able to occupy at least one on-state if triggered by a corresponding alarm generated for the process control entity by at least one alarm generating device of the process control system, where the alarms of at least some of the process control entities (22 – 54) have a causal dependency on each other, thereby providing an alarm flow through these process control entities forming at least one process control entity chain of linked process control entities,
  - wherein the display objects (56 – 88) associated with the process control entities (22 – 54) of said process control entity chain are organized on the alarm summary screen in a display object chain with display objects that border each other, where the order of the display objects in the display object chain follows the order of the process control entities in the process control entity chain.

24. A computer program product for handling alarms in a process control system (10), said computer program product being provided on a data carrier (134) comprising computer program code (136) configured to cause an alarm handling arrangement to, when said computer program code is loaded into said alarm handling arrangement,

- provide an alarm summary screen (ASS) comprising a number of display objects (56 – 90), each display object representing a process control entity (22 – 54) and comprising a number of alarm indicators (AI), each alarm indicator being assigned a specific position in the display object, having an off state and being able to occupy at least one on-state if triggered by a corresponding alarm generated for the process control entity by at least one alarm generating device of the process control system, where the alarms of at least some of the process

control entities (22 – 54) having a causal dependency on each other, thereby providing an alarm flow through these process control entities forming at least one process control entity chain of linked process control entities,

- wherein the display objects (56 – 88) associated with the process control entities (22 – 54) of said process control entity chain are organized on the alarm summary screen in a display object chain with display objects that border each other, where the order of the display objects in the display object chain follows the order of the process control entities in the process control entity chain.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12
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B1
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B2
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Fig. 1

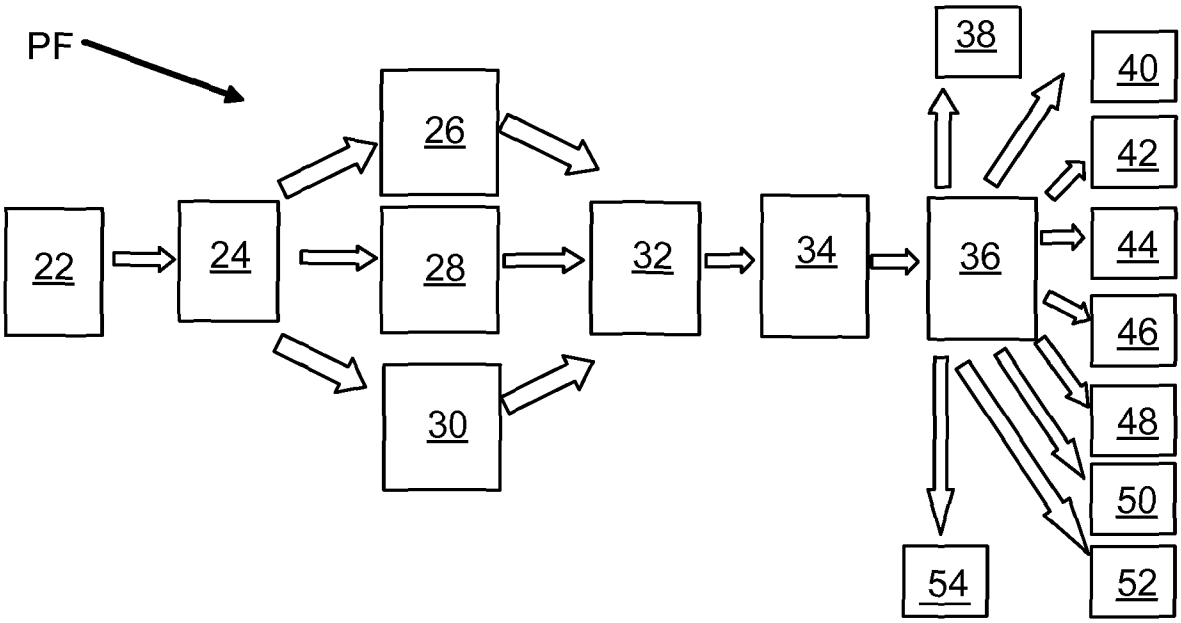
PF
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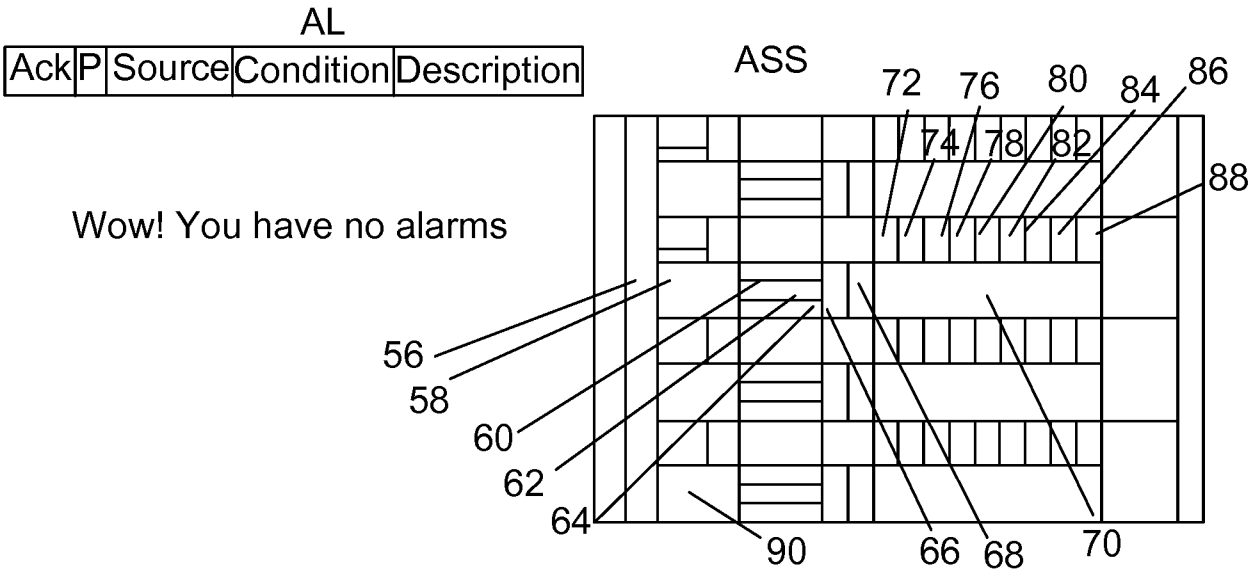
Fig. 2


AL
Ack
P
Source
Condition
Description
Wow! You have no alarms
ASS
72
76
80
84
86
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88
56
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70

Fig. 3

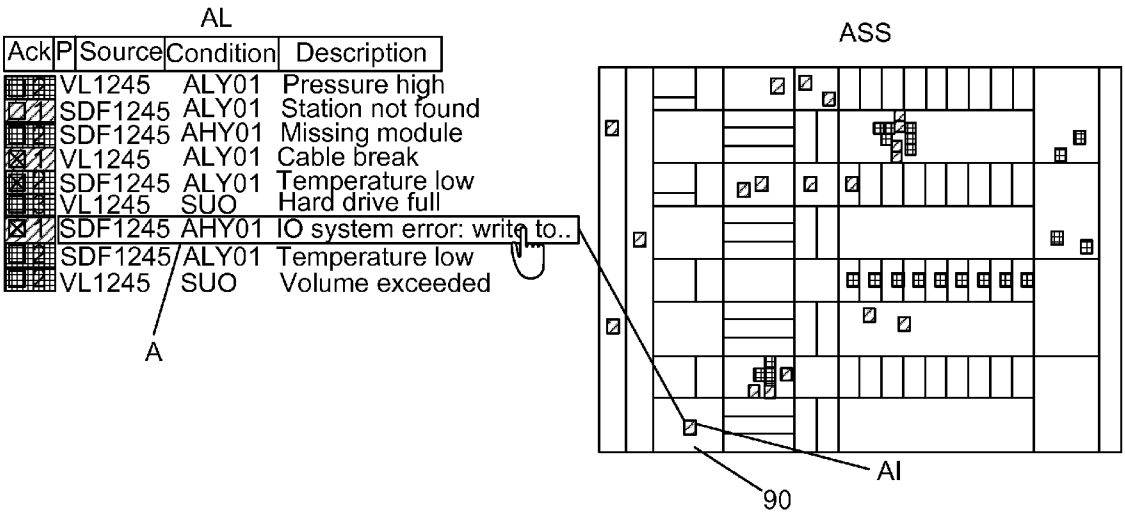
AL
Ack
P
Source
Condition
Description
VL1245 ALY01 Pressure high
SDF1245 ALY01 Station not found
SDF1245 AHY01 Missing module
VL1245 ALY01 Cable break
SDF1245 ALY01 Temperature low
VL1245 SUO Hard drive full
SDF1245 AHY01 IO system error: write to..
SDF1245 ALY01 Temperature low
VL1245 SUO Volume exceeded
A
ASS
AI
90

Fig. 4

AL

Ack	P	Source	Condition	Description
		VL1245	ALY01	Pressure high
		SDF1245	ALY01	Station not found
		VL1245	SUO	Motor lifetime near to end
		SDF1245	ALY01	Missing module
		VL1245	ALY01	Cable break
		SDF1245	ALY01	Temperature low
		VL1245	SUO	Hard drive full
		SDF1245	ALY01	IO system error: write to..
		VL1245	ALY01	Historian error: disk is full
		SDF1245	ALY01	Temperature low
		VL1245	SUO	Volume exceeded
		SDF1245	ALY01	Emergency valve open
		VL1245	ALY01	Flow reached critical level
		SDF1245	ALY01	Gas detected
		VL1245	SUO	Power cable break
		SDF1245	ALY01	Pressure low
		VL1245	ALY01	Missing support module
		SDF1245	ALY01	Flow high

ASS

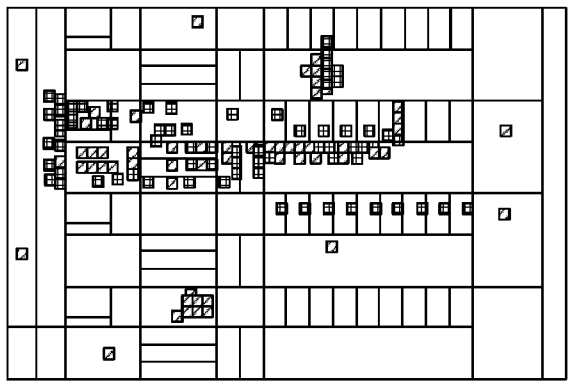

Fig. 5

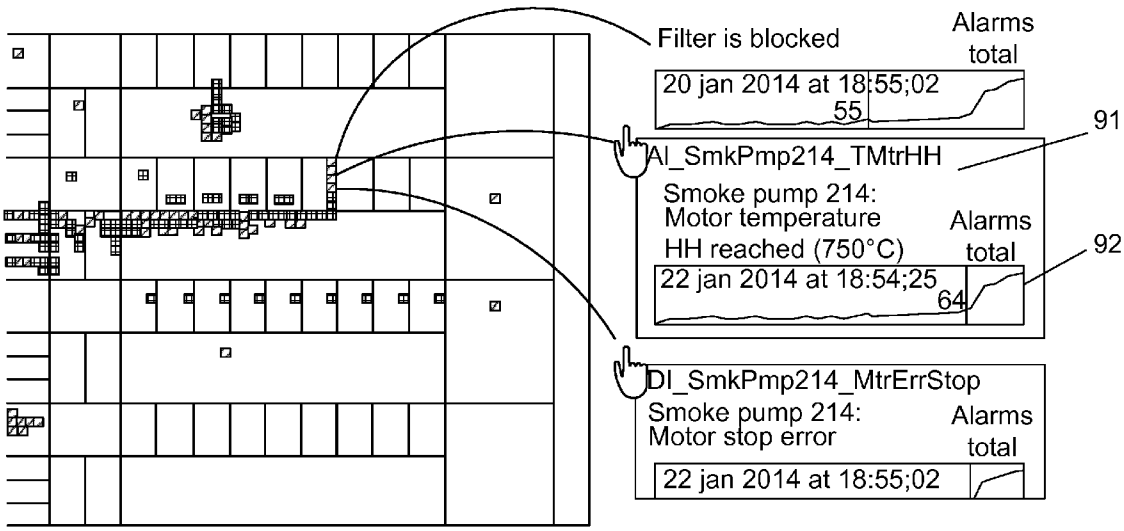
Filter is blocked
Alarms total
20 jan 2014 at 18:55;02
55
91
AI_SmkPmp214_TMtrHH
Smoke pump 214:
Motor temperature
HH reached (750°C)
Alarms total
92
22 jan 2014 at 18:54;25
64
DI_SmkPmp214_MtrErrStop
Smoke pump 214:
Motor stop error
Alarms total
22 jan 2014 at 18:55;02

Fig. 6

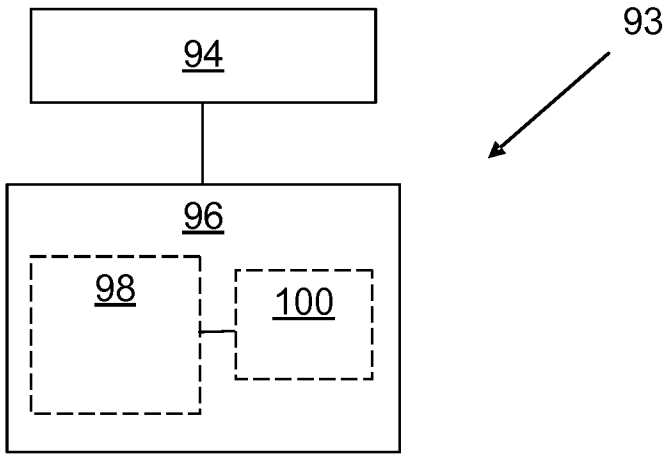

Fig. 7

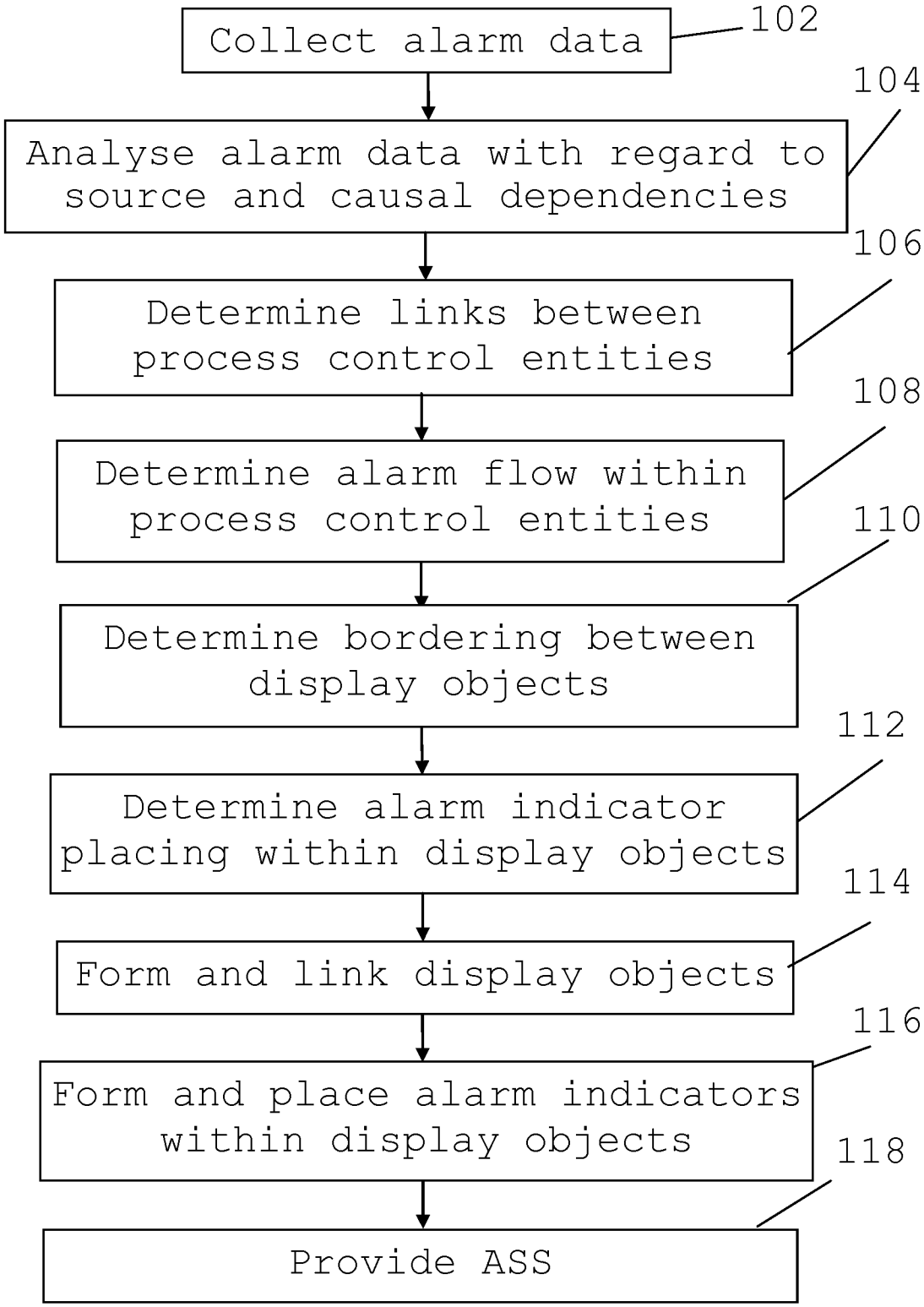
Collect alarm data
102
Analyse alarm data with regard to source and causal dependencies
104
Determine links between process control entities
106
Determine alarm flow within process control entities
108
Determine bordering between display objects
110
Determine alarm indicator placing within display objects
112
Form and link display objects
114
Form and place alarm indicators within display objects
116
Provide ASS
118

Fig. 8

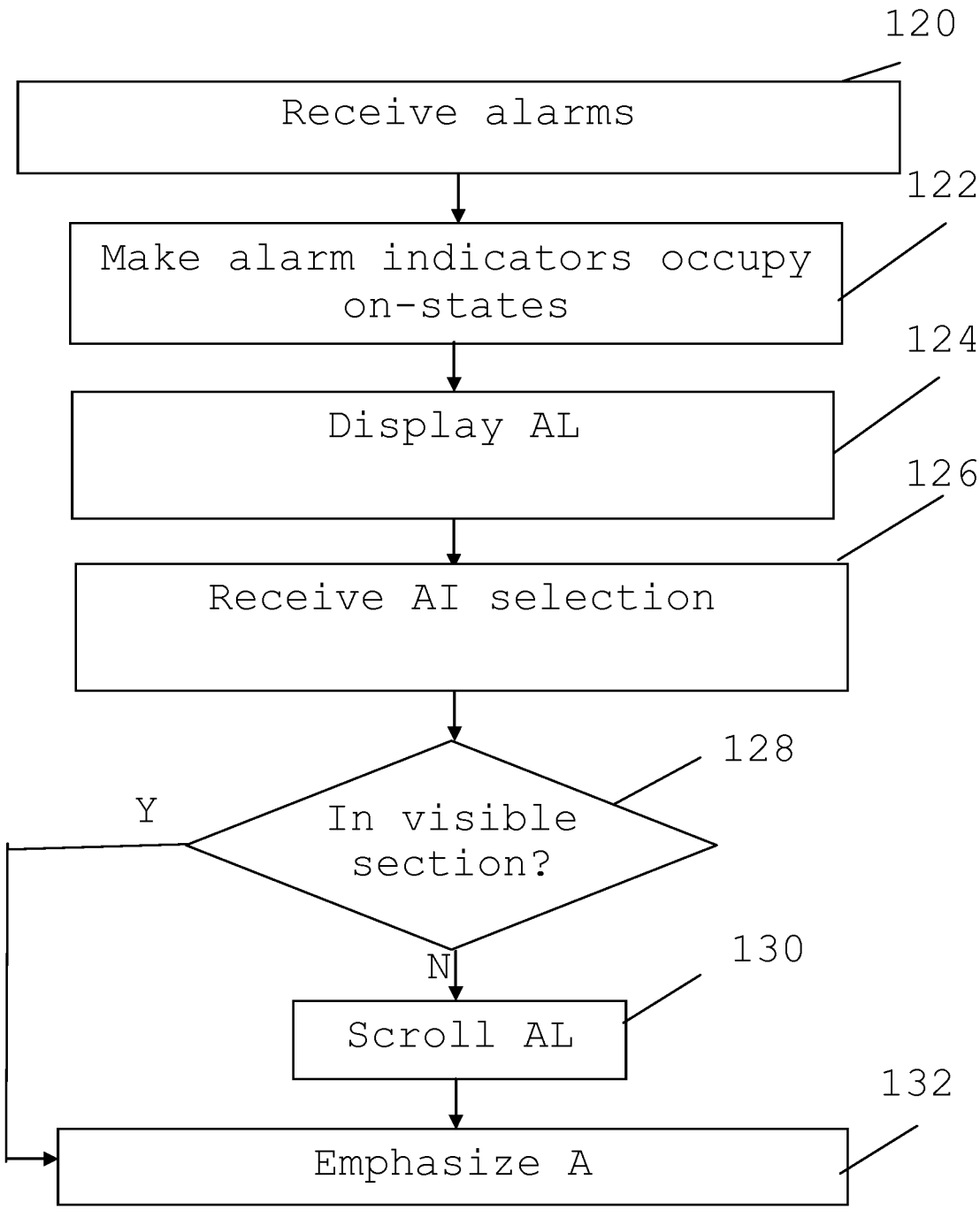
120
Receive alarms
122
Make alarm indicators occupy on-states
124
Display AL
126
Receive AI selection
128
In visible section?
Y
N
130
Scroll AL
132
Emphasize A

Fig. 9

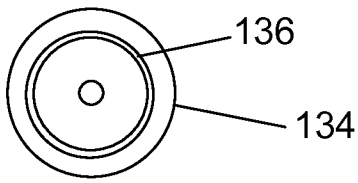
136
134

Fig. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/061041

A. CLASSIFICATION OF SUBJECT MATTER
INV. G05B23/02 G08B21/18
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G05B G08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 690 274 B1 (BRISTOL EDGAR H [US]) 10 February 2004 (2004-02-10) column 1, line 10 - column 40, line 32; figures 1-40 -----	1-24
X	US 2013/099916 A1 (CAMP KIM ORDEAN VAN [US] ET AL) 25 April 2013 (2013-04-25) paragraph [0001] - paragraph [0048]; figures 1-5 -----	1-24

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 December 2015	18/12/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Barriuso Poy, Alex

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/061041

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6690274 B1	10-02-2004	NONE	
US 2013099916 A1	25-04-2013	CN 103064330 A	24-04-2013
		DE 102012110129 A1	25-04-2013
		GB 2496279 A	08-05-2013
		JP 2013093028 A	16-05-2013
		US 2013099916 A1	25-04-2013