

PORTABLE BATTERY-POWERED DEVICES WITH BATTERY TESTERS

The present invention relates generally to portable battery-powered devices, such as battery-powered flashlights and lanterns, having a device for indicating the level of charge or capacity of the batteries contained therein.

Flashlights and a majority of portable lanterns are battery-operated using either non-rechargeable or rechargeable batteries. One problem commonly associated with these batteries is determining the useful or remaining life of the battery. If the batteries are already in a flashlight or portable lantern, the quickest way to determine the strength of the battery is by turning the flashlight or lantern on. If the incandescent or fluorescent lamp illuminates, then most individuals are satisfied that the batteries are good.

However, if the flashlight or portable lantern does not illuminate, then the question is whether the problem lies in the batteries or the lamp bulb. The user must then either replace the batteries in the flashlight with new batteries and/or replace the bulb, or remove the existing batteries and/or the bulb for testing.

Several devices have been developed for testing batteries to determine the freshness or state of charge of the cell. For example, United States Patent No's 4,723,656 and 5,128,616 disclose blister-type packaging for new batteries with a battery condition indicator built into the blister portion of the package. The blister can be deformed to place the tester across the terminals of the battery to be tested.

The tester employs a thermochromic material in combination with a resistive element. The flow of current produces a temperature gradient across the resistive element which, in turn, causes a colour change in the thermochromic material to indicate the state of charge of the battery. Because the testers are associated with the package in which the batteries are purchased, however, they suffer from the drawback that they tend to be discarded with the empty packaging. The state of charge of the batteries then becomes indeterminate once more.

United States Patent No's 4,702,563, 4,702,564, 4,726,661, and 4,737,020 disclose flexible battery testers which have a conductive circuit pattern associated with a layer of thermochromic material. The flexible member is bent so that the circuit pattern can contact the positive and negative terminals of the battery to be tested and, again, the temperature gradient is observed via the thermochromic material and correlated with the state-of-charge of the battery.

Again, these testers suffer from the same deficiency in that the tester is a separate element, which in the case of a package, is usually thrown away or, in the remaining cases, can be lost or misplaced. In either event, the state of charge of the battery is indeterminate once the testing device is no longer available.

US-A-4,876,632 discloses a flashlight containing a device for indicating the level of charge on a battery. The battery life indicator is a module that is mounted between the flashlight head or lamp assembly containing the light reflector and a battery housing assembly for holding the batteries. The battery life indicator module contains an indicator, such as a light-emitting

diode (LED). Internal to the battery life indicator module is a circuit which measures the battery level and activates the indicator to display the battery level.

The module also provides the necessary electrical connection between the batteries and the bulb of the flashlight. The battery life indicator is activated by the On/Off switch of the flashlight so that the power is not drained when the flashlight is not in use.

The disadvantage is that, when the flashlight is turned on, the battery-life indicator module and its associated circuit are also powered and remain on while the flashlight is on. In the event that the flashlight lamp burns out, and the operator fails to notice that the battery-life indicator is activated, the fact that the tester is on will result in a discharge of the batteries.

US-A-4,962,347 discloses a battery-powered flashlight or portable lantern having a built-in device for determining the strength, voltage or capacity of the batteries. The flashlight or lantern includes a housing which holds the batteries and which receives an electrically powered light source mounted thereon which is energised by the batteries. A battery-testing circuit is mounted in the housing having a display which is detectable from the outside of the housing. A three-way switch mounted in the housing is placed in a first position to connect the light source with the batteries, and in a second position to connect the battery-testing circuit with the batteries, and a third position to disconnect the batteries from both the light and the battery-testing circuit.

US-A-4,432,041 discloses a portable lighting device which includes circuitry for detecting a low voltage

condition of the batteries. Upon the detection of a low voltage condition, the circuitry provides an intermittent sound that is indicative of the low voltage condition. A disadvantage associated with this circuitry is that the tester is constantly "ON" in order to monitor the voltage level. Furthermore, the tester circuitry only provides an indication when the voltage level of the batteries is below a certain level. In addition, there is no indication as to the remaining life of the battery, and the state of charge of the battery is indeterminate.

Accordingly, in a first aspect, the present invention provides a handheld, battery-powered device, such as a torch, comprising a battery housing and a battery tester intimately associated therewith, the tester having an externally visible display and being operable independently from the device.

It will be understood that the present invention can apply to any suitable handheld device operating from a drainable power source, such as replaceable or rechargeable batteries. Such devices may include fans and household drills, but the most preferred such device is the torch. Where reference to such as a lantern, torch or flashlight is had herein, this also includes reference to other suitable devices, such as listed above.

By "operable independently" is meant that the tester circuit can be operated when desired. We prefer that the tester can be operated regardless of whether the torch is on or off, but it should at least be operable when the torch is on.

The tester may be provided separately from the device, provided that it can be secured onto the

device. Such a separate tester may be configured such that, for example, one end can be secured by the cap on the battery housing, while the other end can be secured between the housing and the lamp. In such a case, a switch in the device can ensure independent operation of the tester.

Such separate testers are not generally preferable, as they will be located exterior to the housing, and will be subject to wear and tear. However, where such devices are used, it is preferable that they fit within a suitable declivity in the housing of the torch. It will be appreciated that the present invention extends to testers suitable for such use.

More preferably, the tester is incorporated into the body of the housing, or is recessed into the housing, to minimise the effects of constant usage of the device. In such a case, the tester is effectively permanently fixed to the device (barring deliberate attempts at removal).

The tester may be any that is suitable, but will typically involve a flexible strip which is conductive, or conductively treated, electrically secured to one pole of the battery (such as the wall of the housing where this is metallic) and biassable toward electrical connection with the second pole. For this we prefer to use thermochromic dyes, such as are illustrated below, although other types of indicator are also useable and, again, these are illustrated below.

In order to avoid permanent connection with both poles of the battery, a switch must generally be employed. Such a switch may, typically, employ any known type of switch means, although a toggle switch may not be the most convenient. Rather, we prefer to employ

a simple means of direct pressure on a part of the strip which is biased away from contact with an electrical terminal, or where the electrical terminal can make contact with the tester provided that the tester is sufficiently deformed, such as by finger pressure. As stated above, the other end of the tester will generally be in fixed electrical contact with the other terminal.

Unless otherwise indicated, all variations and preferred embodiments for the various types of tester according to the present invention apply equally to all other types of tester falling within the scope of the present invention, including aspects only described with one type of embodiment although it will be appreciated that variations described in connection with any one aspect will generally be preferred for that aspect.

In a further aspect, the present invention provides a portable device, for example a lighting device, comprising in combination:

- a housing for retaining at least one battery;
- a light source attached to the housing and operable by the battery; and
- a laminated battery tester fixed to an exterior surface of the housing and having a first end operably connected to one pole of the battery and a second end operably connectable to an opposite pole of the battery, the battery tester providing an indication of the battery strength. There is preferably a switch means incorporated within the laminated battery tester for placing the second end in electrical contact with the opposite pole of the battery.

In a preferred embodiment, the laminated battery tester includes:

- a flexible substrate having opposite sides;
- an indicator located on one side of the substrate

for indicating the strength of the battery; and

a conductor located on an opposite side of the substrate for selectively completing a circuit between the poles of the battery. In addition, it is preferred that there is a protective layer overlying the indicator and the substrate for protecting the indicator; and that there is an adhesive for bonding the substrate and the conductor to the housing. Although it is not essential, we prefer to provide at least one decorative layer between the indicator and the substrate.

Advantageously, the switch means includes:

first and second terminals in the flashlight in electrical contact with opposite poles of the battery;

a first end of the conductor in electrical contact with the first terminal; and

a second end of the conductor disposed above and spaced from the second terminal and operably connectable to the second terminal by urging the second end against the second terminal.

Also advantageously, the conductor includes:

an electrically conductive material such as metal, metallised film, metallised plastic, ink or paint containing electrically conductive constituents, and is so configured as to provide an area of resistance to a flow of electrical current. The area of resistance is preferably configured so as to provide a desired resistance, so as to activate a particular type of thermochromic ink, for example. Alternatively, but not necessarily exclusively, the area of resistance may be so configured as to vary throughout, so as to activate, for example, one thermochromic ink at a particular place in the area according to battery charge, or to activate different inks.

In a yet further aspect, the present invention

provides a flashlight battery tester, comprising in combination:

- a flashlight housing having first and second terminals, each in electrical continuity with one pole of at least one battery disposed within the housing;

- a display circuit mounted on the flashlight housing and having a first end in electrical contact with the first terminal, and a second end disposed above and flexibly engageable with the second terminal, whereby depression of the second end into contact with the second terminal causes a current to pass through the display circuit and provide an indication of the strength of the battery. Advantageously, the flashlight housing has at least one hole extending through a wall of the housing and exposing one of the terminals.

In a preferred embodiment, the display circuit includes:

- a substrate layer having opposite sides;
- a conductor layer having a resistive portion disposed on a first of the sides of the substrate;
- a protective layer disposed on a second of the sides of the substrate;
- an indicator layer disposed between the protective layer and the substrate layer in an area aligned with the resistive portion of the conductor layer; and
- an adhesive layer disposed on the first of the sides of the substrate for adhering the flashlight battery tester to the flashlight housing.

If desired, there may be provided at least one layer disposed between the substrate layer and the conductor layer. There may also be an insulator layer disposed between the conductor layer and the flashlight housing for insulating the conductor layer from the flashlight housing, the insulator layer having a first and second opening aligned with the first and second terminals.

There is preferably a switch, as described herein, for placing the second end of the conductor in electrical contact with the second terminal to activate the display circuit. The protective, substrate and conductor layers may be suitably flexible with a portion overlying the second terminal of the flashlight such that force applied on the portion toward the second terminal moves the conductor into electrical contact with the second terminal.

Alternatively, a suitable switch may be of the Belleville type. In such a case the switch typically includes:

- a spring disposed over the second terminal between the conductor layer and the second terminal; and

- a conductive plunger disposed within the spring and having a first end in electrical contact with the conductor layer, the opposite end of the plunger being translatable into contact with the second terminal.

In a further aspect, there is provided a battery tester for use on the exterior of a flashlight, the flashlight having a housing for retaining at least one battery, and a light source operably connected through a first switch to the battery, the battery tester comprising in combination:

- a conductor fixed to the exterior of the housing and having a first end operably coupled to one pole of the at least one battery and a second end operably connectable with an opposite pole of the at least one battery, the conductor having a region resistive to an electrical current flowing therethrough; and

- a responsive display overlying the conductor for displaying the capacity of the battery in response to the resistance to the electrical current flowing through the conductor.

Advantageously, this embodiment further includes:
a substrate disposed between the conductor and the responsive display;
a protective layer overlying the responsive display and adhered to the substrate; and
an adhesive bonding the substrate, conductor-responsive display and protective layer to the exterior of the flashlight. A sealer may be provided between the conductor and the adhesive.

The flashlight housing may be metallic. An insulator may be disposed between the conductor and the exterior of the flashlight to prevent the conductor from shorting out across the first and second ends along the exterior of the flashlight.

Where the housing is metallic, it is preferred that one pole of the battery is in electrical contact with the exterior of the flashlight, and the opposite pole of the battery is insulated from and but exposed along the exterior of the flashlight, and located below the second end of the conductor such that depression of the second end engages the conductor with the opposite pole of the battery, causing a current to flow between the first and second ends and provide an indication in the responsive display of the strength of the battery.

In another aspect of the invention, a flashlight or lantern housing has first and second terminals, each in electrical continuity with one pole of at least one battery contained within the housing. A display circuit mounted on the exterior of the housing has a first end in electrical contact with the first terminal and a second end engageable with the second terminal whereby depression of the second end results in a current flowing through the display circuit and providing an indication of the strength of the battery.

According to yet another aspect of the invention, a battery tester is provided for use on the exterior of a flashlight or lantern having a housing for retaining one or more batteries and a light source operably connected through a switch to the battery. In this environment, the battery tester includes in combination a conductor fixed to the exterior of the housing and having a first end operably coupled by a terminal to one pole of the battery and a second end in switching relationship to a second terminal operably coupled to an opposite pole of the battery. The conductor includes a region between the two ends having a controlled resistance to an electrical current. A responsive display overlying the conductor displays the remaining capacity in the battery when electrical current flows through the conductor upon the closing of the switch between the conductor second end and the second terminal. In the case where the flashlight or lantern housing is metallic, the housing serves as one terminal for the conductor. The opposite terminal of the flashlight or lantern is insulated from housing and is operably connectable with the conductor.

In a particularly preferred aspect of the present invention, there is provided a battery tester for use in combination with a portable lighting device such as a flashlight or lantern having a housing for retaining at least one battery including first and second terminals, each in electrical contact with an opposite pole of the battery, a conductor located on the exterior of the housing and having one end in electrical contact with the first terminal and an opposite end operably connectable to the second terminal. An indicator material overlies and is in responsive contact with the conductor to respond to and indicate a state that is present in the conductor. The indicator material is preferably a thermochromic ink responsive to heat changes in the conductor caused by a current flowing

therethrough. The conductor and indicator material are preferably mounted on a flexible substrate imprinted with decorative ink and indicia and protected by a transparent protective layer.

Thus, it can be seen that the present invention has the advantage of providing a simple method for testing batteries in a handheld device which suffers none of the drawbacks of the art.

The battery tester of this invention will function to indicate the battery state-of-charge even if the flashlight or lantern lamp is not functioning, unlike some prior testers where the lamp remains in series with the tester and the batteries. Another advantage of this invention is the low profile, easy construction and low cost of manufacture.

In one form of the invention, a Belleville switch mechanism, such as is described herein, may be used to make the electrical connection between the conductor and the one terminal of the flashlight or lantern. The switching mechanism includes a conductive plunger having one end overlain by the end of the conductor. The plunger is held away from the flashlight or lantern terminal by a Belleville spring disposed between the plunger and the housing. To activate or close the switch, the operator depresses the plunger which contacts the terminal allowing current to flow through the conductor and activate the display. Release of the switch results in the Belleville spring urging the plunger away from the terminal and opening the circuit.

In general, the battery tester is comprised of a means for completing the circuit between the poles of the battery within a tubular body, a means for responding to the capacity of the battery and a means for indicating the capacity of the battery. A means for

completing the circuit may be a tester circuit that is comprised of electrically conductive material such as a metallic foil, or a metallised plastic layer. Other examples include electrically conductive paints or inks, such as those that contain graphite, carbon, or metals or combinations thereof.

The electrically conductive material is typically configured to have first and second ends that are connected to each other via an area of controlled resistivity. The first end is provided to make contact with a first terminal of the flashlight which is, in turn, in contact with one pole of the battery contained therein, and the second end is provided to make contact with a second terminal of the flashlight which, in turn, is in contact with the opposite pole of the battery contained therein. These terminal contact ends are or will be connected to the terminals of the battery to complete the test circuit. Thus, when the tester circuit is completed, electric current can flow through the area of controlled resistivity. The term "controlled resistivity" means that the resistance is controlled to be within the range to activate the responsive means.

The resistance in the area of controlled resistivity can vary or it can be constant. In one embodiment, it is desired to have a varying resistance to indicate the relative remaining useful life of a battery. For example, the current flowing through the tester circuit will generate a specific temperature. The temperature achieved will be proportional to the amount of current supplied by the battery. Thus, the area of controlled resistivity can be of varying width, e.g., tapered, or of varying thickness to achieve the temperature gradient. Alternatively, the area can be of constant width and constant thickness. A further possibility

involves the use of different conductive materials having different resistivities in the area of controlled resistivity. In addition, when using thermochromic materials, materials activated at different temperatures can be used along an area of constant resistance, or continuous or discontinuous segments of a thermochromic material could be used along an area of varying resistance.

The testing means can be further comprised of means for connecting the tester circuit to the terminals of the flashlight. Such means may be terminal connectors that connect the opposite poles of the battery with the terminal contact ends of the tester circuit. Preferably, one terminal contact end of the circuit is out of contact with the terminal of the flashlight so that the tester circuit is open. In this embodiment, the testing means is further comprised of means for turning the tester circuit on, such as a switch.

In a preferred embodiment of the invention, one end of the circuit is permanently in contact with one pole of the battery through a terminal in the flashlight tubular housing. The opposite end contains a switch which places it in electrical contact with a second terminal in the flashlight housing, which is in electrical continuity with the opposite pole of the battery contained therein. The switch of the circuit includes a small opening in a layer between the flashlight terminal and the end of the tester circuit. By forcing the end of the circuit into contact with the flashlight terminal through the opening, the switch is closed and the tester circuit is completed to test the battery. This contact can be conveniently made by applying finger or thumb pressure to the switch area. When the force on the switch is removed, the switch opens and interrupts the circuit.

The testing means further comprises a means for indicating the capacity of the battery. The indicating means will be in responsive contact with the area of controlled resistivity and will respond to and indicate a state that is present in that area. For example, a temperature increase will be generated in that area when a current flows through the tester circuit. If the indicating means is a thermally sensitive material, then it is in thermally transferrable contact with the area of controlled resistivity. If the indicating means is an electrical field or voltage sensitive material, then the indicating means will be in electrical contact with the area of controlled resistivity. The indicating means will indicate the capacity of the battery to the consumer. This indication can be qualitative such as a "good" or "bad" reading, or quantitative such as a remaining percentage of useful life.

In one embodiment, the indicating means can be a thermally sensitive material that is in responsive contact with the area of controlled resistivity of the tester circuit. Thus, the heat generated in the area of controlled resistivity in the tester circuit can be transferred to the thermally sensitive material. The thermally sensitive materials change colour in response to a temperature change. The material is readily viewable to a consumer so that, based on the colour change, the consumer can determine whether the battery is good or needs to be replaced.

To enhance a colour change effect, the thermally sensitive material can be placed over a contrasting colour layer. This colour layer can be applied by printing directly onto the film base or onto the electrically conductive circuit. A message can also be printed onto the contrasting colour layer that can be viewed by the consumer when the thermally sensitive

material changes colour. An alternative means of providing a message can employ a stencil in the form of a thermally non-conductive layer, for example, a layer of double-faced tape in which the message is cut out of the thermally non-conductive layer so that a thin air insulation layer is left in that area under the thermally sensitive material. When the tester is activated, this cut-out message portion, which has poorer thermal conductivity than the surrounding area, results in the thermally sensitive material directly over the message area changing colour, while the surrounding thermally sensitive material, which serves as a heat sink, retains its original colour, thus outlining the message.

The stencil can be reversed so that the message is made of the thermally non-conductive layer and is surrounded by the air insulation layer. When this tester is activated, the thermally sensitive material directly over the message portion will retain its original colour because of better thermal conductivity, and the surrounding thermally sensitive material over the air insulation layer will change colour, thereby outlining the message.

Examples of thermally sensitive materials are liquid crystal materials and thermochromic inks. The indicating materials can be used singularly or in combination. For example, in one embodiment, layers of different indicating material are employed. The layers are activated at different temperatures or states and can be designed to change different colours at different temperatures. For example, the layers of different indicating material are arranged in decreasing temperature of activation with the lowest temperature material in the top layers. Alternatively, the indicating material can be designed to test the battery

at different ambient temperatures by using materials that activate at different temperatures. The material activatable at the corresponding temperature would be associated with the different circuits. For example, the label could be designed with a window for testing at 40°F (4°C), a window for testing at 70°F (21°C) and a window for testing at 90°F (32°C). Depending on what the ambient temperature is, the consumer would look at the corresponding window.

Examples of suitable liquid crystal materials are of the cholesteric type, such as cholesteryl oleate, cholesteryl chloride, cholesteryl caprylate and the like. Examples of suitable thermochromic inks include those comprised of a dye, developer and desensitising agent that are disclosed in US-A-4,835,475. Such inks are available from Matsui International Corp. of El Segundo, California and Sakura Colour Products Corporation of Osaka, Japan.

In another embodiment of this invention, the indicating and responding means can be materials that respond to a voltage change or an electric field. These materials are responsive directly to the remaining capacity of the battery as the current flows through the tester circuit, and so will be disposed in electrically responsive contact with the area of controlled resistivity. Materials for this purpose are known as electrochromic materials and are commercially available. For example, one such provider of such materials is the Donnelly Corporation of Holland, Michigan.

The battery tester of this invention can also comprise additional insulative layers, printing layers, protective layers and the like. Suitable materials for use as the different layers include plasticised or

unplasticised polyvinyl chloride, polyester, metallic films, paper and the like, and they are prepared by known methods, such as laminating the layers together and adhering to each other via an adhesive. In embodiments where conductive ink will be in contact with the adhesive, it is desirable to employ a primer layer or sealant layer between the conductive ink and the adhesive.

Suitable primers and adhesives include UV-cured dielectric materials such as Dielectric LV-3728-39 from Emerson & Cuming Inc. of Woburn, Massachusetts, dielectric ML-25198 from Acheson Colloids of Port Huron, Michigan, and liquitex acrylic gesso available from Binney & Smith Inc. of Easton, Pennsylvania.

The present invention will now be further illustrated with reference to the accompanying drawings, in which:

Figure 1 is a side elevation of a flashlight according to the present invention;

Figure 2 is an enlarged fragmentary plan view of a battery tester on the flashlight shown in Figure 1;

Figure 3 is a fragmentary sectional view of one embodiment of the battery tester taken along line III-III shown in Figure 2;

Figure 4 is a fragmentary sectional view of a second embodiment of the battery tester taken along line IV-IV shown in Figure 2;

Figure 5 is an exploded view of the battery tester shown in Figure 3;

Figure 6 is an exploded view of the battery tester shown in Figure 4; and

Figures 7 and 7b are fragmentary sectional views of an alternative embodiment of a switch for use in the battery tester shown in Figures 2 to 6.

Referring to Figs. 1 and 2, a flashlight or portable lantern 10 generally includes an elongate tubular body or housing 12 having a first end 14 and a second end 16. Tubular body 12 contains a longitudinal battery retention chamber which is dimensioned to accommodate one or more dry-cell batteries used to operate a lamp assembly 18 (not shown in detail) mounted on the first end 14 of tubular body 12. The second end 16 of tubular body 12 may be sealed or receive an end cap 20 which may be removed to insert and remove the batteries received within the battery retention chamber of tubular body 12. Lamp assembly 18 may be operably coupled to the batteries by a switch 22 such as a push button, slide or rotary type.

Flashlight or lantern 10 includes a battery tester 24 which is fixed to the exterior of tubular body 12. As shown generally in Figs. 2 and 3, battery tester 24 is preferably a low profile circuit made from a multi-laminate film adhered to the exterior of tubular body 12. If desired, battery tester 24 may be positioned within a recess 25 formed in the exterior of tubular body 12 which is of generally the same dimension as tester 24. Tester 24 includes an indicator or display area 26 preferably located on a decorative background 28 which is complimentary to the overall exterior design of flashlight 10. Tester 24 also includes a region 30 indicated thereon, preferably by a decorative ink, to indicate the location of a switch which is depressed to close the circuit to activate the

display.

In one embodiment of the flashlight having the externally attached battery tester 24, flashlight 10 has an elongate tubular body 12, such as shown in Fig. 1, made from a non-conductive material such as polypropylene, ABS, polystyrene or similar material. As shown in Fig. 3, tubular housing 12 is preferably perforated by two spaced apart holes 32, 34. Hole 32 preferably overlies a first conductor or terminal 36 which is in electrical contact with one pole of the battery contained within the flashlight tubular body 12. Similarly, hole 34 is located adjacent and receives a second conductor or terminal 38 which is in electrical contact with the opposite pole of the battery contained within the tubular body 12. It is preferred that conductor 38 be shaped to be received within hole 34 such that a portion is at least flush with or protrudes slightly with respect to the outer surface 13 within recess 25 for reasons which will become apparent below. One of the conductors or terminals 36 and 38 may be the same conductor used to complete the electrical circuit through the flashlight switch to activate the lamp in lamp assembly 18.

Referring to Figs. 3 and 5, adhered to the exterior of tubular body 12 and located above holes 32, 34, is a conductive foil, film, or ink 40 made from or containing silver, carbon, nickel or other conductive mixture applied to a substrate 42. In a preferred embodiment,

conductive circuit 40 is a conductive ink layer on the order of 0.5 mil (13 μ m) thick and is adhered to substrate 42 having a thickness on the order of 1 - 5 mils (25 - 130 μ m) and preferably 2 - 3 mils (51 - 76 μ m).

Conductive ink layer 40 is preferably printed on one side of substrate 42 in a shape which may have first and second ends 40a and 40b, respectively, interconnecting a strip 40c which is an area of controlled resistivity. Although area 40c of controlled resistivity may be achieved using the various techniques described earlier, it is preferred in the case of conductive ink layer 40 that a restriction be created in an area which coincides with the location of the display 26 described above. Fixed to substrate 42 on a side opposite that containing conductive circuit 40 may be one or more layers 44, 46, and 48 of decorative ink or metallised film to provide a decorative pattern for background 28 and switch 30. Deposited on the decorative inks in a region overlying and coinciding with the controlled resistivity portion of conductive circuit 40 is a 2 to 3 mil thick layer of thermochromic ink 50, such as those described above. The thermochromic ink and decorative ink layers are covered by a protective top layer 52 having a thickness of approximately 1 mil bonded thereto by an approximately 0.5 mil thick layer of laminating adhesive 54. The entire battery tester 24 is then retained against the exterior of flashlight tubular body 12 by approximately a 0.5 mil thick layer of pressure sensitive adhesive 56 to hold the battery tester 24 above holes 32, 34 and flashlight terminals 36, 38. Alternatively, adhesive layer 56 may be omitted and an adhesive layer applied, e.g., by roll-coating, to the face of substrate 42 adjacent conductive ink 40. In that embodiment, a primer or sealant layer 41 may be disposed between conductive ink layer 40 and substrate 42 to prevent any undesirable reaction between the conductive ink and the adhesive.

In the case of flashlights or portable lanterns having metallic or conductive bodies 112, the externally attached battery tester 124, shown in Figs. 4 and 6,

will be attached to the exterior surface 113 of the flashlight body or housing and include a conductive circuit 140 similar to that described above adjacent to or otherwise printed on one surface of PVC or polyester substrate 142. On the opposite surface of substrate 142, to that containing conductive circuit 140, are one or more layers 144, 146, and 148 of decorative ink or metallisation used to compose or form the background 128 (corresponding to 28 above) of tester 124. Deposited or printed on the decorative ink and/or metallisation layer is the thermochromic ink 150 in an area preferably limited to that of the controlled resistivity portion of conductive circuit 140. The entire top of tester 124 is then covered by a protective top layer 152 of e.g., PVC, polyester, or polyethylene, which is bonded to tester 124 by a layer of adhesive 154 (not shown in Figure 6).

The side of substrate 142 containing conductive circuit 140 is bonded to an insulative layer 156 with localised portions 158, 159 of the insulative layer left open which coincide with portions of conductive layer 140 adapted to engage flashlight terminals 136, 138. Insulative layer 156 is, in turn, bonded to the exterior of flashlight tubular body 112 by an adhesive 160. Adhesive layer 160 is similar in shape to insulative layer 156 and does not cover that portion of conductive circuit 140 adapted to make electrical contact with terminals 136, 138.

Conductive circuit 140 can be printed, using conductive ink, on the side of substrate 142 adjacent insulative layer 156 and can be surrounded by an adhesive layer (not shown here) to adhere substrate 142, carrying conductive ink layer 140, to insulative layer 156. Alternatively, an adhesive layer such as layer 141 shown in Fig. 6 can be applied, e.g., by printing or roll-coating, to that side of substrate 142. In that

embodiment, a primer or sealer (not shown) would be coated over the adhesive layer before printing the conductive ink 140 thereon to prevent any undesirable reaction between the adhesive layer and the conductive ink. If the conductive circuit 140 is a metal foil, an adhesive layer, such as layer 141, can again be applied to that surface of substrate 142 adjacent the conductive circuit 140. This adhesive layer 141, which extends beyond the edges of conductive circuit 140, adheres substrate 142 and conductive circuit 140 to insulative layer 156, which in turn is adhered to the exterior of the flashlight body 112 by adhesive layer 160.

The metallic tubular body 112 of the flashlight is modified slightly from that of the plastic tubular body 12 described earlier. Flashlight terminal 138 is preferably in electrical contact with tubular body 112 which is in electrical contact with one end 140a of conductor 140. Flashlight terminal 136 is separated from the inside of tubular body 112 by an insulative material 162 and by an annular insulator 134 disposed within hole 132 piercing body 112. Terminal 136 is formed to extend slightly up through hole 132 and insulator 134 to allow terminal 136 and the second end 140b of conductor 140 to come into electrical contact by depressing switch area 130 without grounding against the metallic tubular body 112.

In operation, battery tester 24, 124 is activated by depressing switch area 30, 130 to force end 40b, 140b of conductor 40, 140 into electrical contact with flashlight terminal 36, 136, thus completing the circuit through conductor 40, 140. The increase in heat associated with the current flowing through the controlled resistance portion of conductor 40, 140 is transferred through substrate 42, 142 to thermochromic ink 50, 150. Thermochromic ink 50, 150 then reacts and

changes colour in response to the localised heating and thus indicates to the user the remaining capacity of the battery within the flashlight.

In an alternative embodiment of the battery tester 24, 124 described above, a switch 200, shown in Figs. 7a and 7b, may include a Belleville spring mechanism 202 including a conductive plunger such as cylinder 204 terminating at an upper end in a flange 206. Plunger 204 is positioned within a Belleville washer 208 bent to form a spring which supports plunger 204 by flange 206 such that plunger 204 overlies hole 210 formed in the flashlight body 212 and is away from flashlight terminal 214. Belleville spring mechanism 202 is overlain by the conductive circuit 240 and substrate 242 so that upon depression of switch 200, plunger 204 makes electrical contact with one flashlight terminal 214, such as those described above. The conductive circuit 240 and substrate 242 are, in turn, overlain by one or more decorative layers such as described above, but not shown, and protective layer 252. In this alternate embodiment, it is axiomatic that the opposite end of conductor circuit 240 is in permanent electrical contact with the opposite flashlight terminal to complete the circuit.

This embodiment of the switch operates in much the same manner as the previous embodiments. As shown in Fig. 7b, the operator depresses switch 200 which moves plunger 204 downwardly into contact with flashlight terminal 214. Plunger 204, which is conductive, contacts circuit 240 causing current to flow therethrough and heat the thermochromic indicator described earlier. Release of switch 200 results in Belleville spring washer 208 moving plunger 204 upwards and away from flashlight terminal 214, opening the tester circuit.



Claims

1. A handheld, battery-powered device, such as a torch, comprising a battery housing and a battery tester intimately associated with the housing, the tester having an externally visible display, characterised in that the tester is operable independently from the device.
2. A portable lighting device comprising in combination:
 - a housing for retaining at least one battery;
 - a light source attached to the housing and operable by the battery; and
 - a laminated battery tester fixed to an exterior surface of the housing and having a first end operably connected to one pole of the battery and a second end operably connectable to an opposite pole of the battery, the battery tester providing an indication of the battery strength.
3. A flashlight battery tester, comprising in combination:
 - a flashlight housing having first and second terminals, each in electrical continuity with one pole of at least one battery disposed within the housing;
 - a display circuit mounted on the flashlight housing and having a first end in electrical contact with the first terminal, and a second end disposed above and flexibly engageable with the second terminal, whereby depression of the second end into contact with the second terminal causes a current to pass through the display circuit thereby to provide an indication of the strength of the battery.
4. A battery tester for use on the exterior of a flashlight, the flashlight having a housing for retaining at least one battery, and a light source



operably connected through a first switch to the battery, the battery tester comprising in combination:

a conductor fixed to the exterior of the housing and having a first end operably coupled to one pole of the at least one battery and a second end operably connectable with an opposite pole of the at least one battery, the conductor having a region resistive to an electrical current flowing therethrough; and

a responsive display overlying the conductor for displaying the capacity of the battery in response to the resistance to the electrical current flowing through the conductor.

5. A device according to any preceding claim which is a battery-powered torch.

6. A device according to any preceding claim, wherein the tester is effectively permanently secured to the housing.

7. A device according to any preceding claim, wherein the tester comprises a flexible strip which is conductive, or conductively treated, which is electrically secured to one pole of the battery and which is biasable toward electrical connection with the second pole.

8. A device according to any preceding claim wherein a thermochromic dye is employed in the tester to indicate the level of charge of any battery in the device according to heat generated by a resistive element in the tester.

9. A device according to any preceding claim, comprising a manual switch to complete or break the testing circuit, as required, particularly preferably where the switch is only in the on position for so long



as manual pressure is applied.

10. A device according to any preceding claim, comprising a Belleville switch to complete the tester circuit.

11. A battery tester suitable for use in accordance with any preceding claim.