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United States Patent [19]

Baranowski et al.

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[45] **Date of Patent: Dec. 30, 1997**

[54] **BATTERY CHARGER WITH POWER DISSIPATION CONTROL**

[75] Inventors: **Robert Baranowski**, Crystal Lake; **Matthew Whiting Taylor**, Gurnee, both of Ill.

[73] Assignee: **Motorola, Inc.**, Schaumburg, Ill.

[21] Appl. No.: **657,699**

[22] Filed: **May 29, 1996**

[51] **Int. Cl.**[6] **H01M 10/46**

[52] **U.S. Cl.** **320/49**; 320/51; 320/54

[58] **Field of Search** 320/5, 12, 13, 320/21, 27, 30, 35, 36, 39, 40, 49, 51, 54

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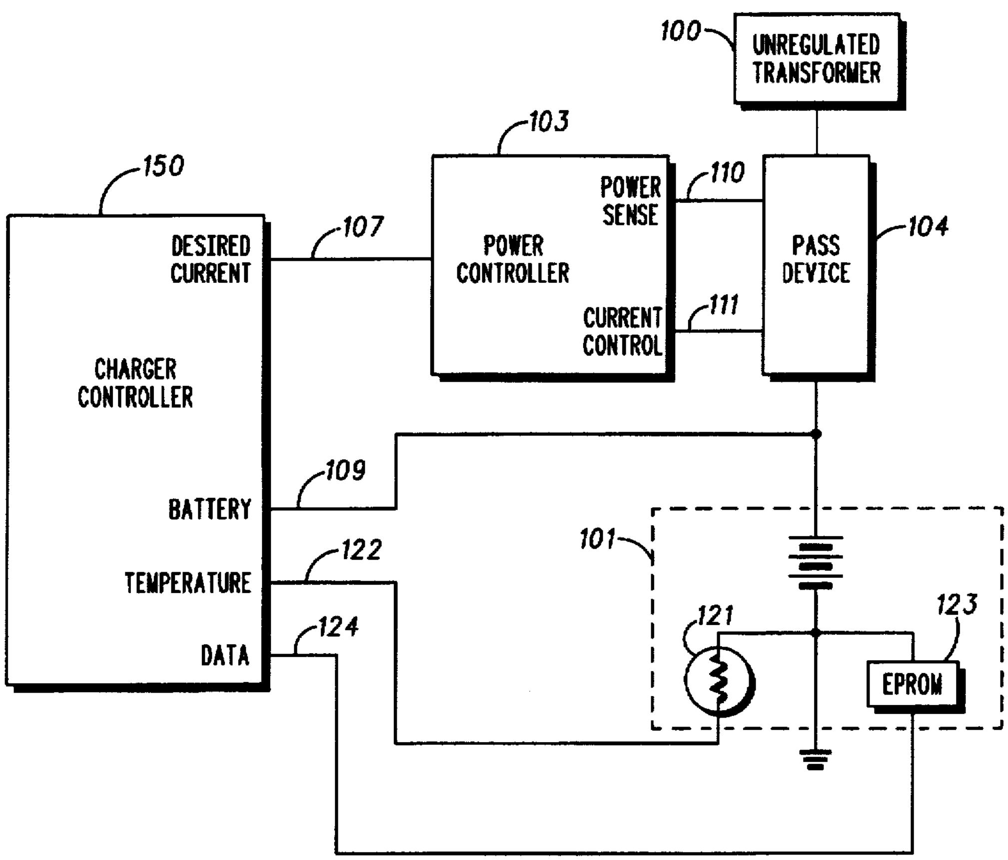
Primary Examiner—Edward Tso
Attorney, Agent, or Firm—Sylvia Chen

[57] **ABSTRACT**

A battery charger uses an unregulated DC transformer (**100**) as a power source for charging a battery pack (**101**) through a pass device (**104**). A charger controller (**150**) instantaneously computes a desired charging current value for maximizing the charging efficiency of the battery charger based on the present voltage of the battery pack (**101**), ambient temperature data received from a thermistor (**121**), and charging rates and other charging parameters received from a data-storage device (**123**) in the battery pack. The charger controller sends the calculated desired charging current information to a power controller (**103**). The power controller (**103**) monitors the instantaneous power dissipation of the pass device (**104**) and scales the desired charging current value to prevent excessive power dissipation in the pass device (**104**). By allowing the charging voltage to vary and dynamically adjusting the charging current, various types of batteries can be recharged without the use of an expensive tracking regulator.

20 Claims, 3 Drawing Sheets



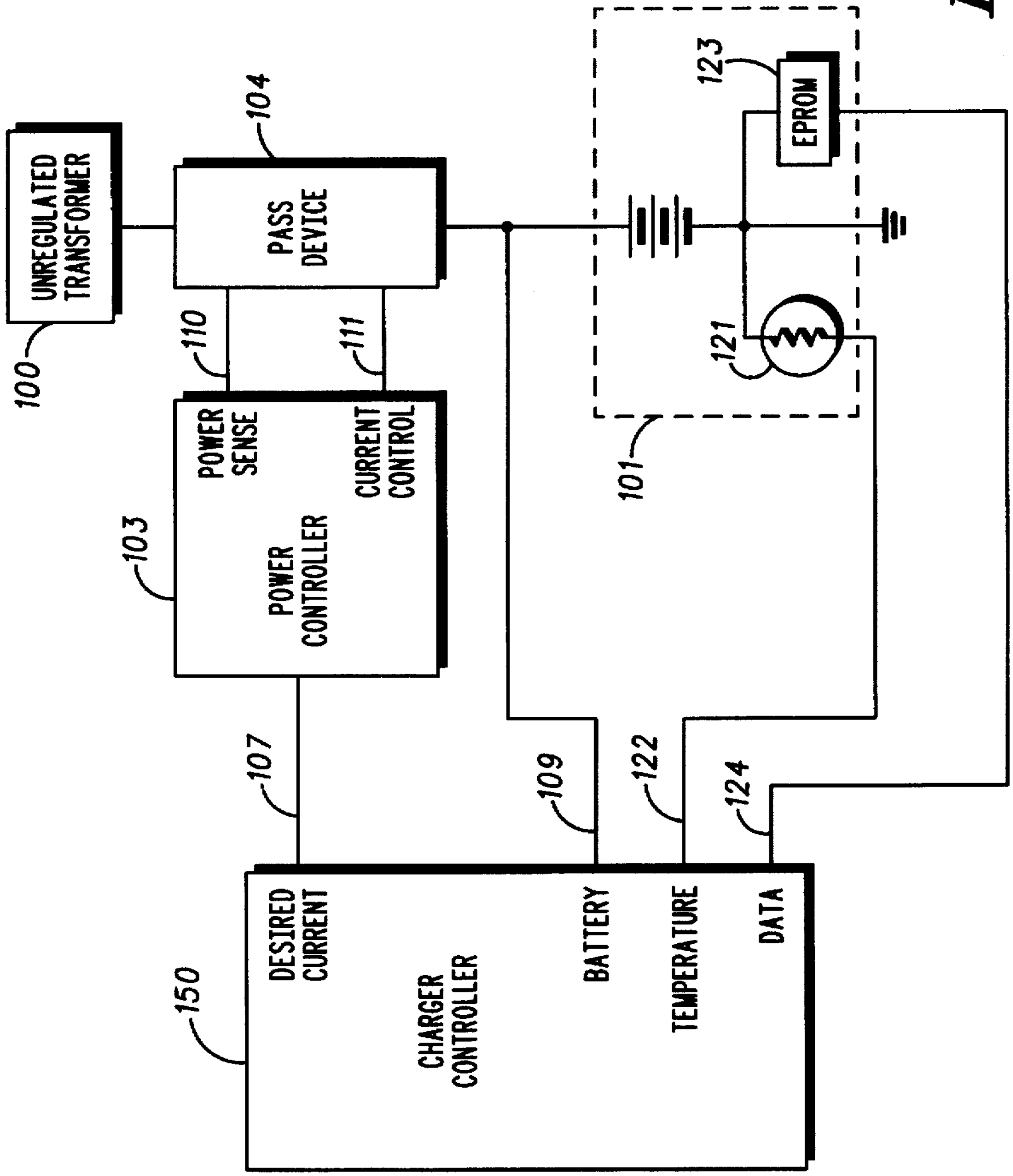
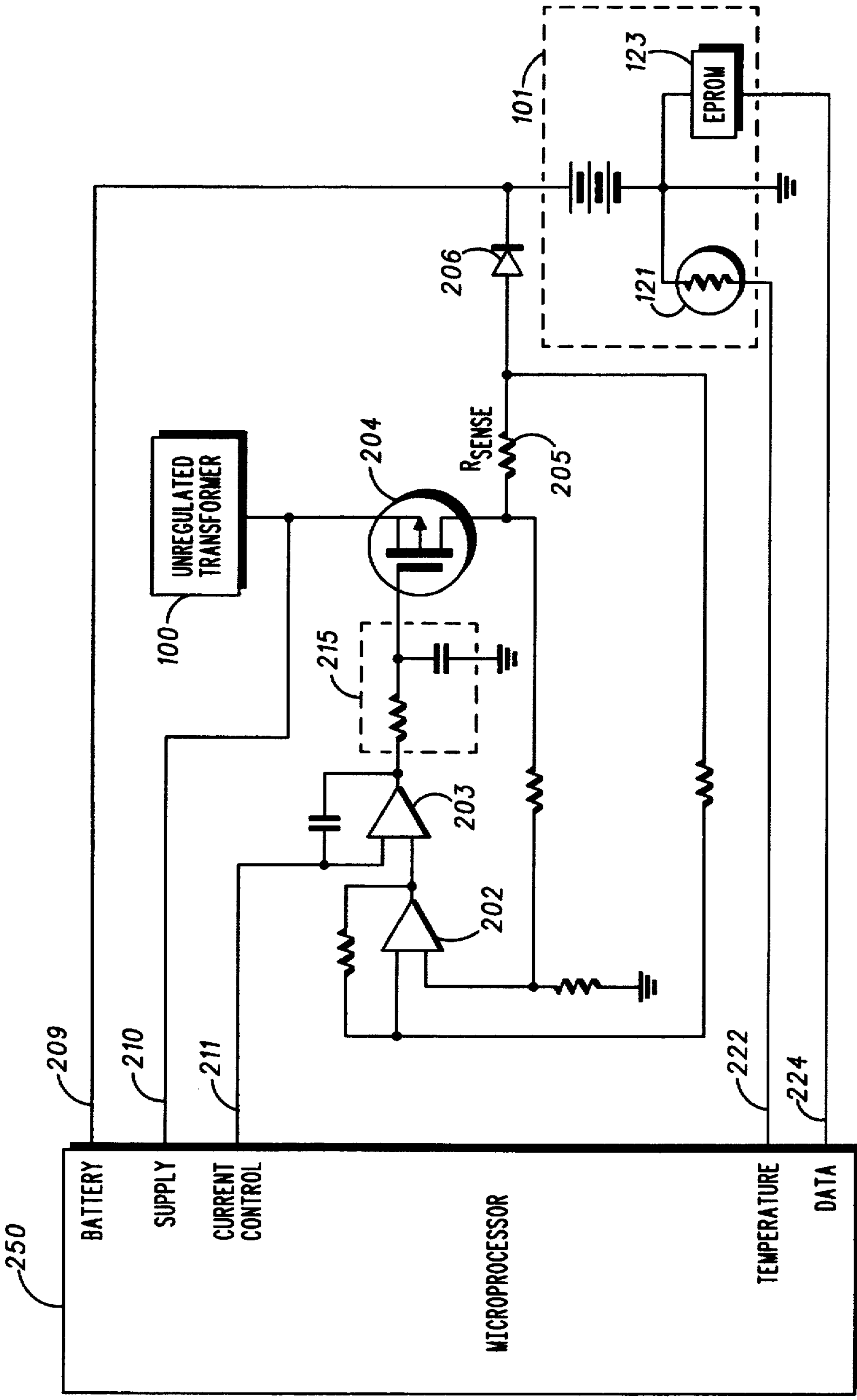

UNREGULATED TRANSFORMER
100
PASS DEVICE
104
110
111
POWER SENSE
CURRENT CONTROL
POWER CONTROLLER
103
101
121
123
EPROM
107
109
122
124
DESIRED CURRENT
CHARGER CONTROLLER
BATTERY
TEMPERATURE
DATA
150

FIG. 1



101
123
EPROM
206
121
UNREGULATED TRANSFORMER
204
R SENSE
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100
215
203
202
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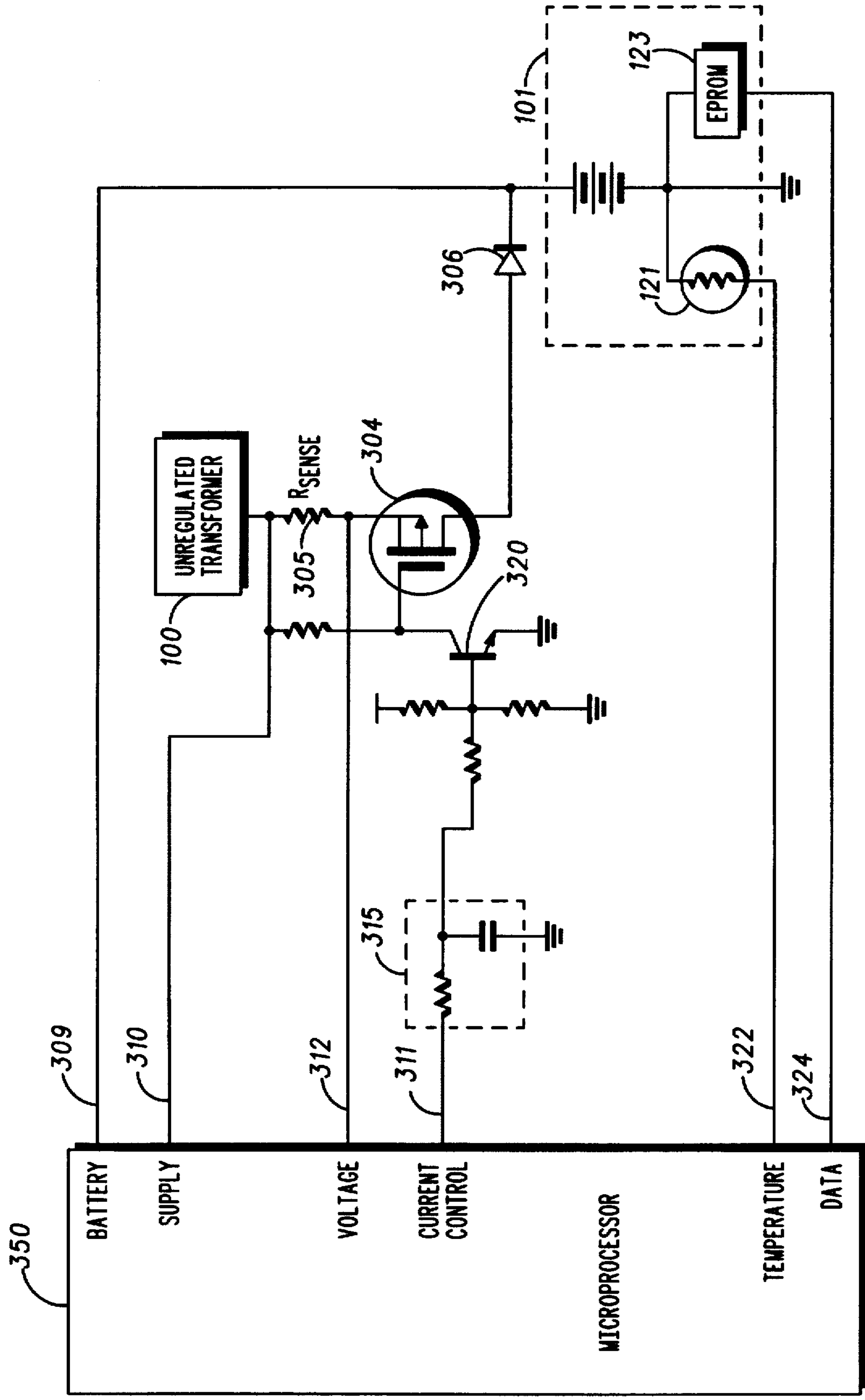
222
224
250
BATTERY
SUPPLY
CURRENT CONTROL
MICROPROCESSOR
TEMPERATURE
DATA

FIG. 2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R SENSE
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315
309
310
312
311
322
324
350
BATTERY
SUPPLY
VOLTAGE
CURRENT CONTROL
MICROPROCESSOR
TEMPERATURE
DATA

FIG. 3

BATTERY CHARGER WITH POWER DISSIPATION CONTROL

FIELD OF THE INVENTION

This invention relates generally to battery chargers, and more particularly to fast charging of batteries using a pass device.

BACKGROUND OF THE INVENTION

Battery chargers generally use a regulator which rectifies an alternating current (AC) to produce a direct current (DC) for charging a battery. In one type of charger, called a series pass charger, a linear switch pass device such as a metal-oxide-semiconductor field-effect transistor (MOSFET) is connected between a regulator and the battery. When a battery is charging, the power dissipated by the pass device is equal to the difference between the input and output voltages of the pass device multiplied by the maximum charging current. When a battery is deeply discharged, the battery voltage, which is the voltage at the output of the pass device, is much less than the regulator voltage, which is the voltage at the input of the pass device. During this condition, the power dissipated by the pass device could exceed maximum power ratings of typical device packages found in portable electronic devices. During this period of high power dissipation by the pass device, excess heat is generated and the overall efficiency of the charger is very poor.

Conventional fast chargers for portable devices that are space and heat critical use an external tracking regulator to limit power dissipation in the charger's pass device. The tracking regulator provides a voltage that is a constant positive offset from the voltage of the battery being charged, thus holding the difference between the input and output voltages of the pass device relatively constant. A microprocessor senses the battery voltage and creates an analog control voltage proportional to a desired charging current. The charging current is controlled by a hardware feedback loop that senses a voltage drop across a sense resistor, scales it, and compares it to the control voltage. When the charging software calls for a change in the charging current based on a change in the battery voltage, the microprocessor changes the control voltage accordingly.

By keeping the voltage drop across the pass device relatively constant and only varying the charging current, the charger can easily control the power dissipation of the pass device. The tracking regulator that keeps the voltage drop constant, however, is application specific and expensive. Thus, there is a need for a battery charger that both limits power dissipation and eliminates the need for an expensive tracking regulator.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a block diagram of a battery charger according to a preferred embodiment.

FIG. 2 shows a battery charger according to a first preferred embodiment,

FIG. 3 shows a battery charger according to a second preferred embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The battery charger with power dissipation control includes a feedback loop that senses a present battery voltage, monitors the instantaneous power dissipation of a pass device, and creates a current control signal for charging a battery pack of a device such as a portable radiotelephone. A controller in the feedback loop may include hardware,

software, or a combination of hardware and software. The controller adjusts the current control signal, based on the present pass device power dissipation, to ensure that the power dissipation of the pass device does not exceed calculated long-term and short-term power maximums. Also, polling a thermistor in the battery pack allows the controller to more accurately determine the power maximums of the pass device, because the maximum power that can be dissipated by the device varies with the ambient temperature around the device.

This battery charger dynamically adjusts for varying charging voltages, which allows replacement of the expensive external tracking regulator found in traditional battery charging topologies by a simple, unregulated DC transformer. Additionally, the voltage slump of a low-cost, unregulated DC transformer at high current amounts reduces the power that needs to be dissipated in the pass device, and the feedback loop monitors and exploits this characteristic. With software flexibility and proper selection of a low-cost, unregulated DC transformer, many types of batteries can be efficiently charged to capacity, including nickel-cadmium (NiCad), nickel-metal-hydride (NiMH), and lithium-ion (LiIon) batteries.

FIG. 1 shows a block diagram of a battery charger according to a preferred embodiment. In this approach, an inexpensive, unregulated DC transformer **100** such as a wall transformer provides an unregulated voltage to pass device **104** for charging battery pack **101**. Battery pack **101** may be a battery pack for a portable radiotelephone and include a data storage device **123**, which can be an electronic programmable read-only memory, such as an EPROM or EEPROM, retaining information such as charge rates and other charging parameters. Charger controller **150** can receive information from the data storage device through data input **124** to aid in the efficient charging of the battery.

Charger controller **150** can also determine the ambient temperature before charging a battery by polling a thermistor **121**, which is built into most battery packs, using temperature sense input **122**. Because maximum power dissipation of the pass device varies with temperature, the ambient temperature data can be used to scale the calculated maximum allowable power dissipation of the pass device. This scaling can improve charging times beyond any worst-case times based upon a worst-case dissipation scenario of the pass device **104**.

Charger controller **150** also receives the instantaneous battery voltage through battery sense input **109**. Thus, with information from data input **124**, temperature sense input **122**, and battery sense input **109**, charger controller **150** can compute a desired charging current value based on stored charging rates and other charging parameters, the ambient temperature, and the present battery voltage. This computed desired charging current value is transmitted to power controller **103** through desired current output **107**.

Power controller **103** produces a current control signal based on the desired charging current information from charger controller **150** and the instantaneous power dissipation of the pass device **104** as sensed through power sense input **110**. A power FET with current sensing capability could easily be used to determine the instantaneous power dissipation of the pass device using the current output from the FET and calculating the voltage drop across the pass device **104**. Power controller **103** scales the desired charging current value from charger controller **150** based on the information from power sense input **110** to create a current control signal. The current control signal is sent from current control output **111** of power controller **103** to the pass device **104** to keep the power dissipated by pass device **104** within acceptable power ratings.

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