(57)   Claim

1. An apparatus for identifying an external power adapter attached to a device, said external power adapter being adapted to receive a source of primary power and provide power to said device, the apparatus including:

a resistor network having a first resistor and a second resistor, said first resistor being disposed within said external power adapter and operatively coupled to said second resistor disposed within said device, said resistor network generating a sense voltage associated with said external power adapter; and

a control circuit disposed within said device adapted to receive said sense voltage to identify said external power adapter.

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(54) Title: METHOD AND APPARATUS FOR DETERMINING EXTERNAL POWER SUPPLY TYPE
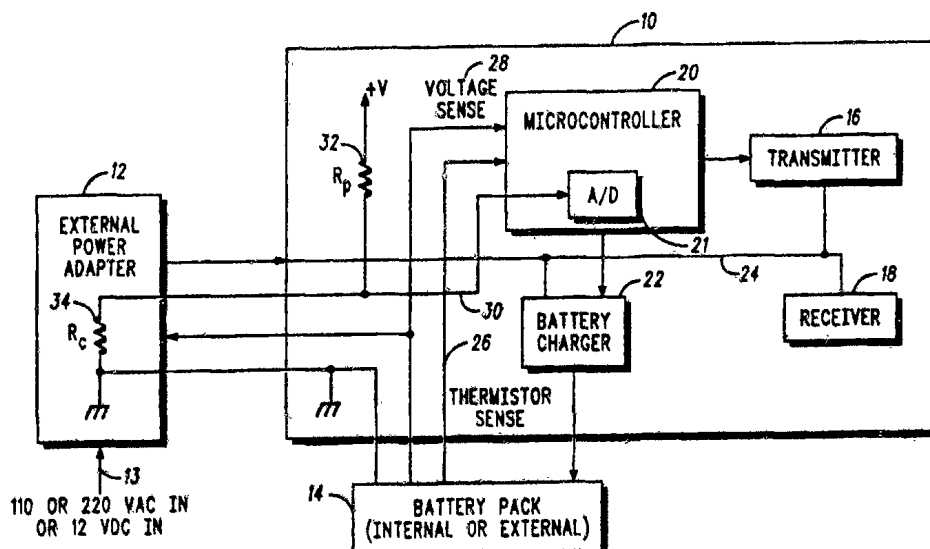
(57) Abstract

In summary, the present invention provides a method and apparatus for determining an external power supply type and modifying the charging of the internal battery (14) based upon the external power supply type and battery information. The device has an external power adapter (12) used to provide power to the device (10), as well as charging current for the battery which is regulated by the internal battery charger. A microcontroller (20) in the device (10) regulates the charging current to the battery (14). The microcontroller (20) preferably contains an A/D converter (21) which is connected to a pull-up resistor (32) internal to the device, and to a pull-down resistor (34) in the external power adapter (12). The voltage generated by the resistor divider network including the pull-up resistor (32) and the pull-down resistor (34) in the external power adapter is used to identify the external power adapter type. By changing the value of the pull-down resistor (34) in the external power supply to identify the external power supply, the microcontroller (20) in the apparatus may determine the optimum charging profile to use for the battery based upon the charger type and other information relating to the battery.

METHOD AND APPARATUS FOR DETERMINING
EXTERNAL POWER SUPPLY TYPE

5   The present invention is generally related to power
adapters, and more particularly to a method and apparatus
for determining the type of external power adapter and
modifying operating characteristics based upon the external
10   power adapter type.

15   In a portable, battery-powered device such as a
cellular telephone, an external power input is usually
provided so that the user can operate the device from a
primary source of power such as house current or a vehicle's
power source in order to conserve battery power. It is also
desirable to have a battery charger internal to the device for
20   recharging the unit's battery pack, which may be internal or
external to the device. The device and its internal battery
charger require a power supply or adapter external to the
device to supply the proper voltage and current needed by
the device to charge the internal battery or power the device.
25   Further, there are often a variety of external power
supplies. For example, a high power version may be offered
for fast charging the battery, while a low cost, low power
version may be offered for slow charging the battery.
Because the operation of the internal charger will differ
30   depending on which external adapter is connected, the
device must sense which type of external power adapter is
present.
            Accordingly, there is a need to provide a means for
detecting the type of external power adapter which is
35   connected to a device, and modify the operation of the

apparatus as a function of the type of power adapter and battery. The invention leads to greater system flexibility and improved performance with all types of external power supplies.

According to one aspect of the present invention there is provided an
5 apparatus for identifying an external power adapter attached to a device, said external power adapter being adapted to receive a source of primary power and provide power to said device, the apparatus including:

a resistor network having a first resistor and a second resistor, said first resistor being disposed within said external power adapter and operatively
10 coupled to said second resistor disposed within said device, said resistor network generating a sense voltage associated with said external power adapter; and

a control circuit disposed within said device adapted to receive said sense voltage to identify said external power adapter.

According to a further aspect of the present invention there is provided an
15 apparatus including:

an external power adapter adapted to receive power from a primary source of power;

a portable device adapted to receive power from said external power adapter and generate a regulated voltage;

20 a resistor network having a first resistor and a second resistor, said first resistor being disposed within said external power adapter and operatively coupled to said second resistor disposed within said portable device and coupled to said regulated voltage, said resistor network generating a sense voltage for identifying the type of said external power adapter; and

25 a microcontroller disposed within said portable device adapted to receive said sense voltage identifying said type of said external power adapter.

According to a still further aspect of the present invention there is provided a method for identifying an external power adapter coupled to a device, said method including the steps of:

30 coupling a first resistive element positioned within the external power adapter to a second resistive element positioned within the device to create a resistor divider network;

generate an external power adapter sense voltage based upon a reference voltage; and

identify the external power adapter by the external power adapter sense voltage.

5   According to a still further aspect of the present invention there is provided a portable electronic device for identifying a type of an external power adapter attached thereto for receiving a source of primary power and providing power input to said electronic device, the portable electronic device including:

a resistor being disposed within said electronic device, said resistor

10   corresponding to one of a plurality of components forming a network for generating a sense voltage associated with said external power adapter; and

a control circuit disposed within said device adapted to receive said sense voltage to identify said external power adapter.

A preferred embodiment of the present invention will now be described

15   with reference to the accompanying drawings wherein:-

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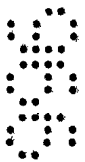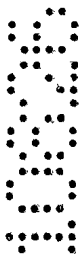
FIG. 1 is a block diagram of an apparatus for
determining external power adapter type according to the
present invention.

FIG. 2 is a flow chart showing the operation of a
portable device having an external power adapter according
to the present invention.

FIG. 3 is a flow chart showing the method for
determining external power adapter type according to the
present invention.

FIG. 4 is a flow chart showing the method for
powering/charging a portable device having an external
power adapter according to the present invention.

The present invention provides a method and
apparatus for determining an external power adapter type.
FIG. 1 generally shows a device having an external power
adapter used to provide power to the device, as well as
charging current for a battery which is regulated by the
internal battery charger. A microcontroller in the device
regulates the charging current to the battery. The
microcontroller preferably contains an A/D converter which is
connected to a pull-up resistor internal to the device, and to a
pull-down resistor in the external power adapter. The power
adapter is essentially a regulated power supply which may
be connected to a primary source of power such as the AC
line, or to a 12 VDC supply in an automotive application.

The external power adapter may be of a high current,
high power type capable of fast charging the battery, or

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alternatively, it may be of a low current type which is only capable of slow charging the battery. By changing the value of the pull-down resistor in the external power adapter to identify the external power adapter type, the microcontroller in the apparatus may determine the optimum charging profile to use for the battery based upon the charger type and other information relating to the battery.

Referring specifically to the elements shown in FIG. 1, a portable device 10 has an attached external power adapter 12 which is powered by way of line 13. Portable device 10 also includes a battery 14 which could be either internal or external to the portable device. By way of example, the portable device 10 could a portable cellular telephone having a transmitter 16 and a receiver 18. However, it will understood that any other device, portable or fixed, adapted to receive external power could employ the apparatus and method of the present invention. Transmitter 16 is controlled by a microcontroller 20 having an analog-to-digital converter 21. Portable device 10 also includes a battery charger 22. Transmitter 16, receiver 18, and battery charger 22 are all powered by a line 24 from external adapter 12.

Generally, battery 14 will include a sensing element such as a resistor, thermistor, open circuit, short circuit or other element which may provide auxillary sensing capability. Operationally, batteries of different types exhibit different "end of life" voltage characteristics and effective series resistances. Since different types of batteries can be interchangeably used to provide power for the same equipment (i.e. for a Cellular Portable Telephone), knowledge of the type of battery may be useful to the equipment in establishing operating parameters such as transmitter output power or a "low battery" warning condition. Battery types that can be charged should be charged at differing rates and with differing conditions. Also, non-rechargeable battery types should not be subjected to recharging attempts.

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A portable telephone having battery charger which accepts all battery types ideally should adapt the rate of charge (charge current) and the types of charge controls used in accordance with the battery type. It is known for a device to automatically recognize the battery type which is to be charged and adapt its charging parameters accordingly. Applicants herein incorporate by reference U.S. Patent No. 5,164,652 entitled "Method and Apparatus for Determining Battery Type and Modifying Operating Characteristics", invented by Robert M. Johnson and Michael P. Metroka and assigned to Motorola, Inc. assignees of the present invention. U.S. Patent No. 5,164,652 describes a battery type detector for battery-using and battery-charging equipment.

The 5,164,652 patent also discloses modifying operational characteristics of the equipment in accordance with the battery-type detected. A battery sense line 26 and a voltage sense line 28 coupled from the battery to microcontroller 20 provide the necessary information to optimize battery charging according to U.S. Patent No. 5,164,652. Microcontroller 20 contains predetermined information about the battery type and will establish the rate and type of charge controls to provide an optimum rate of charge for a rechargeable battery while not charging a non-chargeable battery type. The microprocessor recalls from its internal memory the charging characteristics of the particular battery type. The battery terminal voltage is sensed by conventional voltage detection techniques and input to microprocessor 20 where it is compared with the battery terminal voltage charge characteristic curve recalled from storage. The appropriate amount of current is allowed to enter the battery terminals as determined by microprocessor and the external power adapter.

An external power sense line 30 is coupled from external power adapter 12 to portable device 10 at microcontroller 20. Portable device 10 includes a pull-up

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resistor 32 coupled to the external power sense line 30.
Similarly, external power adapter 12 includes a pull-down
resistor 34 (type-detection resistor) which is also coupled to
external power sense line 30. The pull-up resistor 32 and the
5   pull-down resistor 34 form a voltage divider network which
generates a voltage identifying the type of external power
adapter

In the preferred embodiment, the device is compatible
with older power supplies which do not contain a type
10   detection resistor. Older power supplies do not contain the
necessary voltage tracking circuit, or may not provide
sufficient voltage to charge the attached battery under all
conditions. The device may determine that an older power
supply is connected by recognizing the lack of a type
15   detection resistor. In this case, the input to A/D circuit 21 is
pulled to +V by pull-up resistor 32, and thus the
microcontroller is able to detect the lack of pull-down resistor
34 in the external adapter. Thus, the microcontroller may
disable the internal charger to prevent charging with older
20   power supplies.

As shown in the following Table 1, different external
power supplies which could be attached to the device are
listed. Generally, the charger type is listed in the second
column. Also, as shown in the third column, an external
25   adapter could be attached to a device which is in a test mode.
The preferred value for resistor 34 is listed in column 4.

Table 1

Charger #	Charger Type	Test Mode	Resistor	Voltage
1	Non	Off	Open	V_1
2	Fast	Off	33K	V_2
3	Slow	Off	10K	V_3
4	—	On	3.3K	V_4

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5	Other	Off	3.0K	V$_5$
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

While five different external power adapters are listed in Table 1, any number of adapters could be used within the scope of the present invention.

As shown in Table 2, an example of the A/D conversion is shown for a device adapted to receive 5 external power adapters. The associated voltage value generated by a resistor 32 (having a value of 10K) and a resistor 34 (hving a value listed in Column 2)is listed in column 3. While the A/D count range and guard band are given by way of example, other ranges and guard bands could be used. Alternatively, a different number of input devices could be employed and different resistor values, voltages, A/D count range and guard bands could be established.

Table 2

State	Resistor	Voltage	A/D Count Range	Guard Band
1	Open	2.75	0-9	10-31
2	33K	2.11	32-76	77-98
3	10K	1.37	99-150	151-168
4	3.3K	0.63	169-217	218-234
5	3.0K	0.00	235-255	—

While an A/D converter is preferably employed to determine the type of external power adapter, a logic circuit similar to that shown in FIG. 3 of US Patent 5, 164,652, which is incorporated by reference, could alternatively be employed to determine the type of external adapter within the scope of the present invention.

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Turning now to FIG. 2, a flow chart shows the operation of a device having an external power adapter according to the present invention. When the device is operated at a step 50, the presence of an external adapter is determined at step 52. If no external power adapter is present, the device is powered by the battery at a step 53. If an external power adapter is present, the type of adapter is determined at step 54. The method for determining the external battery type will described in detail in reference to FIG. 3, and can be accomplished by the apparatus of FIG. 1.

Regardless of whether an external power adapter is present or not, the battery type is determined at step 56. This can be accomplished by the apparatus and methods described in U.S. Patent No. 5,164,652. Finally, at a step 58, the telephone is powered by the battery (or adapter if present), or the battery is optimally charged by the adapter, if present, based upon the type of battery and type of external power adapter attached to the device. That is, the charging parameters are modified according to the type of battery and the capability of the charger according to U.S. Patent No. 5,164,652. The method for powering/charging a portable device having an external power adapter according to the present invention is described in detail in reference to FIG. 4.

Turning now to FIG. 3, a flow chart shows the method for determining external power adapter type according to the present invention. A voltage divider network is created between the external power adapter and the portable device at a step 62. The voltage divider network can be provided according to the present invention by coupling a first resistor in the external power adapter to a second resistor in the portable device, as shown for example in the apparatus of FIG. 1. At a step 64, a voltage generated by the voltage divider is provided to a microcontroller or some other control circuit in the portable device. Preferably, the voltage is then converted to a digital equivalent in an A/D converter in the

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microcontroller at a step 66. The digital conversion is then compared to a voltage lookup table in the microcontroller at a step 68 to determined the external power adapter type. While an analog to digital conversion is preferred, the analog signal could alternatively be compared to values in a look-up table.

Turning now to FIG. 4, a flow chart shows the method for powering/charging a portable device having an external power adapter according to the present invention. At a step 72, if the external adapter is not a charger, the external power adapter will only power the portable device at a step 74. If the adapter is a charger, the telephone will determine whether the device is in use at a step 78. For example, with a portable cellular telephone, it will be determined whether the telephone is in an "off hook" condition. If the device is in use, the external adapter will only power the device at a step 78. However, if the device is not in use, the device will determine whether the charger is a fast charger or a slow charger at a step 80. This can be determined according to the apparatus (FIG. 1) and method (FIG. 3) described above. If the device is not in use and the device is a not a fast charger, the external adapter will slow charge the battery at step 82. If the device is not in use and the device is a fast charger, the external adapter will fast charge the battery at a step 84. However, it will be understood that a power adapter could charge a battery while powering the device.

In summary, the present invention provides a method and apparatus for determining an external power adapter type and preferably modifying the charging of the internal battery based upon the external power adapter type and battery information. The device has an external power adapter used to provide power to the device, as well as charging current for the battery which is regulated by the internal battery charger. The power adapter is essentially a regulated power supply which may be connected to the AC line, or to 12 VDC supply in an automotive application. The

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external power adapter may be of a high current, high power
type capable of fast charging the battery pack, or
alternatively, it may be of a low current type which is only
capable of slow charging the attached battery. A

5   microcontroller in the device regulates the charging current to
the battery. The microcontroller preferably contains an A/D
converter which is connected to a pull-up resistor internal to
the device, and to a pull-down resistor in the external power
adapter. The voltage generated by the resistor divider

10   network is used to identify the external power adapter type.
By changing the value of the pull-down resistor in the
external power adapter to identify the external power adapter,
the microcontroller in the apparatus may determine the
optimum charging profile to use for the battery based upon

15   the charger type and other information relating to the battery.

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Claims

1. An apparatus for identifying an external power adapter attached to a device, said external power adapter being adapted to receive a source of primary power and provide power to ⌃said device, the apparatus i٠ :luding:

a resistor network having a first resistor and a second resistor, said first resistor being disposed within said external power adapter and operatively coupled to said second resistor disposed within said device, said resistor network generating a sense voltage associated with said external power adapter; and

a control circuit disposed within said device adapted to receive said sense voltage to identify said external power adapter.

2. The apparatus for identifying an external power adapter according to Claim 1 further including a battery integrally connected to said device.

3. The apparatus for identifying an external power adapter according to Claim 2 further including a battery charger disposed within said device, said battery charger being adapted to receive ⌃said source of primary power from said external power adapter to charge said battery.

4. The apparatus for identifying an external power adapter according to Claim 3 further including a sense line from said battery providing a signal identifying the battery type of said battery.

5. The apparatus for identifying an external power adapter according to Claim 4 wherein said control circuit regulates said charger circuit to charge said battery based upon said external power adapter type and said battery type.
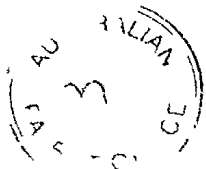
- 12 -

6. An apparatus including:

an external power adapter adapted to receive power from a primary source of power;

5   a portable device adapted to receive power from said external power adapter and generate a regulated voltage;

a resistor network having a first resistor and a second resistor, said first resistor being disposed within said external power adapter and operatively coupled to said second

10   resistor disposed within said portable device and coupled to said regulated voltage, said resistor network generating a sense voltage for identifying the type of said external power adapter; and

a microcontroller disposed within said portable device

15   adapted to receive said sense voltage identifying said type of said external power adapter.

7. The apparatus according to Claim 6 further including a battery integrally connected to said portable device.

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8. The apparatus for identifying an external power adapter according to Claim 7 further including a charger circuit disposed within said device, said charger circuit being adapted to receive power from said external power adapter to

25   charge said battery.

9. The apparatus for identifying an external power adapter according to Claim 8 further including a sense line from said battery providing a signal identifying the battery type of said

30   battery, wherein said control circuit regulates said charger circuit to charge said battery based upon said charger type and said battery type.

10. A method for identifying an external power adapter

35   coupled to a device, said method including the steps of:

coupling a first resistive element positioned within the external power adapter to a second resistive element positioned within the device to create a resistor divider network;

generate an external power adapter sense voltage based upon a reference

5   voltage; and

identify the external power adapter by the external power adapter sense voltage.

11.   A portable electronic device for identifying a type of an external power adapter attached thereto for receiving a source of primary power and providing

10   power input to said electronic device, the portable electronic device including:

a resistor being disposed within said electronic device, said resistor corresponding to one of a plurality of components forming a network for generating a sense voltage associated with said external power adapter; and

a control circuit disposed within said device adapted to receive said sense

15   voltage to identify said external power adapter.

12.   A device according to Claim 11 further including a battery integrally connected to said portable electronic device.

13.   A device according to Claim 12 further including a battery charger disposed within said portable electronic device for receiving power from said

20   external power adapter to charge said battery.

14.   A device according to Claim 13 further including a sense line from said battery providing a signal identifying the type of said battery.

15.   A device according to Claim 14 wherein said control circuit regulates said charger circuit to charge said battery based upon said external power adapter

25   type and the type of said battery.

16.   Apparatus for identifying an external power adapter attached to a device substantially as herein described with reference to the accompanying drawings.
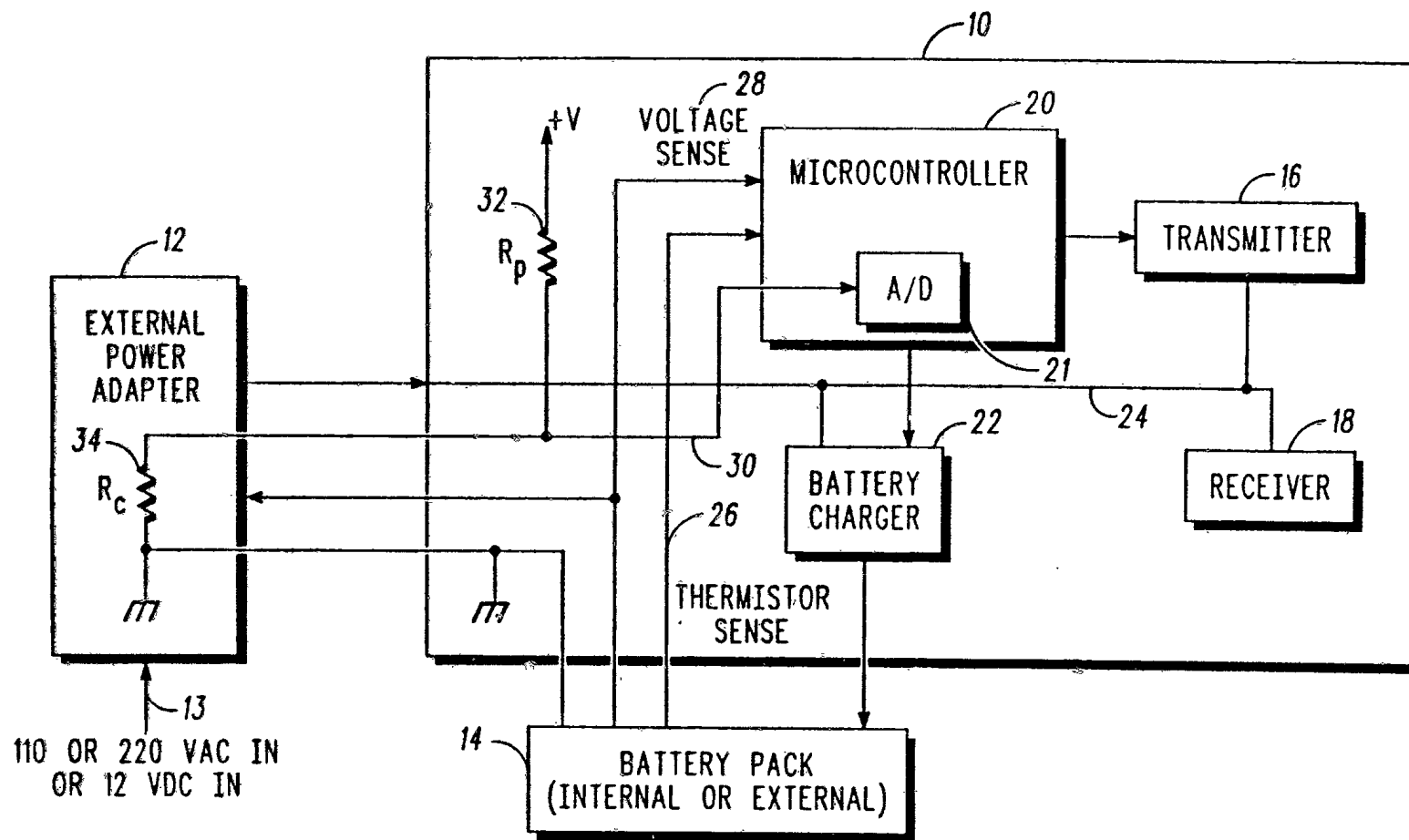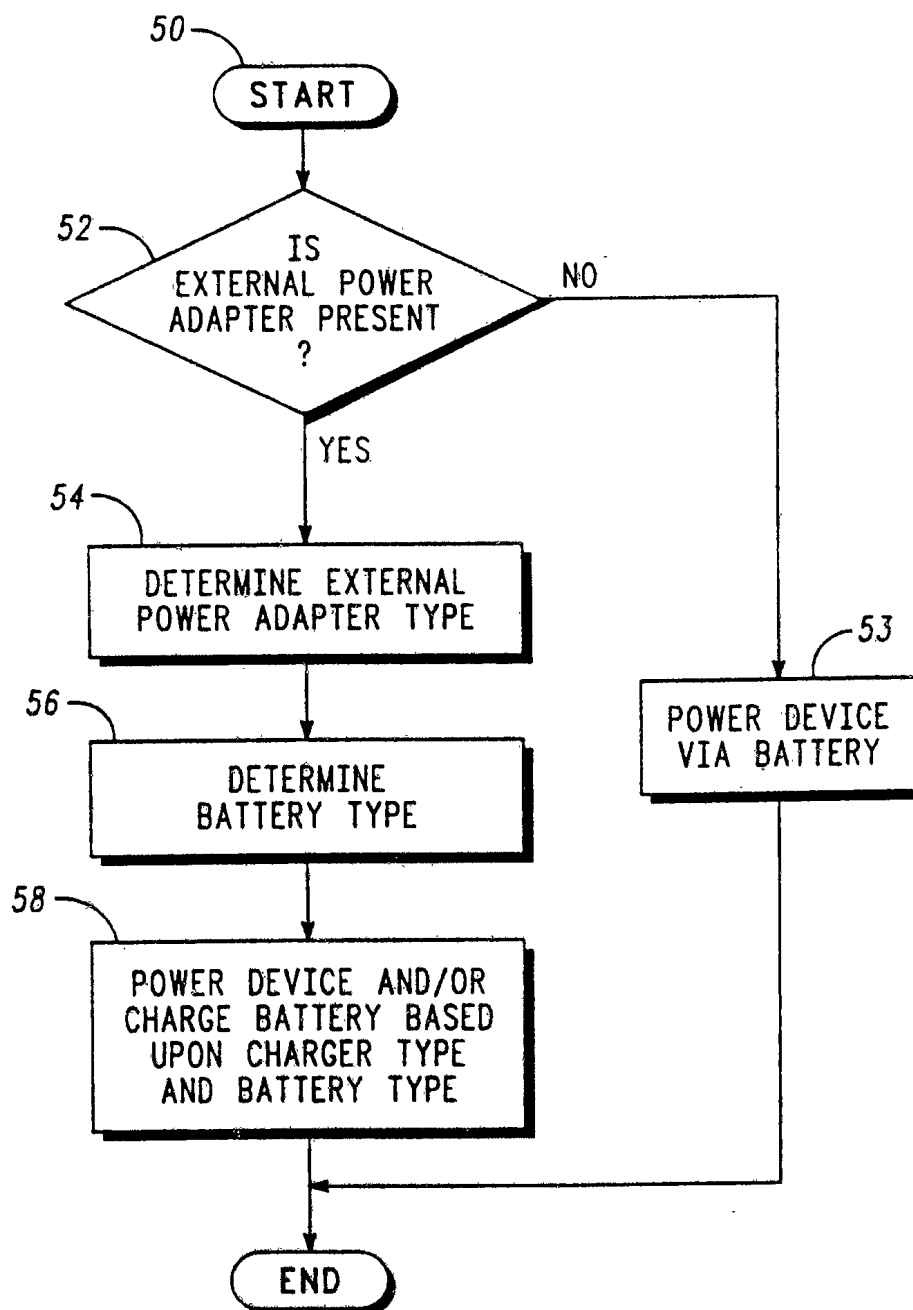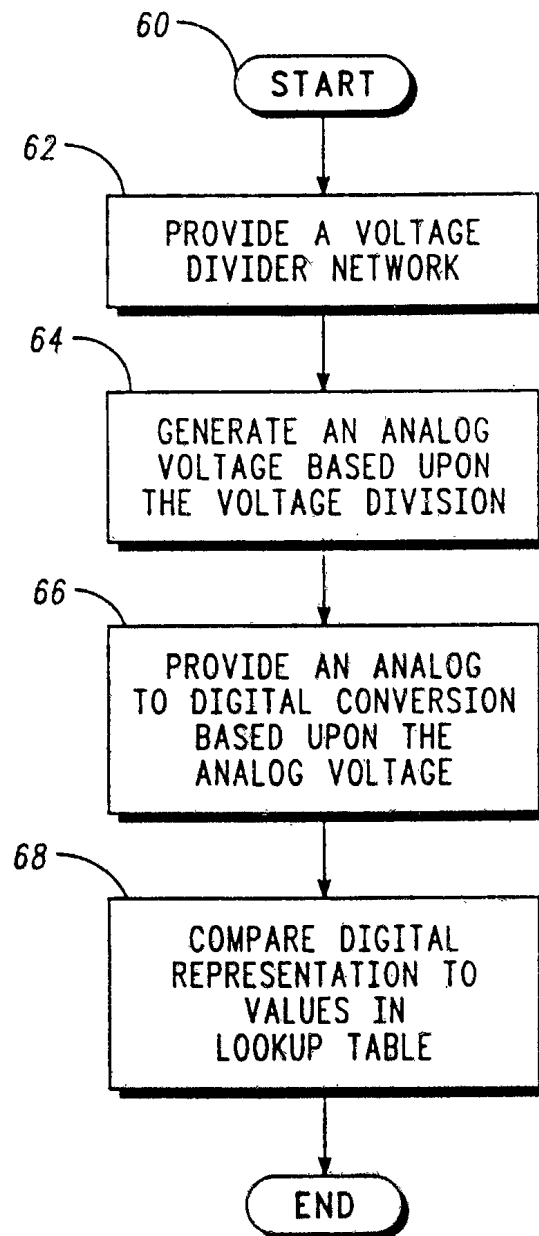
FIG.1
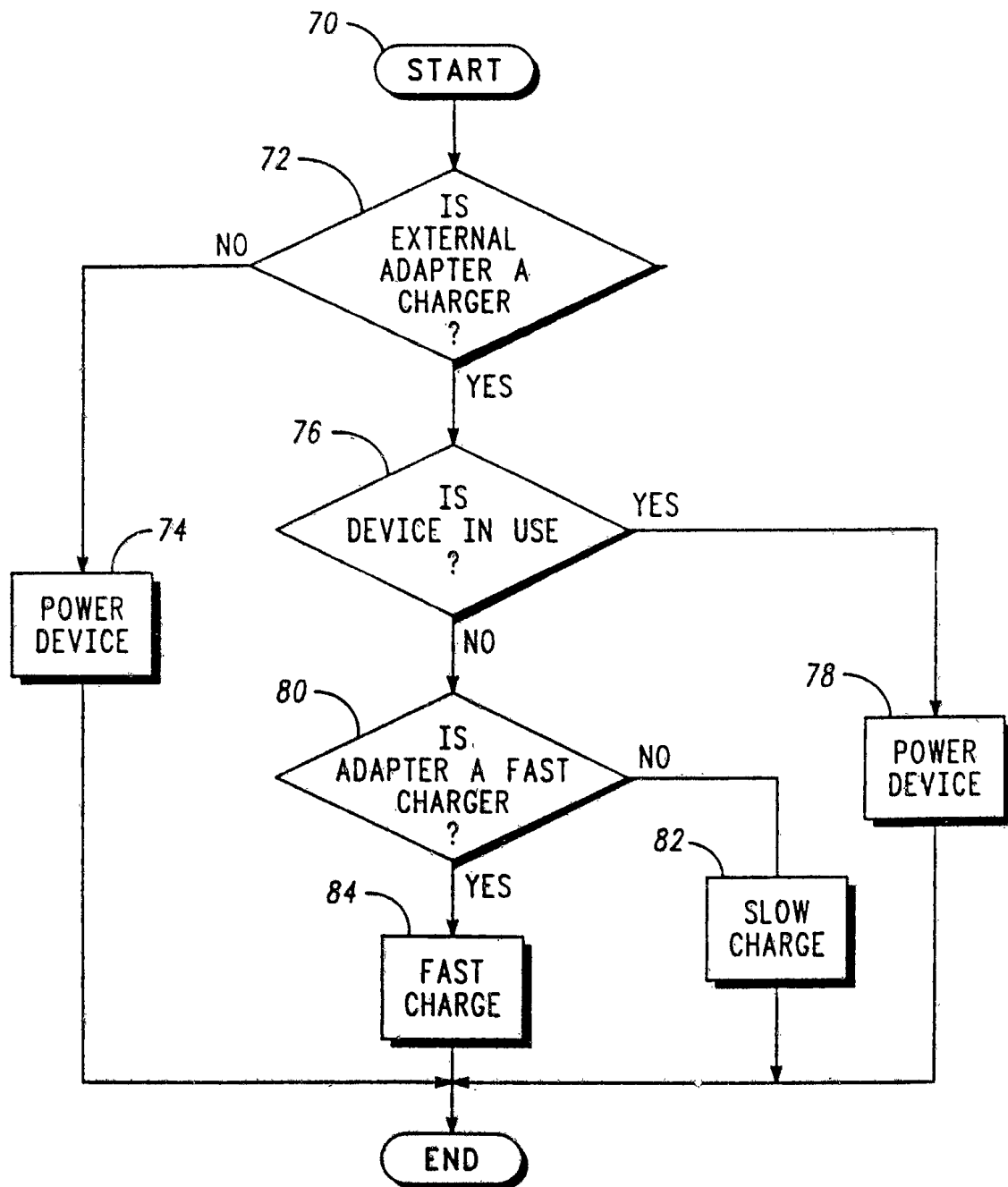
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              60 ─┐
                  ┌─────────────┐
                  │   START     │
                  └──────┬──────┘
                         │
                         ▼
    62 ─┐    ┌────────────────────────┐
         │  │   PROVIDE A VOLTAGE     │
         │  │   DIVIDER NETWORK       │
            └───────────┬────────────┘
                        │
                        ▼
    64 ─┐    ┌────────────────────────┐
         │  │   GENERATE AN ANALOG    │
         │  │   VOLTAGE BASED UPON    │
         │  │  THE VOLTAGE DIVISION   │
            └───────────┬────────────┘
                        │
                        ▼
    66 ─┐    ┌────────────────────────┐
         │  │    PROVIDE AN ANALOG    │
         │  │  TO DIGITAL CONVERSION  │
         │  │    BASED UPON THE       │
         │  │    ANALOG VOLTAGE       │
            └───────────┬────────────┘
                        │
                        ▼
    68 ─┐    ┌────────────────────────┐
         │  │    COMPARE DIGITAL      │
         │  │  REPRESENTATION TO      │
         │  │     VALUES IN           │
         │  │    LOOKUP TABLE         │
            └───────────┬────────────┘
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FIG.4

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INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER	

IPC(6)   :H02J 7/00

US CL   :320/2, 15

According to International Patent Classification (IPC) or to both national classification and IPC

B.   FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

  U.S. : 320/2, 15, 22, 23, 24, 39, 40; 363/143

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

  APS, search terms:determin?, power supply or supply type

C.   DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,232,260 (LAMBKIN) 04 November 1980, see entire document.	1-10
A, E	US, A, 5,369,352 (TOEPFER ET AL.) 29 November 1994, see entire document.	1-10

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance		
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 FEBRUARY 1995	**09 MAR 1995**

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