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### Wearable Article and Electronics Arrangement for Transferring Power

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#### Abstract

The wearable article **11** comprises a power source **111** and a processor **112**. The processor **112** determines whether a power transfer condition is satisfied. In response, the processor **112** is arranged to control the wearable article **11** to transfer power from the power source **111** to an electrical load of an external apparatus. The wearable article **11** may comprise an interface element **114** for forming an electrical connection with the external apparatus. The wearable article **11** may comprise a power transmitter **113** for beaming electromagnetic energy to the external apparatus. The wearable article **11** may be a garment.

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## **Background/Summary**

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. application Ser. No. 18/539,614, filed Dec. 14, 2023, which is a continuation of U.S. application Ser. No. 17/765,724, which is a U.S. National Phase entry of PCT/GB2020/052722, filed Oct. 28, 2020, which claims priority to United Kingdom Patent Application number 1915658.7 filed 29 Oct. 2019, all of which are herein incorporated by reference in their entirety.

### **BACKGROUND**

[0002] The present invention is directed towards a wearable article, textile article and method for transferring power to other electronic apparatuses.

[0003] Wearable articles such as garments incorporate sensors designed to interface with a wearer of the article or the surrounding environment. The sensors may determine information such as the wearer's heart rate, rate of respiration, activity level, and body positioning. Such properties can be measured with a sensor assembly that includes a sensor for signal transduction and/or microprocessors for analysis.

[0004] US Patent Application Publication No. 2016/0071397 discloses a garment which incorporates batteries to power electronics coupled with the garment. A belt that stores energy and distributes it across the electrical devices on the wearer is employed. The belt may charge or power pants through conductive areas on the inside of the belt loops of the pants. Alternatively, the belt buckle may act as the connection for voltage to flow from the belt to pants or a shirt. Inductive charging may be employed. A transmitter coil in the belt may induce a voltage in a receiver coil found in the shirts and pants.

[0005] It is desirable to enable to provide improved mechanisms for transferring power between a wearable article and other electronic apparatuses.

### **SUMMARY**

[0006] According to the present disclosure there is provided a wearable article, textile article, and method as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims, and the description which follows.

[0007] According to a first aspect of the present disclosure, there is provided a wearable article. The wearable article comprises a power source and a processor. The processor is arranged to determine whether a power transfer condition is satisfied. In response to determining that the power transfer condition is satisfied, the processor is arranged to control the wearable article to transfer power from the power source to an electrical load of an external apparatus communicatively coupled to the wearable article.

[0008] Beneficially, the wearable article transfers power to an external apparatus. This enables power to be shared between the wearable article and other apparatuses such as other wearable articles. The wearable article may have a relatively large power source (e.g. with a relatively large power capacity). The wearable article may act as a charging hub for other apparatuses with smaller or no power sources or power sources with a limited amount of charge remaining. The wearable article is only arranged to transfer power if a power transfer condition is satisfied. This prevents or

helps avoid the transfer of power in undesirable situations such as when the power source of the wearable article has only a limited amount of charge remaining.

[0009] The wearable article may further comprise a communicator. The communicator may be arranged to send and/or receive data to/from the external apparatus or another apparatus. The communicator may be arranged to receive the data from the external apparatus over a near-field communication protocol. The communicator may comprise a reader arranged to read a radio frequency identification (RFID) tag of the external apparatus so as to obtain the data from the external apparatus.

[0010] The wearable article may be arranged to receive data from the external apparatus, e.g. via the communicator of the wearable article. The wearable article may be arranged to transmit data to the external apparatus or another apparatus, e.g. via the communicator. The wearable article may be arranged to perform an action on the received data. The action may comprise one or more of storing the data in a memory; processing the data; and transmitting the data. In examples of the present disclosure, the external apparatus may transfer data to the wearable article if it is determined that the external apparatus does not have sufficient remaining charge to operate (e.g. for a predetermined duration).

[0011] The communicator may be arranged to receive identification information from the external apparatus. The identification information may relate to the identity of a user associated with the external apparatus. The processor may be arranged to determine from the identification information whether the power transfer condition is satisfied. The power transfer condition may be satisfied if the identification information identifies that the external apparatus is authorised to receive power from the wearable article. Advantageously, the wearable article communicates with the external apparatus and determines to transfer power based on the information received from the external apparatus.

[0012] In response to determining that the power transfer condition is not satisfied, the wearable article may not be controlled to transfer power to the electrical load of the external apparatus. In this way, power is not transferred to the external apparatus.

[0013] The identification information may comprise biometric information identifying a user associated with the external apparatus. The processor may be arranged to determine from the biometric information whether the user associated with the external apparatus is authorised to receive power from the wearable article. The processor may be arranged to determine from the biometric information whether the user associated with the external apparatus is the same as a user wearing the wearable article. The power transfer condition may be satisfied if the user associated with the external apparatus is the same as the user wearing the wearable article. The processor may be arranged to compare biometric information identifying the user wearing the wearable article to the biometric information identifying the user associated with the external apparatus to determine whether the user associated with the external apparatus is the same as a user wearing the wearable article. The biometric information identifying the user associated with the wearable article may be obtained from sensor data sensed by a sensor of the wearable article.

[0014] The communicator may be a wireless communicator operable to communicate the data wirelessly. The communicator may provide wireless communication capabilities for the wearable article and may enable the wearable article to communicate via one or more wireless communication protocols such as used for communication on: a wireless wide area network (WWAN), a wireless metro area network (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN), a near field communication (NFC), and a cellular communication network. The cellular communication network may be a fourth generation (4G) LTE, LTE Advanced (LTE-A), fifth generation (5G), sixth generation (6G), and/or any other present or future developed cellular wireless network. The communicator may comprise a plurality of communicators. A first communicator of the wearable article may be provided for cellular communication and a separate communicator may be provided for short-range local

communication over WLAN, WPAN, NFC, or Bluetooth®, Wi-Fi or any other electromagnetic RF communication protocol.

[0015] The power transfer condition may be satisfied if the power source has a remaining charge that is greater than a predetermined threshold. Advantageously, the wearable article may only transfer power to the external apparatus if the wearable article has sufficient remaining charge to enable the wearable article to function. The predetermined threshold may be selected as appropriate by the skilled person in the art based on factors such as the capacity of the power source. The predetermined threshold may be configurable by the user of the wearable article. The power transfer condition may be satisfied if the power source has a remaining charge that is sufficient to power the wearable article for a time that is greater than a predetermined threshold.

Advantageously, the wearable article may only transfer power to the external apparatus if the wearable article has sufficient remaining charge to enable the wearable article to function for more than a predetermined period of time. The power transfer condition may be satisfied if the wearable article receives an authorisation command from the user to transfer power to the external apparatus. Advantageously, the wearable article may only transfer power to the external apparatus if the user wearing the wearable article approves the transfer of power. The wearable article may be arranged to determine any or a combination of the amount of power to transfer, the rate of power transfer, and the duration of the power transfer based on factors such as the remaining charge of the wearable article, the power demand of the wearable article on the power source, and the desired duration of operation of the wearable article.

[0016] The power transfer condition may be satisfied if a remaining charge of the external apparatus is less than a predetermined threshold. Advantageously, the wearable article may only transfer power to the external apparatus if the external apparatus needs the power to function. The wearable article may be arranged to receive power status level information from the external apparatus which indicates the remaining charge for the external apparatus. The communicator of the wearable article may be arranged to receive the power status level information. The wearable article may be arranged to determine whether to transfer power based on the received power status level information. The wearable article may be arranged to determine any or a combination of the amount of power to transfer, the rate of power transfer, and the duration of the power transfer from the power status level information and optionally any other information received from the external apparatus and/or derived from properties such as the remaining charge of the wearable article.

[0017] The wearable article may further comprise a power transmitter arranged to transfer power from the power source to the electrical load of the external apparatus. The power transmitter may be arranged to wirelessly transfer power from the power source to a power receiver of the external apparatus. The power transmitter may be arranged to transfer power from the power source to the power receiver over a contactless interface. The power transmitter may be arranged to inductively transfer power. The power transmitter may comprise a first resonator and the power receiver may comprise a second resonator. The power transmitter may comprise a power transmitter coil, and the power receiver may comprise a power receiver coil.

[0018] The power transmitter may be arranged to beam electromagnetic energy from the power source to a power receiver of the external apparatus. The power transmitter may be arranged to wirelessly beam electromagnetic energy in the form of microwaves. The microwaves may be focused microwaves. The wearable article may comprise a transducer. The transducer may be arranged to convert electrical energy from the power source into a beam of microwave energy to be transmitted by the power transmitter. The power transmitter may be arranged to beam electromagnetic energy over a first wireless network. The power transmitter may be a mobile transmitter. The mobile transmitter may be arranged to transmit data over a second wireless network. The second wireless network may be different from the first wireless network. The mobile transmitter may be a mobile transceiver. The mobile transceiver may be arranged to receive data from the external apparatus over the second wireless network. The second wireless network is a

cellular network, a local area wireless network, or a personal area wireless network. The first wireless network is a cellular network, a local area wireless network, or a personal area wireless network. The wearable article may be arranged to locate the external apparatus (e.g. via communication with the external apparatus) and transmit a directed beam of electromagnetic energy to the external apparatus.

[0019] At least a component of the wearable article may be removable from the wearable article. The power source may be removable from the wearable article. The processor may be removable from the wearable article. Beneficially, this enables the power source and/or processor to be removed prior to washing of the wearable article for example. The power source and the processor may form an electronics module which is removable from the wearable article.

[0020] The wearable article may further comprise an interface element arranged to form a mechanical and/or electrical connection with the external apparatus. The interface element may form an electrical connection with the external apparatus so as to enable power to be transferred from the power source to the electrical load of the external apparatus. In this example, the interface element forms a physical coupling with the external apparatus such that a conductive connection is formed between the wearable article and the external apparatus. In effect, a wired connection may be considered as being formed between the wearable article and the external apparatus. The interface element may form a mechanical coupling. Beneficially, the mechanical coupling enables the wearable article to be securely coupled to the external apparatus so as to reduce the risk of or prevent the power coupling (e.g. conductive or inductive) between the wearable article and the external apparatus from breaking during the transfer of power between the wearable article and the external apparatus. The interface element may comprise a magnetic material. The magnetic material may be arranged to couple with magnetic material of the external apparatus to form the mechanical and/or conductive connection between the wearable article and the external apparatus. The interface element may comprise a fastener element. The fastener element may be arranged to couple with a corresponding fastener element of the external apparatus to form the mechanical and/or conductive connection between the wearable article and the external apparatus. The fastener may be a zipper, button, clasp, toggle, stud, snap fastener, popper, eyelet, buckle, tie or ribbon. The wearable article may comprise a conductive pathway which extends from the power source to the interface element.

[0021] The wearable article may further comprise a sensor or a plurality of sensors. The sensor may be arranged to sense one or more signals external to the wearer. The sensor may be any or a combination of a temperature sensor, a camera, a location tracking module such as a GPS module, and a chemical sensor. The sensor may be a biosensor arranged to measure one or more biosignals of a user wearing the wearable article. Here, "biosignal" may refer to any signal in a living being that can be measured and monitored. The term "biosignal" is not limited to electrical signals and can refer to other forms of non-electrical biosignals. The biosensor may be used for measuring one or a combination of bioelectrical, bioimpedance, biochemical, biomechanical, bioacoustics, biooptical or biothermal signals of the wearer. The bioelectrical measurements include electrocardiograms (ECG), electrogastrograms (EGG), electroencephalograms (EEG), and electromyography (EMG). The bioimpedance measurements include plethysmography (e.g., for respiration), body composition (e.g., hydration, fat, etc.), and electroimpedance tomography (EIT). The biomagnetic measurements include magnetoneurograms (MNG), magnetoencephalography (MEG), magnetogastrogram (MGG), magnetocardiogram (MCG). The biochemical measurements include glucose/lactose measurements which may be performed using chemical analysis of the wearer's sweat. The biomechanical measurements include blood pressure. The bioacoustics measurements include phonocardiograms (PCG). The biooptical measurements include orthopantomogram (OPG). The biothermal measurements include skin temperature and core body temperature measurements. The biosensor may comprise a radar unit. The wearable article may sense a combination of external signals and biosignals of the wearer.

[0022] The wearable article may comprise a Universal Integrated Circuit Card (UICC) that enables the wearable article to access services provided by a mobile network operator (MNO). The UICC may include at least a read-only memory (ROM) configured to store an MNO profile that the wearable article can utilize to register and interact with an MNO. The UICC may be in the form of a Subscriber Identity Module (SIM) card. The wearable article may have a receiving section arranged to receive the SIM card. In other examples, the UICC is embedded directly into a controller of the wearable article. That is, the UICC may be an electronic/embedded UICC (eUICC). A eUICC is beneficial as it removes the need to store a number of MNO profiles, i.e. electronic Subscriber Identity Modules (eSIMs). Moreover, eSIMs can be remotely provisioned to wearable articles. The wearable article may comprise a secure element that represents an embedded Universal Integrated Circuit Card (eUICC).

[0023] The external apparatus may be a second wearable article. The wearable article and/or the external apparatus may be a textile article. The textile article may include upholstery, such as upholstery that may be positioned on pieces of furniture, vehicle seating, as wall or ceiling décor, among other examples. The wearable article and/or the external apparatus may be a garment. The garment may refer to an item of clothing or apparel. The garment may be a top. The top may be a shirt, t-shirt, blouse, sweater, jacket/coat, or vest. The garment may be a dress, brassiere, shorts, pants, arm or leg sleeve, vest, jacket/coat, glove, armband, underwear, headband, hat/cap, collar, wristband, stocking, sock, or shoe, athletic clothing, swimwear, wetsuit or drysuit. The garment/textile article may be constructed from a woven or a non-woven material. The garment/textile article may be constructed from natural fibres, synthetic fibres, or a natural fibre blended with one or more other materials which can be natural or synthetic. The yarn may be cotton. The cotton may be blended with polyester and/or viscose and/or polyamide according to the application. Silk may also be used as the natural fibre. Cellulose, wool, hemp and jute are also natural fibres that may be used in the garment/textile article. Polyester, polycotton, nylon and viscose are synthetic fibres that may be used in the garment/textile article. The garment may be a tight-fitting garment. Beneficially, a tight-fitting garment helps ensure that any sensors of the garment are held in contact with or in the proximity of a skin surface of the wearer. The garment may be a compression garment. The garment may be an athletic garment such as an elastomeric athletic garment.

[0024] The power source may comprise a plurality of power sources. The power source may be a battery. The battery may be a rechargeable battery. The battery may be a rechargeable battery adapted to be charged wirelessly such as by inductive charging. The power source may comprise an energy harvesting device. The energy harvesting device may be configured to generate electric power signals in response to kinetic events such as kinetic events performed by a wearer of the wearable article. The kinetic event could include walking, running, exercising or respiration of the wearer. The energy harvesting material may comprise a piezoelectric material which generates electricity in response to mechanical deformation of the converter. The energy harvesting device may harvest energy from body heat of a wearer of the wearable article. The energy harvesting device may be a thermoelectric energy harvesting device. The power source may be a super capacitor, or an energy cell.

[0025] There is also provided an electronics arrangement for the wearable article of the first aspect of the disclosure. The electronics arrangement comprises the power source and the processor. The processor is arranged to determine whether a power transfer condition is satisfied. In response to determining that the power transfer condition is satisfied, the processor is arranged to control the electronics arrangement to transfer power from the power source to an electrical load of an external apparatus communicatively coupled to the wearable article. The electronics arrangement may be arranged to be coupled to the wearable article or otherwise integrated into the wearable article. The electronics arrangement may be an electronics module.

[0026] According to a second aspect of the present disclosure, there is provided a method of

transferring power from a wearable article to an external apparatus. The method comprises determining, by the wearable article, whether a power transfer condition is satisfied. In response to determining that the power transfer condition is satisfied, the method comprises transferring, by the wearable article, power from a power source of the wearable article to an electrical load of the external apparatus.

[0027] According to a third aspect of the present disclosure, there is provided a wearable article comprising a power source and an interface element. The interface element comprises magnetic material. The magnetic material is arranged to form an electrical connection with an external apparatus so as to enable power to be transferred from the power source to an electrical load of the external apparatus. The wearable article may comprise any or a combination of features described above in relation to the first aspect of the present disclosure.

[0028] Advantageously, the present disclosure provides a wearable article with an interface element comprising a magnetic material. The magnetic material facilitates the coupling of the wearable article to the external apparatus to provide an easy to use mechanism for transferring power from the wearable article to the external apparatus. Moreover, the magnetic material helps maintain the coupling between the wearable article and the external apparatus during the transfer of power even in situations where a user wearing the wearable article is moving.

[0029] According to a fourth aspect of the present disclosure, there is provided a method of transferring power from a wearable article to an external apparatus. The method comprises providing the wearable article of the third aspect of the present disclosure. The method comprises forming, by the wearable article, an electrical connection between the interface element of the wearable article and the external apparatus. The method comprises transferring, by the wearable article, power from the power source of the wearable article to an electrical load of the external apparatus via the electrical connection.

[0030] According to a fifth aspect of the present disclosure, there is provided an electronics module for a wearable article. The electronics module comprises a power source. The electronics module comprises a power transmitter arranged to beam electromagnetic energy from the power source to a power receiver of an external apparatus. The electronics module may comprise any or a combination of features described above in relation to the wearable article of the first or third aspect of the present disclosure. A wearable article comprising the electronics module is also provided.

[0031] Advantageously, the present disclosure provides a mechanism for beaming electromagnetic energy from the wearable article to the external apparatus. This enables the wearable article to transfer power over a distance and does not require a physical or close coupling between the wearable article and the external apparatus as may be required for conductive or inductive charging.

[0032] Beneficially, the present disclosure enables a first wearable article such as footwear or a backpack which may have space for a larger power source to charge other wearable articles such as t-shirts, headwear or smartwatches which may be physically separated and spaced apart from the first wearable article.

[0033] According to a sixth aspect of the present disclosure, there is provided a method of transferring power from a wearable article to an external apparatus. The method comprises using a power transmitter of the wearable article to beam electromagnetic energy from the power source to a power receiver of the external apparatus.

[0034] According to a seventh aspect of the present disclosure, there is provided a garment. The garment comprises an electronics module comprising a processor and a first power source. The garment comprises a mounting arrangement. The garment comprises an electrically conductive pathway extending from the first power source to the mounting arrangement. The mounting arrangement is arranged to releasably retain a second power source. When the second power source is retained by the mounting arrangement, the first power source of the electronics module is

arranged to receive power from the second power source via the electrically conductive pathway. The mounting arrangement may comprise a pocket. The garment may comprise any or a combination of features described above in relation to the wearable article of the first, third or fifth aspect of the present disclosure.

[0035] Advantageously, the garment provides a mounting arrangement to enable a power source to be releasably retained by the garment and thereby transfer power to the garment. This provides a convenient mechanism for charging a power source of the garment even when the garment is being worn.

[0036] According to an eighth aspect of the present disclosure, there is provided a garment. The garment comprises an electronics module mounting arrangement arranged to releasably retain an electronics module comprising a processor and a first power source. The garment comprises a second power source mounting arrangement arranged to releasably retain a second power source. The garment comprises an electrically conductive pathway extending from the first mounting arrangement to the second mounting arrangement. When the electronics module is retained by the electronics module mounting arrangement, and when the second power source is retained by the second power source mounting arrangement, the first power source of the electronics module is arranged to receive power from the second power source via the electrically conductive pathway. The second power source mounting arrangement may comprise a pocket. The garment may comprise any or a combination of features described above in relation to the wearable article of the first, third, fifth or seventh aspect of the present disclosure.

[0037] According to a ninth aspect of the present disclosure, there is provided a garment. The garment comprises a mounting arrangement. The garment comprises an electrically conductive pathway extending from the mounting arrangement. The electrically conductive pathway terminates in a power receiver at the mounting arrangement. The mounting arrangement may be arranged to releasably retain a power source comprising a power transmitter. When the second power source is retained by the mounting arrangement, the power receiver is arranged to wirelessly receive power from the power transmitter of the power source. The mounting arrangement may comprise a pocket. The garment may comprise any or a combination of features described above in relation to the wearable article of the first, third, fifth, seventh, or eighth aspect of the present disclosure.

[0038] According to a tenth aspect of the present disclosure, there is provided a wearable article. The wearable article comprises a power source; a processor; and a communicator. The processor is operable to: determine power status level information for the power source; determine, from the power status level information, whether to transfer data to an external apparatus; and in response to determining to transfer data, control the communicator to transfer data to the external apparatus. The wearable article may comprise any of the features described above in relation to the first, third, fifth, seventh, eighth or ninth aspect of the present disclosure.

[0039] Advantageously, the wearable article is arranged to determine whether to transfer power to an external apparatus based on a determined power status level for the wearable article. This enables the wearable article to transfer data to the external apparatus if the power status is low. This prevents or reduces the risk of the loss of data if the power source of the wearable article runs out of charge. In particular examples, the present disclosure enables the wearable article to dump data stored on the wearable article to an external device if the power status is low.

[0040] The data may comprise sensor data sensed by one or more sensors of the wearable article. The data may comprise the power status level information. The data may comprise identification information for the apparatus and/or a user associated with the wearable article. The data may comprise instructions for handling the data. The electronics arrangement may be arranged to receive power from a power source of the external apparatus such that power is transferred from the power source of the external apparatus to the power source of the wearable article.

[0041] The wearable articles referred to in the above aspects of the present disclosure may be any



form of electronic device which may be worn by a user such as a smart watch, necklace, bracelet, or glasses. The wearable article may be a textile article.

[0042] The external apparatus referred to in the above aspects of the present disclosure may be a textile article, wearable article or garment but is not limited to these examples. The external apparatus may, for example, be any other form of electric device such as a user electronic device. The external apparatus may be any device capable of communicating with the wearable article over a wired or wireless communication network. The external apparatus may be a wireless device or a wired device. The wireless/wired device may be a mobile phone, tablet computer, gaming system, MP3 player, point-of-sale device. A wireless device is intended to encompass any compatible mobile technology computing device that connects to a wireless communication network, such as mobile phones, mobile equipment, mobile stations, user equipment, cellular phones, smartphones, handsets or the like, wireless dongles or other mobile computing devices. The wireless communication network is intended to encompass any type of wireless network such as mobile/cellular networks used to provide mobile phone services. The external apparatus may be a medical device. The external apparatus may be a skin surface sensor. Skin surface sensors will be understood as referring to a sensor that is adhered or otherwise attached to the skin. The external apparatus may be an implantable medical device.

[0043] The present disclosure is not limited to transferring power between wearable articles. That is, while the above examples generally refer to wearable article the aspects of the present disclosure may apply to textile articles which may not necessarily be wearable. The textile article may include upholstery, such as upholstery that may be positioned on pieces of furniture, vehicle seating, as wall or ceiling décor, among other examples

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

[0044] Examples of the present disclosure will now be described with reference to the accompanying drawings, in which:

[0045] FIG. 1 shows an example system comprising wearable articles according to aspects of the present disclosure;

[0046] FIG. 2 shows a simplified schematic diagram of an example wearable article according to aspects of the present disclosure;

[0047] FIG. 3 shows a simplified schematic diagram of another example wearable article according to aspects of the present disclosure;

[0048] FIG. 4 shows a simplified schematic diagram of yet another example wearable article according to aspects of the present disclosure;

[0049] FIG. 5 shows a simplified schematic diagram of yet another example wearable article according to aspects of the present disclosure;

[0050] FIG. 6 shows a simplified schematic diagram of an example garment according to aspects of the present disclosure;

[0051] FIG. 7 shows a sectional view of the garment shown in FIG. 6;

[0052] FIG. 8 shows a flow diagram for an example method according to aspects of the present disclosure;

[0053] FIG. 9 shows a flow diagram for another example method according to aspects of the present disclosure; and

[0054] FIG. 10 shows a flow diagram for yet another example method according to aspects of the present disclosure.

### DETAILED DESCRIPTION

[0055] The following description with reference to the accompanying drawings is provided to

assist in a comprehensive understanding of various embodiments of the disclosure as defined by the claims and their equivalents. It includes various specific details to assist in that understanding but these are to be regarded as merely exemplary. Accordingly, those of ordinary skill in the art will recognize that various changes and modifications of the various embodiments described herein can be made without departing from the scope and spirit of the disclosure. In addition, descriptions of well-known functions and constructions may be omitted for clarity and conciseness.

[0056] The terms and words used in the following description and claims are not limited to the bibliographical meanings, but, are merely used by the inventor to enable a clear and consistent understanding of the disclosure. Accordingly, it should be apparent to those skilled in the art that the following description of various embodiments of the disclosure is provided for illustration purpose only and not for the purpose of limiting the disclosure as defined by the appended claims and their equivalents.

[0057] It is to be understood that the singular forms “a,” “an,” and “the” include plural referents unless the context clearly dictates otherwise.

[0058] Referring to FIGS. 1 through 5, there is shown a user wearing wearable articles **11**, **13**, **15**, **17**. The wearable articles **11**, **13**, **15**, **17** include a first wearable article **11** the form of a t-shirt **11**, a second wearable article **13** in the form of a pair of trousers **13**, a third wearable article **15** in the form of footwear **15**, and a fourth wearable article **17** in the form of a hat **17**. The first wearable article **11** is arranged to transfer power from the power source **111** to the power sources **131**, **151**, **171** of the second, third and fourth wearable articles **13**, **15**, and **17**. The wearable articles **11**, **13**, **15**, **17** comprise electronics arrangements. Electronics arrangement refer to a collection of electronics components that may be able to interact with one another. Some or all of the electronics components may be provided together in an electronics module.

[0059] The first wearable article **11** comprises a first power source **111**, a processor **112**, power transmitter **113**, interface element **114**, power receiver **115**, sensor **116** and communicator **117**. A power bus (not shown) extends from the power source **111** to the power transmitter **113**, interface element **114**, and power receiver **115** to enable power to be transferred from the first power source **111** to power sources of other wearable articles **13**, **15**, **17** and vice versa, The power source **111**, power transmitter **113**, interface element **114**, and power receiver **115** are communicatively connected to the processor **112** which is arranged to selectively control these elements.

[0060] The first wearable article **11** is arranged to form a communicative coupling with the wearable articles **13**, **15**, **17** so as to transfer power from the first power source **111** to second power sources of the wearable articles **13**, **15**, **17**. The communicative coupling is formed via one or a combination of the power transmitter **113** and the interface element **114**. Generally, the power transmitter **113** is used to transfer power wirelessly such as inductively or over an air interface, and the interface element **114** is used to transfer power over a wired interface by forming a conductive pathway between the power source **111** of the wearable article **11** and a power source of another wearable article **13**, **15**, **17**.

[0061] In some examples, the power transmitter **113** is arranged to inductively transfer power. In these examples the power transmitter **113** comprises one or more transmitter elements such as transmitter coils and the power receiver of the other wearable article **13**, **15**, **17** comprises one or more receiver elements such as receiver coils. The transmitter elements may be located at different positions in the wearable article **11** or may be arranged together.

[0062] The power receiver **115** of the first wearable article **11** is arranged to form a communicative coupling with the wearable articles **13**, **15**, **17** or another article (not shown) so as to receive power for charging the first power source **111**. In one example, the power receiver **115** may receive power from the footwear **15** as footwear **15** generally have sufficient space for the storage of a relatively large power source. The power receiver **115** may receive power from a backpack or other device for example.

[0063] The sensor **119** is arranged to sense data and the communicator **121** is arranged to transmit

or receive data from an external device such as the wearable articles **13, 15, 17**. The sensor **119** and the communicator **121** are controlled by the processor **113**. The power transmitter **113** and the power receiver **115** may be provided as a single unit which may be referred to as a power transceiver **113, 115**.

[0064] The second wearable article **13** comprises a power source **131**, processor **132**, interface element **133**, sensor **135**, and communicator **136**.

[0065] The first wearable article **11** is conductively connected to the second wearable article **13** to enable power to be transferred from the first wearable article **11** to the second wearable article **13**. The interface element **114** of the first wearable article **11** forms a conductive and mechanical connection with the interface element **133** of the second wearable article **13** so as to enable power to be transferred from the first power source **111** to the second power source **131** of the second wearable article **13**. The interface element **114** forms a physical coupling with the second wearable article **13** such that a conductive connection is formed between the first wearable article **11** and the second wearable article **13**. In effect, a wired connection is formed between the first wearable article **11** and the second wearable article **13**.

[0066] The interface element **114** is provided in the form of a magnetic material provided on an inside lower surface of the first wearable article **11** (e.g. the skin facing surface of the t-shirt **11**). A conductive pathway extends from the first power source **111** to the interface element **114** of the first wearable article **11**.

[0067] The second wearable article **13** comprises an interface element **133** which is arranged to connect with the interface element **114** of the first wearable article **11**. A conductive pathway extends from the second power source **131** to the interface element **133** of the second wearable article **13**. Thus, when the interface element **114** of the first wearable article **11** is connected to the interface element **133** of the second wearable article **13**, the first power source **111** is in conductive connection with the second power source **131**. The interface element **133** is provided in the form of a magnetic material provided on an outer upper surface of the second wearable article **13** (e.g. the outside facing surface of the trousers **13**). In this way, when the user wears t-shirt **11**, the t-shirt **11** drapes over the trousers **13** which results in the interface elements **114, 133** being magnetically attracted towards one another to form a conductive and mechanical coupling. It will be appreciated that the interface element **114** may be provided on an outside surface of the first wearable article **11** and the interface element **133** may be provided on an inside surface of the second wearable article **13** if, for example, the t-shirt **11** is desired to be tucked into the trousers **13**. The use of a magnetic material for the interface element **114, 133** is beneficial as it helps ensure that a conductive coupling is formed with minimal effort from the user. The magnetic material may also enhance alignment when wireless (e.g. inductive) charging is performed. For example, magnetic material such as permanent magnets may be placed in the vicinity of the power transmitter **113** of the wearable article **11** and corresponding ferromagnetic material may be placed within or near the power receiver of the other wearable article **13, 15, 17**. Other forms of interface element such as fasteners may help temporarily align the power transmitter of the wearable article **11** with the power receiver of the other wearable article **13, 15, 17** to facilitate charging.

[0068] The third wearable article **15** comprises a power source **151**, processor **152**, power receiver **153**, sensor **155** and communicator **156**. The fourth wearable article **17** comprises a power source **171**, processor **172**, power transmitter **173**, power receiver **174**, sensor **175** and communicator **176**.

[0069] The first wearable article **11** is communicatively connected to the third and fourth wearable articles **15, 17** so as to enable power to be transferred from the first wearable article **11** to the third and fourth wearable articles **15, 17** over a wireless network. In particular, the power transmitter **113** of the first wearable article **11** is arranged to wirelessly transmit power from the first power source **111** to the power sources **151, 171** of the third wearable article **15** and the fourth wearable article **17**. The third wearable article **15** and the fourth wearable article **17** comprise power receivers **153, 174** arranged to receive power transmitted by the first wearable article **11**.

[0070] The first wearable article **11** is therefore able to transfer power to the third and fourth wearable articles **15**, **17** wirelessly without a physical conductive connection between the articles **15**, **17**. The power transmitter **113** of the first wearable article **11** is driven by electric power from the first power source **111**. The power transmitter **113** generates a time-varying electromagnetic field, which transmits power wirelessly to the power receiver **153**, **154** of the third or fourth wearable article **15**, **17**.

[0071] In this example, the third and fourth wearable articles **15**, **17** are physically separated from the wearable article **11** by a relatively large air gap which generally means that inductive charging is not feasible. To charge the third and further wearable articles **15**, **17**, the power transmitter **113** of the first wearable article **11** beams the electromagnetic energy from the wearable articles **15**, **17**.

[0072] The beaming of energy may be performed using microwaves and in particular focused microwaves. In these examples, the first wearable article **11** may comprise a transducer (not shown) which is arranged to convert electrical energy from the power source **111** into a focused beam of microwave energy that is transmitted by the power transmitter **113**. The power transmitter **113** may comprise one or a plurality of antennas for the purpose of transmitting the microwave energy. The first wearable article **11** may have information relating to the location of the wearable articles **15**, **17** so that the beamed energy is directed towards the wearable articles **15**, **17**. This information may be obtained through RF communication between the wearable article **11** and the wearable articles **15**, **17** or by other means. The wearable article **11** may be pre-programmed to determine the locations of the wearable articles **15**, **17** based on factors such as the type of wearable articles **15**, **17**. For example, if the wearable article **11** is able to determine that the wearable article **15** is an item of footwear, the wearable article **11** may be able to determine to beam energy in a downwards direction. Another example of the beaming of energy involves the use of ultrasonic waves rather than microwaves.

[0073] The beaming of energy may be performed over a wireless network. In this arrangement, the power transmitter **113** may be arranged to transmit power over a first wireless network which may, for example, be a short-range wireless network such as a wireless personal area network (PAN). The power transmitter **113** may be part of or may be the communicator **117**. That is, the transmitter of the communicator **117** may be the power transmitter **113**. The power transmitter **113** may be a mobile transmitter **113** arranged to transmit power over a wireless network such as a cellular network. Beneficially, the same mobile transmitter **113** used to transfer power may be arranged to transmit and/or receive data to the wearable articles **15**, **17** or other external devices. Power may be transferred over a first wireless network and data may be transferred over a second wireless network which may be different to the first wireless network. The second wireless network may be a cellular network. In preferred implementations, the mobile transmitter **113** is a mobile transceiver **113**, **115** arranged to transmit and receive data and power over the wireless networks. The mobile transceiver **113** may transmit and/or receive data over a cellular network and may transmit and/or receive power over a personal area network. The power may be transmitted in the form of pulsed RF energy, continuous RF energy, intermittent RF energy, and/or multiband RF energy.

[0074] In some implementations, the wearable article **11** is arranged to transfer power whenever the wearable article **11** is brought into communication with another of the wearable articles **13**, **15**, **17**. In preferred implementations, however, the wearable article **11** performs an additional determination step before transferring power. This determination step is beneficial as it ensures that power is transferred only when certain conditions are met. This helps reduce unnecessary power drain for the wearable article **11** and helps avoid the transfer of power to apparatuses without the user's authorisation.

[0075] In some examples, the processor **112** of the wearable article **11** is arranged to determine whether a power transfer condition is satisfied. In response to determining that the power transfer condition is satisfied, the processor **112** is arranged to control the wearable article **11** to transfer power from the power source **111** to one of the other wearable articles **13**, **15**, **17**. The power

transfer condition may relate to information received from the wearable article **13, 15, 17**. The information may relate to the identity of the wearable article **13, 15, 17**, the identity of a user wearing the wearable article **13, 15, 17**, and/or an available charge level of the wearable article **13, 15, 17**. The processor **112** of the wearable article **11** may determine whether the power transfer condition is satisfied based on information received from the wearable article **13, 15, 17**.

[0076] In some examples, the communicator **117** of the wearable article **11** receives identification information from the wearable article **13, 15, 17**. The processor **112** determines from the identification information whether the power transfer condition is satisfied.

[0077] In some examples, the power transfer condition is satisfied if the identification information identifies that the wearable article **13, 15, 17** is authorised to receive power from the wearable article **11**. This may mean that the wearable article **13, 15, 17** is associated with the user wearing the wearable article **11** or with another user that is authorised by the user wearing the wearable article **11**. For example, the user wearing the wearable article **11** may authorise family members or friends to be able to receive power from the wearable article **11**. The identification information may be biometric information identifying a user associated with the wearable article **13, 15, 17**. The biometric information may be sensed by a sensor of the wearable article **13, 15, 17**. The processor **112** is arranged to determine from the biometric information whether the user associated with the wearable article **13, 15, 17** is authorised to receive power from the wearable article **11**. The processor **112** may make the determination by comparing the biometric information identifying the user wearing the wearable article **11** to the biometric information identifying the user associated with the wearable article **13, 15, 17** to determine whether the user associated with the wearable article **13, 15, 17** is the same as a user wearing the wearable article **11**.

[0078] Before power is transferred, the wearable article **11** may first determine how much (if any) power it may transfer. This determination may be based on several metrics. One example metric is whether the power source **111** has a remaining charge that is greater than a predetermined threshold. This means that the processor **112** determines whether the power source **111** has sufficient spare power to be transferred to the wearable article **13, 15, 17**. Another example metric is whether the power source **111** has a remaining charge that is sufficient to power the wearable article **11** for a time that is greater than a predetermined threshold. This may mean that the processor **112** estimates the remaining battery life of the wearable article **11** and determines whether to transfer power based on this estimate. For example, if the wearable article **11** has less than one hour of battery life remaining, the processor **112** may determine not to transfer power to the wearable article **13, 15, 17**. Of course, other time durations are within the scope of the present disclosure. Another example metric is whether the wearable article **11** has received an authorisation command from the user to transfer power to the wearable article **13, 15, 17**. The user may be prompted by a user electronic device in communication with the wearable article **11** or the wearable article **11** itself to authorise the transfer of power. The user may be presented with information indicating amongst other things the remaining battery life of the wearable article **11**. The user may authorise the transfer of power via a user input, gesture, or voice command amongst others. Another example metric is whether a remaining charge of the wearable article **13, 15, 17** is less than a predetermined threshold. This may mean that the wearable article **11** receives power status level information from the wearable article **13, 15, 17** which indicates the remaining charge for the wearable article **13, 15, 17**. If the wearable article **13, 15, 17** has sufficient remaining charge then the wearable article **11** may determine not to transfer power.

[0079] In some implementations, the wearable article **13, 15, 17** is arranged to transfer data to the wearable article **11** based on a determined power status level information of the wearable article **13, 15, 17**. In these examples, the processor **132, 152, 172** of the wearable article **13, 15, 17** determines power status level information for the power source **131, 151, 171**. The processor **132, 152, 172** then determines, from the power status level information, whether to transfer data to the wearable article **11**. In response to determining to transfer data, the processor **132, 152, 172** controls the

communicator **136**, **156**, **176** to transfer data to the wearable article **11**. The power status level information may relate to the remaining charge for the power source **131**, **151**, **171**. The processor **132**, **152**, **172** may determine to transfer data if the remaining charge is less than a predetermined threshold or if the remaining charge is only sufficient to power the wearable article **13**, **15**, **17** for a time that is less than a predetermined threshold.

[0080] In example implementations, the data comprises sensor data sensed by one or more sensors **135**, **155**, **175** of the wearable article **13**, **15**, **17**. The sensor data may be raw or processed sensor data. Transferring sensor data to the wearable article **11** provides the wearable article **13**, **15**, **17** with a mechanism to offload and backup sensor data. This protects against the data being lost if, for example, the wearable article **13**, **15**, **17** runs out of power and is shut down. The data may further comprise instructions for handling the sensor data. The instructions may relate to how to process the sensor data. This may enable the wearable article **13**, **15**, **17** to offload some of the processing tasks to the wearable article **11** so as to help conserve the battery life of the wearable article **13**, **15**, **17**. The data may additionally or separately comprise the power status level information and/or identification information for the apparatus and/or a user associated with the wearable article **13**, **15**, **17**.

[0081] Referring to FIG. **6**, there is shown an example garment **19** according to aspects of the present disclosure. The garment **19** is in the form of a T-shirt. The garment **19** comprises an electronics module **191** comprising a processor and a first power source. The electronics module **191** may be the same as or similar to the electronics arrangements described above in relation to wearable articles **11**, **13**, **15**, **17**. The garment further comprises a mounting arrangement **193** which, in this example, is in the form of a pocket positioned **193** on the outside surface of the garment **19**. The pocket **193** has an opening at the top. The garment **19** further comprises an electrically conductive pathway **195** which extends from the first power source of the electronics module **191** to the mounting arrangement **193**. The electrically conductive pathway **195** may be hidden in the garment **19** and may not be visible from an outside surface of the garment **19**.

[0082] The mounting arrangement **193** is arranged to releasably retain a second power source (not shown). This may mean that the second power source is able to be positioned within the pocket **193**. The second power source may be a user electronic device such as a mobile phone or a power bank. When the second power source is retained by the mounting arrangement **193**, the first power source and the second power source are brought into electrical communication via the electrically conductive pathway. This enables the electronics module **191** to receive power from the second power source via the electrically conductive pathway **195** or vice versa. In this way, the second power source may be used to charge the power source of the electronics module **191**.

[0083] Referring to FIG. **7**, there is shown a sectional view of the garment **19** in FIG. **6**. The sectional view shows that a power receiver **197** comprising one or more coils is provided within the garment **19** in the vicinity of the mounting arrangement. The electrically conductive pathway **195** terminates in the power receiver **197** which means that the electrically conductive pathway **195** electrically connects the electronics module **191** to the power receiver **197**. The second power source comprises a power transmitter comprising one or more coils. When the second power source is retained by the mounting arrangement **193**, an inductive coupling is formed between the power receiver **197** and the power transmitter which enables the second power source to inductively transfer power to the first power source of the electronics module **191**.

[0084] In some examples, the mounting arrangement **193** comprises an interface element arranged to form a mechanical and/or electrical connection with the second power source. The interface element may provide a mechanical connection to help hold the second power source in a fixed position relative to the power receiver **197**. This may enhance the transfer of power from the second power source to the first power source by helping to ensure that that an inductive coupling is formed and maintained. The interface element may form an electrical connection with the second power source so as to enable power to be transferred from the first power source to the second

power source. The electrical connection may be separate to or in addition to the inductive coupling. That is, rather than just inductively charging the second power source, the interface element may form a physical conductive connection between the first and second power source so as to enable the transfer of power.

[0085] In some implementations, the interface element comprises a magnetic material. The magnetic material is arranged to couple with magnetic material of the second power source to form the mechanical and/or conductive connection with the second power source.

[0086] In some implementations, the interface element comprises a fastener element. The fastener element is arranged to couple with a corresponding fastener element of the second power source to form the mechanical and/or conductive connection with the second power source.

[0087] In some implementations, the electronics module **191** is removable from the garment **19**. In these implementations, the garment may comprise a second mounting arrangement (not shown). The second mounting arrangement may be arranged to releasably retain the electronics module.

[0088] Referring to FIG. **8**, there is shown an example method of transferring power from a wearable article to an external apparatus according to aspects of the present disclosure. Step **S101** of the method comprises determining, by the wearable article, whether a power transfer condition is satisfied. In response to determining that the power transfer condition is satisfied, step **S102** of the method comprises transferring, by the wearable article, power from the power source to an electrical load of the external apparatus.

[0089] Referring to FIG. **9**, there is shown an example method of transferring power from a wearable article to an external apparatus. Step **S201** of the method comprises providing a wearable article comprising: a power source; and an interface element comprising magnetic material, wherein the magnetic material is arranged to form an electrical connection with an external apparatus so as to enable power to be transferred from the power source to an electrical load of the external apparatus. Step **S202** of the method comprises forming, by the wearable article, an electrical connection between the interface element of the wearable article and the external apparatus. Step **S203** of the method comprises transferring, by the wearable article, power from a first power source of the wearable article to an electrical load of the external apparatus via the electrical connection.

[0090] Referring to FIG. **10**, there is shown an example method of transferring power from a wearable article to an external apparatus. The method comprises providing the wearable article. The method comprises using a power transmitter of the wearable article to beam electromagnetic energy from the power source to a power receiver of the external apparatus.

[0091] At least some of the example embodiments described herein may be constructed, partially or wholly, using dedicated special-purpose hardware. Terms such as ‘component’, ‘module’ or ‘unit’ used herein may include, but are not limited to, a hardware device, such as circuitry in the form of discrete or integrated components, a Field Programmable Gate Array (FPGA) or Application Specific Integrated Circuit (ASIC), which performs certain tasks or provides the associated functionality. In some embodiments, the described elements may be configured to reside on a tangible, persistent, addressable storage medium and may be configured to execute on one or more processors. These functional elements may in some embodiments include, by way of example, components, such as software components, object-oriented software components, class components and task components, processes, functions, attributes, procedures, subroutines, segments of program code, drivers, firmware, microcode, circuitry, data, databases, data structures, tables, arrays, and variables. Although the example embodiments have been described with reference to the components, modules and units discussed herein, such functional elements may be combined into fewer elements or separated into additional elements. Various combinations of optional features have been described herein, and it will be appreciated that described features may be combined in any suitable combination. In particular, the features of any one example embodiment may be combined with features of any other embodiment, as appropriate, except where such

combinations are mutually exclusive. Throughout this specification, the term “comprising” or “comprises” means including the component(s) specified but not to the exclusion of the presence of others.

[0092] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0093] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0094] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

## Claims

**1-15.** (canceled)

**16.** A wearable article comprising: a power source; a power transmitter arranged to transmit electromagnetic energy waves from the power source to a power receiver of an external apparatus.

**17.** A wearable article as claimed in claim 16, wherein the power transmitter is arranged to transmit a directed beam of electromagnetic energy to the external apparatus.

**18.** A wearable article as claimed in claim 16, wherein the electromagnetic energy waves are microwaves.

**19.** A wearable article as claimed in claim 18, wherein the electromagnetic energy waves are in the form of a beam of focused microwaves.

**20.** A wearable article as claimed in claim 18, wherein the wearable article comprises a transducer, and wherein the transducer is arranged to convert electrical energy from the power source into the microwaves.

**21.** A wearable article as claimed in claim 16, wherein the power transmitter is arranged to transmit the electromagnetic energy waves over a first wireless network.

**22.** A wearable article as claimed in claim 21, wherein the power transmitter is a mobile transmitter.

**23.** A wearable article as claimed in claim 22, wherein the mobile transmitter is a mobile transceiver operable to send and/or receive data over a wireless network.

**24.** A wearable article as claimed in claim 23, wherein the mobile transceiver is operable to send and/or receive data to/from the external apparatus.

**25.** A wearable article as claimed in claim 21, wherein the mobile transmitter is arranged to transmit data over a second wireless network that is different to the first wireless network.

**26.** A wearable article as claimed in claim 25, wherein the second wireless network is a cellular network.

**27.** A wearable article as claimed in claim 21, wherein the first wireless network is a personal area network.

**28.** A wearable article as claimed in claim 16, wherein the wearable article is arranged to determine a location of the external apparatus, and direct the electromagnetic energy waves to the determined location of the external apparatus.

**29.** A wearable article as claimed in claim 28, wherein the wearable article determines the location of the external apparatus based on communication with the external apparatus.

**30.** A wearable article as claimed in claim 28, wherein the wearable article determines the location of the external apparatus based on a property of the external apparatus.



**31.** A wearable article as claimed in claim 16, wherein the power transmitter is arranged to simultaneously transmit the electromagnetic energy waves to a plurality of external apparatuses.

**32.** A wearable article as claimed in claim 16, wherein the electromagnetic energy waves are ultrasonic waves.

**33.** A wearable article as claimed in claim 16, further comprising a processor, wherein the processor is arranged to determine whether a power transfer condition is satisfied, and, in response to determining that the power transfer condition is satisfied, the processor is arranged to control the power transmitter to transmit electromagnetic energy waves from the power source to the power receiver of the external apparatus.

**34.** A wearable article as claimed in claim 33, wherein the wearable article is arranged to receive identification information from the external apparatus, and wherein the processor is arranged to determine from the identification information whether the power transfer condition is satisfied.

**35.** A system comprising: a first wearable article comprising a power receiver; a second wearable article comprising a power source; and a power transmitter arranged to transmit electromagnetic energy waves from the power source to the power receiver of the first wearable article.

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