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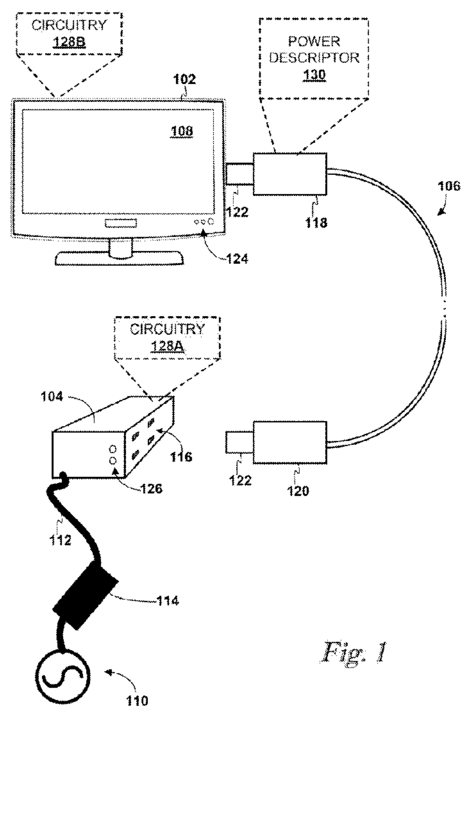

Fig. 1

(57) Abstract: Examples are described herein for determining power configurations. In various examples, an apparatus may include circuitry to determine the power configuration of a hub, a head component, and a removable cable that couples the head component and the hub. The power configuration may include: a first amount of power supplied to the hub via a mains power outlet, and a second amount of power that is deliverable by the hub to the head component via the removable cable. The circuitry may cause an output component that is separate from a display operated by the head component to render output that is modulated to convey an aspect of the power configuration.

DETERMINING POWER CONFIGURATION

Background

[0001] Technologies that facilitate transfer of both data and power between various electronic devices are becoming more commonplace. As an example, the Universal Serial Bus (USB) industry standard provides various specifications for cables and/or connectors to exchange both power and data between various types of computing devices, peripheral devices, *etc.* Different types of USB cables and/or connectors have different data and/or power transfer capabilities. For example, cables complying with the USB-C standard can transmit as much as one hundred watts (five amps of current at twenty volts), of power.

Brief Description of the Drawings

[0002] Features of the present disclosure are illustrated by way of example and not limited in the following figure(s), in which like numerals indicate like elements.

[0003] Fig. 1 schematically depicts an environment in which selected aspects of the present disclosure may be implemented, in accordance with an example of the present disclosure.

[0004] Fig. 2 schematically depicts an apparatus that implements selected aspects of the present disclosure, in accordance with an example of the present disclosure.

[0005] Fig. 3 schematically depicts a hub configured with selected aspects of the present disclosure, in accordance with an example of the present disclosure.

[0006] Fig. 4 depicts an example method for a hub to practice selected aspects of the present disclosure.

[0007] Fig. 5 depicts an example method for a head component to practice selected aspects of the present disclosure.

Detailed Description

[0008] For simplicity and illustrative purposes, the present disclosure is described by referring mainly to various examples thereof. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. However, examples consistent with the present disclosure may be practiced without limitation to these specific details. In other instances, some methods and structures have not been described in detail so as not to unnecessarily obscure the present disclosure.

[0009] The elements depicted in the accompanying figures may include additional components and some of the components described in those figures may be removed and/or modified. The elements depicted in the figures are not drawn to scale and the elements may have different sizes and/or configurations other than as shown in the figures.

[0010] As noted above, technologies that facilitate transfer of both data and power between various electronic devices are becoming more commonplace. Some cables and/or connectors have similar or identical form factors, and yet have different operational capabilities. This can lead to confusion in some instances. Assume, for example, that a particular cable or connector (*e.g.*, a USB-C cable) is incapable of delivering sufficient power to a computing device such as a tablet computer or laptop computer. The computing device may not be able to report such an error to a user using audio and/or visual output rendered by, for instance, an operating system (OS) executing on the computing device. Without some other means for conveying an error message to the user, the user may not be able to easily discern why the computing device is not operating, or is not operating properly.

[0011] Examples are described herein for determining, and for conveying aspects of, a power configuration of a plurality of components that are coupled with each other using cables and/or connectors, such as USB cables and/or connectors. These connected components may include, for instance, a hub and what will be referred to herein as a "head component" or "head unit." A "hub" or "dock" may be a device with some number of ports to which various other electronic devices can connect, so that the hub can facilitate transfer of power and/or data between these connected electronic devices. A "head component" may refer to a data processing device such as a laptop computer, tablet computer, *etc.*, that processes data in various ways. In some examples, the head component may be a tablet-style computing device with an integral touch screen display. Some such tablet-style computing devices may be designed for use as transactional terminals, such as point-of-sale terminals, although other types of terminals are contemplated.

[0012] A "power configuration" as used herein refers to information about capabilities of multiple electronic devices to exchange power between them. A power configuration may include, for instance, a data structure that includes various amounts of power that are deliverable to/between various connected electronic devices, given how those devices are connected to each other and/or to external power sources. For example, a power configuration of a hub and head component that are coupled using a removable cable (*e.g.*, a USB-C cable) may include a first amount of power supplied to the hub via mains power (*e.g.*, city power, hydro power, AC mains, *etc.*), *e.g.*, from a wall outlet, and a second amount of power that is deliverable by the hub to the head component via the removable cable. The amounts of power that collectively form a power configuration may be ascertained in various ways and stored in memory (and/or processed) as, for instance, individual variables (*e.g.*, floats, doubles, integers), as variables of a power configuration data structure, *etc.*

[0013] The second amount of power may be based on, for instance, an operational parameter of the removable cable (as noted previously, standard USB-C cables can carry up to one hundred watts), and/or based on an amount of power supplied by mains power. This operational parameter may be determined in some examples based on information stored on and/or provided by the removable cable, such as via a power delivery object (PDO) associated with various USB standards. USB ports of other devices may also provide respective operational parameters of those devices, *e.g.*, as PDOs.

[0014] Once the power configuration is determined, aspects of the power configuration can be conveyed to a user with various output components such as light-emitting diodes (LEDs), speakers (particularly embedded speakers), *etc.* These output components may be separate from output devices such as displays and “regular” speakers that render output generated by applications and/or an operating system (OS) of the head component. For example, a head component may not be able to render output on its display if it doesn’t have enough power, but it may have internal circuitry such as an application-specific integrated circuit (ASIC) that can modulate output of integral LEDs to convey a message about the head component’s lack of power.

[0015] Circuitry that performs selected aspects of the present disclosure may be integral with one or both of the hub and the head component. In some examples, the hub may include circuitry that operates output component(s) integral with the hub to convey aspects of a power configuration of the hub and head component. These aspects may include, for instance, the hub not receiving enough power from mains to power the head component or a removable cable that connects the hub to the head component being incapable of providing sufficient power to the head component. The latter may be particularly applicable where multiple different cables are physically connectable to ports of the hub and head component (and those cables may appear physically similar or identical), but not all of those physically interchangeable cables are capable of carrying the same amount of power (or capable of the same data transfer rates).

[0016] In some examples, the head component may also include circuitry that performs selected aspects of the present disclosure, such as an ASIC separate from other processing unit(s) of the head component. In some examples, the head component circuitry may determine the amount of power that is deliverable by the hub to the head component via the removable cable, *e.g.*, from a message (*e.g.*, PDO) the head component receives from the hub. If the amount of power is insufficient to fully or properly power the head component, its circuitry may operate the aforementioned output components (*e.g.*, embedded speaker, LEDs) to convey to the user that the head component is not able to receive sufficient power.

[0017] Output rendered by output components may be modulated to convey aspect(s) of the power configuration of the hub and head component in various ways. With LEDs, for instance, the LEDs may be selectively energized to emit temporal patterns (*e.g.*, akin to Morse code) and/or colors that convey an aspect of a power configuration to a user. For example, assume that the head component consumes 140 watts of power but the removable cable is a standard USB-C cable that can carry up to 100 watts of power. In such a scenario, LEDs on the hub (or on the head component) may be energized to emit some number of blinks (*e.g.*, five) in one color (*e.g.*, red), followed by a pause, and then some number of blinks (*e.g.*, five) in another color (*e.g.*, white), to convey that the removable cable that was used to connect the head component to the hub cannot carry enough power to properly power the head component.

[0018] Fig. 1 schematically depicts an environment in which selected aspects of the present disclosure may be implemented, in accordance with an example of the present disclosure. In Fig. 1, a head component 102 is connected to a hub 104 using a removable cable 106. In Fig. 1, head component 102 is a computing device that takes the form of a tablet-like device with a touch screen 108. In other examples, head component 102 may take other forms, such as a computing device having separate input components such as a mouse and/or keyboard, and/or separate output components such as a separate display. Other types of computing devices are contemplated, including but not limited to set top boxes, smart phones, laptop computers, and so forth.

[0019] Hub 104, which may alternatively be referred to as a “dock” or “port replicator,” is a device that can be used to operably couple head component 102 with any number of electronic peripheral devices. Peripheral devices may take various forms, including but not limited to monitors, keyboards, mice, printers, projectors, cameras such as “webcams” that also include other input devices such as microphones, speakers, and any other input and/or output device.

[0020] In many cases, and as is depicted in Fig. 1, hub 104 may be connected to and receive power from a power source 110. In Fig. 1, power source 110 takes the form of A/C mains electricity, but other forms, such as DC mains electricity, battery power, *etc.*, are also contemplated. As used herein, “mains” electricity refers to a general-purpose power supply that provides AC and/or DC electrical power to homes and business. When individuals plug electronic devices and/or appliances into wall outlets, they are usually connecting those devices to mains electricity. Mains electricity may also be referred to by other monikers in various regions of the world. Some of those monikers include, for instance, “utility power,” “household power," "household electricity," "house current," "domestic power," "wall power," "line power" "city power," "street power," “hydro,” and so forth.

[0021] In Fig. 1, a power cable 112 connects hub 104 to power source 110. Because power source 110 is AC-based, and various computing devices such as head component 102 often operate on DC power, power cable 112 includes an AC-DC convertor 114. If power source 110 is a DC-based power source, convertor 114 may be omitted. In some examples, power cable 112 may transmit power, but not data. In other examples, power cable 112 may be capable of transmitting both power and data, *e.g.*, where a power-line communication apparatus is connected between an AC mains outlet and power cable 112.

[0022] Hub 104 distributes power it receives from power source 110 to whichever electronic devices are connected to various ports 116 of hub 104. In Fig. 1, hub 104 includes four ports, but other hubs configured with selected aspects of the present disclosure may include other numbers of ports 116. In some examples, the port(s) 116 may be various types of USB ports, including but not limited to those referred to as USB-C, USB-A, microUSB, Micro-B, Mini-A, Mini-B, *etc.* Ports supporting other peripheral communication technologies are also contemplated, including but not limited to serial, DisplayPort ("DP") technology, technology that combines peripheral component interconnect ("PCI") express ("PCIe") with DP technology, various types of digital visual interface ("DVI"), various types of high-definition multimedia interface ("HDMI"), video graphics array ("VGA"), *etc.*.

[0023] Because hub 104 is connected to power source 110, hub 104 may act as a power supply to other components that are connected to it, including but not limited to head component 102 and/or any peripheral devices that are also connected to hub 104 (or to head component 102). Some of these connected peripheral devices, such as smart phones, may also include their own internal power supplies, such as batteries, which may or may not be recharged by hub 104.

[0024] Removable cable 106 includes a first connector 118 and a second connector 120 which may or may not be identical to first connector 118. In Fig. 1, for example, ports 116 are female ports, and both first connector 118 and second connector 120 each includes a male contact 122. In some examples, the ports 116 are male ports and connectors 118 and 120 have female contacts.

[0025] Various components depicted in Fig. 1 may be equipped with rudimentary output components such as lights and/or embedded speakers (emit simple noises such as beeps) that are separate from more advanced output components such as displays (*e.g.*, touch screen 108) or speakers. For example, head component 102 is equipped with integral LEDs 124. Similarly, hub 104 is equipped with integral LEDs 126. LEDs 124 and/or 126 may be energized to emit light at various hues (colors), patterns, intervals, *etc.* As will be explained in more detail shortly, techniques described herein may be employed to selectively energize these LEDs 124 and/or 126 to convey information, such as aspect(s) of a "power configuration" between head component 102, hub 104, and removable cable 106, for example.

[0026] As noted previously power configuration between head component 102, hub 104, and removable cable 106 may include information about capabilities of these electronic devices to exchange power between them. In some examples, a power configuration may include a first amount of power supplied to hub 104 via power source 110, and a second amount of power that is deliverable by hub 104 to head component 102 via removable cable 106. Based on these two pieces of information, hub 104 and/or head component 102 can selectively modulate light emitted by LEDs 124 and/or 126 to convey various aspects of the power configuration, such as error codes. These error codes may convey various information to a user, such as: that a component has been improperly connected to another component; that a component cannot receive sufficient power to operate properly; that one component (*e.g.*, cable 106) is incompatible with other components; *etc.*

[0027] Other types of output components besides LEDs may be employed in a similar fashion to convey similar information. For example, embedded speaker(s) (not depicted) installed on a printed circuit board (*e.g.*, a motherboard) of head component 102 and/or hub 104 may be operated to emit beeps of various pitches and/or lengths. As with flashing LEDs 124 and/or 126, the beeps emitted by such embedded speaker(s) can be modulated to convey aspect(s) of a detected power configuration.

[0028] As an illustrative example, head component 102 in Fig. 1 takes the form of a tablet-like computing device that can be used for transactional processing, *e.g.*, as a point-of-sale terminal. Head component 102 may include a USB port (not depicted), such as a USB-C port, that can be used to connect head component 102 to another electronic device to receive power, and in some cases, data as well. If head component 102 is capable of operating within the operational power parameters of USB-C—*e.g.*, 100 watts or less—then a standard USB-C cable can be used as removable cable 106 to connect head component 102 to hub 104.

[0029] But suppose head component 102 draws more than 100 watts of power, *e.g.*, 140 watts. Suppose further that the physical port (not depicted) on head component 102 is still physically compatible with USB-C connectors. If a standard USB-C cable with a 100-watt maximum power throughput is used to connect such a head component 102 to hub 104, head component 102 will not be able to operate properly. Head component 102 may not be able to operate an OS and/or render content on touch screen 108, in which case it may be difficult for a user to discern what they had done incorrectly, especially since the standard USB-C cable connector was physically compatible with the port on head component 102.

[0030] Accordingly, in various examples, circuitry may be provided, *e.g.*, as part of hub 104 (indicated at 128A) and/or as part of head component 102 (indicated at 128B), that causes output components such as LEDs 124 and/or 126 to render modulated output that conveys information about the power configuration to the user. Unless otherwise indicated, reference to "circuitry 128" herein refers to either circuitry 128A, circuitry 128B, or some combination of both. Circuitry 128 can take various forms, such as an ASIC, a field-programmable gate array (FPGA), and/or a processor executing computer-readable instructions stored in memory.

[0031] Circuitry 128 may determine a power configuration of head component 102, hub 104, and removable cable 106 in various ways. In some examples, circuitry 128A or 128B may read a power descriptor 130 that is made available by removable cable 106 (*e.g.*, stored in memory of removable cable 106) to obtain aspect(s) of a power configuration. For example, if removable cable 106 is a USB-C cable, then removable cable 106 may provide its power limit as part of a PDO. This power limit may represent the amount of power that is deliverable by removable cable 106.

[0032] In some examples, circuitry 128 may determine an amount of power that is deliverable by removable cable 106 based on the amount of power that is supplied to hub 104 by power source 110. For example, if power source 110 supplies 90 watts (and likely less) of power, then hub 104 can determine that it can deliver, at maximum, 90 watts of power over removable cable 106, regardless of any power limits of removable cable 106.

[0033] In some examples, circuitry 128A of hub 104 may inform downstream component(s) such as head component 102 of the amount of power that may be deliverable by hub 104 over removable cable 106. For example, circuitry 128A of hub 104 may transmit the amount of power that is deliverable over removable cable 106 to circuitry 128B of head component 102. Circuitry 128B may then operate output components such as LEDs 124 to render output that is modulated to indicate that aspect of the power configuration.

[0034] For example, if the amount of power indicated by circuitry 128A to circuitry 128B is below an operational threshold of head component 102, then circuitry 128B may energize LEDs 124 to emit light in a sequence and/or colors that convey to a user the fact that head component 102 cannot pull sufficient power to operate properly. In some examples, circuitry 128B may be operable independently of other parts of head component 102, such as a central processing unit that controls its overall function. Consequently, even if head component 102 is unable to operate properly, a user may still be informed as to the lack of sufficient power.

[0035] To enable circuitry 128 to inform a user of aspect(s) of the power configuration, so that the user can take remedial action if there is an error, circuitry 128 may compare aspect(s) of the power configuration with, for instance, a lookup table. The lookup table may be stored in memory integral with hub 104, head component 102, another remote computing device or memory, or even removable cable 106. This lookup table may indicate how various output components, such as embedded speaker(s) of hub 104 and/or head component 102, or LEDs 124 and/or 126, should be energized to emit output modulated with information conveying the aspect(s) of the power configuration.

[0036] Table 1, provided below, provides an illustrative example (and assumes for the moment that a compatible removable cable connects hub 104 to head component 102):

Table 1

AC Power	Hub Power	Min. USB-C power	Max upstream power	LED 126	LED 124
<120W	120W	15W	0W	*x* blinks	Off, or *y* blinks
120W	120W	15W	0W	ON	Off, or *y* blinks
150W	120W	15W	45W	ON	*y* blinks
280W	120W	15W	140W	ON	ON

[0037] As shown in Table 1, the hub minimum power is 120W and the minimum USB-C power is 15W. In some examples, the hub minimum power may be obtained from a hub descriptor, which may be data such as a PDO stored in memory associated with, for example, a USB port of hub 104. For AC power (*e.g.*, power source 110) supplied to hub 104 that is less than 120W, the maximum upstream power is 0W. Consequently, circuitry 128A of hub 104 may cause LEDs 126 to emit an error code of *x* blinks. If head component 102 has some other power source, such as an internal battery, then circuitry 128B of head component 102 may cause LEDs 124 to emit an error code of y blinks (*x* and *y* being integers greater than zero); otherwise LEDs 124 may remain off to indicate no power received at head component 102.

[0038] Similarly, for AC power supplied to hub 104 that is equal to 120W, the minimum upstream power is still 15W. Consequently, circuitry 128A of hub 104 may cause LEDs 126 to emit steady light ("ON"), and circuitry 128B of head component 102 may either remain off, or, if some other source of power (*e.g.*, an internal battery) is available, then circuitry 128B of head component 102 may cause LEDs 124 to emit an error code of *y* blinks. In other implementations, circuitry 128A of hub 104 may determine that hub 104 cannot deliver sufficient power to head component 102, and may modulate output of LEDs 126 to convey the fact that while hub 104 has sufficient power for itself, it lacks sufficient surplus power to deliver to head component 102. For example, if head component 102 is connected to a port 116 designated as "port 3," then output of LEDs 126 of hub 104 may be modulated to identify this port, e.g., with three blinks.

[0039] For AC power supplied to hub 104 that is equal to 150W, the maximum upstream power is 45W. This still may not be enough power for head component 102, which may use 140W, for instance. Consequently, circuitry 128A of hub 104 may cause LEDs 126 to emit steady light ("ON"). Because circuitry 128B of head component 102 still receives some power, circuitry 128B may cause LEDs 124 to emit an error code of *y* blinks. In some examples, operational parameters of head component 102 may be provided in memory associated with, for instance, a USB port of head component 102 (*e.g.*, a PDO).

[0040] For AC power supplied to hub 104 that is equal to 280W, the maximum upstream power is 140W (or higher, but for this example it can be assumed that removable cable 106 has its own power limit of 140W). Accordingly, head component 102 now receives sufficient power to operate. Consequently, circuitry 128A of hub 104 may cause LEDs 126 to emit steady light ("ON"), and circuitry 128B of head component 102 may cause LEDs 124 to also emit steady light ("ON").

[0041] As can be seen in the example illustrated by Table 1, a user may be presented with different outputs at different output components to convey different error codes (or codes indicating normal function). In some examples, these output components may be operated to generate output that conveys errors about the electronic devices that host these output components and/or other electronic devices. For example, hub 104 could convey information about itself and/or about head component 102. In some cases, the user may be able to consult documentation associated with hub 104, head component 102, or even removable cable 106, to determine what the error code indicates. Then, the user may take appropriate remedial action.

[0042] Table 2, below, provides an illustrative example of a lookup table that might be consulted by circuitry 128 to determine how to modulate output rendered by output components such as LEDs 124 and/or 126 and/or embedded speakers. Table 2 assumes that hub 104 uses 120W of power for normal operation, and that head component 102 uses 140W of power. In various examples, these operational parameters may be obtained from the respective components, *e.g.*, in the form hub descriptors, head component descriptors, and cable descriptors, any of which may take the form of PDOs. In some examples, a combination of these various descriptors may dictate how various output components are energized and/or modulated to convey information, *e.g.*, as illustrated in Table 2.

Table 2

Power source 110	**LED 126 if incompatible removable cable attached**	**LED 126 if compatible removable cable attached**	**LED 124 if incompatible removable cable attached**	**LED 124 if compatible removable cable attached**
90-119 W	OFF	OFF	OFF	OFF
120W	*x* red, *y* white	ON	*x* red, *y* white	*n* red, *m* white
180W	*x* red, *y* white	ON	*x* red, *y* white	ON
200W	*x* red, *y* white	ON	*x* red, *y* white	ON
230W	*x* red, *y* white	ON	*x* red, *y* white	ON
>280W	*x* red, *y* white	ON	*x* red, *y* white	ON

[0043] Referring to Table 2, if any less than 120W are received from power source 110, then both LEDs 126 of hub 104 and LEDs 124 of head component 102 may remain off, because neither component is receiving sufficient power. If 120W are received from power source 110 at hub 104, then it may be determined by circuitry 128 whether a compatible removable cable 106 attaches hub 104 to head component 102. "Compatible" in this context means that removable cable can deliver 140W to head component 102. More generally, "compatible" as used herein to describe a cable that is capable of delivering enough power to downstream components so that those downstream components are able to operate according to some desired standard (*e.g.* normal operation).

[0044] Once 120W or more are supplied to hub 104, then circuitry 128A of hub 104 can energize LEDs 126. Circuitry 128A then determines whether a compatible removable cable 106 connects head component 102 to hub 104. If the answer is yes, then LEDs 126 are energized to emit steady light ("ON") to signify that, from the perspective of hub 104, everything is functioning properly.

However, if an incompatible removable cable 106 (*e.g.*, cannot deliver 140W) is provided, then circuitry 128A of hub 104 may energize LEDs 126 with *x* red flashes and *y* white flashes (again, *x* and *y* are non-zero integers that may or may not be equal to each other) to signify that an incompatible cable is attached.

[0045] From the perspective of head component 102, once 120W or greater are supplied to hub 104, then circuitry 128B of head component 102 energize LEDs 124. For example, and similar to circuitry 128A, circuitry 128B may determine whether removable cable 106 is compatible. If the answer is yes, but 120W are supplied to hub 104, then LEDs 124 of head component 102 may be energized to emit *m* red flashes and *n* white flashes (*m* and *n* being positive integers) to signify that even though removable cable 106 is capable of carrying 140W, upstream hub 104 is not supplied with enough power to deliver 140W over removable cable 106. Otherwise, if a compatible removable cable 106 is detected by circuitry 128B of head component 102 and power supplied to hub 104 is 180W or more (as shown in Table 2), then LEDs 124 of head component 102 may be energized to emit a steady light, indicating proper operation.

[0046] However, if an incompatible removable cable 106 (*e.g.*, cannot deliver 140W) is detected (e.g., by comparing PDOs to lookup tables such as Table 1 or Table 2), then circuitry 128B of head component 102 may energize LEDs 124 with *x* red flashes and *y* white flashes (again, *x* and *y* are non-zero integers that may or may not be equal to each other) to signify that an incompatible cable is attached. In various examples, circuitry 128B of head component may determine whether removable cable 106 is compatible by reading the power descriptor 130 from removable cable 106, receiving a transmission from circuitry 128A of hub 104 indicating whether removable cable 106 is compatible (*e.g.*, circuitry 128A transmits the amount of power it is able to deliver through cable 106, and circuitry 128B compares this to a minimum threshold), and/or by detecting current supplied from hub 104 through removable cable 106.

[0047] Fig. 2 schematically depicts an apparatus 101 configured with selected aspects of the present disclosure, in accordance with an example of the present disclosure. The apparatus 101 of Fig. 2 includes circuitry 128 that may include all or portions of circuitry 128A of hub 104 and/or 128B of head component 102. In some examples, circuitry 128 may be wholly or partially integral with removable cable 106. In this manner, the apparatus 101 depicted in Fig. 1 may represent 102, 104, 106 or any other electronic device.

[0048] At block 202, circuitry 128 is to determine the power configuration of hub 104, head component 102, and removable cable 106 that couples head component 102 and hub 104. As noted previously, the power configuration may include: a first amount of power supplied to the hub via a mains power outlet, and a second amount of power that is deliverable by the hub to the head component via the removable cable.

[0049] At block 204, circuitry 128 is to cause an output component that is separate from a display (*e.g.*, 108) operated by head component 102 to render output that is modulated to convey an aspect of the power configuration determined at block 202. This output component may take the form of, for instance, LEDs 124 and/or 126 and/or an embedded speaker that is integral with hub 104 and/or head component 102, *e.g.*, on a printed circuit board such as a motherboard. The modulated output may include emitted light and/or sound that is modulated to convey information, *e.g.*, with blinks, changing colors, changing tones, *etc.*

[0050] Fig. 3 schematically depicts a hub 104 configured with selected aspects of the present disclosure, in accordance with an example of the present disclosure. As described previously, hub 104 includes circuitry 128A, a plurality of ports 116, and an output component, such as an LED 126 in Fig. 3.

[0051] At block 302, circuitry 128A is to determine an amount of power that is deliverable by a cable that connects a computing device to a given port of the plurality of ports of the hub. For example, circuitry 128A may detect an amount of power it receives from power source 110 (which may serve as a *de facto* power limit as to the amount of power hub 104 can deliver downstream) and/or may read a cable descriptor (*e.g.*, PDO) that indicates a power capability of removable cable 106.

[0052] At block 304, circuitry 128A may compare the amount of power determined at block 302 to an operational parameter of the computing device. At block 306, circuitry 128A may operate an output component (*e.g.*, LED 126) integral with hub 104 to convey a result of the comparison. For example, if the amount of power determined at block 302 is less than a minimal amount of power utilized by head component 102, then circuitry 128A may cause LED 126 to emit various sequences of flashes and/or colors to indicate an error. If the amount of power is sufficient, on the other hand, circuitry 128A may cause LED 126 to emit steady light to indicate a suitable power configuration for proper operation of head component 102.

[0053] Fig. 4 depicts an example method 400 for a hub 104 to practice selected aspects of the present disclosure. In various examples, the operations of Fig. 4 that are described herein as being performable by hub 104 may be performed in whole or in part by circuitry 128A. At block 402, hub 104 may determine an amount of power supplied to hub 104 by power source 110. At block 404, hub 104 may determine whether the amount of power satisfies a threshold, such as a minimum operational parameter of head component 102. If the answer at block 404 is no, then at block 406, hub 104 may modulate output of an output component such as LEDs 126 to convey a first error code, such as a sequence of blinks or flashes.

[0054] If the answer at block 404 is yes, on the other hand, then at block 408, hub 104 may read a power descriptor of removable cable 106, *e.g.*, to determine a maximum power throughput of removable cable 106. At block 410, hub 104 may determine whether information it gleaned from the power descriptor at block 408 satisfies some criterion. For example, head component 102 may have a minimum operational power usage of 140W. If removable cable 106 is not capable of delivering 140W of power, head component 102 may not operate properly. In such a case, hub 104 may modulate output of LEDs 126 to convey a second error code which is presumably different than the first error code of block 406. If the answer at block 410 is yes, on the other hand, then at block 414, hub 104 may modulate output of LEDs 126 to convey normal operation, such as a steady white light.

[0055] Fig. 5 depicts an example method 500 for a head component 102 to practice selected aspects of the present disclosure. In various examples, the operations of Fig. 5 that are described herein as being performable by head component 102 may be performed in whole or in part by circuitry 128B. The operations of method 500 may be similar to the operations of method 500 in many respects, and may in fact be performed in parallel or contemporaneously with the operations of method 500, except from the perspective of head component 102, rather than hub 104.

[0056] At block 502, head component 102 may determine an amount of power supplied to hub 104 by power source 110. For example, circuitry 128A of hub 104 may transmit an indication of the power it receives from power source 110 to circuitry 128B of head component 102. At block 504, head component 102 may determine whether the amount of power satisfies a threshold, such as a minimum operational parameter of head component 102. If the answer at block 504 is no, then at block 506, head component 102 may modulate output of an output component such as LEDs 124 to convey a first error code, such as a sequence of blinks or flashes.

[0057] If the answer at block 504 is yes, on the other hand, then at block 508, head component 102 may determine a power configuration of removable cable 106, *e.g.*, to determine a maximum power throughput of removable cable 106. In some examples, head component 102 may determine the power configuration based on a message it receives from hub 104 that indicates the maximum power throughput of cable that hub 104 read directly from removable cable 106. In other examples, circuitry 128B of head component 102 may independently read the power descriptor 130 of removable cable 106 itself.

[0058] At block 510, head component 102 may determine whether the maximum power throughput of removable cable 106 determined at block 508 satisfies some criterion. For example, head component 102 may have a minimum operational power usage of 140W. If removable cable 106 is not capable of delivering 140W of power, head component 102 may not operate properly. In such a case, head component 102 may modulate output of LEDs 124 to convey a second error code which is presumably different than the first error code of block 506. If the answer at block 510 is yes, on the other hand, then at block 514, head component 102 may modulate output of LEDs 124 to convey normal operation, such as a steady white light.

[0059] Although described specifically throughout the entirety of the instant disclosure, representative examples of the present disclosure have utility over a wide range of applications, and the above discussion is not intended and should not be construed to be limiting, but is offered as an illustrative discussion of aspects of the disclosure.

CLAIMS

What is claimed is:

1. An apparatus comprising circuitry to:

determine a power configuration of a hub, a head component, and a removable cable that couples the head component and the hub, wherein the power configuration includes:

a first amount of power supplied to the hub via a mains power outlet, and

a second amount of power that is deliverable by the hub to the head component via the removable cable; and

cause an output component that is separate from a display operated by the head component to render output that is modulated to convey an aspect of the power configuration.

2. The apparatus of claim 1, wherein the circuitry is integral with the hub.

3. The apparatus of claim 1, wherein the second amount of power that is deliverable by the hub to the head component comprises a power limit of the removable cable.

4. The apparatus of claim 3, wherein the power limit is determined from a power descriptor obtained from the removable cable.

5. The apparatus of claim 4, wherein the power descriptor comprises a power delivery object (PDO).

6. The apparatus of claim 1, wherein the second amount of power that is deliverable by the hub to the head component is determined based on the first amount of power.

7. The apparatus of claim 1, wherein the output component comprises a light-emitting diode or an embedded speaker.

8. The apparatus of claim 7, wherein the output component is integral with the hub.

9. The apparatus of claim 1, wherein the output component is integral with the head component, and the circuitry is to transmit the second amount of power to the head component.

10. The apparatus of claim 1, wherein the aspect comprises the cable being incapable of delivering sufficient power to the head component.

11. A hub comprising

a plurality of ports;

an output component; and

circuitry coupled with the plurality of ports and the output component, the circuitry to:

determine an amount of power that is deliverable by a cable that connects a computing device to a given port of the plurality of ports of the hub;

compare the amount of power to an operational parameter of the computing device; and

operate an output component integral with the hub to convey a result of the comparison.

12. The hub of claim 11, wherein the computing device comprises a tablet computer with integral touch screen.

13. The hub of claim 11, wherein the amount of power is determined from a power delivery object (PDO) obtained from the cable.

14. The hub of claim 11, wherein the given port comprises a universal serial bus (USB) port.

15. The hub of claim 11, wherein the output component comprises a light-emitting diode or a speaker.

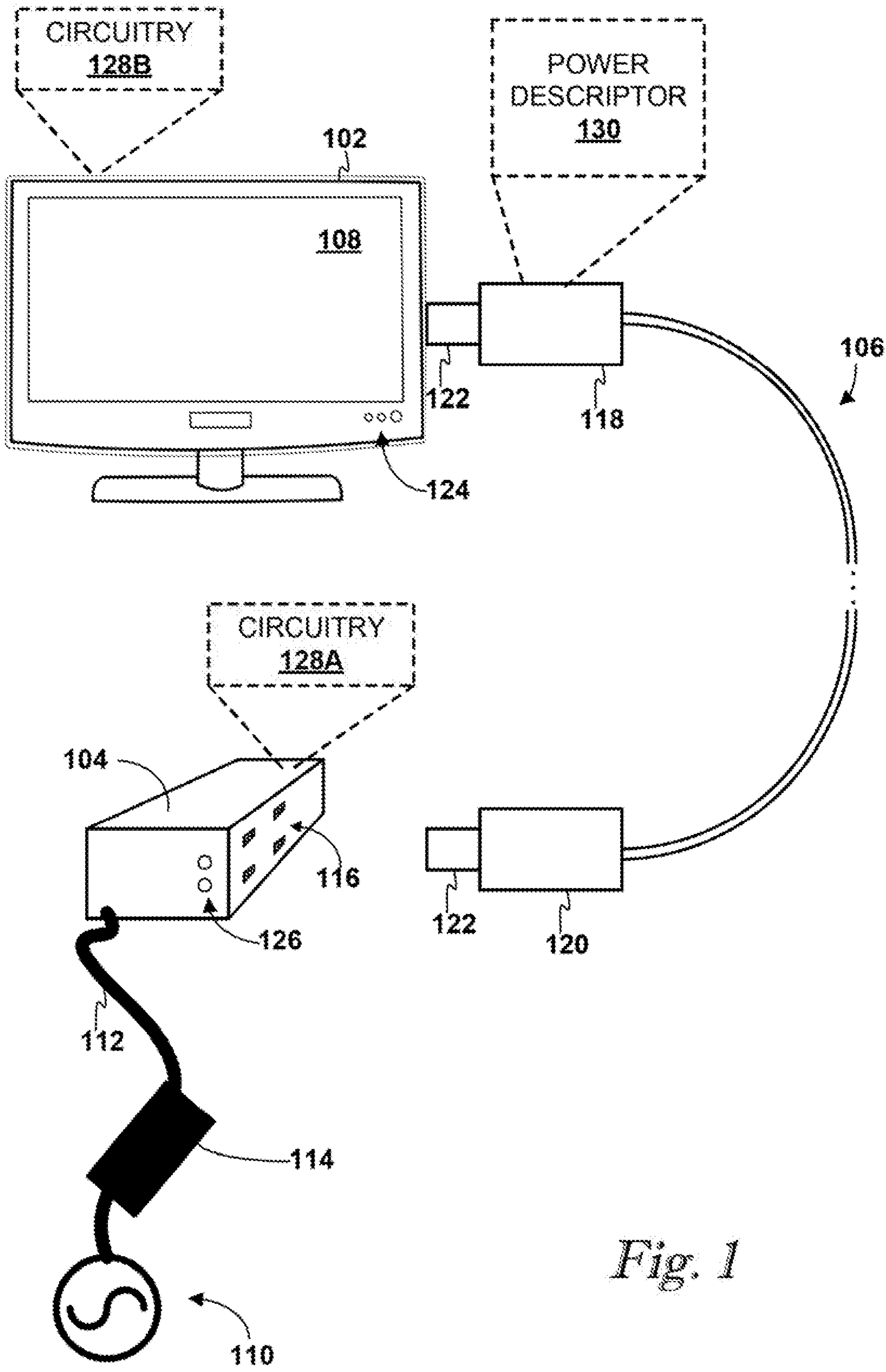
CIRCUITRY
128B
POWER
DESCRIPTOR
130
102
108
106
122
118
124
CIRCUITRY
128A
104
116
126
122
120
112
114
110

Fig. 1

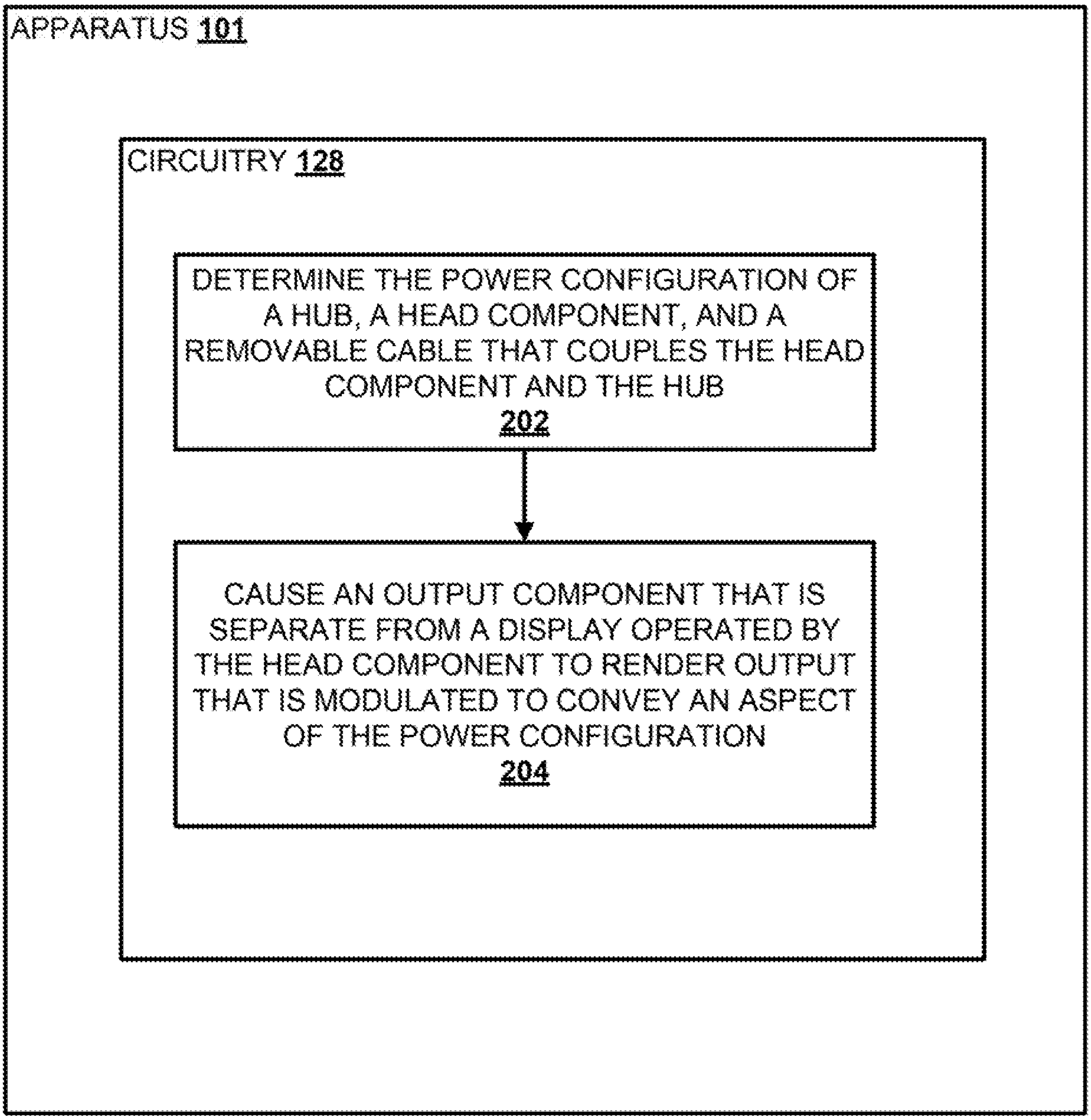
APPARATUS 101
CIRCUITRY 128
DETERMINE THE POWER CONFIGURATION OF A HUB, A HEAD COMPONENT, AND A REMOVABLE CABLE THAT COUPLES THE HEAD COMPONENT AND THE HUB
202
CAUSE AN OUTPUT COMPONENT THAT IS SEPARATE FROM A DISPLAY OPERATED BY THE HEAD COMPONENT TO RENDER OUTPUT THAT IS MODULATED TO CONVEY AN ASPECT OF THE POWER CONFIGURATION
204

Fig. 2

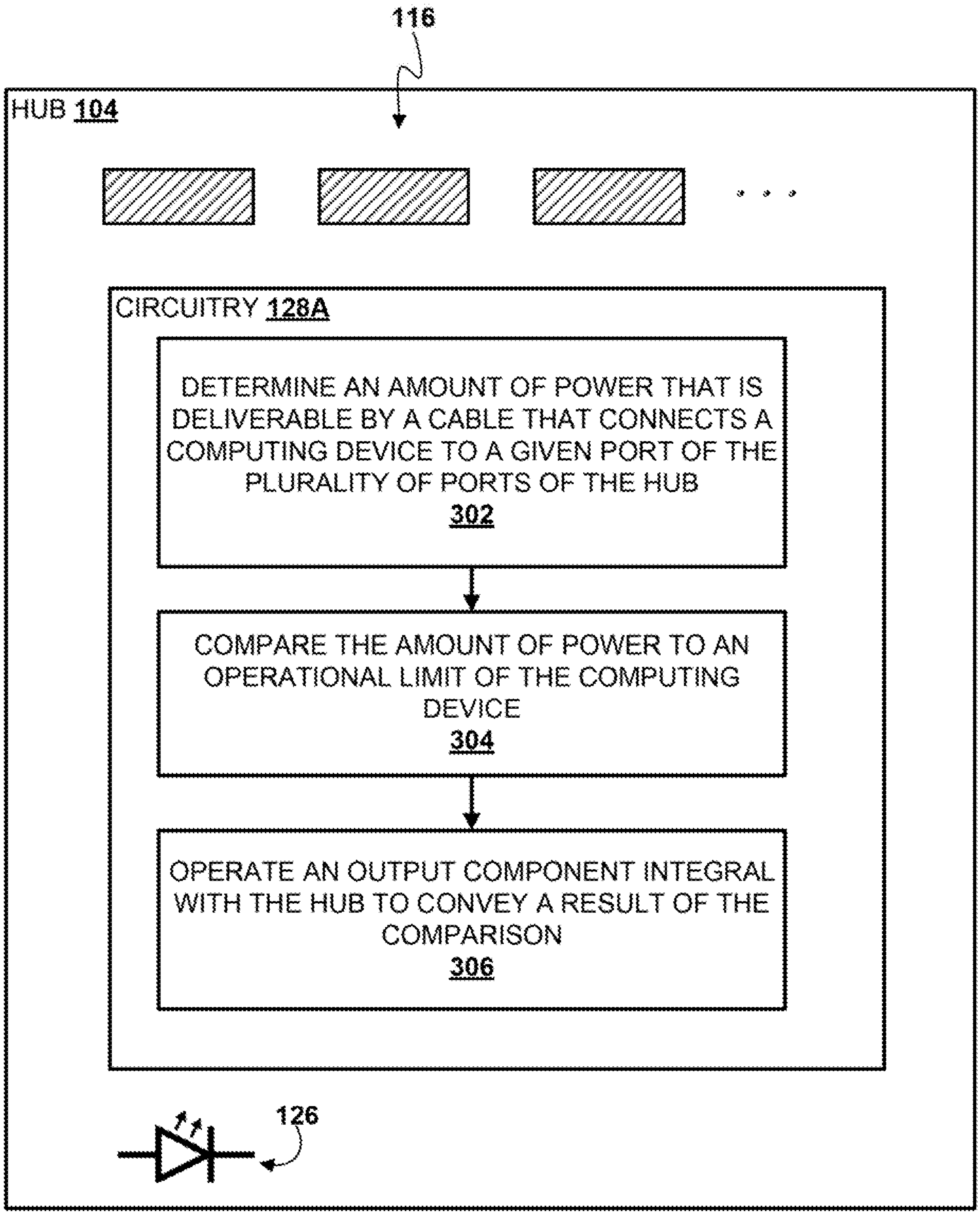
116
HUB 104
. . .
CIRCUITRY 128A
DETERMINE AN AMOUNT OF POWER THAT IS DELIVERABLE BY A CABLE THAT CONNECTS A COMPUTING DEVICE TO A GIVEN PORT OF THE PLURALITY OF PORTS OF THE HUB
302
COMPARE THE AMOUNT OF POWER TO AN OPERATIONAL LIMIT OF THE COMPUTING DEVICE
304
OPERATE AN OUTPUT COMPONENT INTEGRAL WITH THE HUB TO CONVEY A RESULT OF THE COMPARISON
306
126

Fig. 3

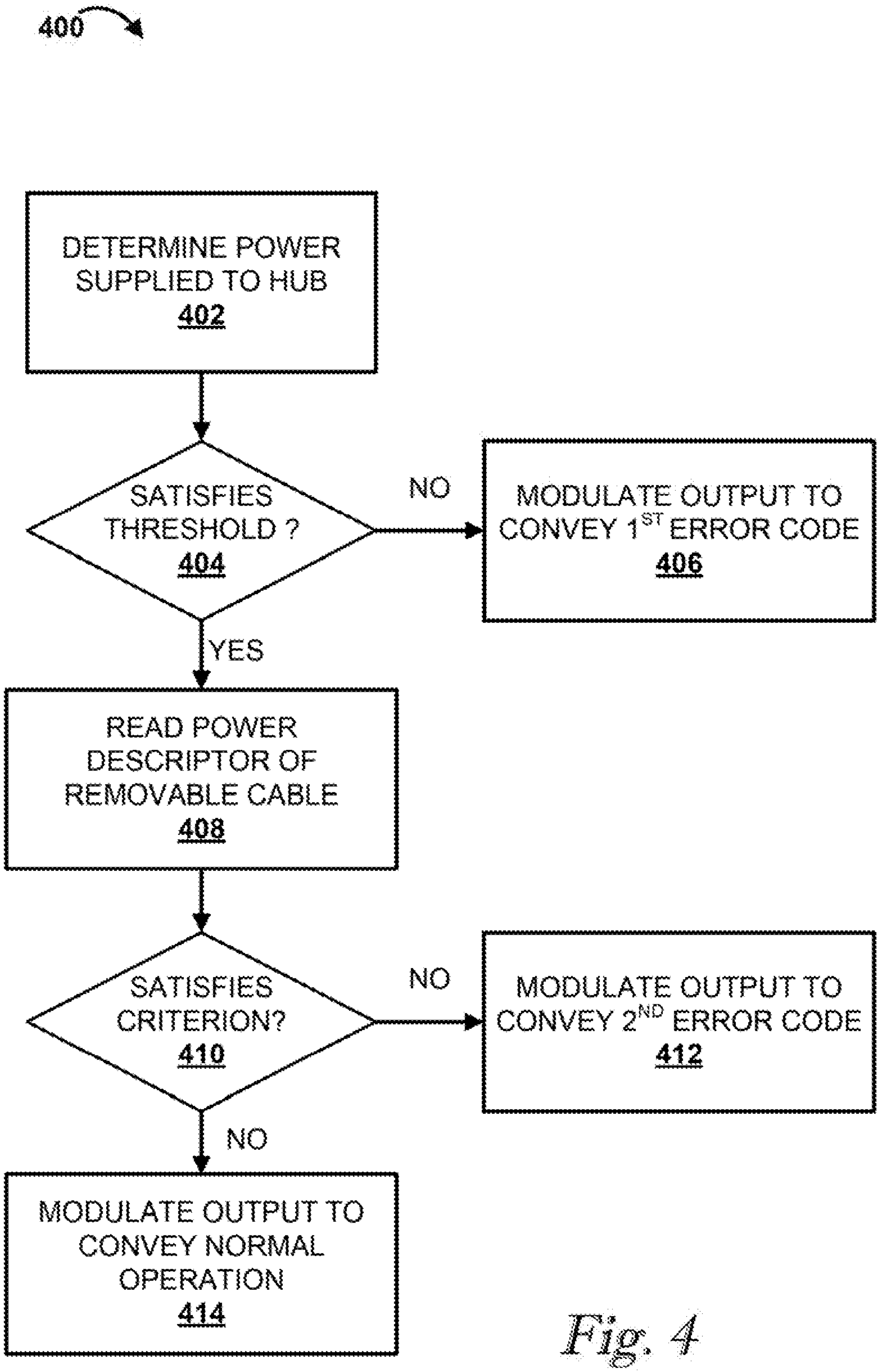
400
DETERMINE POWER SUPPLIED TO HUB 402
SATISFIES THRESHOLD ? 404
NO
MODULATE OUTPUT TO CONVEY 1ST ERROR CODE 406
YES
READ POWER DESCRIPTOR OF REMOVABLE CABLE 408
SATISFIES CRITERION? 410
NO
MODULATE OUTPUT TO CONVEY 2ND ERROR CODE 412
NO
MODULATE OUTPUT TO CONVEY NORMAL OPERATION 414

Fig. 4

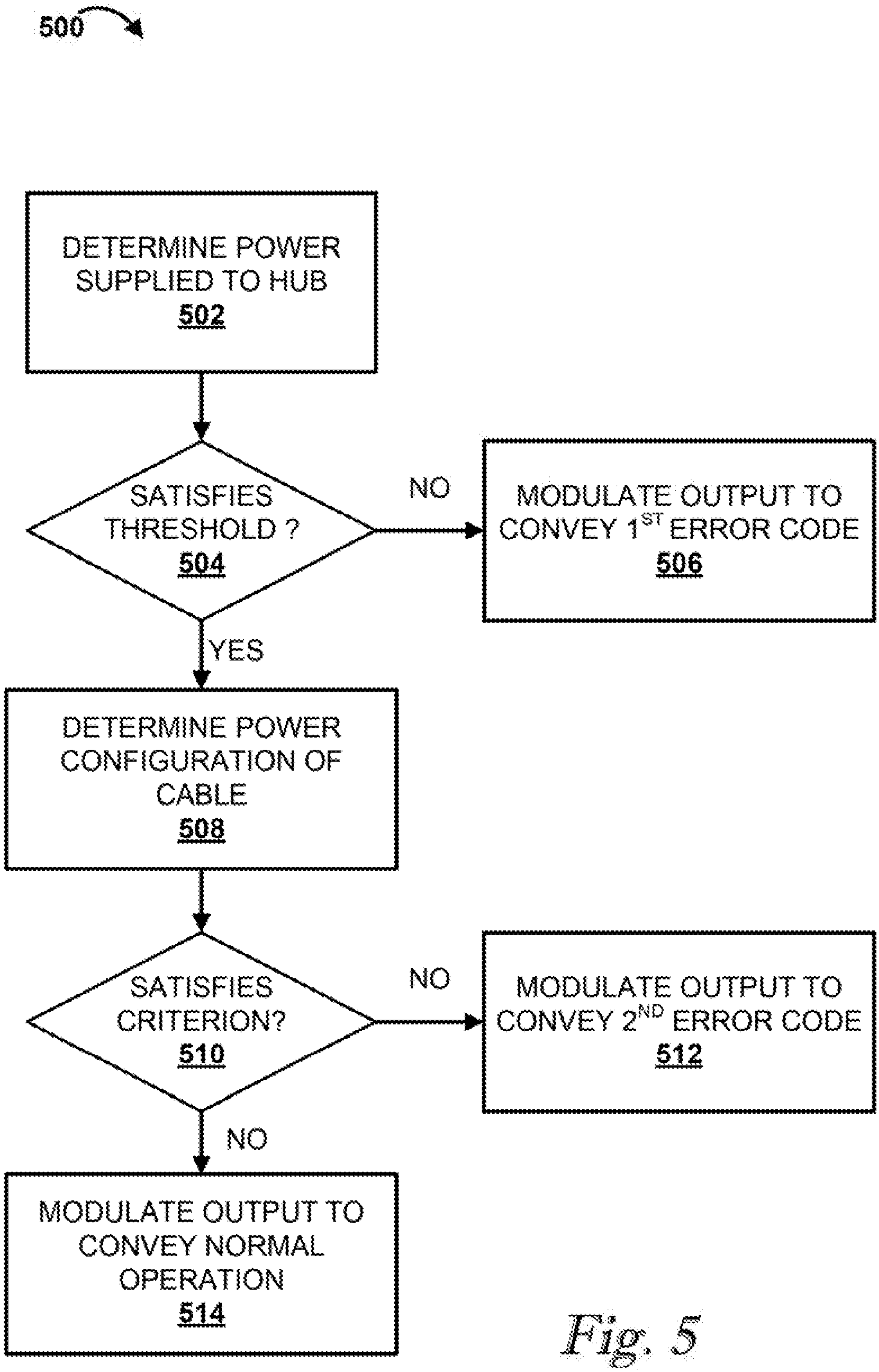
500
DETERMINE POWER SUPPLIED TO HUB
502
SATISFIES THRESHOLD ?
504
NO
MODULATE OUTPUT TO CONVEY 1ST ERROR CODE
506
YES
DETERMINE POWER CONFIGURATION OF CABLE
508
SATISFIES CRITERION?
510
NO
MODULATE OUTPUT TO CONVEY 2ND ERROR CODE
512
NO
MODULATE OUTPUT TO CONVEY NORMAL OPERATION
514

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2020/041998

A. CLASSIFICATION OF SUBJECT MATTER

G06F 1/26 *(2016.01)*

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)

G06F 1/00, 1/26

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)

PatSearch (RUPTO Internal), USPTO, PAJ, Espacenet, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 20100042174 A (KO DAE SUN) 23.04.2010, paragraphs [0001], [0017]-[0022], figure 1	1-15
Y	TW 201913268 A (GEMI SEMICONDUCTOR INC) 01.04.2019, paragraphs [0013]-[0016], [0029]-[0033]	3-6, 11-15
Y	US 2008/0133815 A1 (BELKIN INTERNATIONAL, INC) 05.06.2008, paragraphs [0015], [0036]	1-15
Y	US 2016226283 A1 (INTEL CORPORATION) 04.08.2016, paragraph [0013]	12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

04 February 2021 (04.02.2021)

Date of mailing of the international search report

25 February 2021 (25.02.2021)

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