

the electrical safety device when the processor determines that the surface temperature of the plug exceeds the predetermined threshold. In this way, if the temperature of the plug of an electrical appliance reaches a level deemed to be hazardous, the electrical safety device can block the supply of current to the appliance, thereby addressing the hazard.

The electrical safety device may have one, two or more sockets, each of which may have its own current sensor and relay switch.

Preferably the electrical safety device comprises one or more wireless communications links configured to communicate with a remote device. This allows the electrical safety device to be employed in an electrical safety system (i.e. an electrical safety device network) throughout a building to identify risks, alert a user and address the risks. Preferably the electrical safety device is configured to communicate with other electrical safety devices and/or remote devices both by a Wi-Fi® network and a narrow band radio frequency network. This provides contingency in the case of failure of one of the networks.

Preferably the electrical safety device comprises one or more additional local sensors, the one or more local sensors comprising one or more of: a smoke and/or gas sensor; a carbon monoxide sensor; a moisture and/or water sensor; and a current sensor, allowing the device to sense the presence of a greater range of hazard and identify hazards more reliably. In preferable examples the electrical safety device includes each of a smoke and/or gas sensor; a carbon monoxide sensor; and a current sensor; wherein the processor is configured to determine whether corresponding parameter sensed by each sensor exceeds a predetermined threshold value. This combination of sensors allows for substantially all household hazards relating to electrical equipment to be identified reliably. Preferably the processor is configured to identify the presence of a hazard based on the output of a combination of sensors. In particular the processor uses a combination approach in which the output of a plurality of sensors is used to more reliably identify a risk. For example, the processor may employ a machine learning algorithm which uses the output of a plurality of sensors to identify a risk. In this way, a hazard can be identified more reliably

The electrical safety device provides further advantages when provided in an electrical safety system including one or more electrical safety devices and one or more remote devices. In this way the devices can communicate to notify a user of the risk and take action automatically or when prompted by a user to address the hazard.

In another aspect of the invention there is provided an electrical safety system comprising: an electrical safety device according to any preceding claim; and one or more remote devices; wherein the electrical safety device comprises a communications link and the electrical safety device is configured to send a signal to the remote device using the communications link when the processor determines that the surface temperature of the mains plug has exceeded the predetermined threshold.

In this way, the remote device can either alert a user or take action to address a potential hazard. A remote device includes another other device connected to the network which is not an electrical safety device as described above, for example a smartphone, smart television, voice assistant device or other smart user device; a remotely controlled valve; a router or hub; a docking station for a mobile phone; a fire alarm; a smoke alarm; a sprinkler system.

Preferably the communications link comprises a wireless communications link, wherein the wireless communications link is preferably provided by one or more of: a narrow band radio frequency network, a Wi-Fi® wireless communications link and a Bluetooth® wireless communications link. The electrical system may comprise one or more electrical safety devices and one or more remote devices, wherein the electrical safety devices and remote devices form a mesh network in which the electrical safety devices and remote devices can communicate. In this way, each device can communicate with the other devices such that coordinated actions and alerts can be provided. Preferably the electrical safety devices and remote devices are configured to communicate both by a Wi-Fi® network and a narrow band radio frequency network to provide contingency in case one network goes down. The narrow band radio frequency network may specifically a 868MHz band.

The internal electrical components preferably comprise one or more of: a motor, a compressor, a heater, a power source, a fuse, electrical circuitry or any other components which may overheat.

- 5 The thermal sensor is preferably mounted within the housing of the electrical appliance so as to face the internal electrical components without being in contact. Preferably the thermal sensor is a thermal camera so as to image a substantial portion of the surface area of the internal electrical components.
- 10 The processor of the electrical appliance may be configured to determine when the surface temperature displays behaviour indicative of a potential electrical hazard. For example it may be configured to determine when the temperature gradients exceed a certain level, when the surface temperature distribution across the plug displays a particular behaviour or the rate of change of the
- 15 surface temperature displays a particular behaviour. The processor may use a machine learning algorithm and may be trained to identify such behaviour indicative of particular hazard. The electrical safety device may additionally include a memory configured to hold data relating to surface temperature behaviour associated with particular hazard wherein the processor is configured
- 20 to receive surface temperature data from the thermal sensor and compare this against the data stored in the memory to determine the presence of a hazard.

- The electrical appliance preferably further comprises one or more wireless communications links configured to communicate with an electrical safety device
- 25 as defined above and/or remote device. This allows the electrical appliance to be employed in an electrical safety system (as described above) throughout a building to identify risks, alert a user and address the risks. Preferably the electrical appliance is configured to communicate with other electrical safety devices and/or remote devices both by a Wi-Fi® network and a narrow band
 - 30 radio frequency network. This provides contingency in the case of failure of one of the networks.

Preferably the electrical appliance comprises one or more local sensors. the one or more local sensors comprising one or more of: a smoke and/or gas sensor; a

of one or more parameters may indicate the presence of a hazard. The device 100 may include an internal memory holding such sensor parameter data with the processor configured to compare the received data with data indicative of a hazard held in the memory in order to identify the presence of a hazard. The
5 processor may use more complex algorithms such as machine learning algorithms which can be trained to identify changes in the parameters associated with increased risks of a potential hazard. For example, the machine learning algorithm may include a neural network (or support vector machine) which functions to receive the data from the sensors as inputs and, once trained
10 on a set of simulated hazards, may be able to identify a real-life hazard from a combination of inputs from the sensors using weights and thresholds that may not be set or predetermined by the operator. In another example, a linear regression model may be used to identify changes of parameters over time to predict or estimate a level of risk.

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The electrical safety device 100 can also include a water sensor 116 arranged to detect the presence of water in the vicinity of the device 100, as shown in Figure 2A. In particular the water sensor 116 may comprise a water sensor body 117 arranged to lie on the ground below the electrical safety device 100 so as to
20 detect collecting water on a surface below the device 100. The water sensor body 117 is connected to the device by a water sensor connection 118 as shown in Figure 2A. The connection 118 may comprise a plug which plugs into a corresponding socket on the side of the device to connect the water sensor to the internal processor such that the processor can receive signals from the water
25 sensor to identify the presence of water and alert a user using the alarm or wireless communications link to a user device. The presence of water may be particularly hazardous when there is an electrical fault with the appliance and the additional water sensor 116 can detect the presence of a leak from a household appliance or mains water in order to identify such a hazard.

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In addition to providing an alarm or sending an alert to a remote device such as a smartphone, the electrical safety device 100 can also take actions automatically, or when prompted by a user, to respond to the detected hazards. In this way, the electrical safety device 100 forms part of an electrical safety

that a hazard is detected by one of the electrical safety devices 100, 200 in the electrical safety device network.

5 The main supply isolation control unit 260 may also include a number of local sensors with similar functionality to the electrical safety devices 100, 200 in order to detect the presence of a local hazard and shut off the main supply accordingly. In particular the main supply control unit 260 may include a thermal sensor 261, for example as explained above with reference to the electrical safety device 100, 200, configured to detect the presence of a spark, flame or
10 rising temperature in the local vicinity; a smoke and gas sensor 263; a carbon monoxide sensor 264; and an optional water sensor 226 to detect the presence of water collecting on the ground below the control unit 260. The mains supply isolation unit 250 therefore has the required functionality to detect the presence of local hazards and shut off the mains supply accordingly, as well as alert other
15 devices in the network. The mains supply control unit 260 also comprises an internal alarm sounder 265 to alert a user of the presence of the hazard and it can also transmit signals to a user device such as a smart phone or smart TV to alert the user with the location description of the detected hazard. The device may also have an internal battery back-up 268 as with the devices described
20 above. The device may be connected directly to the mains power supply via connection 269.

The main supply isolation unit 250 described above therefore provides additional functionality in terms of the control unit 260 with various sensors to detect local
25 hazards. However a less complex main supply isolation unit may be provided more simply in the form of a motorised valve 251 and a wireless receiver 252 configured to receive a signal sent by an electrical safety device 100, 200, as shown in Figure 5B. In this case the motorised valve 251 lies in the main supply line, for example the mains water feed, header water tank or mains gas supply
30 and includes a wireless receiver component 252 which simply comprises means to receive a signal sent by an electrical safety device within the electrical safety system and actuate the valve to shut off the main supply.

The electrical safety system of the present invention may also include a mains electrical isolation unit 350, as shown in Figure 6. The mains electrical isolation unit 250 comprises a mains electrical isolation control unit 360 which has exactly the same functionality as the control unit 260 described above with respect to Figure 5A. In particular, it can receive signals sent from the electrical safety devices 100, 200 and remote devices in the electrical safety system network and can detect a number of local hazards using one or more local sensors. The electrical isolation unit 250 differs from the main supply isolation unit 250 in that it comprises a cabled or wireless communications link 352 to the main switch 351 within a consumer electrical unit (or a fuse box). In this way, when the main supply isolation control unit 360 either receives a signal from an electrical safety device indicative of the detection of a hazard or it detects a local hazard with one or more of the local sensors within the control unit 360, the internal processor sends a signal via the communications link 352 to the main switch 351 of the consumer unit 353 which shuts off the mains electrical supply. In this way a potential hazard can be prevented from spreading further by cutting the electrical supply to the building. In an alternative example all of the functionality of the control unit 360 may be directly integrated into a consumer unit/fuse box. Furthermore, as with the isolation units described above, a simpler version may be provided which simply includes a wireless receiver built into the consumer unit 353 and an actuator which switches the main switch 351 in the consumer unit 353 when the wireless receiver receives the signal from a remote device or electrical safety device 100, 200.

25 Electrical safety system

Figure 7 illustrates an exemplary electrical safety system network 400 according to the present invention. The electrical safety system 400 can include a plurality of electrical safety devices 100, 200 as described above and plurality of remote devices 250, 251, 350, 402. All of the remote devices and electrical safety devices may be able to communicate via wireless connectivity, for example radio narrow band frequency, Wi-Fi® and Bluetooth® wireless communications links. Preferably the devices are each configured to communicate over two communication channels such that all of the devices can operate on two different types of networks as a failsafe. In this example, the devices can communicate

via Wi-Fi® network 404 and a radio mesh network 403, for example 868 MHz. The connectivity of each of the devices in the network may be managed by a central smart hub 401 which is connected to the home router 405 and can manage the connectivity between the various remote devices and electrical safety devices. The smart hub 401 may also have the functionality described above in terms of sensors, connectivity and alerts associated with the devices previously described. By providing two communications networks, if one network goes down the devices can still communicate to provide an alert or take specific responses to shut down the main supply to mitigate the risk of a particular hazard.

As described above, one particular remote device may be a smartphone 402 as shown in Figure 7. The smartphone (or other smart user device) may run an app with which the user can manage the system and receive alerts. In particular, when a hazard is detected a signal may be sent to the users smartphone and the app can display information on the hazard, for example that a fire has been detected, the location of the fire and provide options for the user to address the risk, for example by shutting off an electrical supply or calling emergency services. The app may also be configured to monitor current usage of the electrical appliances plugged into the electrical safety devices 100, 200. In particular, the electrical safety devices comprise a current sensor which can be used to monitor the amount of current which is used by a particular device plugged into the electrical safety device 100, 200. In this way, the user can monitor current usage and identify any potentially faulty units which display unusual current usage characteristics.

Because the current sensor measures the current provided by each socket, the electrical safety system can also monitor power consumption across each individual electrical safety device outlet point. This data can be provided to the smartphone app and stored in a memory to allow a user to optimise their electricity usage. This will provide a more accurate measure of power consumption and pin point any high current items using more electricity than normal over a period of time and send an alert to a smartphone. Furthermore, it can be used as a safety system, for example if no activity has been detected at

smartphone. Communications between devices may be direct using a local network or may be via a remote server.

5 An electrical safety plug adapter comprises a socket, arranged to receive a plug of an external device, and a plug part, arranged to be inserted to a socket of an external power supply, such as a mains wall socket. The plug adapter is generally arranged to provide selective electrical connection between an electrical appliance (external device) and a household power supply (mains wall socket).

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The adapter device includes at least one hazard sensor that is able to determine a potential hazard and disconnect the external device from the power supply. In this way, the adapter device can provide local detection of the hazard and prevent the external device from exacerbating the hazard. For example, if a refrigerator catches fire, the power supply to the refrigerator can be turned off which prevents the refrigerator from exacerbating the fire conditions. Additionally, earlier detection of a hazard is more likely than conventional detection systems as the sensors are closer to probable hazard causes.

20 The socket and plug part are connected through an internal circuitry of the adapter. The internal circuit may include a relay, arranged to selectively control the current between the plug part and the socket. Alternative means for selectively turning off power supply to the external devices are also contemplated. The internal circuitry may also include components for wireless communication, such as Mesh Radio Network, Wi-Fi® and Bluetooth chipsets®.

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The adapter further comprises an integrated set of hazard detection sensors, such as CO, CO₂, smoke, gas, thermal, flame and water detection sensors. Each of the sensors are connected, through the internal circuitry, to the network of the system.

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The smoke sensor is arranged to sense ambient levels of smoke, and may comprise sensing components arranged to utilise either, or both, of optical detection methods (such as photoelectric detection), or physical detection

In the event that one of the on-board sensors detects a parameter which indicates a potential hazard and/or fire, the adapter automatically actuates the relay such that the electrical connection between the plug part and the socket is interrupted. This ensures that, when a potential hazard is perceived by the
5 adapter, electrical power supply to the potentially hazardous appliance is immediately switched off.

The adapter may further be connected, through its Mesh Radio Network, Wi-Fi® or Bluetooth® chipsets, to a system network. The adapter may be connected
10 using a Wi-Fi® communications link to the internet or a local network, each device being in communication with one another or to a central server. A mesh network module may also be provided which enables the adapter to communicate with a device at a premises such as an isolation unit described below or a central hub located at the premises which communicates with all
15 devices at the premises.

If a wireless communication device, such as a smartphone, is connected to the network, the plug may communicate with the wireless communication device to send an alert. Typically, such an alert may comprise a visible message and/or an
20 audible sound.

The adapter may further comprise one or more LEDs to indicate the status of the adapter. For example, one LED may indicate an alarm status, while another LED may indicate normal status, and another LED may indicate communications
25 taking place.

The adapter can be arranged to provide power from a wall supply to various household appliances. For example, the adapter may be arranged to connect to a power supply, a coffee maker, a microwave, a kettle, an extension sockets, a
30 toaster, a hair straightener, washing machine, dishwasher, wall boiler, electric oven, tumble dryer, fridge/freezer or consumer unit.

Alternatively, the internal circuitry, wireless communication module and the hazard detection sensors described above may be built in to an integrated wall

socket. In use, if a hazardous level of fire, water, CO or CO₂ is detected locally or from any other remote device in the network, the integrated wall socket will automatically shut-off to isolate electrical supply to any connected appliances. As with the other devices in the network, a wireless communication module
5 allows the integrated wall socket to wirelessly communicate via Wi-Fi® and radio narrow band frequency 868 MHz wireless communications links on a meshed network to other devices in the network.

In another example, the internal circuitry, wireless communication module and
10 the hazard detection sensors described above may be installed in a docking unit. The docking unit may further comprise a connection member to allow a connection to an external mobile communication device such as a smartphone. In use, if a hazardous level of fire, water, CO or CO₂ is detected locally or from any other remote device in the network, the docking unit will sound an alarm
15 from an on-board speaker. If an external mobile communication device is connected to the docking unit when a hazard is detected, the docking unit can further send a signal to the mobile communication device to sound an alarm from the external device. As with the other devices in the network, a wireless communication module allows the docking unit to wirelessly communicate via
20 Wi-Fi® and radio narrow band frequency 868 MHz wireless communications links on a meshed network to other devices in the network.

In addition to disconnecting the local power supply to the connected appliance or external device, the internal circuitry may also be configured to provide a
25 disconnection message to a remote device or isolation unit. The isolation unit may be configured to disconnect a hazard causing condition or other aspect that may exacerbate the hazard.

For example, a water sensor positioned on the floor of a kitchen and connected
30 to the adapter may sense the presence of water and remotely activate a valve which disconnects mains water supply to the premises so as to prevent further flood damage. Additionally, the detection of a fire hazard using the smoke or fire sensors may also disconnect the gas supply which could exacerbate the effects of a fire.

further valves or to send a message to a wireless communications device such as a smartphone.

Typically, the isolation valve of the isolation unit is a motorised valve, arranged
5 to isolate a main water supply if a leak is detected locally or from any other remote device in the network/system.

The devices of the system including the local adapter and the remote isolation
unit may each comprise one or more CPUs or microprocessors which perform
10 the functionality described. Instructions may be stored on a computer readable medium which when executed by the processor(s) cause the processors to execute the instructions. The devices may include a watchdog CPU which functions to reset radio or Wi-Fi® modules.