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### Battery assembly for head-mounted display

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#### Abstract

A head-mountable device can include an optical module to present visual information to a user, a structure movably attached to the optical module, the structure defining a motion path of the optical module. The structure can include a housing defining an internal volume, and a battery disposed within the internal volume.

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Background/Summary

FIELD

(1) The described embodiments relate generally to a battery assembly for head-mounted displays. More particularly, the present embodiments relate to a battery integrated guide rail for an optical module of a head-mountable device.

BACKGROUND

(2) A primary challenge when developing head-mounted displays (HMDs), particularly HMDs that have small form factors, is achieving a suitable battery life while still maintaining functionality and an acceptable shape and size. Performing the necessary computing functions, while still making the HMD stylish and light enough that a user could wear the device for an extended period of time demands novel solutions.

(3) Given the power needs of HMDs and current battery technology, a user may be required to remove and charge the device several times a day or keep the device tethered to a power source. Additionally, internal batteries with lower power capacities can be utilized to maintain power to fundamental operations of the system, such as memory retention. Accordingly, there is a need to enhance the options for power sources in an HMD.

SUMMARY

(4) According to some aspects of the present disclosure, a head-mountable device can include an optical module to present visual information to a user, a structure movably attached to the optical module, the structure defining a motion path of the optical module. The structure can include a housing defining an internal volume, and a battery disposed within the internal volume.

(5) In some examples, the structure can be a first guide rail, the battery can be a first battery, the optical module can be a first optical module, and the head-mountable device can further include a second optical module movably attached to a second guide rail, the second guide rail housing a second battery. The structure can include an upper structure, the optical module being movably attached to the upper structural component, and a lower structure, the lower structural component housing a second battery.

- (6) In some examples, the structure can include a guide rail that defines a motion pathway of the optical module. The structure can be cylindrical. The structure can include an electrical connection establishing electrical communication between the battery and the head-mountable device. The housing can define an air gap between an internal surface of the housing and the battery.
- (7) In some examples, the structure can be attached to a mounting enclosure of the head-mountable device, an electrical pathway positioned through the mounting enclosure. The head-mountable device can include a cable extending from the battery through an open end of the structure. The battery can include an anode material and a cathode material. Each of the anode material and the cathode material can directly contact the housing of the structure.
- (8) According to some aspects, a guide rail for a head-mounted display can include a housing defining an exterior surface and an internal volume, and a power source positioned in the internal volume. The exterior surface of the guide rail can interface with a movable lens structure.
- (9) In some examples, the power source can be removable from the housing. The power source can be fixed in the housing via an adhesive. The guide rail can include a sled fixed to the battery and removably attached to the housing. The sled can include a protrusion to releasably couple with a recess of the housing. The housing can include a carbon fiber filled composite. The housing can define a vent forming an airflow path between the internal volume and an ambient environment.
- (10) According to some aspects, a head-mountable device can include a battery including a battery housing, and an optical module including an actuator rotatably engaging the battery housing to translate the optical module. In some examples, the battery can include a cylindrical cell. The battery housing can include a flame resistant material.
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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

- (1) The disclosure will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:
- (2) FIG. 1 shows a top view of a head-mountable device.
- (3) FIG. 2 shows a schematic block diagram.
- (4) FIG. 3 shows a top view of a head-mountable device.
- (5) FIG. 4 shows a rear view of a head-mountable device.
- (6) FIG. 5 shows a side cross-sectional view a head-mountable device
- (7) FIG. 6A shows a perspective view of a guide rail.
- (8) FIG. 6B shows a cross-sectional perspective view of a guide rail.
- (9) FIG. 7 shows a cross-sectional view of a battery integrated guide rail.
- (10) FIG. 8 shows a cross-sectional view of a battery integrated guide rail.
- (11) FIG. 9 shows a cross-sectional view of a battery integrated guide rail.
- (12) FIG. 10 shows a cross-sectional view of a battery integrated guide rail.
- (13) FIG. 11 shows a cross-sectional view of a battery integrated guide rail.
- (14) FIG. 12 shows a cross-sectional view of a battery integrated guide rail.
- (15) FIG. 13 shows a cross-sectional perspective view of battery.

### DETAILED DESCRIPTION

- (16) Reference will now be made in detail to representative embodiments illustrated in the accompanying drawings. It should be understood that the following descriptions are not intended to limit the embodiments to one preferred embodiment. To the contrary, it is intended to cover alternatives, modifications, and equivalents as can be included within the spirit and scope of the described embodiments as defined by the appended claims.
- (17) Given the power needs of HMDs, a user may be faced with the decision of either removing

and charging the device several times a day or keeping the device tethered to a power source. Accordingly, there is a need to enhance the available options for power sources in an HMD. The present disclosure provides solutions that enable a battery to be integrated into a structural component or structure, such as a guide rail for an optical module, without increasing the overall size or shape of the HMD.

(18) HMDs can utilize on board batteries to handle peak loads or to provide greater portability. Further, HMDs need to be lightweight and space efficient to enhance the user experience. HMDs are formed with a number of structural components, including guide rods (also referred to herein as guide rails or structural components) to allow optical modules to translate for adjustment to accommodate the user's interpupillary distance (IPD). In some examples, the guide rods can be hollow to reduce weight.

(19) The present disclosure describes using guide rods as the thermal and mechanical enclosure for a cylindrical cell battery. In some examples, the battery integrated into a guide rod can be a pouch cell, prismatic cell, or any other suitable lithium battery. The battery housing becomes a linear mechanism surface that can be tuned for a low coefficient of friction to facilitate the continued function as a guide rail. Similarly, the properties of composite materials selected for the guide rail housing can provide thermal resistance and mechanical strength. Further, complexity of traditional mechanical housings for batteries are eliminated, thereby reducing costs and weight, and enabling more efficient packaging solutions in system.

(20) While some HMDs can also include a larger primary battery that is integrated into the HMD housing or a separate external battery that is tethered to the HMD, the inclusion of batteries into the guide rails can be advantageous for any number of low-power functionalities or peak power loads. For example, the batteries integrated into the guide rails can be used when the HMD is unplugged from a primary power source, can be used during a reboot process, can be used for memory retention, and/or can be used for low battery modes.

(21) The guide rail can include an interconnect extending out from the battery and connected to a main logic board (MLB). In some examples, the HMD can include at least one guide rail, and in some examples can include four guide rails (two upper and two lower). Each guide rail can be integrated with a battery positioned within the hollow volume of the guide rail housing. In some examples, the guide rail can be a structural component with an optical module movably attached thereto.

(22) These and other embodiments are discussed below with reference to FIGS. 1-13. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these Figures is for explanatory purposes only and should not be construed as limiting. Furthermore, as used herein, a system, a method, an article, a component, a feature, or a sub-feature comprising at least one of a first option, a second option, or a third option should be understood as referring to a system, a method, an article, a component, a feature, or a sub-feature that can include one of each listed option (e.g., only one of the first option, only one of the second option, or only one of the third option), multiple of a single listed option (e.g., two or more of the first option), two options simultaneously (e.g., one of the first option and one of the second option), or combination thereof (e.g., two of the first option and one of the second option).

(23) A top view of an illustrative electronic device **110** is shown in FIG. 1. Electronic device **110** of FIG. 1 can include an HMD, which can include smart glasses or alternative reality or virtual reality goggles. As shown in FIG. 1, device **110** can include a housing **112**. The housing **112** can include a housing wall, external housing, housing structures, enclosure, or case that can be formed from materials such as polymer, glass, metal, crystalline materials such as sapphire, ceramic, fabric, foam, wood, other materials, and/or combinations of these materials.

(24) The electronic device **110** can be any suitable shape. The housing **112** can form a head-mounted housing in the shape of a pair of goggles (e.g., goggles having optional head straps such as straps **112T**, a nose bridge portion in nose bridge region NB that is configured to fit over a user's

nose and help support housing **112** on the user's nose, etc.) and/or other head-mounted structures. The housing **112** can define an interior region **126** and an exterior region **128**. The housing **112** can include portions such as front portion (front wall) **112F** on front face F of the device **110**, a rear portion (rear wall) **112R** on an opposing rear face R of the device **110**, and sidewall portions **112W** on the sides W that extend between the front portion **112F** and the rear portion **112R**, such that the housing **112** encloses the interior region **126**.

(25) Electrical and optical components can be mounted within housing **112** (e.g., in the interior region **126**). As an example, the housing **112** can include optical components disposed within the interior region **126**, such as displays **114** and lenses **138**. The displays **114** and the lenses **138** can be mounted in optical modules **130** (sometimes referred to as lens barrels, display and lens support structures, etc.). Images, visual information, or any visual data from the displays **114** can be viewed (i.e., visible to the user) from eye boxes **136** through the lenses **138**. A left display and left lens in a left optical module **130** can be used to present a left-eye image to a user's left eye in a left eye box **136**, and a right display and right lens in a right optical module **130** may be used to present a right-eye image to a user's right eye in right eye box **136**. Manual adjustment mechanisms and/or electrically adjustable actuators **113** (e.g., motors or other electrically adjustable positioners) may be used to move optical modules **130** horizontally across the front of the user's face (e.g., to adjust distance D between modules **130** along a direction parallel to the X-axis or nearly parallel to the X-axis of FIG. 1). The optical modules **130** can include actuators that rotatably engage a guide rail or battery housing to move the optical module along a path defined by the guide rail/battery. Optical modules **130** may, for example, be moved closer to each other or farther apart from each other as needed to accommodate different user interpupillary distances (IPD).

(26) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIG. 1 can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIG. 1.

(27) A schematic diagram of an illustrative electronic device is shown in FIG. 2. Device **210** of FIG. 2 may be operated as a stand-alone device and/or the resources of device **210** may be used to communicate with external electronic equipment. As an example, communications circuitry in device **210** may be used to transmit user input information, sensor information, and/or other information to external electronic devices (e.g., wirelessly or via wired connections) and/or may be used to receive such information from external electronic devices. Each of these external devices may include components of the type shown by device **210** of FIG. 2.

(28) As shown in FIG. 2, the electronic device **210** can include control circuitry **220**. Control circuitry **220** may include storage and processing circuitry for supporting the operation of the device **210**. The storage and processing circuitry can include storage such as nonvolatile memory (e.g., flash memory or other electrically-programmable-read-only memory configured to form a solid-state drive), volatile memory (e.g., static or dynamic random-access-memory), etc. Processing circuitry in control circuitry **220** can be used to gather input from sensors (e.g., cameras) and other input devices and may be used to control output devices. The processing circuitry can be based on one or more microprocessors, microcontrollers, digital signal processors, baseband processors and other wireless communications circuits, power management units, audio chips, application specific integrated circuits, etc. During operation, control circuitry **220** can use display(s) **214** and other output devices in providing a user with visual output and other output.

(29) To support communications between the device **210** and external equipment, the control circuitry **220** can communicate using communications circuitry **222**. The communications circuitry **222** can include antennas, radio-frequency transceiver circuitry, and other wireless communications

circuitry and/or wired communications circuitry. The circuitry **222**, which can sometimes be referred to as control circuitry and/or control and communications circuitry, can support bidirectional wireless communications between the device **210** and external equipment (e.g., a companion device such as a computer, cellular telephone, or other electronic device, an accessory such as a point device, computer stylus, or other input device, speakers, or other output devices, etc.) over a wireless link. For example, the circuitry **222** can include radio-frequency transceiver circuitry such as wireless local area network transceiver circuitry configured to support communications over a wireless local area network link, near-field communications transceiver circuitry configured to support communications over a near-field communications link, cellular telephone transceiver circuitry configured to support communications over a cellular telephone link, or transceiver circuitry configured to support communications over any other suitable wired or wireless communications link. Wireless communications may, for example, be supported over a Bluetooth® link, a Wi-Fi® link, a wireless link operating at a frequency between 10 GHz and 400 GHz, a 60 GHz link, or other millimeter wave link, a cellular telephone link, or other wireless communications link. The device **210** can include power circuits for transmitting and/or receiving wired and/or wireless power and may include batteries or other energy storage devices. For example, the device **210** can include a coil and a rectifier to receive wireless power that is provided to circuitry in device **210**.

(30) The device **210** can include input-output devices **224**. Electronic components such as input-output devices **224** can be used in gathering user input, in gathering information on the environment surrounding the user, and/or in providing a user with output.

(31) The input-output devices **224** can include one or more displays such as display(s) **214**. The display(s) **214** can include one or more display devices such as organic light-emitting diode display panels (panels with organic light-emitting diode pixels formed on polymer substrates or silicon substrates that contain pixel control circuitry), liquid crystal display panels, microelectromechanical systems displays (e.g., two-dimensional mirror arrays or scanning mirror display devices), display panels having pixel arrays formed from crystalline semiconductor light-emitting diode dies (sometimes referred to as micro LEDs), and/or other display devices.

(32) The input-output devices **224** can include cameras **234**. The cameras **234** can include visible light cameras, infrared cameras, and/or cameras that are sensitive at multiple wavelengths, may include three-dimensional camera systems such as depth sensors (e.g., structured light sensors and/or depth sensors based on stereo imaging devices that capture three-dimensional images), may include time-of-flight cameras, and/or may include other cameras. The cameras **234** can face toward the user of device **210** and/or away from the user of device **210**.

(33) The sensors **216** in input-output devices **224** can include force sensors (e.g., strain gauges, capacitive force sensors, resistive force sensors, etc.), audio sensors such as microphones, touch and/or proximity sensors including capacitive sensors such as a touch sensor that forms a button, trackpad, or other input device), and other sensors. If desired, sensors **216** may include optical sensors such as optical sensors that emit and detect light, ultrasonic sensors, optical touch sensors, optical proximity sensors, and/or other touch sensors and/or proximity sensors, monochromatic and color ambient light sensors, fingerprint sensors, iris scanning sensors, retinal scanning sensors, and other biometric sensors, temperature sensors, sensors for measuring three-dimensional non-contact gestures (“air gestures”), pressure sensors, sensors for detecting position, orientation, and/or motion (e.g., accelerometers, magnetic sensors such as compass sensors, gyroscopes, and/or inertial measurement units that contain some or all of these sensors), health sensors such as blood oxygen sensors, heart rate sensors, blood flow sensors, and/or other health sensors, radio-frequency sensors, optical sensors such as self-mixing sensors and light detection and ranging (LIDAR) sensors, humidity sensors, moisture sensors, gaze tracking sensors, electromyography sensors to sense muscle activation, facial sensors, interferometric sensors, time-of-flight sensors, magnetic sensors, resistive sensors, distance sensors, angle sensors, and/or other sensors. In some

arrangements, device **210** may use sensors **216** and/or other input-output devices **224** to gather user input. For example, input-output devices **224** such as buttons may be used to gather button press input, touch sensors overlapping displays can be used for gathering user touch screen input, touch pads may be used in gathering touch input, microphones may be used for gathering audio input (e.g., voice commands), accelerometers may be used in monitoring when a finger contacts an input surface and may therefore be used to gather finger press input, etc.

(34) Input-output devices **224** may include optical components such as depth sensors (e.g., structured light sensors or other sensors that gather three-dimensional image data), optical proximity sensors, ambient light sensors (e.g., color ambient light sensors), optical time-of-flight sensors and other sensors **216** that are sensitive to visible and/or infrared light and that may emit visible and/or infrared light (e.g., devices **224** may contain optical sensors that emit and/or detect light). For example, a visible-light image sensor in a camera may have a visible light flash or an associated infrared flood illuminator to provide illumination while the image sensor captures a two-dimensional and/or three-dimensional image. An infrared camera such as an infrared structured light camera that captures three-dimensional infrared images may have an infrared flood illuminator that emits infrared flood illumination and/or may have a dot projector that emits an array of infrared light beams. Infrared proximity sensors may emit infrared light and detect the infrared light after the infrared light has reflected from a target object.

(35) If desired, electronic device **210** may include additional components (see, e.g., other devices **218** in input-output devices **224**). The additional components may include haptic output devices, actuators for moving movable structures in device **210**, audio output devices such as speakers, light-emitting diodes for status indicators, light sources such as light-emitting diodes that illuminate portions of a housing and/or display structure, other optical output devices, and/or other circuitry for gathering input and/or providing output. Device **210** may also include a battery or other energy storage device, connector ports for supporting wired communication with ancillary equipment and for receiving wired power, and other circuitry.

(36) To help maintain desired alignment between optical modules **230** as the optical modules **230** are moved by actuators, optical modules **230** may be mounted on optical module guiding structures such as guide rails or other elongated support members. This type of arrangement is shown in the top view of FIG. 3.

(37) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIG. 2 can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIG. 2.

(38) FIG. 3 illustrates a top view of an HMD or electronic device **310** including optical modules **330** movable along a guide rail **344**. The electronic device **310** can be substantially similar to, including some or all of the features of, the electronic devices described herein. As shown in FIG. 3, the optical modules **330** can be movably or slidably coupled to guide rail **344** to allow the optical modules **330** to move horizontally (e.g., laterally along the X-axis to accommodate different user interpupillary distances).

(39) The guide rails **344** can include a circular cross-sectional shape (e.g., guide rail **344** may be cylindrical rods) or may have other cross-sectional shapes. Guide rod **344** may be formed from metal, polymer, composites, and/or other materials. Hollow and/or solid members may be used in forming guide rail **344**. To help reduce friction between guide rail **344** and the optical modules **330**, the guide rail **344** and/or mating portions of optical modules **330** can include a low-friction coating (e.g., nickel, etc.).

(40) In some examples, the guide rail **344** can span the width of housing **312**. For example, the

electronic device **310** can include left and right guide rails **344** in the device **310** that are joined at a housing support structure and are aligned with nose bridge portion NB. Additionally, in some examples, left and right guide rails **344** may be formed as integral portions of a single guide rail that extends across the housing **312**. The guide rail **344** can be straight or can have a bend or curve at the nose bridge portion NB (e.g., to rake the left and right sides of the guide rails backwards slightly to conform to the shape of a user's face). As shown in the rear view of device **410** of FIG. **4**, there may be upper and lower guide rails **444T** and **444B** (collectively referred to as guide rails **444**). In some examples, the device **410** can include four guide rails (two upper and two lower). Arrangements with fewer guide rails or more guide rails can also be used, in some examples.

(41) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIGS. **3** and **4** can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIGS. **3** and **4**.

(42) FIG. **5** is a side view of an illustrative optical module mounted on guide rails **544**. In the example of FIG. **5**, optical module **530** has an upper portion such as portion **530T** and a lower portion such as portion **530B**. Portions **530T** and/or **530B** may be integrally formed with main supporting structure **530M** of the lens barrel structures and/or other support structures of optical module **530**, and/or may be separate members that are coupled (e.g., using welds, fasteners, adhesive, etc.) to main supporting structure **530M**. Lens **538** may be aligned with display **514** so that an image on display **514** can be viewed through lens **538** from eye box **536**.

(43) As shown in FIG. **5**, optical module **530** may have portions that receive and couple to guide rails **544** while allowing optical module **530** to slide along guide rails **544**. For example, upper portion **530T** may have a guide rail opening (optical module opening) **550** such as opening **550T** that receives upper guide rail **544T** and lower portion **530B** may have a guide rail opening such as opening **550B** that receives lower guide rail **544B**. Openings **550T** and **550B** may be cylindrical openings with circular cross-sectional shapes that receive the cylindrical members forming rails **544T** and **544B** and/or may have other shapes that partly or fully surround rails **544T** and **544B**.

(44) To prevent rails **544** from becoming stuck in guide rail openings **550** of optical module **530**, the inner diameter of optical module openings may be slightly larger (e.g., by 2-50 microns, at least 5 microns, less than 100 microns, or other suitable amount) than the outer diameter of rails **544**. To prevent excess motion, which could lead to misalignment of optical modules, device **510** may be provided with guide rail biasing systems. The guide rail biasing systems may have movable biasing members (e.g., pins, plates, spherical members, hemispherical members, etc.) and biasing elements that apply force to the biasing members. The biasing elements may be, for example, springs such as coil springs, leaf springs, and/or other spring members, may be compressed polymer (e.g., elastomeric material, foam, etc.), may be magnets, and/or may be other biasing components that can be used to bias the biasing members in a desired direction.

(45) Using the guide rail biasing systems, guide rails **544** may be pushed towards desired positions within openings **550** to help remove undesired play between guide rails **544** and openings **550**. As an example, guide rails **544** may be pressed against the inner surfaces of openings **550** (e.g., at a location on the side of openings **550** that faces eye boxes **536** rather than the opposing side of openings **550** that faces outwardly away from the user) and/or may be pressed against a structure mounted within openings **550** such as a pin or other support member.

(46) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIG. **5** can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and



configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIG. 5.

(47) FIG. 6A shows a perspective view of a guide rail **644**. The guide rail **644** can be substantially similar to, including some or all of the features of, the guide rails described herein. The guide rail **644** can include an exterior shell, casing, or housing **645**. The housing **645** can define an elongated cylindrical shape. The length of the housing **645** can be several times greater than the width or diameter. In some examples, a cross-section of the housing **645** can be circular, however other shapes are possible including rectangular, oval, etc.

(48) The housing **645** of the guide rail **644** can include or can be made from a variety of materials. In some examples, the housing **645** can include a material having a low coefficient of friction such that the housing **645** includes a smooth exterior surface. The housing **645** can be a composite of materials, in some examples. In other examples, the housing **645** can be a clad of materials. The housing **645** can include one or more of carbon fiber, a carbon fiber filled composite, epoxy-based carbon fiber prepreg, stainless steel, titanium, aluminum, or plastic. The resin may be thermoset, such as an epoxy, or thermoplastic, such as PEEK. The housing material can be selected or tuned to have high thermal resistance and mechanical strength properties. The housing **645** can, in some examples, include a flame-resistant material. In some examples, the guide rail **644** can include an inner layer of flame-resistant material adjacent the housing **645**. In some other examples, the guide rail **644** can include a flame-retardant epoxy resin or plastic overlaying structural carbon layers of the housing **645**.

(49) In some examples, the housing **645** of the guide rail **644** can be hollow (i.e., the housing **644** defining an interior volume). The hollow nature of the guide rail **644** can reduce the overall weight of the system and can also utilize improved stiffness of a hollow structure.

(50) FIG. 6B shows a cross-sectional perspective view of the guide rail **644**. As shown, a power source, such as a battery **602**, can be housed, positioned, surrounded, encapsulated, or disposed within the internal volume defined by the housing **645** of the guide rail **644**. Thus, the guide rail **644** can be integrated with a battery, or in other words, the guide rail **644** can be a battery integrated guide rail. Further details regarding battery integrated guide rails are described below.

(51) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIGS. 6A and 6B can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIGS. 6A and 6B.

(52) FIG. 7 shows a cross-sectional view of a guide rail **744**. The guide rail **744** can be substantially similar to, including some or all of the features of, the guide rails described herein. In some examples, the HMD can include a mounting component **749**. The mounting component **749** can be part of the enclosure of the HMD. In some examples, the guide rail **744** can be received into a recess **751** of the mounting component **749**. The guide rail **744** can be removably or fixedly mounted or attached to the mounting component **749**.

(53) In some examples, the guide rail **744** can include an exterior shell or housing **745**. A battery **702** can be fixed within the guide rail **744**. In some examples, the battery **702** can be adhered to the interior of the guide rail **744** using adhesive **747**. The adhesive **747** can partially or entirely fill the space between the battery **702** and the housing **745**. In some examples, the adhesive **747** can provide shear coupling between opposing sides of the housing **745** of the guide rail **744**. Thus, the battery **702** can be permanently or fixedly secured within the housing **745** of the guide rails **744**.

(54) In some examples, the battery **702** can include an electrical contact, terminal, connection, or outlet **753**. The electrical contact **753** can create an electrical pathway to transfer power from the

battery **702** to the HMD. In some examples, the enclosure **749** can include an electrical terminal, connector, or contact that is positioned to engage with the electrical contact **753** of the battery **702** to establish an electrical connection. In some examples, a cable, a wire, or a flex cable **757** can transfer power from the battery **702** to the components of the HMD. In other examples, a conductive surface can be formed on the enclosure **749** to establish an electrical via between the battery **702** and an electrical component within the HMD.

(55) The guide rail **744** can be coupled to the enclosure **749** using any suitable attachment. For example, the guide rail **744** can be adhered, bolted, screwed, friction fitted, fastened, or magnetically coupled to the enclosure **749**. In some examples, the contacts **753** and **755** are electromagnets that aid in coupling the guide rail **744** to the enclosure **749** and establish an electrical connection between the battery and a main-logic board or other electrical component of the HMD. The guide rail **744** can, in some examples, be pivotally mounted to the enclosure **749**.

(56) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIG. 7 can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIG. 7.

(57) FIG. 8 shows a cross-sectional view of a battery integrated guide rail **844** according to one exemplary embodiment. As shown in FIG. 8, the guide rail **844** can be substantially similar to, including some or all of the features of, the guide rails described herein. In some examples, the guide rail **844** can include one or more biased contact pins **853**. The biased contact pins **853** can include, for example, spring-loaded pogo pins. The biased contact pins **853** can be biased into cavities or grooves **859** in the enclosure **849**. The cavities **859** can be formed within the recess **851**. In some examples, electrical terminals **855** can be positioned or exposed within the cavities **859** to establish an electrical connection with the biasing contact pins **853**. Thus, the battery **802** can be in electrical communication with the HMD via biasing contact pins **853** and terminals **855**.

(58) In some examples, the biasing contact pins **853** can include a spring to extend the contact pins **853** into the cavities **859**. The biasing contact pins **853** can aid in securing the guide rail **844** within the recess **851**. The biasing contact pins **853** can be depressed under a force from the user, such as a pulling motion on the guide rail **844**, in order to remove the guide rail **844** from the enclosure **849**. In some examples, the guide rail **844** can be removably inserted into the enclosure **849** by pushing or pressing the guide rail **844** into the recess **851**. Upon contacting the enclosure **849**, the biasing contact pins **853** can depress or compress in order to allow passage of the guide rail housing **845** into the recess **851**. Once the guide rail **844** passes a certain distance into the cavity **851**, the biasing contact pins **853** can decompress or extend into the cavities **859**, thereby removably retaining the guide rail **844** to the enclosure **849** and establishing an electrical communication between the battery **802** and the HMD.

(59) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIG. 8 can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIG. 8.

(60) FIG. 9 shows a cross-sectional view of a battery integrated guide rail **944**. The guide rail **944** can be substantially similar to, including some or all of the features of, the guide rails described herein. The guide rail **944** can include a support or sled **960** on which the battery **902** can be positioned. The sled **960** can be positioned within the internal volume **962** of the housing **945**. The

sled **960** can be positioned between the battery **902** and the housing **945**. In some examples, a cross-section of the guide rail **944** can be circular or curved. In some examples, the sled **960** can include a shape that conforms to or matches a shape of the interior surface of the housing **945**. For example, in the embodiment of FIG. **9**, the sled **960** can be curved to match a curvature of the housing **945**. The battery **902** can be secured to the sled **960**. In some examples, the battery **902** can be adhered to the sled **960** via an adhesive **947**. In some examples, the sled **960** can include wheels or rollers. As discussed in greater detail with regard to FIGS. **11** and **12**, in some examples the sled **960** can be movable relative to the housing **945** to insert and remove the battery **902** from the housing **945**.

(61) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIG. **9** can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIG. **9**.

(62) FIG. **10** shows a cross-sectional view of a battery integrated guide rail. The guide rail **944** can be substantially similar to, including some or all of the features of, the guide rails described herein. In some examples, the housing **1045** of the guide rail **1044** can include one or more apertures or openings **1064** to vent or cool the battery **1002**. In other words, the openings **1064** in the housing **1045** can define an airflow path, placing the internal volume **1062** of the housing **1045** in fluid communication with the outside environment. Thus, the battery **1002** can be cooled by forming holes **1064** in the housing **1045**. Further venting examples and embodiments are discussed below with reference to FIG. **13**.

(63) FIG. **10** shows only a top portion of the housing as including openings. However, it will be understood the openings can be located around/along an entirety of the housing **1045**, including a lower portion of the housing **1045**. Although not illustrated in FIG. **10**, in some examples, the sled **1060** can include openings to allow heat generated by the battery **1002** to vent into the outside environment. Further details regarding guide rails, and specifically regarding the sled configurations are described below with reference to FIGS. **11** and **12**.

(64) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIG. **10** can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIG. **10**.

(65) FIG. **11** shows a cross-sectional view of a battery integrated guide rail **1144**. The guide rail **1144** can be substantially similar to, including some or all of the features of, the guide rails described herein.

(66) It can be advantageous to produce a battery integrated guide rail that includes an easily removable battery **1102**. However, the desire to remove the battery **1102** must be balanced with the need to securely attach the battery **1102** within the guide rail **1144**. As shown in FIG. **11**, the battery **1102** can be fixedly attached to a removable support or sled **1160** which is detachably coupled to the housing **1145** of the guide rail **1144**. In some examples, the sled **1160** can be a distinct component of the guide rail **1144** that is adhered to the battery **1102**. In some examples, the sled **1160** can be an exterior portion or surface of the battery **1102** (i.e., not a separate component from the battery **1102**).

(67) In some examples, the sled **1160** can be removed or detached from the housing **1145**. The sled **1160** can be attached to the housing **1145** using any suitable attachment mechanism. For example,

the sled **1160** can include one or more attachment components that couple to corresponding attachment components of the housing. In the specific example illustrated in FIG. **11**, the sled **1160** includes feet, protrusions, or clips **1166** that engage or clip into recesses or retention apertures **1168** defined by, or formed in, the housing **1145**. In some examples, the feet **1166** and/or the recesses **1168** can be shaped and designed to allow for removable coupling with each other. For example, the feet **1166** can include a flexible design that allows the feet to bend or flex in order to be removed from the recesses **1168**. In some examples, the feet **1166** can include an angled surface, such as a slope or a ramp that allows the feet **1166** to be withdrawn from the recess **1168** to remove the sled **1160** and battery **1102** from the housing **1145**.

(68) In some examples, the sled **1160** can include a bracket portion, such as a flange **1170**, that engages or contacts a portion of the housing **1145**, such as an edge or end of the housing **1145**. The flange **1170** can be secured to the end of the housing **1145** via a fastener **1172**, thereby securing the sled **1160** in place relative to the housing **1145**. It will be understood that other attachment means for removably coupling the sled **1160** to the housing **1145** can be used to securely couple the sled **1160** to the housing **1145**, including but not limited to magnets, adhesive, fasteners, or any other suitable coupler.

(69) In some examples, the battery **1102** can include a wire or a cable, such as flexible circuitry that establishes an electrical connection between the battery **1102** and the HMD. The cable **1157** can extend from an end of the battery **1102** and through an open end of the housing **1145** and can provide power to the HMD. The cable **1157** can be sufficiently long and can include enough slack to accommodate for motion of the guide rail **1144** relative to the HMD.

(70) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIG. **11** can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIG. **11**.

(71) FIG. **12** shows a cross-sectional view of a battery integrated guide rail **1244**. The guide rail **1244** can be substantially similar to, including some or all of the features of, the guide rails described herein. In some examples, the housing **1245** can define one or more through-holes or openings **1266** which extend entirely through the wall of the housing **1245**, as opposed to the recesses **1168** of FIG. **11** which do not extend entirely through the housing **1245**. The openings **1268** can be positioned to receive the feet **1266** of the sled **1260**. The openings **1268** can allow the feet **1266** to be accessible from an exterior of the guide rail **1244**. In some examples, a user can press or manipulate the feet **1266** through the openings **1268** in order to depress and detach the sled **1260** from the housing **1245** and remove the battery **1202**.

(72) In some examples, the sled **1260** can form a hard stop or barrier that the optical module contacts and prevents further motion of the optical module beyond the hard stop. In some examples, the sled **1260** can include a cable guide or strain relief for an interconnect cable. In other examples, the sled **1260** can include crumple zones or locations of designed failure when predefined forces are reached, to protect ends of the guide rail **1244**. In other words, the sled **1260** can include protective sections that cushion or structurally support the guide rail **1244**.

(73) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIG. **12** can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIG. **12**.

(74) FIG. 13 shows a cross-sectional perspective view of battery 1302. The battery 1302 can be substantially similar to, including some or all of the features of, the batteries and/or guide rails described herein. In some examples, the battery 1302 can include a housing or shell 1345 that forms an exterior protective surface and container of the battery cells 1374. The battery cells 1374 can include a roll of anode and cathode components. The anode and cathode components 1374 can be electrically connected to the HMD via cable 1357.

(75) As illustrated in FIG. 13. In some examples, the shell 1345 can include elongated vents 1364 that run along and around the shell 1345 in order to improve thermals of the battery 1302. The vents 1364 can include mesh or protective screens to prevent debris ingress.

(76) In some examples, the battery 1302 can include cylindrical cells that include a roll of anode and cathode material 1374 that is positioned in the outer casing 1345. The outer casing 1345 can include steel or aluminum. In some examples, the outer casing 1345 is the guide rail. The anode and cathode components 1374 can contact directly the outer casing 1345. In other words, the anode and cathode components 1374 can directly contact the housing of a guide rail. In other examples, the outer casing is surrounded by or encapsulated by the guide rail housing.

(77) In some examples, the outer casing 1345 can structurally support the cylindrical cells 1374 to maintain their shape. However, the examples where the outer casing 1345 is surrounded by the housing of the guide rail, it may not be necessary for the outer casing 1345 to be structurally rigid. Instead, the outer casing 1345 can be thin and flexible, relying instead on the guide rail housing for structural support of the battery 1302. It will be understood that the traditional housing of the battery (i.e., outer casing 1345) can be replaced by the housing of the guide rail when integrating the battery into a guide rail.

(78) In some examples, an optical module of an HMD can be movably attached to the battery 1302, such that the battery 1302 guides motion of the optical module. In this manner, the battery 1302 can be a guide rail, such as those described herein.

(79) Any of the features, components, and/or parts, including the arrangements and configurations thereof shown in FIG. 13 can be included, either alone or in any combination, in any of the other examples of devices, features, components, and parts shown in the other figures described herein. Likewise, any of the features, components, and/or parts, including the arrangements and configurations thereof shown and described with reference to the other figures can be included, either alone or in any combination, in the example of the devices, features, components, and parts shown in FIG. 13.

(80) To the extent applicable to the present technology, gathering and use of data available from various sources can be used to improve the delivery to users of invitational content or any other content that may be of interest to them. The present disclosure contemplates that in some instances, this gathered data may include personal information data that uniquely identifies or can be used to contact or locate a specific person. Such personal information data can include demographic data, location-based data, telephone numbers, email addresses, TWITTER® ID's, home addresses, data or records relating to a user's health or level of fitness (e.g., vital signs measurements, medication information, exercise information), date of birth, or any other identifying or personal information.

(81) The present disclosure recognizes that the use of such personal information data, in the present technology, can be used to the benefit of users. For example, the personal information data can be used to deliver targeted content that is of greater interest to the user. Accordingly, use of such personal information data enables users to calculated control of the delivered content. Further, other uses for personal information data that benefit the user are also contemplated by the present disclosure. For instance, health and fitness data may be used to provide insights into a user's general wellness, or may be used as positive feedback to individuals using technology to pursue wellness goals.

(82) The present disclosure contemplates that the entities responsible for the collection, analysis, disclosure, transfer, storage, or other use of such personal information data will comply with well-

established privacy policies and/or privacy practices. In particular, such entities should implement and consistently use privacy policies and practices that are generally recognized as meeting or exceeding industry or governmental requirements for maintaining personal information data private and secure. Such policies should be easily accessible by users, and should be updated as the collection and/or use of data changes. Personal information from users should be collected for legitimate and reasonable uses of the entity and not shared or sold outside of those legitimate uses. Further, such collection/sharing should occur after receiving the informed consent of the users. Additionally, such entities should consider taking any needed steps for safeguarding and securing access to such personal information data and ensuring that others with access to the personal information data adhere to their privacy policies and procedures. Further, such entities can subject themselves to evaluation by third parties to certify their adherence to widely accepted privacy policies and practices. In addition, policies and practices should be adapted for the particular types of personal information data being collected and/or accessed and adapted to applicable laws and standards, including jurisdiction-specific considerations. For instance, in the US, collection of or access to certain health data may be governed by federal and/or state laws, such as the Health Insurance Portability and Accountability Act (HIPAA); whereas health data in other countries may be subject to other regulations and policies and should be handled accordingly. Hence different privacy practices should be maintained for different personal data types in each country.

(83) Despite the foregoing, the present disclosure also contemplates embodiments in which users selectively block the use of, or access to, personal information data. That is, the present disclosure contemplates that hardware and/or software elements can be provided to prevent or block access to such personal information data. For example, in the case of advertisement delivery services, the present technology can be configured to allow users to select to “opt in” or “opt out” of participation in the collection of personal information data during registration for services or anytime thereafter. In another example, users can select not to provide mood-associated data for targeted content delivery services. In yet another example, users can select to limit the length of time mood-associated data is maintained or entirely prohibit the development of a baseline mood profile. In addition to providing “opt in” and “opt out” options, the present disclosure contemplates providing notifications relating to the access or use of personal information. For instance, a user may be notified upon downloading an app that their personal information data will be accessed and then reminded again just before personal information data is accessed by the app.

(84) Moreover, it is the intent of the present disclosure that personal information data should be managed and handled in a way to minimize risks of unintentional or unauthorized access or use. Risk can be minimized by limiting the collection of data and deleting data once it is no longer needed. In addition, and when applicable, including in certain health related applications, data de-identification can be used to protect a user's privacy. De-identification may be facilitated, when appropriate, by removing specific identifiers (e.g., date of birth, etc.), controlling the amount or specificity of data stored (e.g., collecting location data a city level rather than at an address level), controlling how data is stored (e.g., aggregating data across users), and/or other methods.

(85) Therefore, although the present disclosure broadly covers use of personal information data to implement one or more various disclosed embodiments, the present disclosure also contemplates that the various embodiments can also be implemented without the need for accessing such personal information data. That is, the various embodiments of the present technology are not rendered inoperable due to the lack of all or a portion of such personal information data. For example, content can be selected and delivered to users by inferring preferences based on non-personal information data or a bare minimum amount of personal information, such as the content being requested by the device associated with a user, other non-personal information available to the content delivery services, or publicly available information.

(86) The foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough understanding of the described embodiments. However, it will be apparent to one

skilled in the art that the specific details are not required in order to practice the described embodiments. Thus, the foregoing descriptions of the specific embodiments described herein are presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the embodiments to the precise forms disclosed. It will be apparent to one of ordinary skill in the art that many modifications and variations are possible in view of the above teachings.

## Claims

1. A head-mountable device, comprising: an optical module configured to present visual information to a user; the optical module movably attached to a structure, the structure defining a motion path of the optical module, the structure comprising: a housing defining an internal volume; and a battery disposed within the internal volume.
2. The head-mountable device of claim 1, wherein: the structure is a first guide rail; the battery is a first battery; the optical module is a first optical module; and the head-mountable device further comprises a second optical module movably attached to a second guide rail, the second guide rail housing a second battery.
3. The head-mountable device of claim 1, wherein the structure comprises: an upper structure, the optical module being movably attached to the upper structure; and a lower structure, the lower structure housing a second battery.
4. The head-mountable device of claim 1, wherein the structure comprises a guide rail that defines a motion pathway of the optical module.
5. The head-mountable device of claim 1, wherein the structure is cylindrical.
6. The head-mountable device of claim 1, wherein the structure further comprises an electrical connection establishing electrical communication between the battery and the head-mountable device.
7. The head-mountable device of claim 1, wherein the housing defines an air gap between an internal surface of the housing and the battery.
8. The head-mountable device of claim 1, wherein the structure is attached to a mounting enclosure of the head-mountable device, an electrical pathway positioned through the mounting enclosure.
9. The head-mountable device of claim 1, further comprising a cable extending from the battery through an open end of the structure.
10. The head-mountable device of claim 1, wherein: the battery comprises an anode material and a cathode material; and each of the anode material and the cathode material directly contacts the housing of the structure.
11. A guide rail for a head-mounted display, the guide rail comprising: a housing defining an exterior surface and an internal volume; and a power source positioned in the internal volume; wherein the exterior surface of the guide rail is configured to interface with a movable lens structure.
12. The guide rail of claim 11, wherein the power source is removable from the housing.
13. The guide rail of claim 11, wherein the power source is fixed in the housing via an adhesive.
14. The guide rail of claim 11, further comprising a sled fixed to the battery and removably attached to the housing.
15. The guide rail of claim 14, wherein the sled comprises a protrusion configured to releasably couple with a recess of the housing.
16. The guide rail of claim 11, wherein the housing comprises a carbon fiber filled composite.
17. The guide rail of claim 11, wherein the housing defines a vent forming an airflow path between the internal volume and an ambient environment.
18. A head-mountable device, comprising: a battery including a battery housing; and an optical module including an actuator rotatably engaging the battery housing to translate the optical module.
19. The head-mountable device of claim 18, wherein the battery comprises a cylindrical cell.

20. The head-mountable device of claim 18, wherein the battery housing comprises a flame resistant material.

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