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(19) **United States**(12) **Patent Application Publication****Ahmed et al.**(10) **Pub. No.: US 2023/0417053 A1**(43) **Pub. Date: Dec. 28, 2023**(54) **CHARGING AND PROCESSING CASE FOR WIRELESS EARBUDS WITH IN-THE-EAR ELECTROENCEPHALOGRAPHY IMPLEMENTATION**(21) Appl. No.: **18/459,379**(22) Filed: **Aug. 31, 2023****Related U.S. Application Data**

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Publication Classification

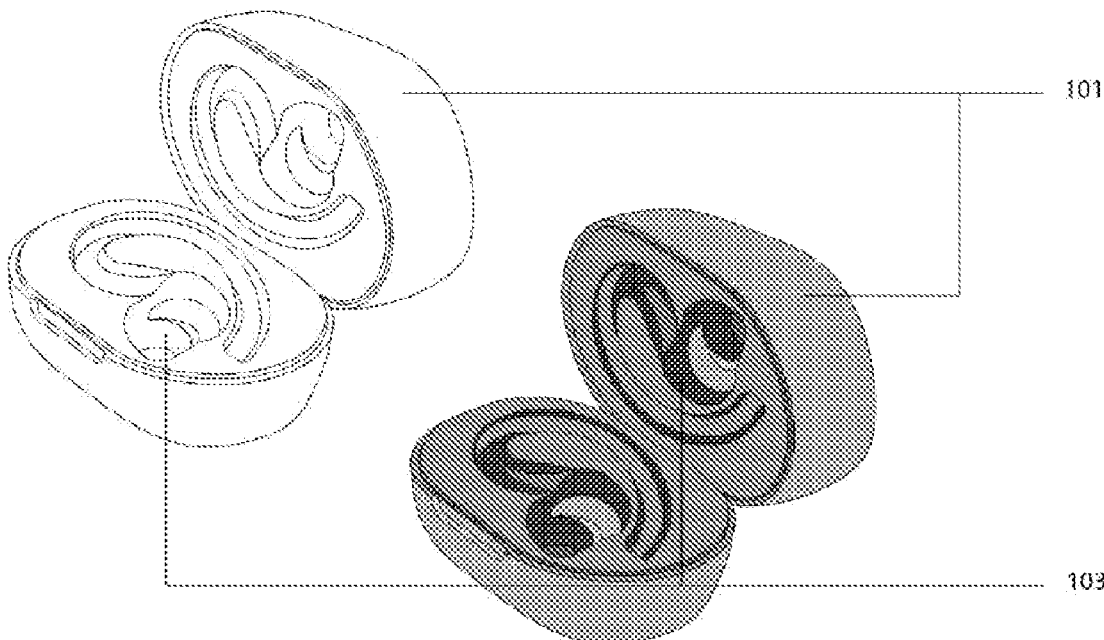
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(57) **ABSTRACT**

This invention presents a wireless earbud case tailored for biometrics and wearable technology. Unlike basic charging cases like those of consumer earbuds in the market currently, this earbud case enriches mobile device interaction. The case processes biometric electroencephalography (EEG) data to aid in monitoring mood, sleep, and neurological health. It wirelessly links via Bluetooth or WiFi to transmit data to a mobile software. It charges earbuds and can indicate battery levels of the earbuds or the case itself. It receives, processes, and transmits EEG data from external sources like earbud-connected electrodes. Then, the processed data displays on devices like phones and computers. Compatible with EEG or magnetoencephalography earbuds, it offers electronic storage for the purpose of data security. This invention optimizes data flow to external devices, such as EEG earbuds for biometric and wearable tech applications.

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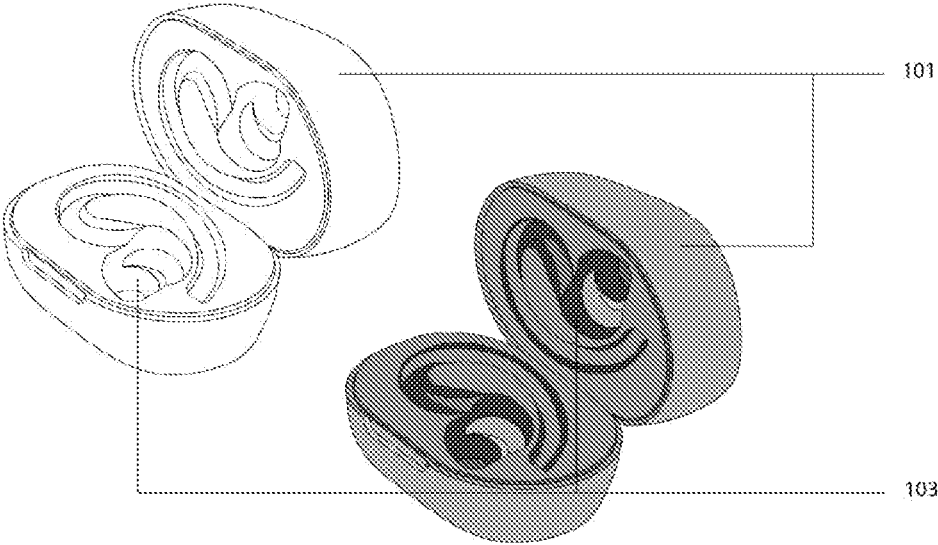


Figure 1

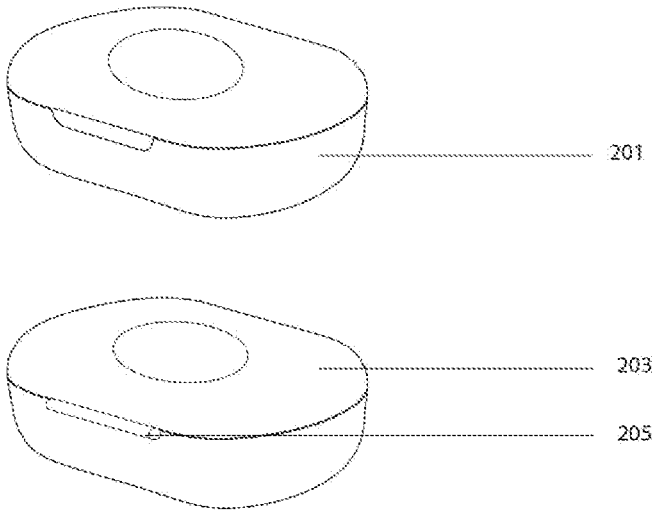
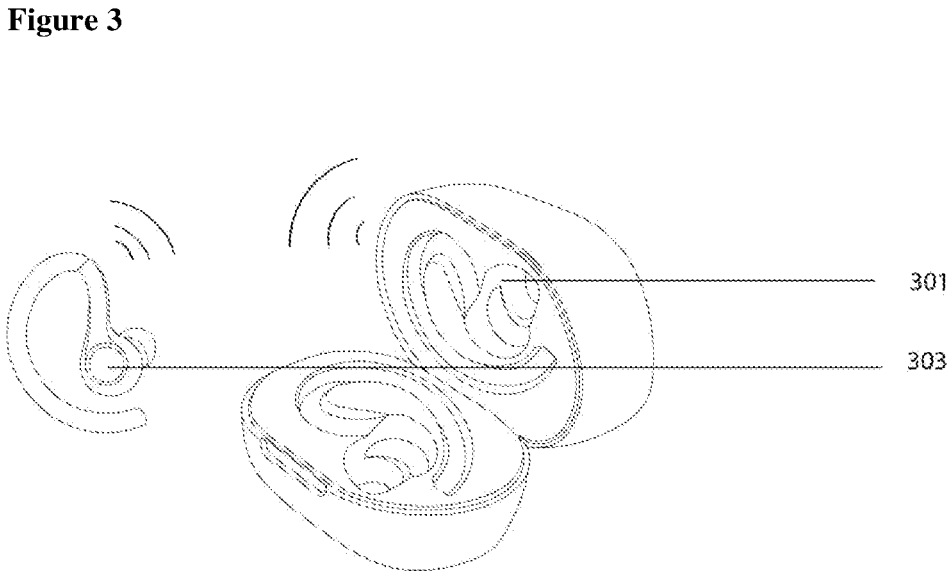


Figure 2



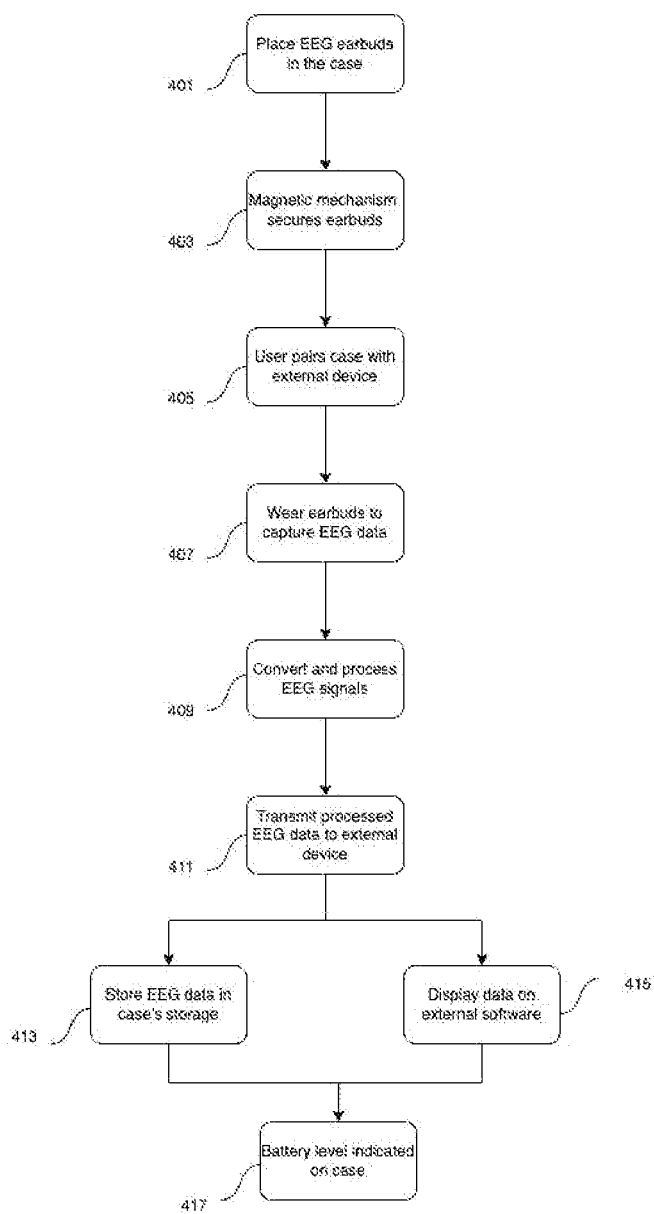


Figure 4

CHARGING AND PROCESSING CASE FOR WIRELESS EARBUDS WITH IN-THE-EAR ELECTROENCEPHALOGRAPHY IMPLEMENTATION

RELATED U.S. APPLICATION DATA

[0001] CONVERSION OF PROVISIONAL (UTILITY) PATENT APPLICATION NO. 63/374,533 FILED ON Sep. 3, 2022

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FIELD OF CLASSIFICATION SEARCH

[0003] CPC H04R 1/10; A61B 5/0476; A61B 5/0408; H04R 1/02; H04W

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FIELD OF THE INVENTION

[0011] The present invention encompasses a multifaceted charging and processing case designed for wireless earbuds in order to converge audio equipment and neural monitoring. The present case is centered on the creation of wireless charging that goes beyond traditional audio accessories. The invention falls in the field of signal processing specifically for neural activity to be monitored and interpreted in conjunction with auditory experiences. The charging case bridges the gap between accessible EEG data capture and comprehensive analysis of the data.

BACKGROUND

[0012] Description of the Problem: Wireless earbuds have become an integral part of our modern lifestyle, as their convenience and connectivity streamline communication and audio playback. However, current products are focused on providing audio playback and communication functionalities and are limited in their scope of use. One underutilized development is the ability to record biometric data: more specifically, the implementation of electroencephalography technology into earbuds. Without a comprehensive solution that bridges the gap between wireless earbuds and advanced biometric data collection, users are left with underutilized devices that fail to fulfill their potential as sources of valuable health and wellness information. Given how costly and inaccessible visiting medical professionals for EEG exams can be, few people are well informed about their cognitive health. This product addresses this issue by

introducing an earbud case that capitalizes on its size and ability to house processing circuitry to process and transmit EEG data to mobile devices.

[0013] Description of the Related Art & Limitations: Various manufacturers, including Apple, Bose, Samsung, and Sony have established a precedent for enhancing user convenience with rechargeable wireless earbuds. For instance, the Apple AirPods case relays battery status information to users by providing notifications about the charging level of the AirPods and the case itself, ensuring users are informed about the readiness of their earbuds. Similarly, U.S. Pat. No. 9,148,717B2 addresses a wireless earbud charging case with a focus on housing earbuds and transferring an electrical charge from a power source to the earbuds. Given that many existing products' designs and functionality are centered around battery management, the existing solutions do not cater to EEG-specific applications. The technical constraints within the established arts highlight the need for a device that can combine wireless earbud charging functionality with the processing demands of EEG-based biometric data. The present invention aims to bridge the gap by offering a wireless earbud case that facilitates the processing and transmission of EEG data to mobile devices. By overcoming the limitations of the related arts, the invention allows for the integration of EEG technology into wireless earbud cases, enabling neurological assessment and analysis.

[0014] Objective of the Invention: The purpose of this invention is to produce a multifunctional earbud charging case. The specific functionality of the invention is to allow the processing of captured EEG data and relay this information to a paired device while simultaneously being able to charge and/or store earbuds capable of capturing this EEG data. By making the earbud case capable of processing this kind of data, the capabilities of wireless earbuds expands, as it overcomes the limitations set by traditionally small size of wireless earbuds. By outsourcing some of this data processing load to the earbuds case, more data can be interpreted and relayed to an EEG monitoring application.

[0015] Brief Summary of the Invention: Existing wireless earbud cases lack the ability to handle complex data beyond basic charging functions. To address this limitation, the presented invention is equipped to process the data and relay it to the paired device and transmit intricate data to a designated application. The wireless earbud case serves as a charging hub and communication bridge for the earbuds. The case facilitates wireless connections, particularly through bluetooth, enabling pairing with other devices. This case incorporates a charging port for its own battery replenishment, which can also be achieved wirelessly. The exterior of the case can feature a light display to notify the user of remaining battery levels. The case holds the capacity to analyze and relay accumulated data. This data revolves around EEG and brainwave patterns acquired from external origins, like electrodes embedded in wireless earbuds. After undergoing processing, the gathered data transforms into an interpretable format. It has the potential to be displayed on external gadgets, such as smartphones and PCs. This invention offers a consolidated resolution that merges earbud charging, wireless linking, and the utilization of brainwave data.

Technical Terminology and Concepts

[0016] Wireless Earbud Case: Protective enclosure designed to hold wireless earbuds and provide various functionalities.

[0017] Electroencephalography (EEG): The recording of electrical activity along the scalp, capturing brain wave patterns that can provide insights into cognitive and neurological conditions.

[0018] Magnetoencephalography (MEG): A technique used to measure the magnetic fields produced by neural activity in the brain, offering complementary information to EEG.

[0019] Bluetooth: Wireless technology standard for short-range communication between devices, commonly used for data transmission between earbuds and the case.

[0020] Analog-to-Digital Converter (ADC): A device that converts analog signals (such as EEG data) into digital signals for processing and transmission.

[0021] Microcontroller: A compact integrated circuit that contains a CPU, memory, and input/output peripherals for controlling various functions.

[0022] Transmitter: A component responsible for transmitting data wirelessly, often used to send processed EEG data to external devices.

[0023] Printed Circuit Board (PCB): A flat board that holds and connects electronic components using conductive pathways, facilitating communication between different components.

[0024] Magnetic Loop Copper Coil Antenna: A loop of copper wire that generates a magnetic field when an electric current passes through it, used for wireless charging and communication.

[0025] Conductive Metals: Materials with high electrical conductivity, allowing them to transmit electric current, commonly used for charging connections.

[0026] Battery Level Indication: Visual or numerical representation of the remaining charge in a battery, often displayed using LED lights or a gauge.

[0027] Data Processing: The manipulation and analysis of collected data to extract meaningful information or insights.

[0028] Biometric Data: Unique physiological or behavioral characteristics of an individual, in this case, EEG and MEG data.

[0029] External Device: A separate device, such as a mobile phone or personal computer, that interacts with the earbud case to display processed data.

[0030] Neurological Abnormalities: Irregularities or conditions affecting the normal functioning of the nervous system, potentially detectable through EEG and MEG data analysis.

SUMMARY

[0031] Charging cases for wireless earbuds are limited to displaying earbud battery levels and conveying status details to paired mobile devices, and are unable to engage with complex datasets such as biometric electroencephalography data. Its technical architecture centers around battery monitoring and provisioning, rendering it insufficient for processing and relaying other intricate information beyond the charging functionality.

[0032] The invention comprises a wireless earbud case equipped with advanced capabilities for capturing and transmitting data to a dedicated mobile app. This data encompasses EEG waveforms and cerebral scans, facilitating the monitoring of various aspects such as emotional states, sleep patterns, potential disruptions in sleep quality, the presence of anomalies like epilepsy, and the early indications of possible neurological disorders. The case establishes a

seamless connection to earbuds through wireless transmission protocols like Bluetooth or WiFi, enabling the comprehensive dataset to be efficiently relayed to the associated software application. Unlike conventional charging cases, this system serves as a multifunctional biometric processing tool, leveraging technology to provide insights into cognitive and neurological wellness via real-time data collection and analysis.

[0033] The case can be manufactured with either plastic or metal and be shaped as a cubical or spherical shape. The case will contain a charging port to charge the case battery. In addition to its charging capability, the case's exterior may feature a colored light display to indicate the battery level of the case. The case will be able to receive, process, and relay the information collected.

[0034] The implementation of a charging and processing case for wireless earbuds with in-ear electroencephalography (EEG) can serve a role in advancing technology and brain health accessibility. The case allows for unobtrusive placement of EEG sensors within the earbuds, enabling continuous, real-time monitoring of brain activity. This presents an opportunity for users to gain insights into their cognitive states, stress levels, focus, and mental well-being throughout their daily activities. By providing users with real-time feedback on their brain activity, the case contributes to cognitive enhancement and neurofeedback training. Users can learn to control their cognitive states, enhancing their focus, relaxation, and overall mental performance. The data collected through the EEG sensors can contribute to scientific research in neuroscience, psychology, and cognitive science. The widespread adoption of this technology can lead to the accumulation of valuable data for the development of neurology. The case's integration of charging, processing, and wireless communication components streamlines the user experience. It eliminates the need for multiple devices and cables, offering a consolidated solution that merges audio entertainment, cognitive monitoring, and communication.

[0035] The invention will possess the capacity to receive, analyze, and transmit the collected data. This data will comprise EEG and cerebral wave activity garnered from incoming transmissions originating from the electrodes interfaced with a wireless earbud. Following processing, the data will undergo translation, rendering it interpretable and displayable on an external apparatus, including but not limited to a mobile phone or personal computer. The accumulated data will encompass EEG waveforms and brain scan data, thereby facilitating the monitoring of mood variations, emotional states, disruptions in sleep quality, neural anomalies, and the nascent phases of neurological ailments. The case's wireless connectivity to earbuds, facilitated through mediums such as Bluetooth or WiFi, will enable information transmission to the designated software.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0036] FIG. 1: EEG Earbud Case Open Orientation

[0037] Description—FIG. 1 illustrates a front-view perspective of the earbuds encapsulated in the EEG earbud case.

[0038] FIG. 2: EEG Earbud Case Front & Rear View

[0039] Description—FIG. 2

[0040] displays both the frontal and rear perspectives of the earbuds case, including the wedge of the case.

[0041] FIG. 3: EEG Earbuds and Case's Magnetic Connectivity

[0042] Description—FIG. 3 portrays a front-view perspective of an EEG earbud magnetically connecting to the proposed earbud case.

[0043] FIG. 4: EEG Earbud System Case Operations

[0044] Description—FIG. 4 depicts the sequential process of capturing, processing, and transmitting EEG data by the earbud and its case for subsequent display.

DETAILED DESCRIPTION

[0045] FIG. 1 shows a front-view illustration of the case, 101, containing the EEG earbuds. The case includes a dedicated charging port and a light display that exhibits the remaining battery percentage to users in real time. This display signals the optimal time for initiating the recharge process. The case, 101, also ensures seamless pairing with a diverse range of devices, as it is engineered to support wireless connectivity. The wireless connectivity improves user experience by simplifying the process of connecting the earbuds to external devices.

[0046] Through the magnetic connection, 103, the earbuds are held securely and are precisely aligned within their designated compartments within the case. This alignment prevents any unnecessary strain on delicate components, safeguarding the earbuds from potential damage. Beyond its role in preventing accidental dislodging, the magnetic mechanism also contributes to the longevity of the earbuds. The magnetic mechanism minimizes wear-and-tear by holding the earbuds firmly in place and ensuring that they remain properly aligned, consequently reducing stress and friction during storage and transport. This innovation enhances user satisfaction by reducing the need for frequent replacements due to damage or malfunction.

[0047] FIG. 2 provides both a front and a rear view illustration of the EEG earbud case. The front view of the case, 201, contains a Printed Circuit Board (PCB). This circuit board houses a network of essential electronic components that collectively drive the functionality of the EEG earbuds, including the Bluetooth module, analogue-to-digital converter, microcontroller, and transmitter. The analogue-to-digital converter stands as an intermediary, responsible for translating the raw analog EEG signals acquired through the earbuds into digital data streams. Next, the microcontroller orchestrates the handling and interpretation of the EEG data extracted from the earbuds. The Bluetooth module then facilitates connection between earbuds and a Bluetooth-enabled device, such as a smartphone, and the transmitter sends the data to the Bluetooth-enabled device.

[0048] The back view of the case, 203, shows an antenna made of a copper coil in a magnetic loop configuration. This specialized antenna acts as both a receiver and transmitter of EEG data.

[0049] Positioned at the heart of the case, the earbuds hold a central position, regardless of the viewing angle, ensuring easy accessibility. The wedge of the case, 205, is a durable and corrosion-resistant metal hinge. This hinge design is pivotal, serving as a gateway to the earbuds while allowing effortless opening and closing of the case. Through the incorporation of durable materials, the hinge's durability is not only assured but also contributes significantly to the overall sturdiness of the case.

[0050] FIG. 3 showcases the magnetic connection between the EEG earbud and the associated earbud case

during optimal function. The magnetic earbud case, 301, handles transmission, reception, and processing of information, which includes the EEG data, brain wave activity, battery status, and Bluetooth connectivity. The data originates from the integrated electrodes and data processing units within the EEG earbud system, and is magnetically transferred to the paired external device. This connection enables the internal unit of the earbud to convey messages, information, and alerts to the external device.

[0051] The magnetic earbud connection, 303, securely links the earbud to the case, enabling data exchange and maintaining earbud stability. This connection also facilitates efficient earbud charging via the case's battery storage. Data collated from the EEG earbud system encompasses diverse elements, such as individualized battery capacity for each earpiece, Bluetooth connectivity, signal robustness, EEG data signatures, analyzed brain activity, and an assortment of biometric markers. The information originating from the magnetic earbud case (301) subsequently finds accessibility, rendering it visible through external Human-Machine Interface (HMI) software. This visibility extends across platforms, including mobile devices and personal computers.

[0052] FIG. 4 portrays a flow chart illustrating a sequence of how the earbud and the case work to capture, process, and transmit EEG data so that it can be displayed. Initially, the EEG earbuds must be securely placed inside of the case, 401, to initiate the pairing procedure and ensure that the earbuds are safely stored when not in use. After the earbuds have been placed, the magnetic mechanism secures the earbuds, 403, protecting the earbuds from damage during transportation or storage. To prepare the system for data capture and processing, the user will proceed to pair the case with an external device, 405, establishing a wireless connection between the EEG earbuds and the external device.

[0053] Next, the user must place the earbuds in their ears in order to start the process of capturing EEG data, 407, the user can wear the earbuds to initiate the capture of data from the wearer's brain. After the earbuds are in the user's ears, the collected EEG data can be converted and processed into EEG signals, 409, which this data will later transmit wirelessly from the EEG earbuds to the paired external device, 411, allowing real-time monitoring and analysis of the user's brainwave activity. The transmitted EEG data is then simultaneously stored in the case for future reference and analysis, 413, and displayed and visualized on external software running on the paired device, 415 in real-time. After this process, the remaining battery level is indicated on the earbud case for the user to view, 417, which permits the user to monitor the remaining battery life of the case and ensures it is charged for future use.

1. A multifunctional charging and processing case for wireless earbuds, comprising:

- a. A protective enclosure configured to hold wireless earbuds and facilitate charging;
- b. An integrated wireless communication module enabling communication with external devices;
- c. An analog-to-digital converter (ADC) for converting analog EEG signals from the wireless earbuds into digital data;
- d. A microcontroller responsible for processing the digitized EEG data and generating interpretable brainwave patterns;
- e. A transmitter for wirelessly transmitting the processed EEG data to a paired external device;

- f. An antenna with a magnetic loop copper coil design for wireless charging and communication;
- g. A battery level indicator comprising a light display for indicating the remaining charge in the case's battery.
- 2. The multifunctional charging and processing case of claim 1, wherein the wireless communication module employs Bluetooth technology.
- 3. The multifunctional charging and processing case of claim 1, further comprising a wireless charging mechanism utilizing magnetic loop copper coil antennas for efficient power transfer.
- 4. The multifunctional charging and processing case of claim 1, wherein the battery level indicator comprises a series of LED lights representing different battery levels.
- 5. The multifunctional charging and processing case of claim 1, further comprising a printed circuit board (PCB) supporting the electronic components and providing connectivity within the case.
- 6. The multifunctional charging and processing case of claim 1, wherein the battery level indicator is configured to display battery status information using different colors and patterns on the light display.
- 7. The multifunctional charging and processing case of claim 1, wherein the wireless communication module supports Wi-Fi connectivity in addition to Bluetooth.
- 8. The multifunctional charging and processing case of claim 1, wherein the analog-to-digital converter (ADC) ensures accurate digitization of EEG signals received from the wireless earbuds.
- 9. A wireless earbud case system for processing and relaying biometric data, comprising:
 - a. A charging and processing case for housing wireless earbuds and processing biometric data;
 - b. Electroencephalography (EEG) sensors integrated within the wireless earbuds for capturing brainwave patterns;
 - c. Bluetooth wireless communication for establishing a connection between the wireless earbuds and external devices;
 - d. A microcontroller unit (MCU) embedded within the case for analyzing the captured EEG data and generating real-time insights;

- e. Data transmission means for wirelessly relaying the analyzed EEG data to a designated mobile application;
- f. An external human-machine interface (HMI) device for displaying the processed EEG data in an interpretable format;
- g. A secure magnetic mechanism within the case for securely holding and charging the wireless earbuds.
- 10. The wireless earbud case system of claim 9, wherein the EEG sensors are integrated within the earbuds in an unobtrusive manner, allowing continuous monitoring during various activities.
- 11. The wireless earbud case system of claim 9, wherein the microcontroller unit performs real-time analysis of EEG data to identify cognitive states, stress levels, emotional well-being, and potential neurological anomalies.
- 12. The wireless earbud case system of claim 9, wherein the data transmission means comprises a transmitter that uses the magnetic loop copper coil antenna to wirelessly send the processed EEG data to the mobile application.
- 13. The wireless earbud case system of claim 9, wherein the external HMI device includes smartphone applications and computer software capable of displaying visual representations of the EEG data.
- 14. The wireless earbud case system of claim 9, wherein the secure magnetic mechanism ensures that the wireless earbuds are held securely in place even during movements and transport.
- 15. The wireless earbud case system of claim 9, wherein the secure magnetic mechanism facilitates efficient charging of the wireless earbuds while maintaining a stable connection for data transmission.
- 16. The wireless earbud case system of claim 9, further comprising a data storage unit within the case for maintaining data integrity and enabling future analysis of historical EEG data.
- 17. The wireless earbud case system of claim 9, wherein the external HMI device includes customizable user interfaces for presenting EEG data insights based on individual preferences.

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