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(54) ALARM NOTIFICATION DEVICE

(57) An alarm notification device having an optimized power draw function in which it a voltage on a supply line to which it is connected is sensed and then used to proactively determine a current to be drawn by the device. In this way, the current drawn by the device on start up can be controlled to avoid an undesirable current surge or overshoot. Moreover, the device may be sensitive to an under voltage condition on the supply line and adapt its operation in order to reduce or eliminate a risk of the supply line becoming catastrophically overloaded. The device may be arranged to provide an alert that indicates the presence of the under voltage condition.

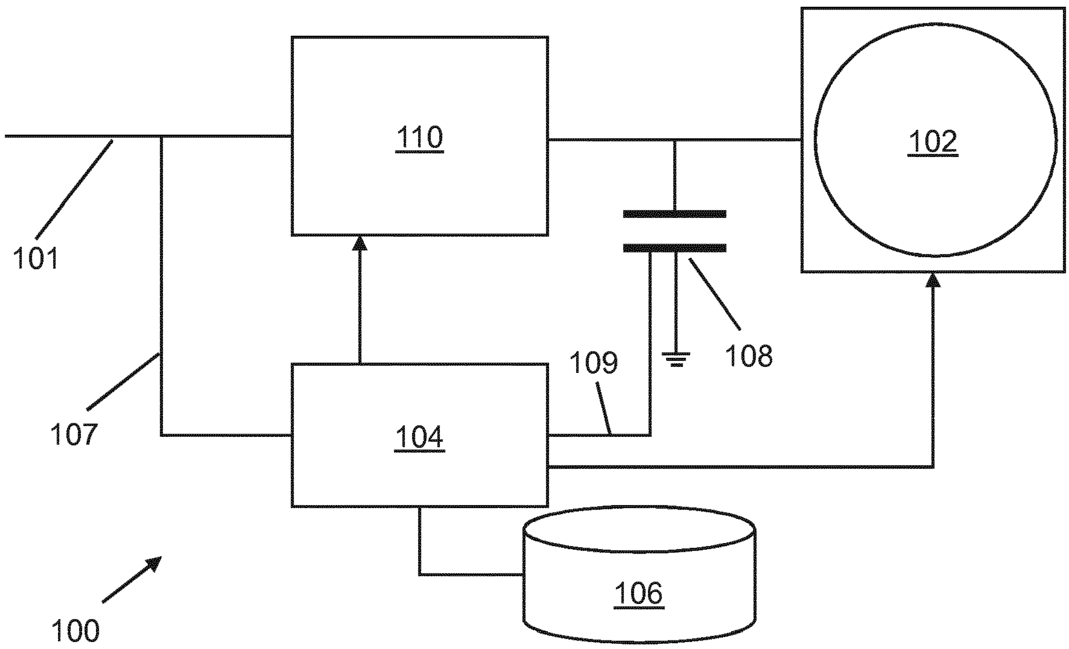

FIG. 1

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Description

FIELD OF THE INVENTION

[0001] The invention relates to alarm notification devices, and in particular to a technique for controlling the power drawn by such devices during operation. The invention may be particularly applicable to non-addressable alarm notification devices, i.e. devices without a dedicated communication channel to a central controller.

BACKGROUND TO THE INVENTION

[0002] It is well known to equip commercial buildings with a set of sensors and alarm notification devices for detecting and notifying occupants of an emergency situation, such as a fire. It is increasingly common for alarm notification devices to provide a visible alert, e.g. in the form of a flashing beacon, preferably in addition to an audible alert. Such notification devices are known as visual alarm devices (VADs), and typically comprise a light-emitting diode (LED) or other light source configured to strobe at a predetermined level of illumination.

[0003] In Europe, the standard EN54-23 governs the required behaviour of a VAD, by setting a required minimum illumination level across the area of coverage of a given notification device. In order to comply with the standard, the notification device must obtain sufficient energy from a supply line to which it is connected in order to provide an activation pulse to enable the light source to emit at least the minimum illumination level.

[0004] Some devices are configured to draw a predetermined level of current from the supply line in order to provide sufficient power in the activation pulse. Such devices are often inefficient, because they typically draw more power than needed. The surplus power is lost, e. g. into a dump load.

[0005] Other devices operate to draw sufficient current from the supply line so that the activation pulse delivers energy to notification device at a predetermined power. Such devices generally use some form of electrical charge storage device (e.g. a capacitor or the like) that is discharged during the activation pulse. In normal operation, the current drawn from the supply line by such devices is inversely proportional to the voltage. This type of "constant power" device is generally more power-efficient that the "constant current" devices mentioned above. However, the "constant power" type of operation can cause current surges on the supply line, especially on initial power up of the device. This effect limits the number of devices that can be connected on one supply line.

SUMMARY OF THE INVENTION

[0006] At its most general, the present invention proposes an alarm notification device that is sensitive to an under voltage condition on the supply line and adapt its operation in order to reduce or eliminate a risk of the line becoming catastrophically overloaded. The device may be arranged to provide an alert that indicates the presence of the under voltage condition. The alarm notification device may also be provided with an optimized power draw functionality, in which the device can operate to sense a voltage on a supply line to which it is connected and proactively determine a current to be drawn by the device using the sensed voltage. In this way, the current drawn by the device on start up can be controlled to avoid an undesirable current surge or overshoot.

[0007] According to one aspect of the invention, there is provided a non-addressable alarm notification device comprising: current control circuitry arranged to adaptively draw current from a supply line; an output device that is selectively activatable to draw power from the current control circuitry to generate an alert signal; and an controller configured to: obtain an input indicative of voltage on the supply line; compare the input indicative of voltage on the supply line to a predetermined threshold; and enter an under voltage prevention mode if a result of the comparison indicates that the voltage on the supply line falls below the threshold, wherein, in the under voltage prevention mode, the current drawn by the current control circuitry is clamped. The controller may be configured to clamp the current drawn, e.g. by forcing the current control circuitry to draw a fixed current, regardless of conditions on the supply line. Thus, during a normal operation cycle of the output device, the controller is configured to compare the input indicative of voltage on the supply line to a predetermined threshold, and enter an under voltage prevention mode if a result of the comparison indicates that the voltage on the supply line has fallen below the threshold. The controller may be arranged to set the predetermined threshold. For example, the controller may be configured to determine an operational voltage on the supply line just before the output device generates an initial alert signal (e.g. at the end of the start up process); and set the predetermined threshold using the determined operational voltage.

[0008] In the under voltage prevention mode, the device may operate in a cyclical manner according to an under voltage operation cycle that comprise an alert period and a recharge period, as discussed below. However, in each under voltage operation cycle, the processor bypasses routines for adjusting the current control circuitry. Accordingly, in the under voltage prevention mode, the processor is configured to clamp the current drawn by the current control circuitry. Clamping the current in this way can prevent the device from adding further load to the supply line. The alarm notification device therefore provides an independent fail-safe mechanism to guard against drops in voltage on the supply line causing it to collapse.

[0009] The device may comprise an under voltage indicator that is activated by the processor when operating in the under voltage prevention mode. The under voltage indicator may be an altered alert signal from the output device. In other words, a property of the alert signal provided by the output device is changed when the device is in the under voltage prevention mode. This enables the easy detection of an undesirable condition on the supply line, e.g. during device testing. In one example, where the output device comprises a light source, the altered alert signal may be comprise a double flash. However, any other suitable indicator may be used.

[0010] The alarm notification device is a non-addressable device (sometimes referred to in the art as a "conventional" device), whereby the controller operates independently of a control panel from which the supply line extends. The supply line may be arranged to supply a DC voltage. In practice the DC voltage may vary as loads are applied to the supply line. The controller may comprise a processor configured to determine at least one operational parameter of the current control circuitry using the input indicative of voltage on the supply line. In this device, the current control circuitry can thus be controlled proactively based on a voltage condition on the supply line, rather than reactively, for example, to meet a power demand from the output device. The proactive control of the current control circuitry by the processor enables the alarm notification device to adapt to those changes in a smooth and power-efficient manner.

[0011] The alarm notification device may further comprise a charge storage device connected to receive current from the current control circuitry, wherein the output device is selectively activatable to draw power from the current control circuitry and the charge storage device. The alarm notification device may be a visual alarm device (VAD), whereby the output device comprises a light source that is arranged to strobe using power drawn from the current control circuitry and the charge storage device. The light source may be an LED or the like.

[0012] The device may comprise a computer-readable memory accessible by the processor. The computer-readable memory may store a data structure that matches the voltage on the supply line with the operational parameter. The processor may be configured to look up the operational parameter from the data structure using the received input. The information in the data structure may be predetermined, e.g. through empirical observation of the operation of the device under different voltage conditions.

[0013] Herein, the phrase "selectively activatable" may mean that the output device is operable under certain conditions, e.g. in an emergency scenario or alarm condition. When activated, the output device may be operate in a cyclical manner, e.g. comprising a plurality of operation cycles each comprising an alert period and a recharge period. In the alert period the output device is arranged to draw power from the current control circuitry and charge storage device. In the recharge period the current control circuitry is arranged to supply current to the charge storage device.

[0014] The alarm notification device may be configured to perform a start up process during a start up period before the output device generates an initial alert signal (i.e. before it enters its first operation cycle). In the start up period, the processor may be configured to read the input, determine the operational parameter using the received input, and apply the determined operational parameter to the control circuitry a plurality of times. Using this technique, the current drawn by the current control circuitry may ramp up during the start up period while the voltage on the supply line settles to an operational value. The proactive control of the current control circuitry enables the current to rise to an operational level in a controlled manner, without undesirable overshoot. This means that the peak current requirement of the device may be less than equivalent devices without the proactive current control, which in turn can allow more devices to be safely connected on a single line.

[0015] The input indicative of the voltage on the supply line may be any suitable sensing signal that is readable by the processor. For example, the processor may comprise an analog-to-digital converter connectable to the supply line. The input may be a digital signal from the analog-to-digital converter that corresponds to the voltage on the supply line.

[0016] The current control circuitry may by arranged to draw current in an adaptive manner, e.g. sensitive to conditions on the supply line. For example, the drawn current may depend on supply line voltage and/or resistance, or on other parameters which after these properties, such as temperature. The current control circuitry may comprise an adjustable current source, such as a digitally controlled current source.

[0017] The charge storage device may comprise any suitable structure for storing and releasing electrical charge. For example, the charge storage device may comprise a capacitor.

[0018] After the start up period, the device may operate in a cyclic manner by performing a plurality of operation cycle in a normal operating mode. In the normal operating mode, the processor may be further configured, in each operation cycle, to read an input indicative of the charge status of the charge storage device. For example, where the charge storage device comprises a capacitor, the input indicative of the charge status may comprise an input indicative of a voltage across the capacitor. The input indicative of the voltage across the capacitor may be any suitable sensing signal that is readable by the processor. For example, the processor may comprise an analog-to-digital converter connectable to the capacitor. The input may be a digital signal from the analog-to-digital converter that corresponds to the voltage across the capacitor.

[0019] The processor may be arranged to compare the charge status of the charge storage device with a predetermined target value, and adjust the current control circuitry using a result of the comparison. The magnitude of the adjustment in this scenario may be constrained, so that the change to the current between adjacent operation cycles is limited. This assists in maintaining a stable voltage on the supply line. In one example, where the current control circuitry comprises a digitally controlled current source, the processor may be configured to perform a least significant bit adjustment of the digitally controlled current source using the result of the comparison.

[0020] The alarm notification device may be arranged to gradually ramp up the power taken by the output device through an initial set of operation cycles. This can be done through control of the predetermined target value. For example, the processor may be configured to increase the predetermined target value between each operation cycle of the initial set of operation cycles. In doing so, the comparison process discussed above can ensure that the current control circuitry is adjustment to cause more current to be drawn where necessary.

[0021] In another aspect, the invention may provide a method of operating a non-addressable alarm notification device, the method comprising: selectively activating an output device by drawing power from current control circuitry to generate an alert signal, wherein the current control circuitry is arranged to draw current from a supply line; detecting a voltage on the supply line; comparing the detected voltage to a predetermined threshold; and if the voltage on the supply line is below the threshold, causing the alarm notification device to operate in an under voltage prevention mode by clamping the current drawn by the current control circuitry.

[0022] The manner of operating the alarm device during start up, during normal operation and during the under voltage prevention mode may represent independent aspects of the invention.

[0023] Also disclosed herein is a method of operating an alarm notification device, the method comprising: (a) detecting a voltage on a supply line; (b) determining, using the detected voltage, an operational parameter for current control circuitry connected to the supply line, wherein the current control circuitry is arranged to draw current from a supply line to charge a charge storage device; (c) applying the operation parameter to the current control circuitry to adjust the current drawn thereby; and (d) repeating steps (a) to (c) in a period before the alarm notification device generates an initial alert signal by activating an output device to draw power from the current control circuitry and the charge storage device.

[0024] Also disclosed herein is a method of operating an alarm notification device, wherein the alarm notification device comprises: current control circuitry arranged to draw current from a supply line to charge a charge storage device, and an output device that is selectively activatable according to a normal operation cycle comprising an alert period and a recharge period, wherein the output device is arranged to draw power from the current control circuitry and charge storage device during the alert period, wherein the current control circuitry is arranged to supply current to the charge storage device during the recharge period, and wherein the method comprises, in each normal operation cycle: (a) detecting a voltage on the supply line; (b) comparing the detected voltage to a predetermined threshold; (c1) if the voltage on the supply line is below the threshold, causing the alarm notification device to operate in an under voltage mode, or (c2) if the voltage on the supply line is above the threshold, comparing a charge status of the charge storage device with a predetermined target value, and adjusting the current control circuitry using a result of the comparison. Causing the alarm notification device to operate in the under voltage mode may comprise clamping the current drawn by the current control circuitry, and/or activating an under voltage indicator.

[0025] Also disclosed herein is an alarm notification device comprising: current control circuitry arranged to draw current from a supply line; a charge storage device connected to receive current from the current control circuitry; an output device that is selectively activatable to draw power from the current control circuitry and the charge storage device to generate an alert signal; and a processor configured to: read an input indicative of voltage on the supply line; and determine an operational parameter of the current control circuitry using the received input.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Embodiments of the invention are described in detail below with reference to the accompanying drawings, in which:

Fig. 1 is a schematic diagram of an alarm notification device that is an embodiment of the invention;

Fig. 2 is a schematic diagram of a non-addressable alarm system in which one or more alarm notification devices according to the invention can be used;

Fig. 3 is a flow diagram that illustrates a start-up process and an ongoing control process for operating an alarm notification device that is an embodiment of the invention; and

Fig. 4 is a flow diagram that illustrates a method of operating an alarm notification device in an under voltage mode, according to another embodiment of the invention.

DETAILED DESCRIPTION; FURTHER OPTIONS AND PREFERENCES

[0027] Fig. 1 is a schematic diagram of an alarm notification device 100 that is an embodiment of the invention. The alarm notification device 100 may be a non-addressable device, i.e. a device arranged to receive only electrical power, without any additional communication capability. However, the invention need not be limited to such devices; the control technique set forth herein may also be applicable to addressable devices.

[0028] The alarm notification device 100 is connectable to a supply line 101 which in turn is connected to a control panel (not shown) that applies a DC voltage on the supply line 101. The control panel may be arranged to provide a normal and standby power supply in a conventional manner.

[0029] The alarm notification device 100 includes an output device 102 for providing an alert in the event of an emergency. The alert may be a cycle of repeated visible or audible signals. For example, the output device 102 may comprise a light source for emitting flashes of visible light. The light source may comprise a light emitting diode (LED) or the like. The output device 102 may include a sounder, e.g. speaker, buzzer, siren or the like, for emitting an audible alert.

[0030] The output device 102 is connected to receive electrical energy for the alert from an electrical charge storage device (e.g. capacitor) 108 and current control circuitry 110, which operates to draw current from the supply line 101. The output device 102 operates in an intermittent (e.g. periodic or cyclic) manner, i.e. alternates between an ON state in which the alert is produced (e.g. light is emitted) and an OFF state in which the alert is not present. In the ON state, electrical current flows the capacitor 108 and current control circuitry 110 into the output device 102. In the OFF state, the capacitor 108 is charged by electrical current flowing from the current control circuitry 110.

[0031] The alarm notification device 100 further comprises a controller, e.g. in the form of a microprocessor 104, for controlling its operation. The microprocessor 104 is arranged to control switching of the output device between the ON and OFF states. For example, the microprocessor 104 may send an activation pulse to the output device 102 that causes it to switch to the ON state.

[0032] The microprocessor 104 is in communication with the current control circuitry 110 to determine and set its operational parameters, i.e. to set the current flow therethrough. The current control circuitry 110 may be configured as an adjustable current source, e.g. arranged to deliver a current having a given (selectable) value irrespective of the voltage on the supply line 101. The operational parameters of the current control circuitry 110 may be one or more signals arranged to configure the adjustable current source.

[0033] The microprocessor 104 is also configured to receive a first sensing signal 107 indicative of the voltage on the supply line 101, and a second sensing signal 109 indicative of the charge status of the capacitor 108. For example, the second sensing signal 109 may be indicative of a voltage across the capacitor 108.

[0034] In use, the microprocessor 104 operates to set the operational parameters of the current control circuitry 110 using either or both of the first sensing signal 107 and the second sensing signal 109. In one example, the microprocessor 104 may be in communication with a computer-readable memory 106 which stores a look-up table that provides pre-set operational parameters for the current control circuitry for each of a plurality of sensed voltages on the supply line. The operational parameters may be based on pre-defined nominal current consumption for the device at a given voltage. By setting the operational parameters of the current control circuitry on this basis, the device can avoid current surges, especially during start up.

[0035] In practice, the voltage on the supply line 101 will be affected by the operation of the alarm notification device 100. The amount by which it is affected may be influenced by external factors, such as the number and type of other devices connected on the same supply line. The device may adapt to fluctuations of supply line voltage using the first sensing signal 107. In practice this may be implemented as a series of adjustments of the operational parameters of the current control circuitry 110 (e.g. with reference to the loop-up table in the memory 106) based on the evolution of the first sensing signal 107. The microprocessor 104 may be arranged to perform this series of adjustments in a time period before the first alert is issued by the output device. In this manner, the power drawn by the alarm notification device 100 can be ramped up to a steady state mode in a controlled manner.

[0036] Ongoing control of the current control circuitry 110 may be performed with reference to the second sensing signal 109, which is indicative of the charge status of the capacitor 108. The microprocessor 104 may be arranged to make minor adjustments to the operational parameters of the current control circuitry 110 using the second sensing signal 109. For example, the microprocessor 104 may compare the second sensing signal 109 to a threshold (which may represent a target charge status for the capacitor 108). A difference between the second sensing signal 109 and the threshold may be used to make a minor increase or minor decrease to the current delivered by the adjustable current source depending on which the second sensing signal 109 is below or above the threshold respectively. The current source may be a digitally controlled current source, where the minor increase or minor decrease is a least significant bit adjustment. Such an adjustment can be performed once on each alert cycle. An advantageous of regular minor adjustments of this kind is that the supply line voltage maintains a stable level.

[0037] Fig. 2 shows a schematic example of an alarm notification system 200 in which a plurality of alarm notification device 204 of the type discussed above with respect to Fig. 1 are connected to a supply line 201 that extends from a control panel 202. In this example, the control panel 202 provides two separate supply lines, each of which has a plurality of alarm notification devices connected thereon. In this example, each supply line has the same number of devices. However, in practice different supply lines may be configured with a different number of types of device. Upon activation in an emergency situation in this latter scenario, the load on each supply line (and therefore the change in voltage on the supply line caused by activation) will differ. By sensing the voltage on the supply line, the alarm notification device of the invention can adapt its start up and ongoing operational parameters to match the voltage supply.

[0038] Fig. 3 is a flow chart illustrating steps in a process 300 of operating an alarm notification device 100 of the type discussed above when an alert is required. The process is typically initiated upon detection of an emergency situation, e.g. via a sensor or manual actuator.

[0039] The process begins by entering a start up operation mode, commencing with a step 302 of applying a trickle current to enable operation of the microprocessor 104, e.g. to control the current control circuitry 110 according to the subsequent steps described below.

[0040] The process continues with a step 304 of detecting a voltage on the supply line 101. In practice this may mean sampling, e.g. using an analog to digital convertor in the microprocessor 104, the first sensing signal 107 to determine a voltage level on the supply line 101.

[0041] The process continues with a step 306 of determining a configuration for the current control circuitry 110 using the detected supply line voltage. In practice this may mean operating the microprocessor to look up operational parameters for the current control circuitry 110 corresponding to the determined voltage level in a table stored in the memory 106. The operational parameters may be associated with a desired current level corresponding to the determined voltage level to be delivered by an adjustable current source in the current control circuitry 110.

[0042] The process continues with a step 308 of applying, e.g. by the microprocessor 104, the configuration to the current control circuitry 110, whereby a current is delivered to the capacitor 108.

[0043] The process continues with a step 310 of determining, e.g. by the microprocessor 104, if a start up process has completed. This step may involve determining with a predetermined start up duration has elapsed, or whether the supply line voltage has been sampled a predetermined number of times. If the microprocessor 104 determines that the start up process is not complete, the process repeats the steps 302, 304, 306 of determining configuration settings for the current control circuitry 110. If the microprocessor 104 determines that the start up process is complete, the process 300 enters an ongoing operation mode, which is discussed below.

[0044] During start up of the device, it is expected that the voltage on the supply line with drop due to the presence of a new load on the supply line, e.g. due to the activation of the notification device and other devices. By sensing the voltage on the line a number of times during the start up operation mode, the alarm notification device can gradually ramp up the current it draws (and therefore the load it exerts on the supply). The device therefore contributes to a stable operation on the supply line as a whole.

[0045] In the ongoing operation mode, the alarm notification device operates cyclically. Each operation cycle comprises an alert period and a recharge period. During the alert period the output device 102 is in an ON state (i.e. the light source is illuminated) and current flows from the capacitor 108 and current control circuitry 110 to power the output device 102. During the recharge period the output device 102 is in an OFF state and current from the current control circuitry 110 flows into the capacitor 108.

[0046] The start up operation mode typically last for less than 3 seconds, so that the first operation cycle (and first alert emitted by the output device) can occur within 3 seconds of detection of the emergency situation.

[0047] An operation cycle starts with a step 312 of triggering an alert period. In practice, this may be done by sending, from the microprocessor 104, an activation pulse to the output device 102. The activation pulse may have a duration equal to a desired duration of the alert period, i.e. the microprocessor 104 may hold the output device 102 in the ON state by means of the activation pulse. The duration of the activation pulse may be determined by the microprocessor 104.

[0048] In an initial portion of the ongoing operation mode, the duration of the activation pulse may also be gradually increased until it reaches a target value, e.g. corresponding to a target (e.g. maximum) power for the output device. This allows for the charge on the capacitor 108 to rise to obtain its target voltage in a steady and controlled manner so that there is no collapse or overshoot of capacitor voltage.

[0049] The microprocessor 104 may be arranged to look up an activation pulse duration from a suitable data structure stored in the memory 106, e.g. using information about the supply line voltage and/or the charge status of the capacitor (e.g. voltage across the capacitor). The data structure may store empirically determined activation pulse duration data that corresponds to capacitor voltage data. By referring to the data structure to gradually increase the activation pulse duration, the microprocessor 104 can ensure that the output device 102 reaches maximum power within a predetermined period, e.g. less than 60 seconds.

[0050] The process continues with a step 314 of detecting a voltage on the supply line 101. This step may be carried out in the alert period or the recharge period of each cycle. This step is similar to step 304 discussed above, and this may mean sampling, e.g. using an analog to digital convertor in the microprocessor 104, the first sensing signal 107 to determine a voltage level on the supply line 101.

[0051] The process continues with a step 316 of determining, e.g. by the microprocessor 104, if the voltage on the supply line is below a minimum threshold. This step may involve comparing the voltage level to a predetermined value. The minimum threshold or predetermined value may be representative of a supply line voltage below which there is an increased risk of the supply becoming catastrophically overloaded, i.e. overloaded to the extent that the line collapses and ceases to provide power. The threshold is determined using the voltage detected on the supply line at the end of the start up operation mode. For example, the threshold may be a predetermined fraction of the voltage detected on the supply line at the end of the start up operation mode. The predetermined fraction may be selected so that the threshold provides a useful fail-safe without being accidentally triggered in normal operation. For example, the predetermined fraction may be 75%.

[0052] If the microprocessor 104 determines that the supply line voltage is below the minimum threshold, the process proceeds to a step 322 of initiating an under voltage prevention mode, which is discussed below with reference to Fig. 4. In the embodiment discussed above, the microprocessor 104 is used to compare the supply line voltage with a threshold. However, this process may be implemented using analog components using suitably configured multipliers and comparators, etc.

[0053] If the microprocessor 104 determines that the supply line voltage is above the minimum threshold, the process proceeds to a step 318 of detecting, e.g. by the microprocessor 104, a charge status of the charge storage device (capacitor) 108. In practice this may mean sampling, e.g. using an analog to digital convertor in the microprocessor 104, the second sensing signal 109 to determine a voltage level across the capacitor 108. The microprocessor 104 may determine the voltage level a plurality of times within each operation cycle and calculate an average thereof for subsequent processing.

[0054] The process continues with a step 320 of determining an adjustment for the operational parameters of the current control circuitry 110 using the detected charge status (e.g. average voltage level across the capacitor). In practice this may mean operating the microprocessor 104 to compare the detected charge status with a target charge status for the capacitor 108. The target charge status may in turn depend on a desired output power for the output device 102. The microprocessor 104 may then determine an adjustment of the operational parameters of the current control circuitry based on whether the detected charge status is above or below the target charge status. The adjustment may be a minor increase or minor decrease of the current delivered by the adjustable current source that acts to bring the charge status of the capacitor closer to the target. As explained above, the minor increase or decrease may be implemented as a least significant bit adjustment of a digitally controlled current source.

[0055] Once the current control circuitry is adjusted, the process loops back to step 312 for another operation cycle.

[0056] Fig. 4 is a flow chart that illustrates the steps in an under voltage prevention mode 322 followed by the device when the microprocessor 104 determines that the supply line voltage has fallen below a predetermined threshold.

[0057] The under voltage prevention mode 322 shown in Fig. 4 has two aspects that are independent of one another. The first aspect is the concept of an under voltage alert notification, i.e. some kind of notification from the device that the under voltage condition exists. The second aspect is the idea of bypassing the current control functionality of the microprocessor while the under voltage condition persists, which acts effectively to clamp the current drawn by the device. This can prevent the device from increasing its load on the supply line, which may assist in stabilising the supply line voltage and therefore preventing or delaying line collapse. In Fig. 4 the under voltage prevention mode comprises both these aspects in combination. However, it should be understood that either aspect could be implemented independently.

[0058] In the embodiment shown in Fig. 4, the alarm notification device continues to operate cyclically in the under voltage prevention mode. Each operation cycle comprises an alert period and a recharge period.

[0059] An under voltage mode operation cycle starts with a step 324 of triggering an under voltage alert notification. In this example, the under voltage alert notification is provided by the output device 102 as part of the alert by changing a property of the alert. For example, this may involve changing a pitch, tone or pattern of an audible alert or altering the appearance or format of a visible alert. In one example, the under voltage alert notification may be a double flash of a LED in the output device 102. In this example, the under voltage alert notification is provided by sending, from the microprocessor 104, an activation pulse to the output device 102 that causes it to emit the desired pattern.

[0060] In other examples, the under voltage alert notification may be provided separately from, e.g. independently of, the output device 102. For example, a separate indicator (e.g. low power LED or the like) may be provided on the notification device to show when the under voltage prevention mode is active.

[0061] The process continues with a step 326 of bypassing the current adjustment routines associated with normal operation of the device. The effect of this step is that the operational parameters of the current control circuitry are fixed, so that current drawn from the supply line is clamped at the value reached when the under voltage prevention mode was initiated.

[0062] The process continues with a step 328 of detecting a voltage on the supply line 101. This step may be carried out in the alert period or the recharge period of each cycle. This step is similar to step 304 discussed above, and this may mean sampling, e.g. using an analog to digital convertor in the microprocessor 104, the first sensing signal 107 to determine a voltage level on the supply line 101.

[0063] The process continues with a step 330 of determining, e.g. by the microprocessor 104, if the voltage on the supply line is still below the minimum threshold. This step is similar to step 316 discussed above, and the same threshold applies.

[0064] If the microprocessor 104 determines that the supply line voltage is still below the minimum threshold, the process remains in the under voltage prevention mode and loops back to being another operation cycle.

[0065] If the microprocessor 104 determines that the supply line voltage is above the minimum threshold, the under voltage prevention mode process may terminate with a step 332 of returning to the normal operating mode, e.g. by beginning a new operation cycle at step 312.

[0066] The under voltage prevention mode acts as a fail-safe mechanism to preserve operation of the alarm notification device for as long as possible. The under voltage prevention mode can allow the device to operate outside its normal constant power regime, and therefore possibly outside the requirements of the EN54-23 standard, in circumstances where continuing to operate using the normal regime could cause rapid overload and collapse of the supply line.

[0067] An alarm notification device that operates according to the principles of the power control technique set forth herein may be identified by any one or more of the following observable properties during operation:

- during start up the charging current into the capacitor exhibiting a series of steps that ramp up to a steady operation current;
- the charging current into the capacitor staying at a fixed level if the voltage on the supply line falls below a threshold; and
- one or more properties of an output notification are changing if the voltage on the supply line falls below a threshold.

[0068] The features disclosed in the foregoing description, or in the following claims, or in the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for obtaining the disclosed results, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

[0069] While the invention has been described in conjunction with the exemplary embodiments described above, many equivalent modifications and variations will be apparent to those skilled in the art when given this disclosure. Accordingly, the exemplary embodiments of the invention set forth above are considered to be illustrative and not limiting. Various changes to the described embodiments may be made without departing from the spirit and scope of the invention.

[0070] For the avoidance of any doubt, any theoretical explanations provided herein are provided for the purposes of improving the understanding of a reader. The inventors do not wish to be bound by any of these theoretical explanations.

[0071] Any section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described.

[0072] Throughout this specification, including the claims which follow, unless the context requires otherwise, the word "comprise" and "include", and variations such as "comprises", "comprising", and "including" will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

[0073] It must be noted that, as used in the specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise.

Claims

1. A non-addressable alarm notification device (100) comprising:

current control circuitry (110) arranged to adaptively draw current from a supply line (101);
an output device (102) that is selectively activatable to draw power from the current control circuitry to generate an alert signal; and
an controller (104) configured to:

obtain an input (107) indicative of voltage on the supply line;
compare the input indicative of voltage on the supply line to a predetermined threshold; and
enter an under voltage prevention mode if a result of the comparison indicates that the voltage on the supply line falls below the threshold,

wherein, in the under voltage prevention mode, the current drawn by the current control circuitry is clamped.

2. The non-addressable alarm notification device of claim 1, wherein the controller comprises a processor configured to determine at least one operational parameter of the current control circuitry using the input indicative of voltage on the supply line.

3. The non-addressable alarm notification device of claim 2 further comprising a charge storage device (108) connected to receive current from the current control circuitry, wherein the output device is selectively activatable to draw power from the current control circuitry and the charge storage device.

4. The non-addressable alarm notification device of claim 3, wherein the processor is further configured to obtain an input (109) indicative of the charge status of the charge storage device.

5. The non-addressable alarm notification device of claim 4, wherein the charge storage device comprises a capacitor, and the input indicative of the charge status comprises an input indicative of a voltage across the capacitor.

6. The non-addressable alarm notification device of claim 5 further comprising a computer-readable memory (106) accessible by the processor, wherein the computer-readable memory stores a data structure that matches the voltage on the supply line and the operational parameter, and wherein the processor is configured to look up the operational parameter from the data structure using the received input, and apply the operational parameter to the current control circuitry.

7. The non-addressable alarm notification device of claim 5 or 6, wherein, in a start up period before the output device generates an initial alert signal, the processor is configured to read the input, determine the operational parameter using the received input, and apply the determined operational parameter to the control circuitry a plurality of times.

8. The non-addressable alarm notification device of claim 7, wherein the current drawn by the current control circuitry ramps up to a steady state mode during the start up period.

9. The non-addressable alarm notification device of any one of claims 3 to 8, wherein the output device is selectively activatable according to a normal operation cycle comprising an alert period and a recharge period,
wherein the output device is arranged to draw power from the current control circuitry and charge storage device during the alert period, and
wherein the current control circuitry is arranged to supply current to the charge storage device during the recharge period.

10. The non-addressable alarm notification device of claim 9, wherein, in each normal operation cycle, the processor is arranged to:

compare a charge status of the charge storage device with a predetermined target value; and
adjust the current control circuitry using a result of the comparison.

11. The non-addressable alarm notification device of claim 10, wherein the current control circuitry comprises a digitally controlled current source, and wherein the processor is configured to perform a least significant bit adjustment of the digitally controlled current source using the result of the comparison.

12. The non-addressable alarm notification device of claim 10 or 11, wherein, between each of an initial set of normal operation cycles, the processor is configured to increase the predetermined target value.

13. The non-addressable alarm notification device of any preceding claim, wherein the control module is configured to:

determine an operational voltage on the supply line just before the output device generates an initial alert signal; and
set the predetermined threshold using the determined operational voltage.

14. The non-addressable alarm notification device of any preceding claim, wherein the current control circuitry comprises an adjustable current source.

15. The non-addressable alarm notification device of any preceding claim configured to generate an alert to indicate operation in the under voltage prevention mode.

16. A method of operating a non-addressable alarm notification device, the method comprising:

selectively activating (312) an output device by drawing power from current control circuitry to generate an alert signal, wherein the current control circuitry is arranged to draw current from a supply line;
detecting (314, 328) a voltage on the supply line;
comparing (316, 330) the detected voltage to a predetermined threshold; and
if the voltage on the supply line is below the threshold, causing (322) the alarm notification device to operate in an under voltage prevention mode by clamping (326) the current drawn by the current control circuitry.

17. The method of claim 16, wherein the output device draws power from the current control circuitry and a charge storage device, and wherein, if the voltage on the supply line is above the threshold, the method further comprises:

comparing a charge status of a charge storage device with a predetermined target value, and
adjusting (320) the current control circuitry using a result of the comparison.

18. The method of claim 17, wherein, before generating an initial alert signal, the method includes:

(a) detecting (304) a voltage on the supply line
(b) determining (306), using the detected voltage, an operational parameter for the current control circuitry connected to the supply line, wherein the current control circuitry is arranged to draw current from the supply line to charge the charge storage device;
(c) applying (308) the operation parameter to the current control circuitry to adjust the current

drawn thereby; and
(d) repeating steps (a) to (c) in a period before the alarm notification device generates the initial alert signal.

19. The method of claim 18, wherein step (b) comprises looking up the operational parameter from a data structure that matches the voltage on the supply line and the operational parameter.

20. The method of any preceding claim further comprising, if the voltage on the supply line is below the threshold, generating (324) an alert.

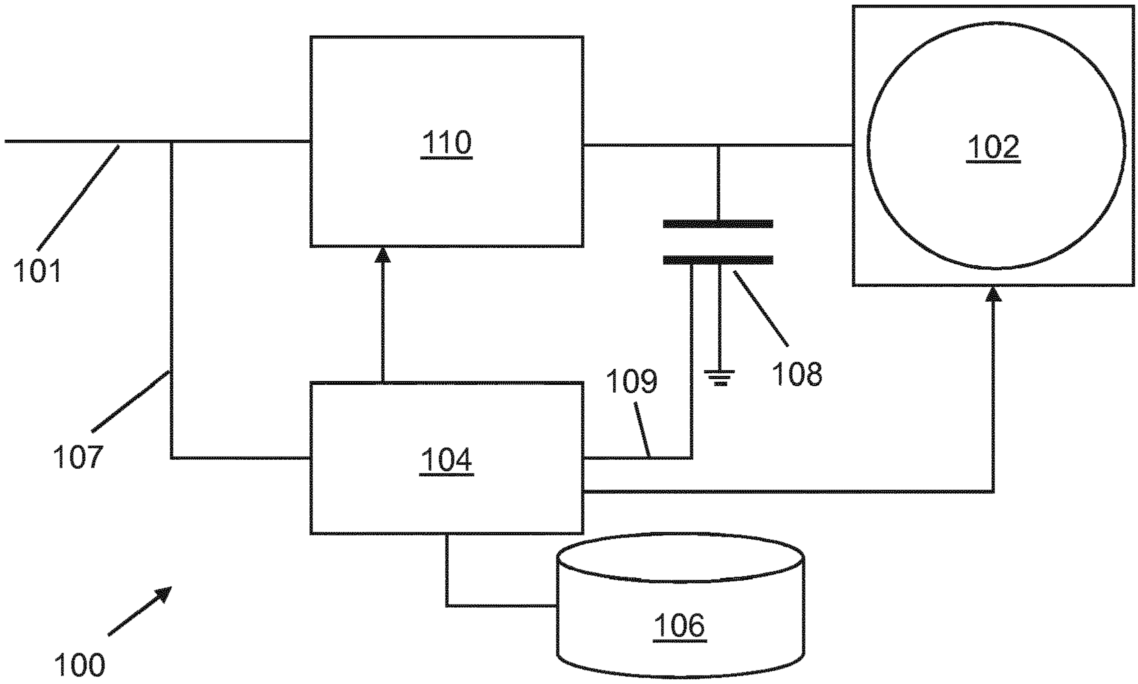

FIG. 1

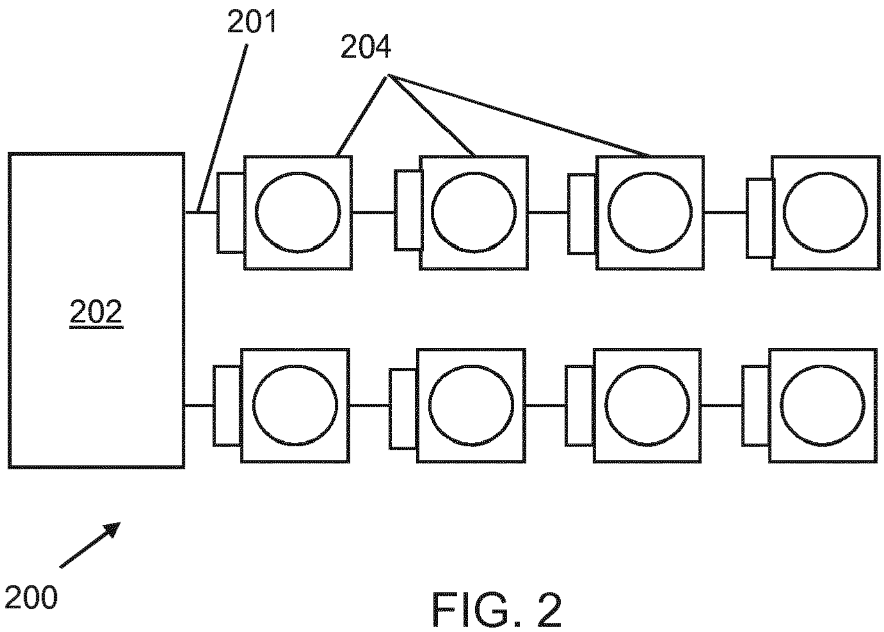

FIG. 2

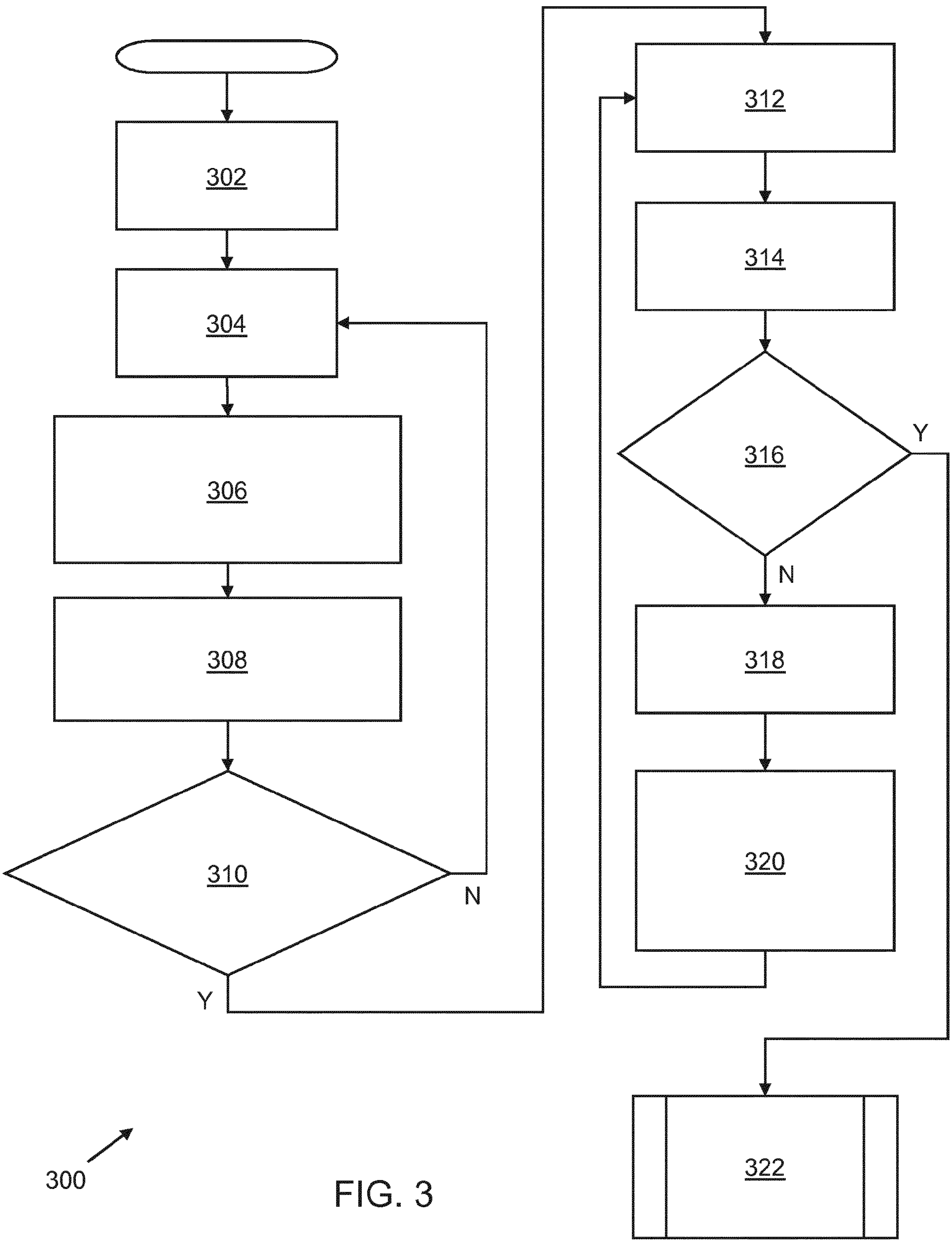

FIG. 3

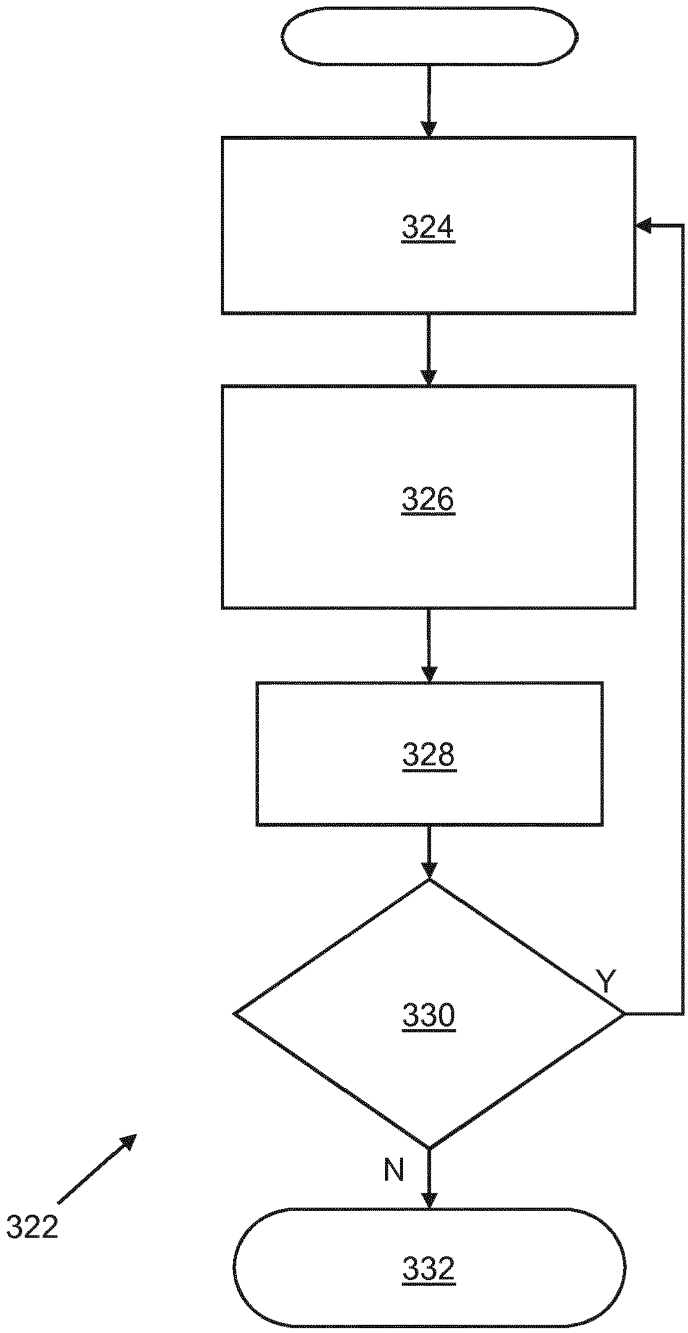

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 19 17 1877

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	3 September 2019	Kurzbauer, Werner

CATEGORY OF CITED DOCUMENTS

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