# United States Patent [19]

**Theobald**

[11] **Patent Number: 5,925,942**

[45] **Date of Patent: Jul. 20, 1999**


[54] **POWER SUPPLY CONTROL APPARATUS AND METHOD SUITABLE FOR USE IN AN ELECTRONIC DEVICE**


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[21] Appl. No.: **08/895,390**

[22] Filed: **Jul. 16, 1997**

[51] **Int. Cl.**[6] .......... **H02J 7/00**

[52] **U.S. Cl.** .......... **307/125**; 307/66; 455/573; 320/137

[58] **Field of Search** .......... 307/125, 64, 66; 455/90, 573; 320/106, 110, 137


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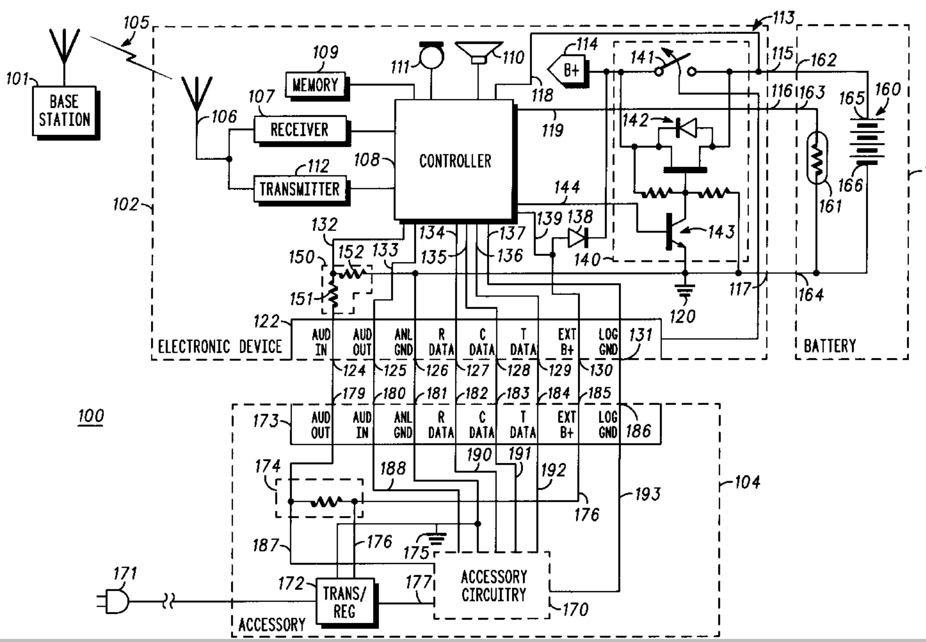
*Attorney, Agent, or Firm*—Mark D. Patrick

[57] **ABSTRACT**


A power supply control apparatus (**113**) for an electronic device (**102**) includes a terminal (**115**) to couple to a battery (**103**), a connector (**122**) to couple to an external power supply (**172**), a switch circuit (**140**) coupled to the terminal (**115**) and the connector (**122**), and a controller (**108**) coupled to the switch circuit (**140**). The switch circuit (**140**) connects the terminal (**115**) to power the electronic device (**102**) from the terminal (**115**) when the battery (**103**) is attached and disconnects the terminal (**115**) to power the electronic device (**102**) from the connector (**122**) when the external power supply (**172**) is attached. The controller (**108**) selectively controls the switch circuit (**140**) to connect the connector (**122**) to the terminal (**115**) so as to charge the battery (**103**) from the external power supply (**172**).


**20 Claims, 2 Drawing Sheets**



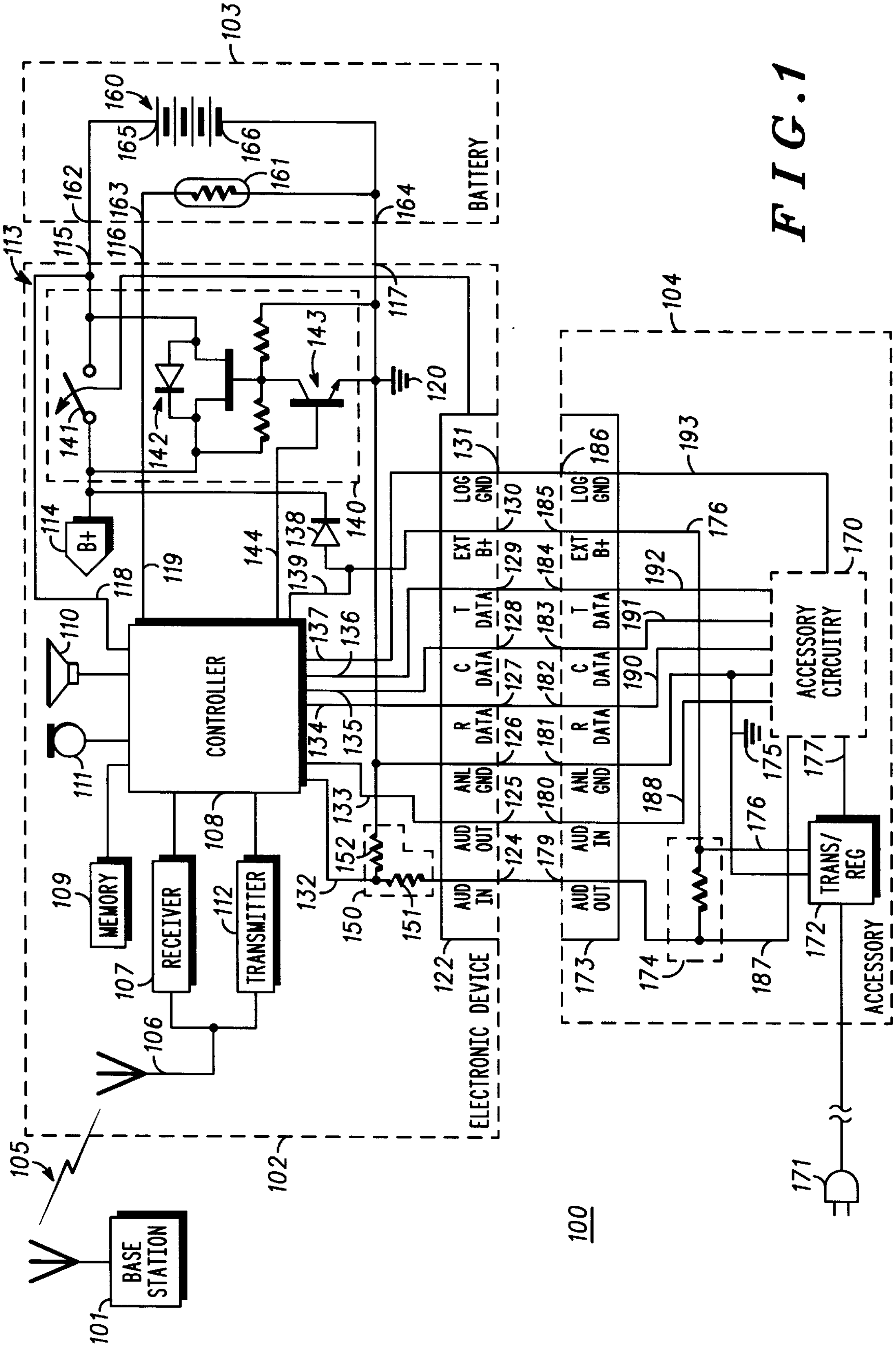

BATTERY
ELECTRONIC DEVICE
BASE STATION
CONTROLLER
MEMORY
RECEIVER
TRANSMITTER
B+
AUD IN
AUD OUT
ANL GND
R DATA
C DATA
T DATA
EXT B+
LOG GND
ACCESSORY CIRCUITRY
TRANS/ REG
ACCESSORY
100

FIG. 1

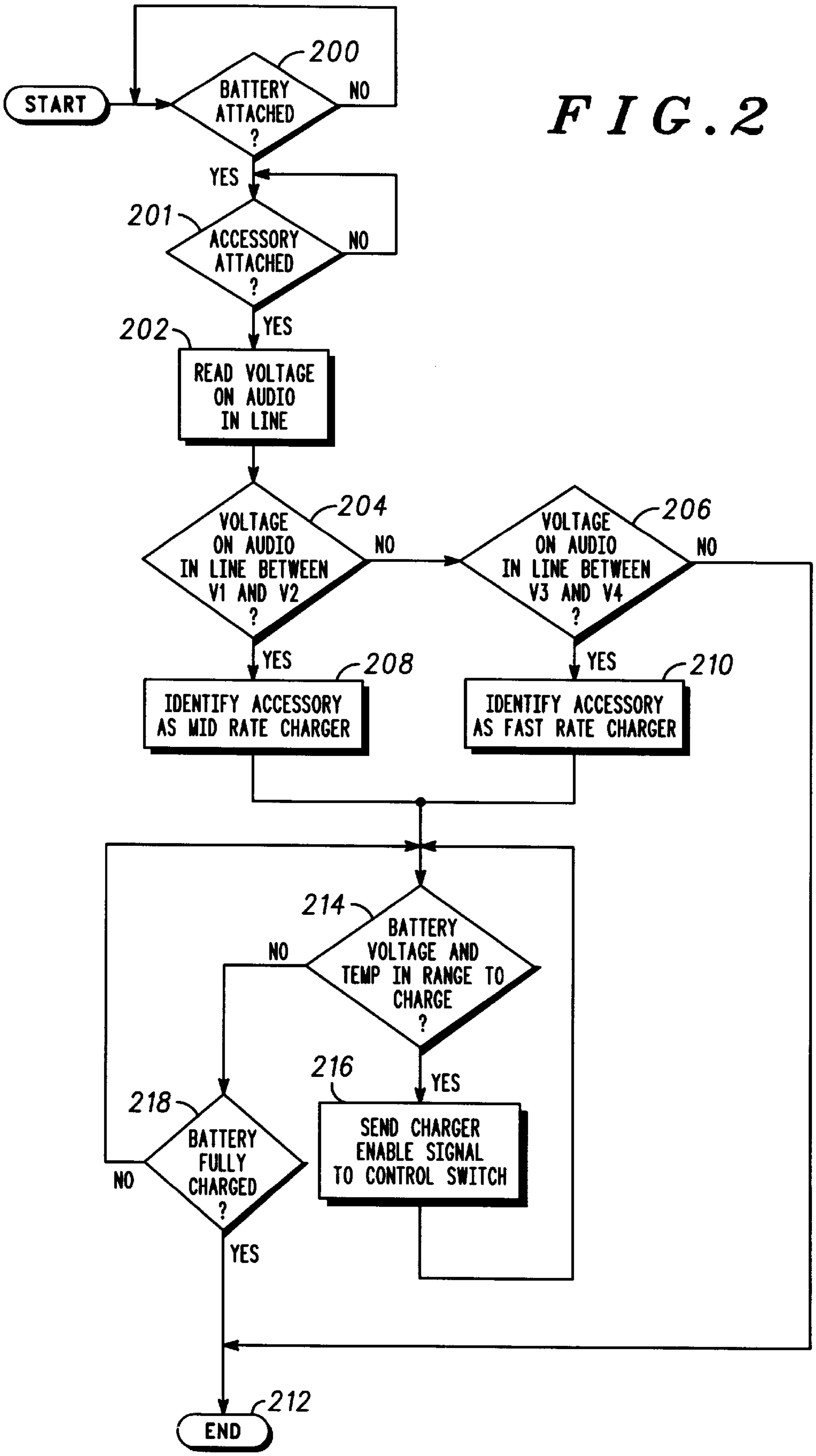

START
BATTERY ATTACHED ?
200
NO
YES
201
ACCESSORY ATTACHED ?
NO
YES
202
READ VOLTAGE ON AUDIO IN LINE
VOLTAGE ON AUDIO IN LINE BETWEEN V1 AND V2 ?
204
NO
VOLTAGE ON AUDIO IN LINE BETWEEN V3 AND V4 ?
206
NO
YES
208
IDENTIFY ACCESSORY AS MID RATE CHARGER
YES
210
IDENTIFY ACCESSORY AS FAST RATE CHARGER
214
BATTERY VOLTAGE AND TEMP IN RANGE TO CHARGE ?
NO
216
YES
SEND CHARGER ENABLE SIGNAL TO CONTROL SWITCH
218
BATTERY FULLY CHARGED ?
NO
YES
212
END

FIG. 2

# POWER SUPPLY CONTROL APPARATUS AND METHOD SUITABLE FOR USE IN AN ELECTRONIC DEVICE

## FIELD OF THE INVENTION

This invention relates generally to electronic devices and, more particularly, to an apparatus and method used by an electronic device for controlling power supplied thereto.

## BACKGROUND OF THE INVENTION

Electronic devices, such as cellular telephones, must be supplied with power in order to operate. A detachable battery is used to supply power to the device, particularly when portability of the device is desired. The battery is secured to the device via a battery connector. The battery supplies power to the device until depletion occurs. Once depleted, the battery must be replaced or recharged if portable operation of the device is to continue. If no replacement battery is available and portability is not a concern, operation of the device may be continued by attaching an accessory to the device.

Accessories are attached to the device via an accessory connector of the device, such as the standardized eight pin J3-type accessory connector used in MicroTAC™ cellular telephones manufactured and sold by Motorola, Inc. from 1989 to the present. The J3-type accessory connector has an external power supply pin; an audio in pin; an audio out pin; data pins for high speed data communications according to the three-wire bus protocol used in radiotelephone products by Motorola, Inc.; and two grounding pins in a predetermined arrangement. To be compatible with the J3-type accessory connector, an accessory must have a connector that is designed to mate with the accessory connector and have the same number and arrangement of pins. Upon attachment of the accessory to the device, the battery is electrically disconnected by an internal switch arrangement employed by the device and the device is powered solely by the accessory, which couples power transformed from an automobile electrical system or a conventional wall socket to the external power supply pin.

Unfortunately, because the battery is disconnected upon attachment of the accessory, charging of the battery can not be accomplished via the accessory connector as described. In the past, charging of the battery was performed by detaching the battery from the battery connector of the device and placing it in a standalone charger or by providing a dedicated charger connector on the device separate from, and in addition to, the accessory connector and the battery connector that fed a current source circuit disposed in the device. The standalone charger lacked portability, while the dedicated charger connector and current source circuit added cost and complexity to the device. Therefore, what is needed is a low cost apparatus and method that permits charging of the battery by the device and maintains backward compatibility with past accessories that mate with the accessory connector of the device.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates, in partial block and partial schematical diagram form, a charging system including an electronic device having a power supply control apparatus, a battery, and an accessory; and

FIG. **2** illustrates, in flow chart form, a power supply control method implemented by the electronic device of FIG. 1.



## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A power supply control apparatus for an electronic device includes a terminal to couple to a battery, a connector to couple to an external power supply, a switch circuit coupled to the terminal and the connector, and a controller coupled to the switch circuit. The switch circuit connects the terminal to power the electronic device from the terminal when the battery is attached and disconnects the terminal to power the electronic device from the connector when the external power supply is attached. The controller selectively controls the switch circuit to connect the connector to the terminal so as to charge the battery from the external power supply. By using the external power supply, previously used only to power the electronic device, to also charge the battery, a low cost and backwards compatible charging system is realized.

FIG. **1** illustrates a charging system **100**. The charging system **100** includes an electronic device **102**, a battery **103**, and an accessory **104**. The electronic device **102** communicates with a base station **101**, which provides wireless communications and features, such as paging, telephone, and short messaging, or the like, to the electronic device **102** when it is located within a geographic area served by the base station **101**. The base station **101** and the electronic device **102** communicate with each other via a communication link, which is preferably radio frequency (RF) signals **105**. In the illustrated embodiment, the electronic device **102** is a cellular telephone and the base station **101** is a cellular telephone service provider.

The electronic device **102** includes an antenna **106**, a receiver **107**, a controller **108**, a memory **109**, a speaker **110**, a microphone **111**, and a transmitter **112**. The controller **108** includes a microprocessor, such as a 68HC11 microprocessor commercially available from Motorola, Inc., known synthesizer circuitry, and known audio logic circuitry. The controller **108** controls the operation of the electronic device **102** according to instructions read from the memory **109**. The antenna **106** detects and emits the RF signals **105**. The receiver **107** operates under control of the controller **108** to convert signals received by the antenna **106** into data signals input to the controller **108** for use thereby and into voice signals input to the controller **108** for output by the speaker **110** as audible speech. The transmitter **112** operates under control of the controller **108** to convert signals, which include data signals generated by the controller **108** and voice signals generated by the controller **108** from audible speech input via the microphone **111**, for emission by the antenna **106**.

The electronic device **102** has a power supply control apparatus **113** that includes, aside from the controller **108**, a supply terminal (B+) **114**, battery terminals **115**, **116**, and **117**, a connector **122**, and a switch circuit **140**. The supply terminal **114** supplies power to electrical circuitry of the electronic device **102**, including but not limited to, the receiver **107**, the controller **108**, and transmitter **112** via electrical connections (not shown).

The battery terminals **115–117** are for electrically connecting to the battery **103**. Battery terminals **115** and **116** are monitored by the controller **108** via lines **118** and **119**. Battery terminal **117** is coupled to an analog ground **120** of the electronic device **102**.

The connector **122** is for physically and electrically connecting to the accessory **104**. The connector **122** has multiple pins including information pins **124**, **125**, **127**, **128**, and **129** designated AUD IN, AUD OUT, and R, C, and T DATA, respectively; grounding pins **126** and **131** designated

ANL GND and LOG GND; and an external power supply pin **130** designated EXT B+. The information pin **124** is coupled to the controller **108** via audio in line **132** and an identification network **150**. The identification network **150** is employed to identify the accessory **104**. In the illustrated embodiment, the identification network **150** includes a resistor **151**, having a value of 15 kΩ, coupled in series with the information pin **124** and the audio in line **132** and a resistor **152**, having a value of 15 kΩ, coupled to the audio in line **132** and the analog ground **120** in a shunt configuration, which give the identification network **150** an impedance of approximately 30 kΩ looking in from the information pin **124**. The information pin **125** is coupled to the controller **108** via audio out line **133**. The information pins **127–129** are coupled to the controller **108** via data lines **134–136**. The grounding pins **126** and **131** are coupled to the analog ground **120** and to a logic ground of the controller **108** via line **137**, respectively. The external power supply pin **130** is coupled to the supply terminal **114** via a diode **138**. The external power supply pin **130** is monitored by the controller **108** via line **139**. The connector **122** is preferably the standardized eight pin J3-type accessory connector employed by MicroTAC™ cellular telephones manufactured and sold by Motorola, Inc. from 1989 to the present, but may be any other suitable multiple pin accessory connector having an external power supply pin and at least one information pin.

The switch circuit **140** selectively connects the battery terminal **115** to the supply terminal **114**. The switch circuit **140** includes a mechanical switch **141**, a transistor switch **142**, and a control switch **143**. The mechanical switch **141** is coupled to the connector **122**, the supply terminal **114**, and the battery terminal **115**. The mechanical switch **141** electrically connects the supply and battery terminals **114** and **115** when the connector **122** is unattached and opens to electrically disconnect the supply and battery terminals **114** and **115** when the accessory **104** is physically attached to the connector **122**.

The transistor switch **142** is coupled in parallel with the mechanical switch **141** to prevent interruption of power to the electronic device **102** when the mechanical switch **141** is opened or closed. The transistor switch **142** provides a conduction path between the supply and battery terminals **114** and **115** until a voltage level at the supply terminal **114** meets or exceeds a voltage level at the battery terminal **115** causing the transistor switch **142** to turn off. The transistor switch **142** is preferably a MOSFET (metal-oxide semiconductor field effect transistor) having gate and drain terminals coupled to the supply terminal **114**, a source terminal coupled to battery terminal **115**, and an intrinsic diode coupled across the source and drain terminals. One skilled in the art will recognize that the mechanical switch **141** in the aforementioned arrangement is redundant and the desired switching of the supply and battery terminals **114** and **115** can be accomplished using only the transistor switch **142**.

The control switch **143** is coupled to the transistor switch **142** and the controller **108** via line **144** to selectively control the transistor switch **142**. In response to an enable signal on line **144**, the control switch **143** turns on and pulls the gate of the transistor switch **142** low, which in turn forces the transistor switch **142** to turn on and provide a current conduction path between the supply and battery terminals **114** and **115**. The control switch **143** is preferably a BJT (bipolar junction transistor) having a collector terminal coupled to the gate of the transistor switch **142**, a base coupled to the controller **108** via line **144**, and an emitter coupled to the analog ground **120**.

Although electronic device **102** is illustrated as a cellular telephone, the present invention will also find application in radios, portable computers, cordless telephones, two-way radios, pagers, personal digital assistants, tape recorders, and the like, and "electronic device" as used herein shall refer to all such battery powered electronic devices and their equivalents.

The battery **103** includes an electrochemical cell **160**, a thermistor **161**, and contacts **162–164**. The electrochemical cell **160** includes a positive polarity terminal **165** coupled to contact **162** and a negative polarity terminal **166** coupled to contact **164**. The electrochemical cell **160** is preferably rechargeable, and can be, for example, any one of the following chemical types: Nickel-Cadmium (NiCd), Nickel-Metal Hydride (NiMH), Alkaline, or Lithium Ion. In the illustrated embodiment, the electrochemical cell **160** supplies a battery voltage supply, preferably of 6 V DC (direct current), at the positive polarity terminal **165**. The thermistor **161** is coupled to the contacts **163** and **164**. A voltage level across the thermistor **161** forms a temperature signal corresponding to the temperature of the electrochemical cell **160**.

The accessory **104** has a plug **171**, a transformer and regulator **172**, a connector **173**, and an identification element **174**. The accessory **104** can be a modem, a hands-free car kit, a battery saver, or the like, and include accessory circuitry **170**. The accessory circuitry **170** can include a microprocessor requiring a logic ground; and data or audio input/output devices such as a keypad, a microphone, or a speaker requiring a connection to an analog ground **175** of the accessory **104**. However, in the illustrated embodiment, the accessory **104** is a low cost mid rate charger or fast rate charger that does not include the accessory circuitry **170**.

The plug **171** is compatible to mate with a conventional wall outlet (not shown) and provide external power (e.g., 110 V AC (alternating current) supply) to the accessory **104** from the outlet. Alternatively, the plug **171** could be compatible to mate with a cigarette lighter port to provide power to the accessory **104** from an automobile electrical system, or with another suitable power supply.

The transformer and regulator **172** is coupled to the plug **171** and has conventional circuitry. The transformer and regulator **172** provides an external power supply to connector **173** via line **176**. In the illustrated embodiment, the external power supply is a current limited constant voltage supply supplying an 8.6 V DC output voltage for both the mid and fast rate chargers, a 340 mA current for the mid rate charger, and a 850 mA current for the fast rate charger. The transformer and regulator **172** preferably includes a tracking circuit that adjusts output power according to feedback received on line **176**. In the event that the accessory **104** has the accessory circuitry **170**, the transformer and regulator **172** outputs regulated power on line **177** to power the accessory circuitry **170**. The transformer and regulator **172** is coupled to the analog ground **175**.

The connector **173** is for physically and electrically connecting to the connector **122** of the electronic device **102**. The connector **173** has multiple pins including information pins **179**, **180**, **182**, **183**, and **184** designated AUD OUT, AUD IN, and R, C, and T DATA, respectively; grounding pins **181** and **186** designated ANL GND and LOG GND; and an external power supply pin **185** designated EXT B+. The information pins **179** and **180** are coupled to an audio out line **187** and an audio in line **188**, respectively. The information pins **181–183** are coupled to data lines **190–192**. The grounding pins **181** and **186** are coupled to the analog ground **175** and logic ground line **193**, respectively. The

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