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# United States Patent [19]

**Bernard**

[11] **Patent Number: 5,497,339**

[45] **Date of Patent: Mar. 5, 1996**

[54] **PORTABLE APPARATUS FOR PROVIDING MULTIPLE INTEGRATED COMMUNICATION MEDIA**

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[73] Assignee: **ETE, Inc.**, San Diego, Calif.

[21] Appl. No.: **284,396**

[22] Filed: **Aug. 2, 1994**

## Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 152,492, Nov. 15, 1993, abandoned.

[51] **Int. Cl.**$^6$ .............................. **G06F 3/00**; G06F 13/00

[52] **U.S. Cl.** ....................................... **364/705.05**; 395/500

[58] **Field of Search** ........................... 364/705.05, 708.1, 364/705.05, 708.1; 395/500

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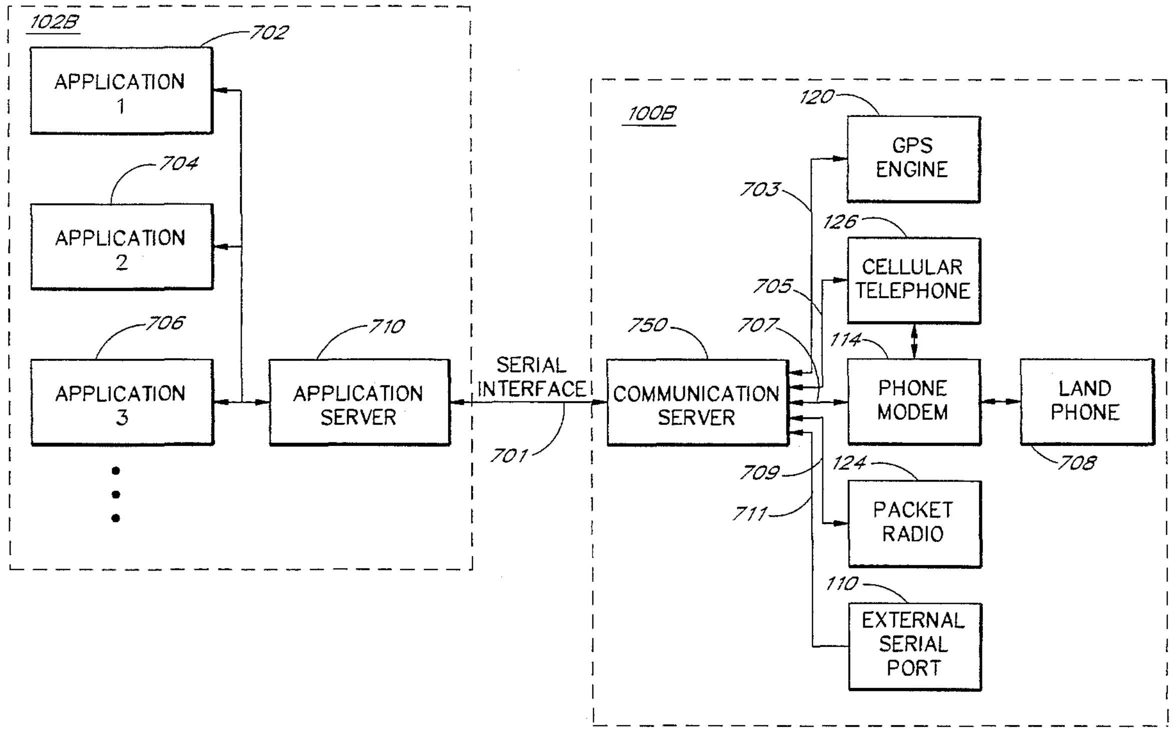
*Primary Examiner*—David H. Malzahn

*Attorney, Agent, or Firm*—Knobbe, Martens, Olson & Bear

[57] **ABSTRACT**

The present invention relates to a communication device for a personal digital assistant (PDA). The PDA mounts within the communication device and the communication device connects electronically to a serial port on the PDA. Through this single serial port, the communication device provides the user of the PDA with access to multiple communication media, such as a telephone modem, a Global Positioning System engine, a packet radio and a cellular telephone. Data from the PDA is directed to a decoder that routes the data to the appropriate communication medium, while data from the communication media are multiplexed onto the single serial interface of the PDA. The communication device also provides a pass-thru serial interface that allows other external devices to communicate directly with the serial port of the PDA. In addition, the communication device can upload software to the PDA that facilitates communications between the PDA and the communication device, and allows the PDA to control the operation of the communication device.

**13 Claims, 19 Drawing Sheets**



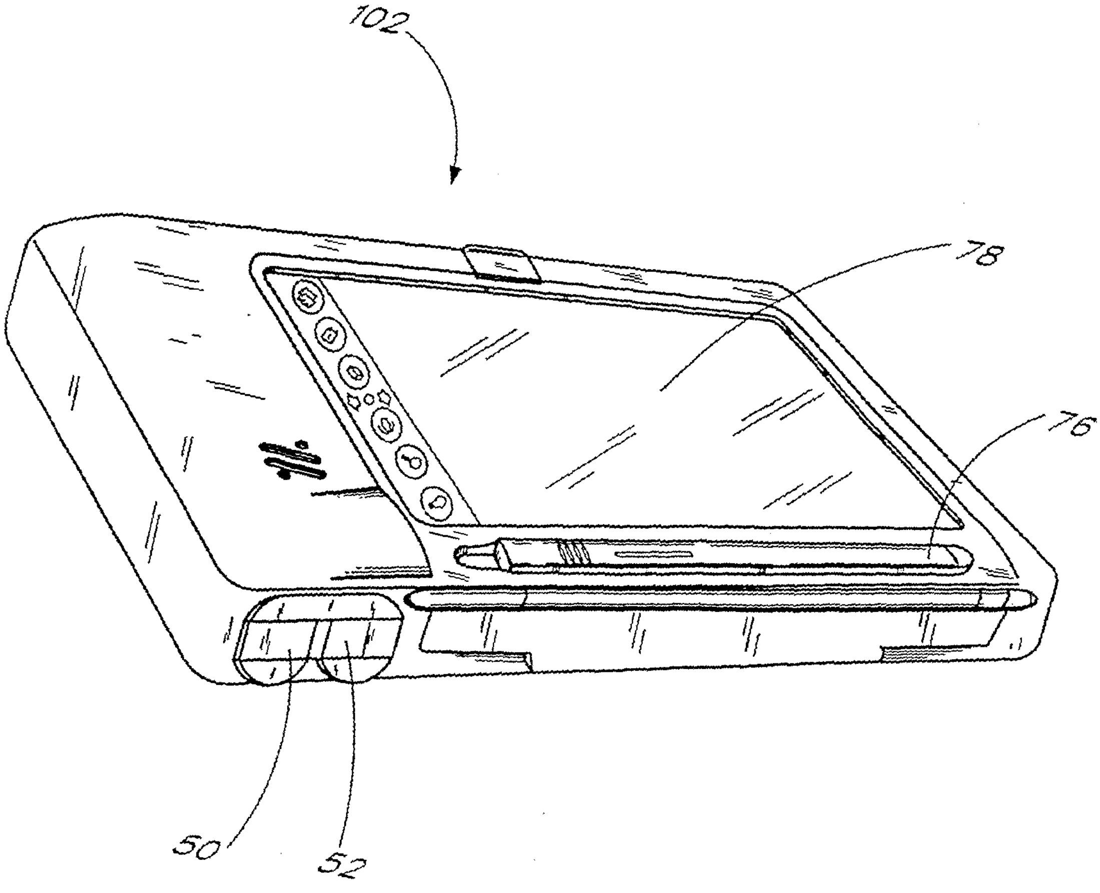


FIG. 1

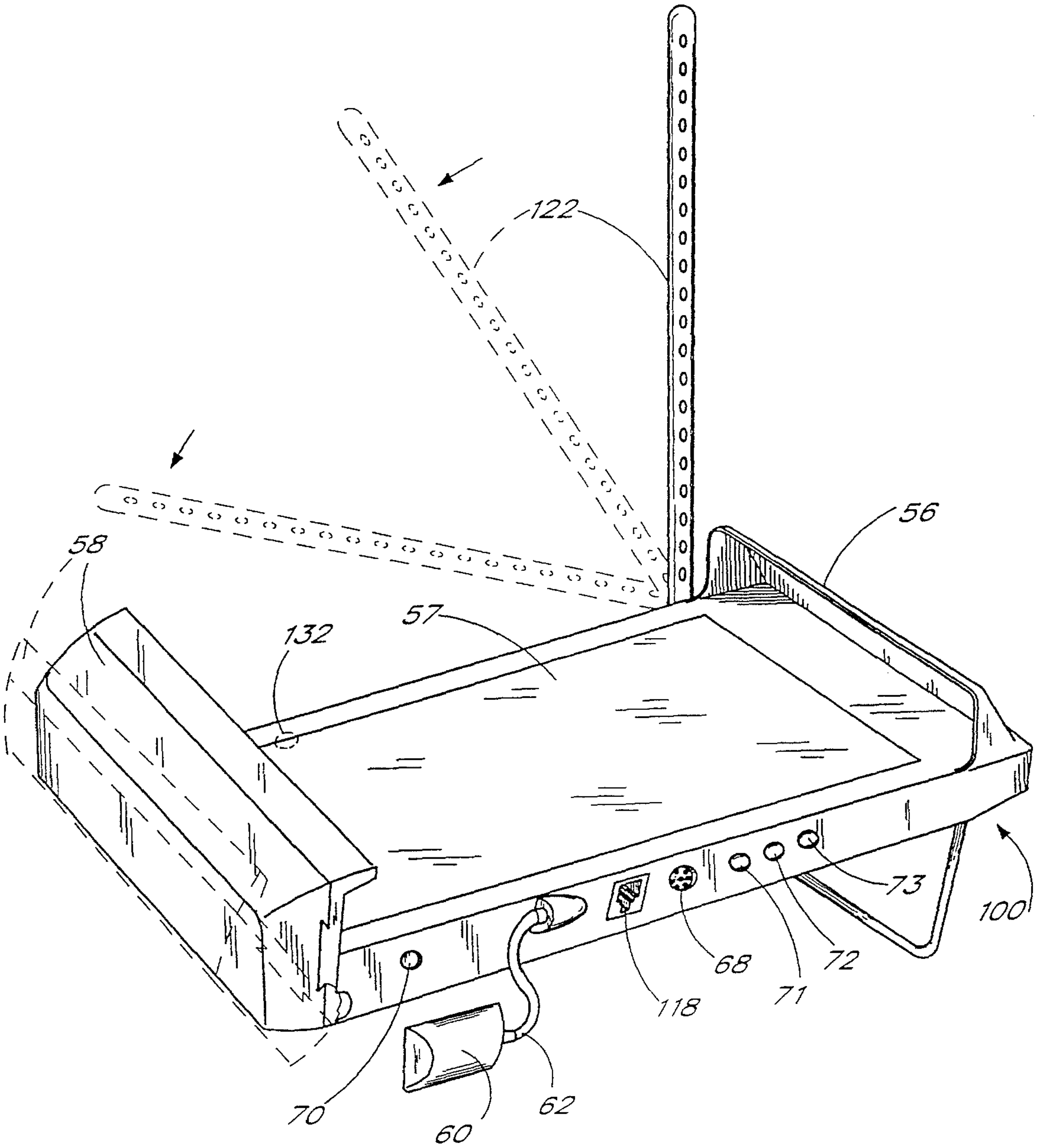


FIG. 2

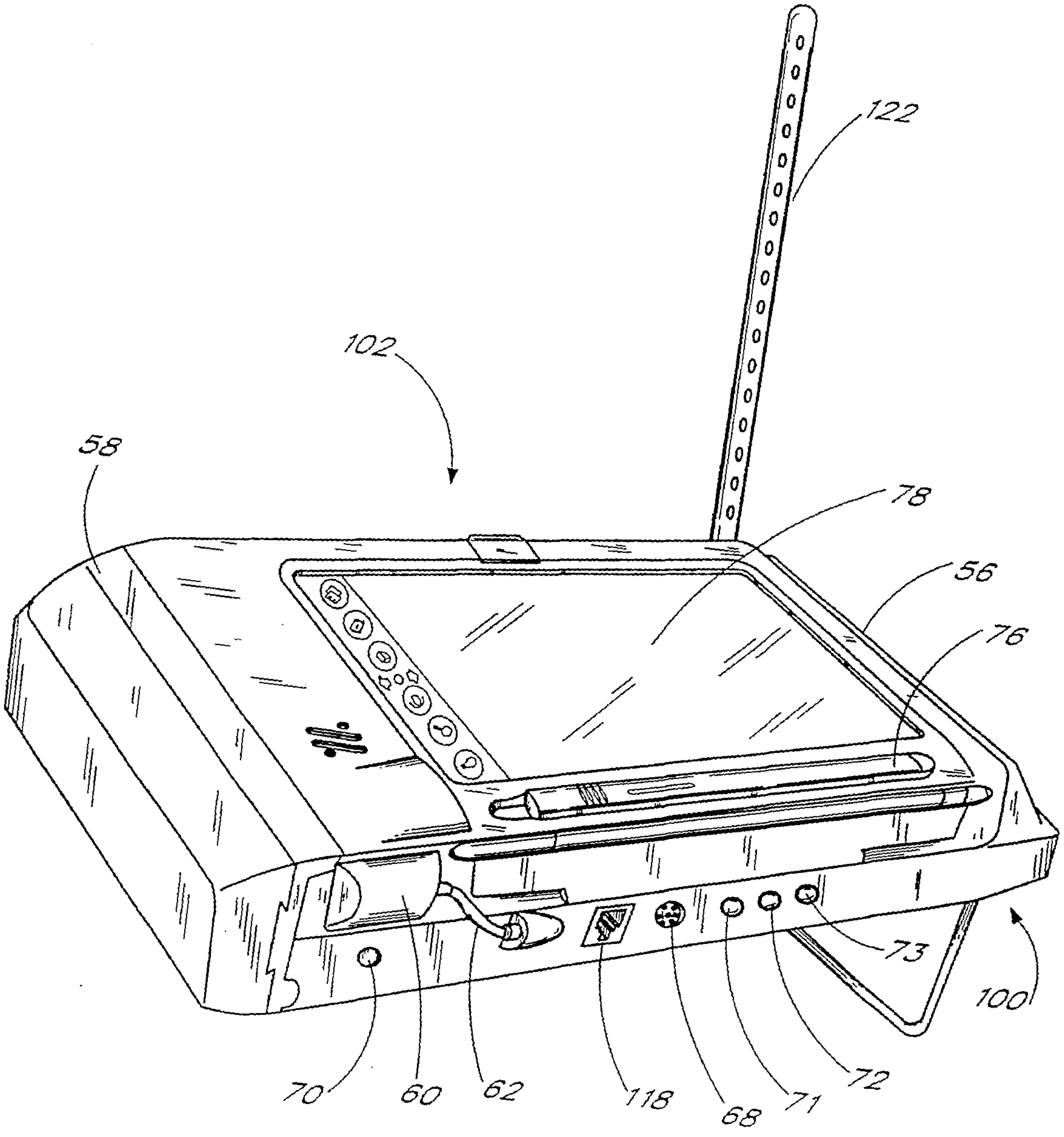


FIG. 3

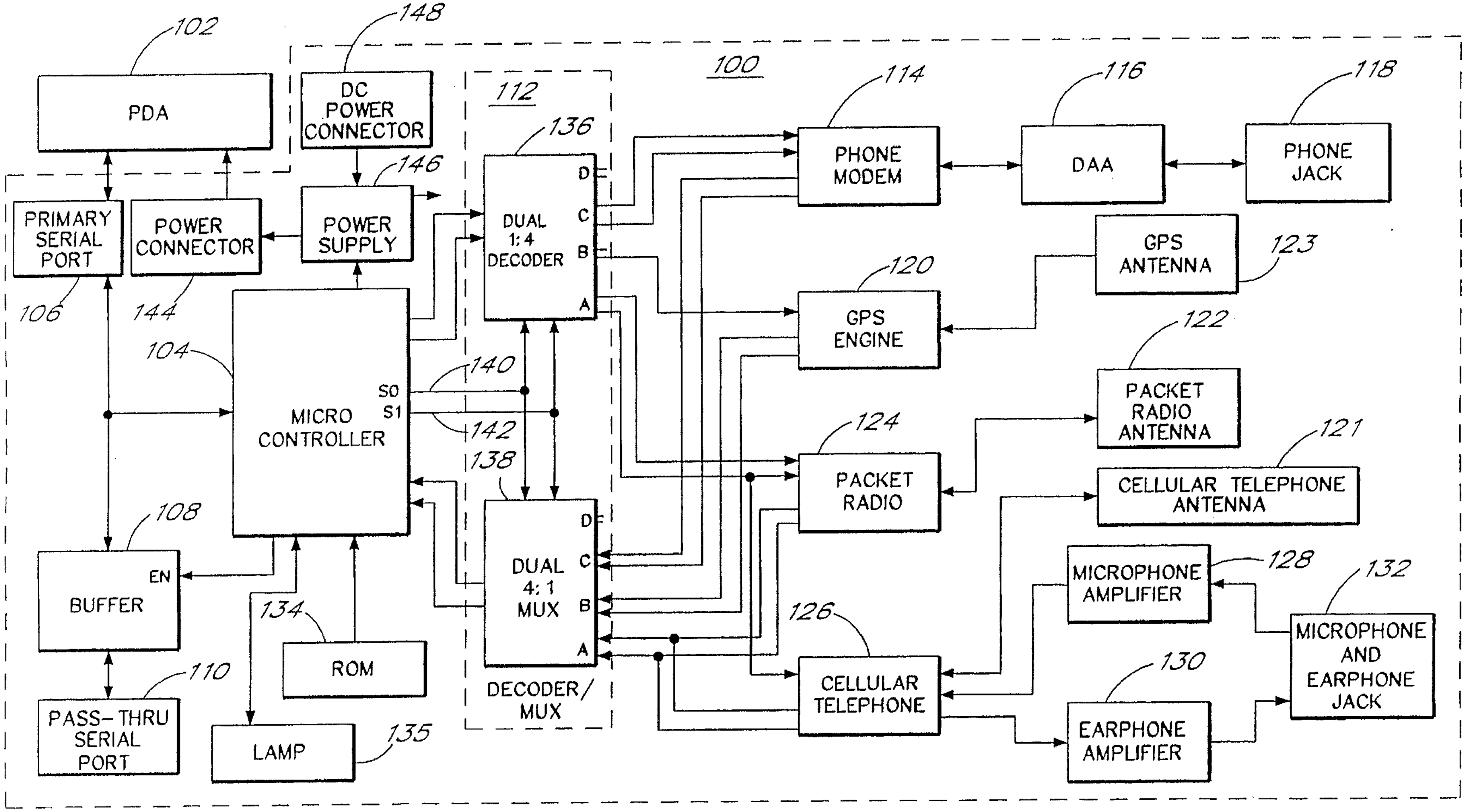

102
PDA
148
DC POWER CONNECTOR
112
136
100
114
PHONE MODEM
116
DAA
118
PHONE JACK
146
PRIMARY SERIAL PORT
POWER CONNECTOR
POWER SUPPLY
DUAL 1:4 DECODER
D
C
B
A
GPS ANTENNA
123
120
GPS ENGINE
106
144
122
104
MICRO CONTROLLER
S0
S1
140
142
PACKET RADIO ANTENNA
124
121
138
PACKET RADIO
CELLULAR TELEPHONE ANTENNA
108
BUFFER
EN
DUAL 4:1 MUX
D
C
B
A
MICROPHONE AMPLIFIER
128
132
134
126
MICROPHONE AND EARPHONE JACK
ROM
110
CELLULAR TELEPHONE
130
PASS-THRU SERIAL PORT
DECODER/ MUX
EARPHONE AMPLIFIER
LAMP
135

FIG. 4

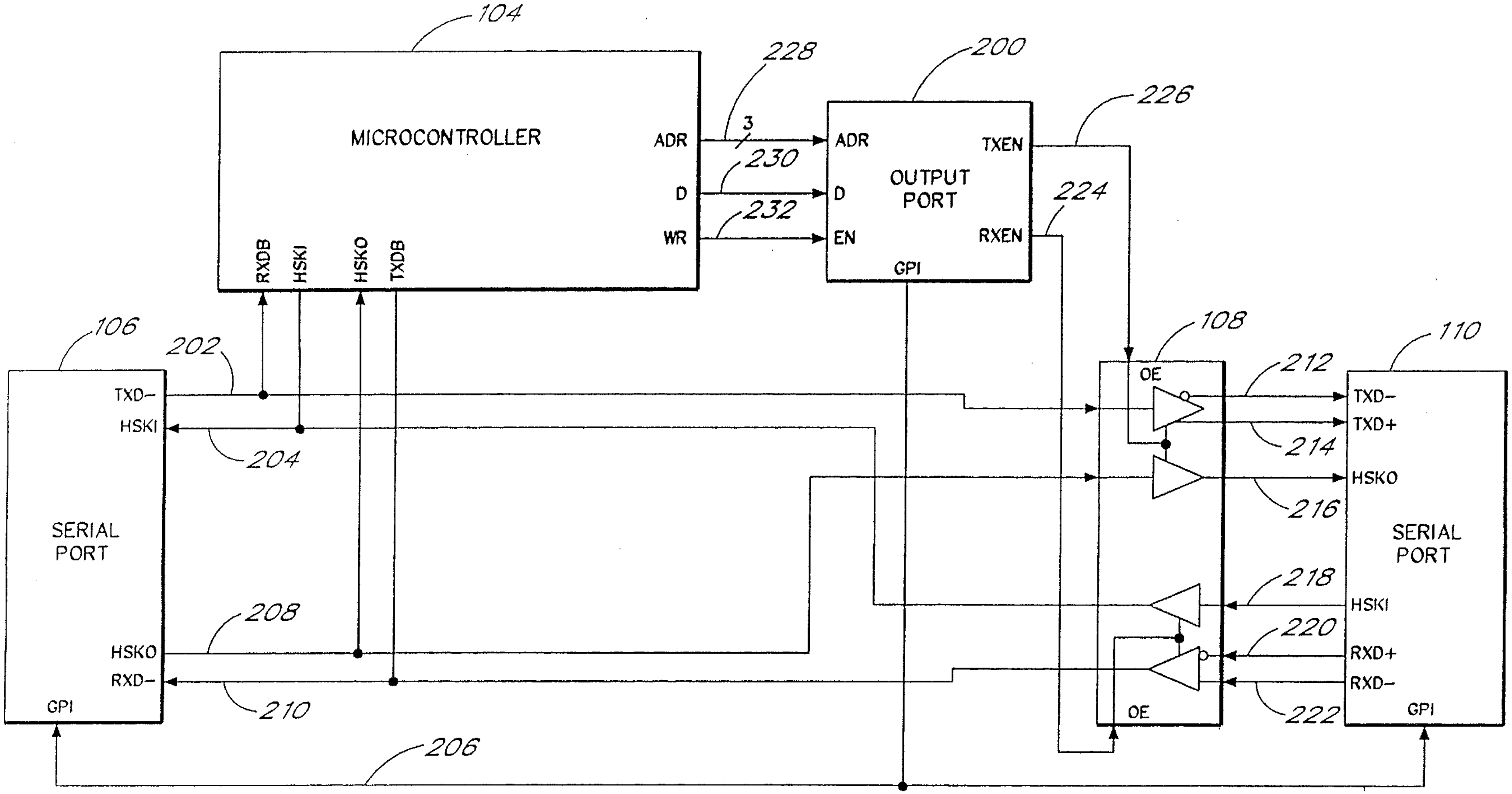

104
MICROCONTROLLER
ADR
D
WR
RXDB
HSKI
HSKO
TXDB
228
3
230
232
200
ADR
D
EN
OUTPUT PORT
TXEN
RXEN
GPI
226
224
106
202
SERIAL PORT
TXD−
HSKI
HSKO
RXD−
GPI
204
208
210
206
108
OE
OE
212
214
216
218
220
222
110
SERIAL PORT
TXD−
TXD+
HSKO
HSKI
RXD+
RXD−
GPI

FIG. 5

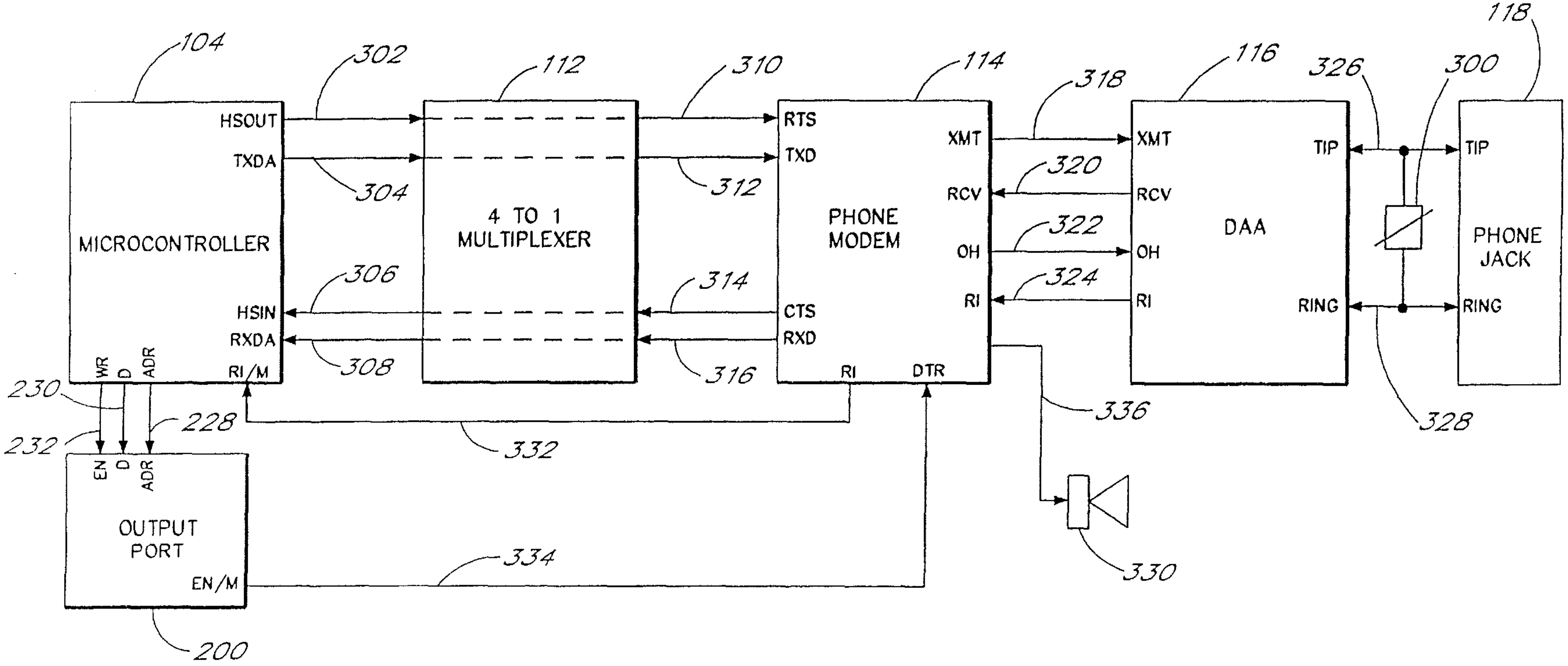

104
MICROCONTROLLER
HSOUT
TXDA
HSIN
RXDA
WR
D
ADR
RI/M
302
304
306
308
112
4 TO 1
MULTIPLEXER
310
312
314
316
114
PHONE
MODEM
RTS
TXD
CTS
RXD
RI
DTR
XMT
RCV
OH
RI
318
320
322
324
116
DAA
XMT
RCV
OH
RI
TIP
RING
326
300
328
118
PHONE
JACK
TIP
RING
336
330
332
334
230
232
228
EN
D
ADR
OUTPUT
PORT
EN/M
200

FIG. 6

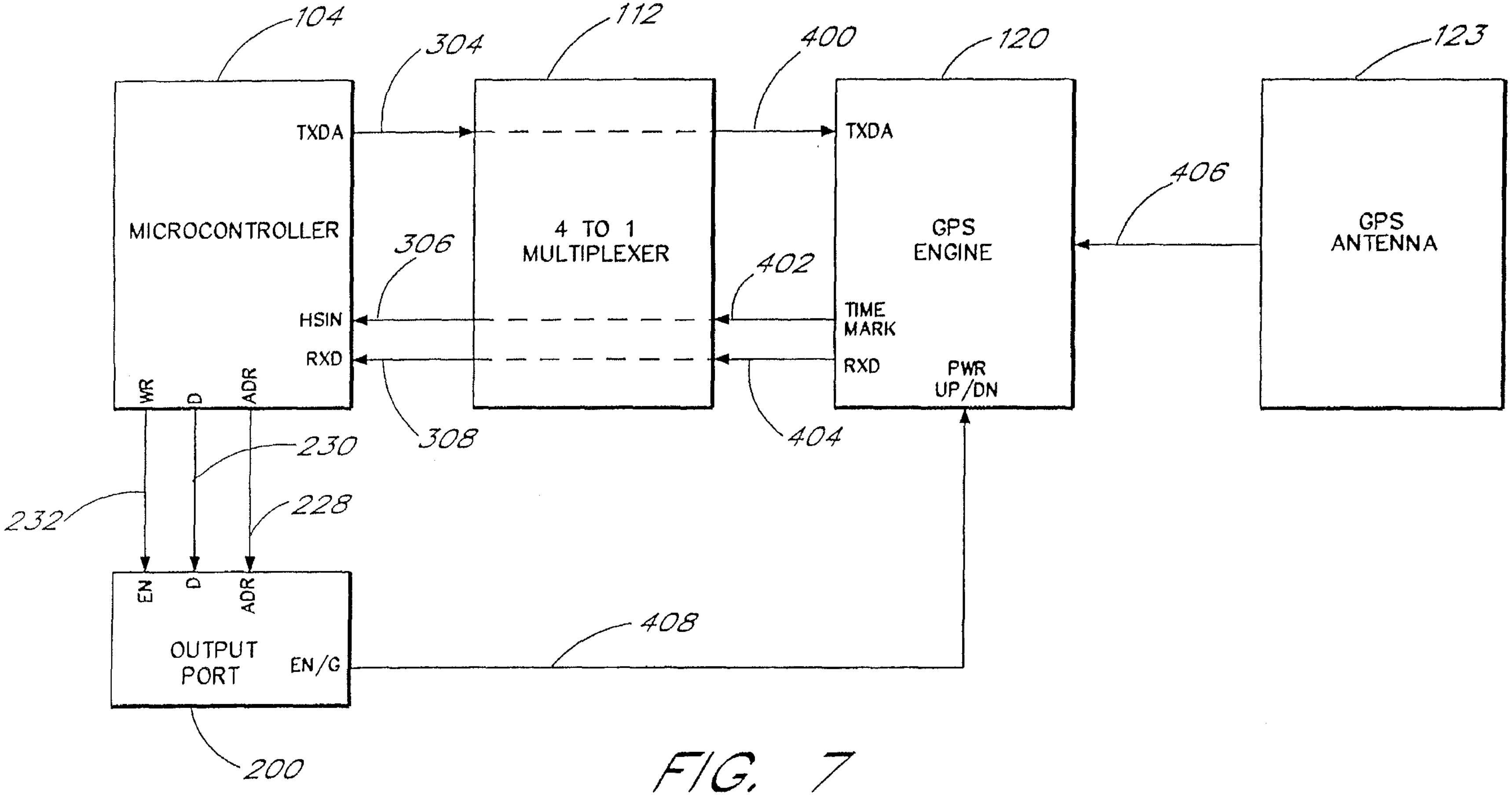

104
MICROCONTROLLER
TXDA
HSIN
RXD
WR
D
ADR
304
306
308
112
4 TO 1
MULTIPLEXER
400
402
404
120
GPS
ENGINE
TXDA
TIME
MARK
RXD
PWR
UP/DN
406
123
GPS
ANTENNA
230
232
228
EN
D
ADR
OUTPUT
PORT
EN/G
408
200

FIG. 7

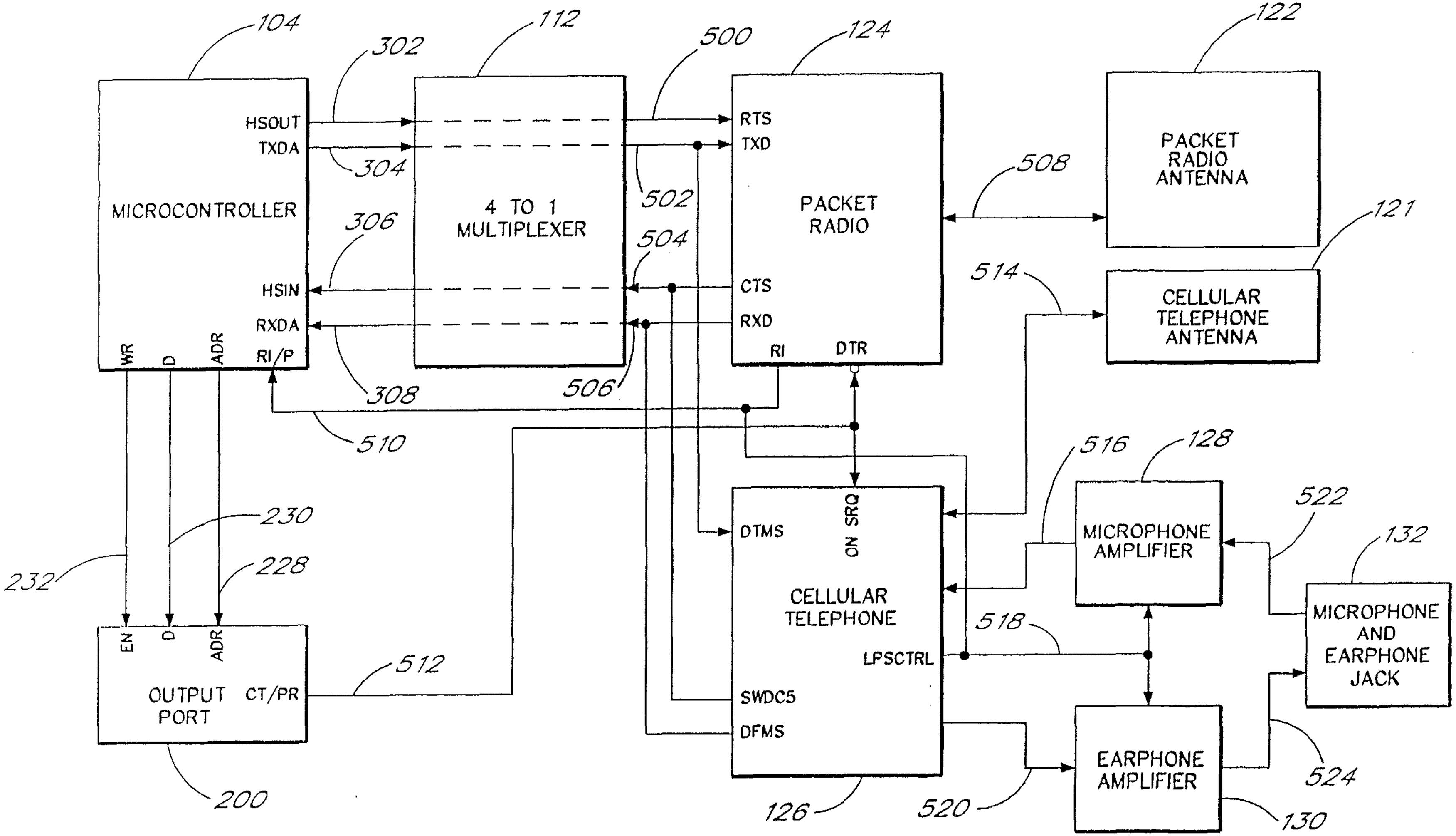

104
112
302
500
124
122
MICROCONTROLLER
HSOUT
TXDA
HSIN
RXDA
WR
D
ADR
RI/P
304
306
308
4 TO 1
MULTIPLEXER
502
504
506
RTS
TXD
CTS
RXD
RI
DTR
PACKET
RADIO
508
PACKET
RADIO
ANTENNA
121
CELLULAR
TELEPHONE
ANTENNA
514
510
516
128
522
132
DTMS
ON SRQ
CELLULAR
TELEPHONE
LPSCTRL
SWDC5
DFMS
MICROPHONE
AMPLIFIER
MICROPHONE
AND
EARPHONE
JACK
518
EARPHONE
AMPLIFIER
230
232
228
EN
D
ADR
OUTPUT
PORT
CT/PR
512
200
126
520
524
130

FIG. 8

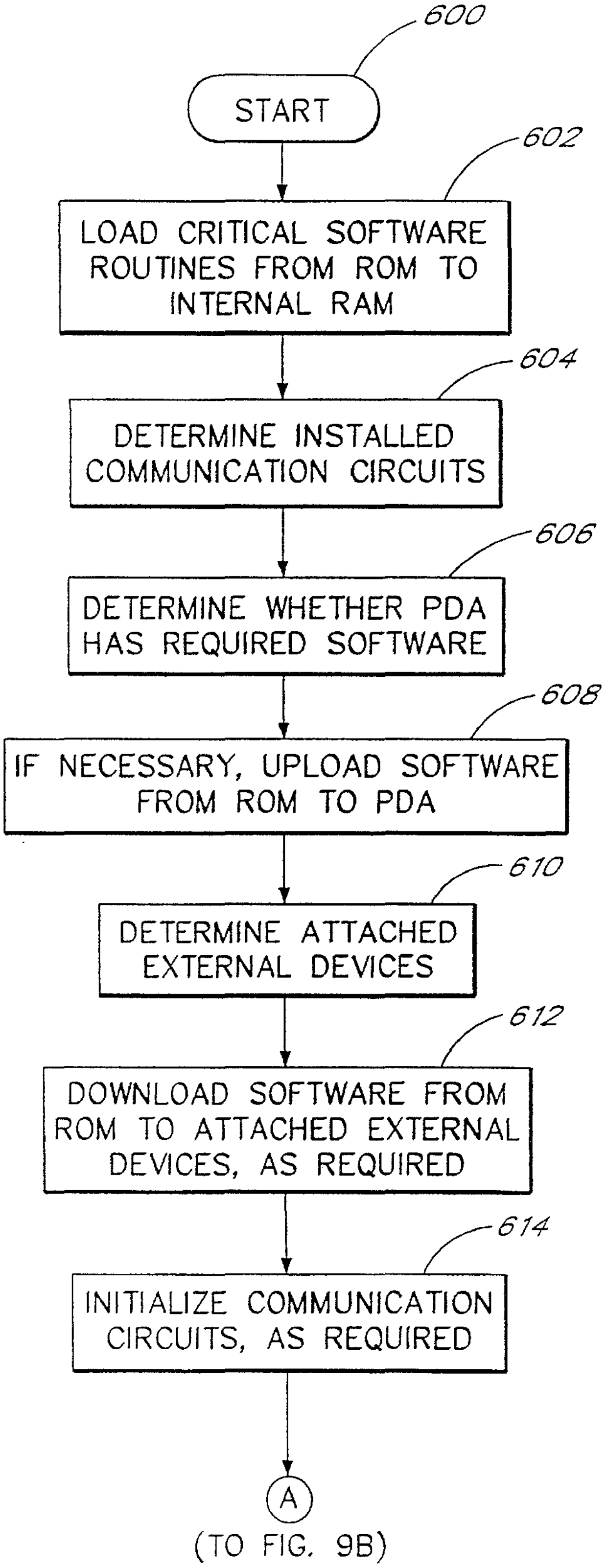

600
START
602
LOAD CRITICAL SOFTWARE ROUTINES FROM ROM TO INTERNAL RAM
604
DETERMINE INSTALLED COMMUNICATION CIRCUITS
606
DETERMINE WHETHER PDA HAS REQUIRED SOFTWARE
608
IF NECESSARY, UPLOAD SOFTWARE FROM ROM TO PDA
610
DETERMINE ATTACHED EXTERNAL DEVICES
612
DOWNLOAD SOFTWARE FROM ROM TO ATTACHED EXTERNAL DEVICES, AS REQUIRED
614
INITIALIZE COMMUNICATION CIRCUITS, AS REQUIRED
A
(TO FIG. 9B)

FIG. 9A

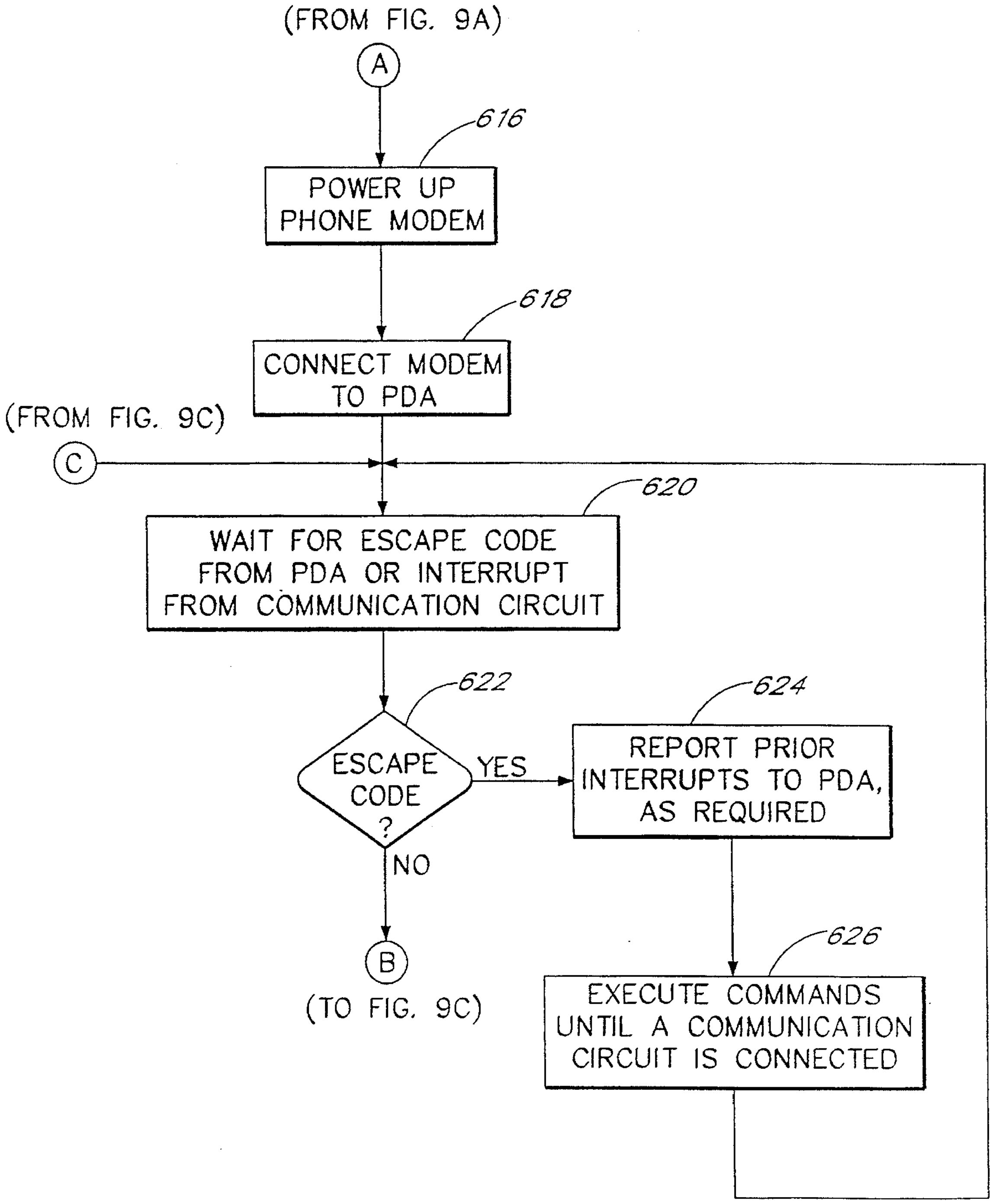

(FROM FIG. 9A)
A
616
POWER UP PHONE MODEM
618
CONNECT MODEM TO PDA
(FROM FIG. 9C)
C
620
WAIT FOR ESCAPE CODE FROM PDA OR INTERRUPT FROM COMMUNICATION CIRCUIT
622
ESCAPE CODE ?
YES
NO
624
REPORT PRIOR INTERRUPTS TO PDA, AS REQUIRED
B
(TO FIG. 9C)
626
EXECUTE COMMANDS UNTIL A COMMUNICATION CIRCUIT IS CONNECTED

FIG. 9B

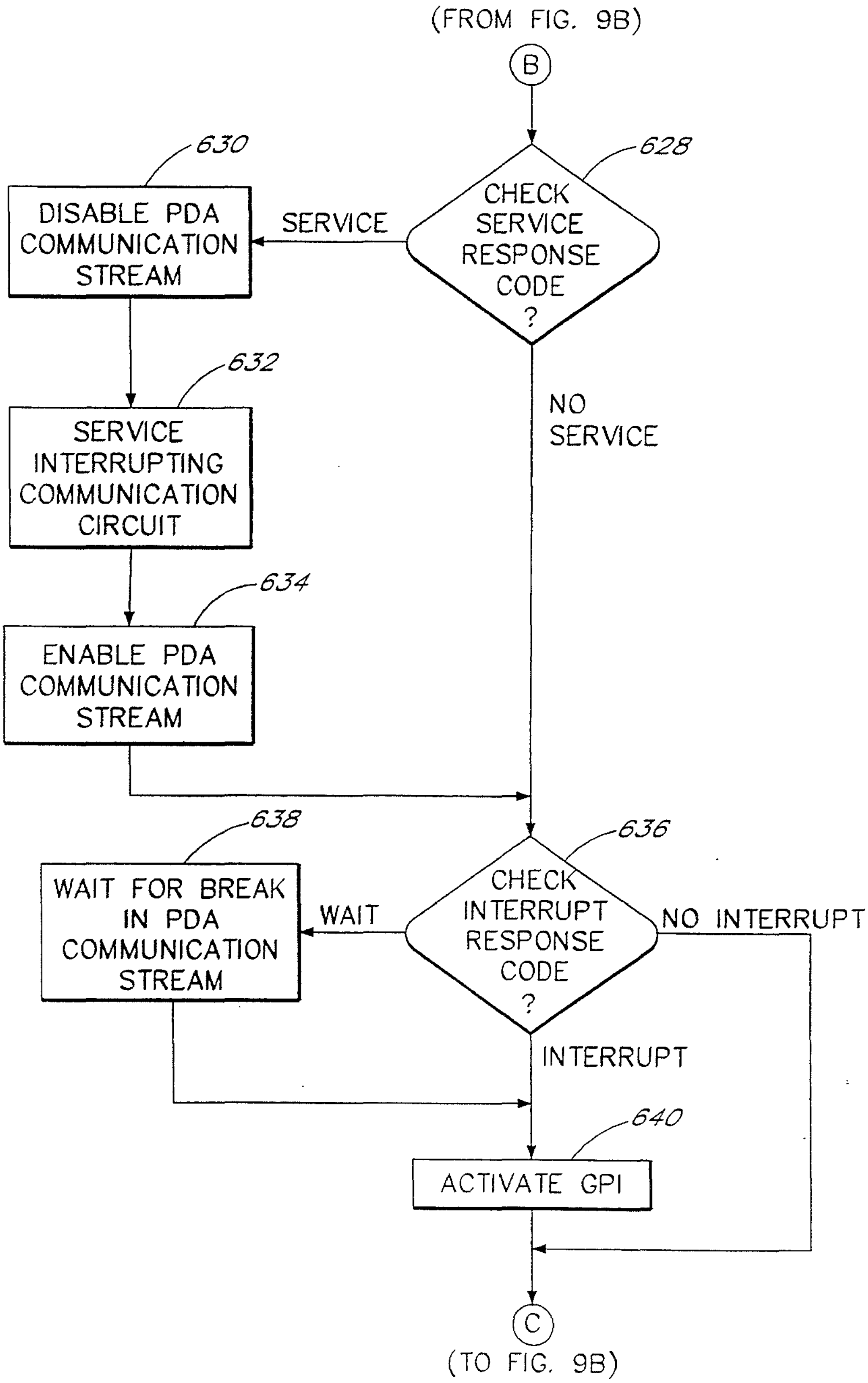

(FROM FIG. 9B)
B
628
CHECK SERVICE RESPONSE CODE ?
SERVICE
630
DISABLE PDA COMMUNICATION STREAM
632
SERVICE INTERRUPTING COMMUNICATION CIRCUIT
634
ENABLE PDA COMMUNICATION STREAM
NO SERVICE
636
CHECK INTERRUPT RESPONSE CODE ?
WAIT
638
WAIT FOR BREAK IN PDA COMMUNICATION STREAM
NO INTERRUPT
INTERRUPT
640
ACTIVATE GPI
C
(TO FIG. 9B)

FIG. 9C

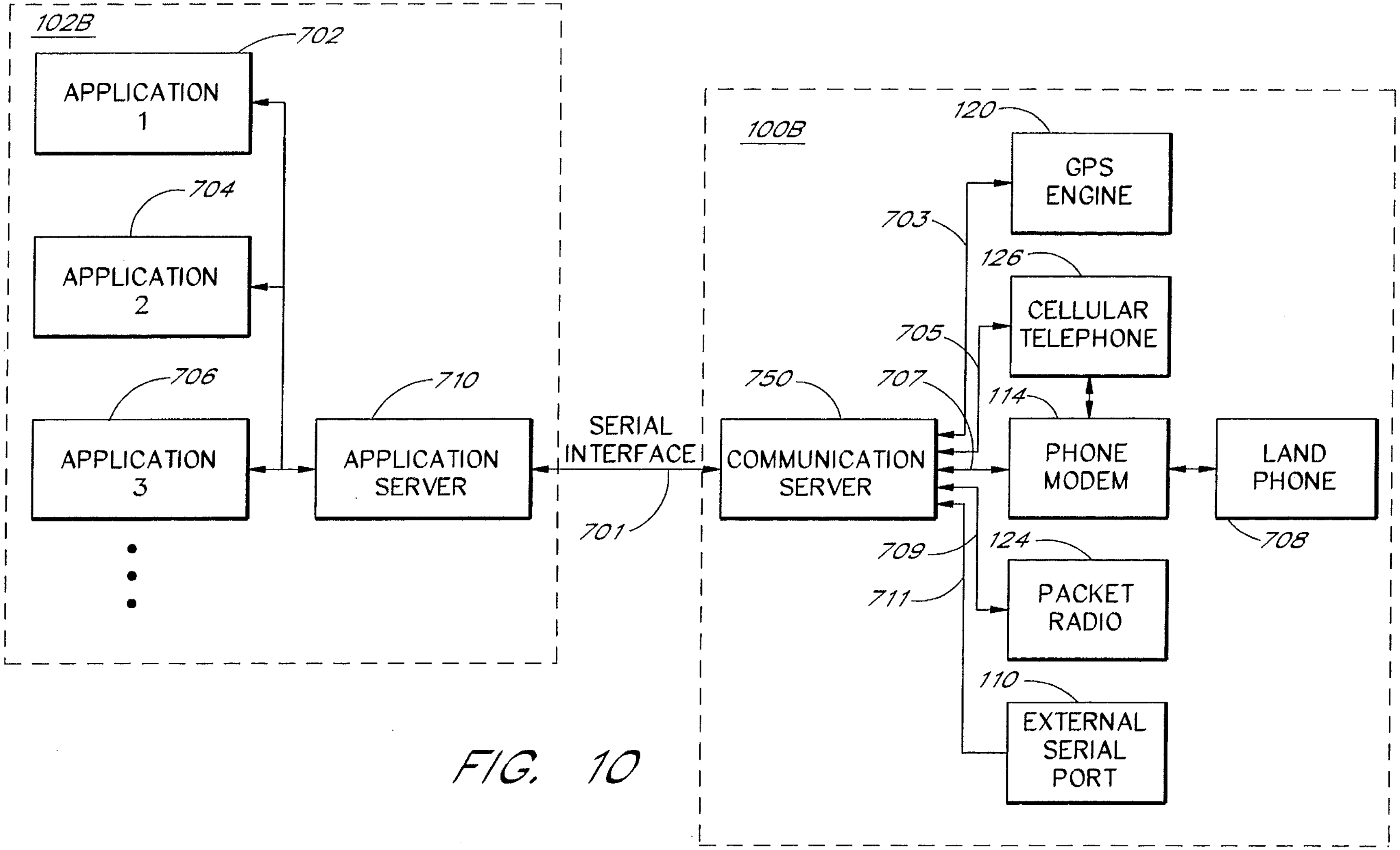

102B
702
APPLICATION 1
704
APPLICATION 2
706
APPLICATION 3
710
APPLICATION SERVER
SERIAL INTERFACE
701
100B
750
COMMUNICATION SERVER
120
GPS ENGINE
703
126
CELLULAR TELEPHONE
705
707
114
PHONE MODEM
LAND PHONE
708
709
124
PACKET RADIO
711
110
EXTERNAL SERIAL PORT

FIG. 10

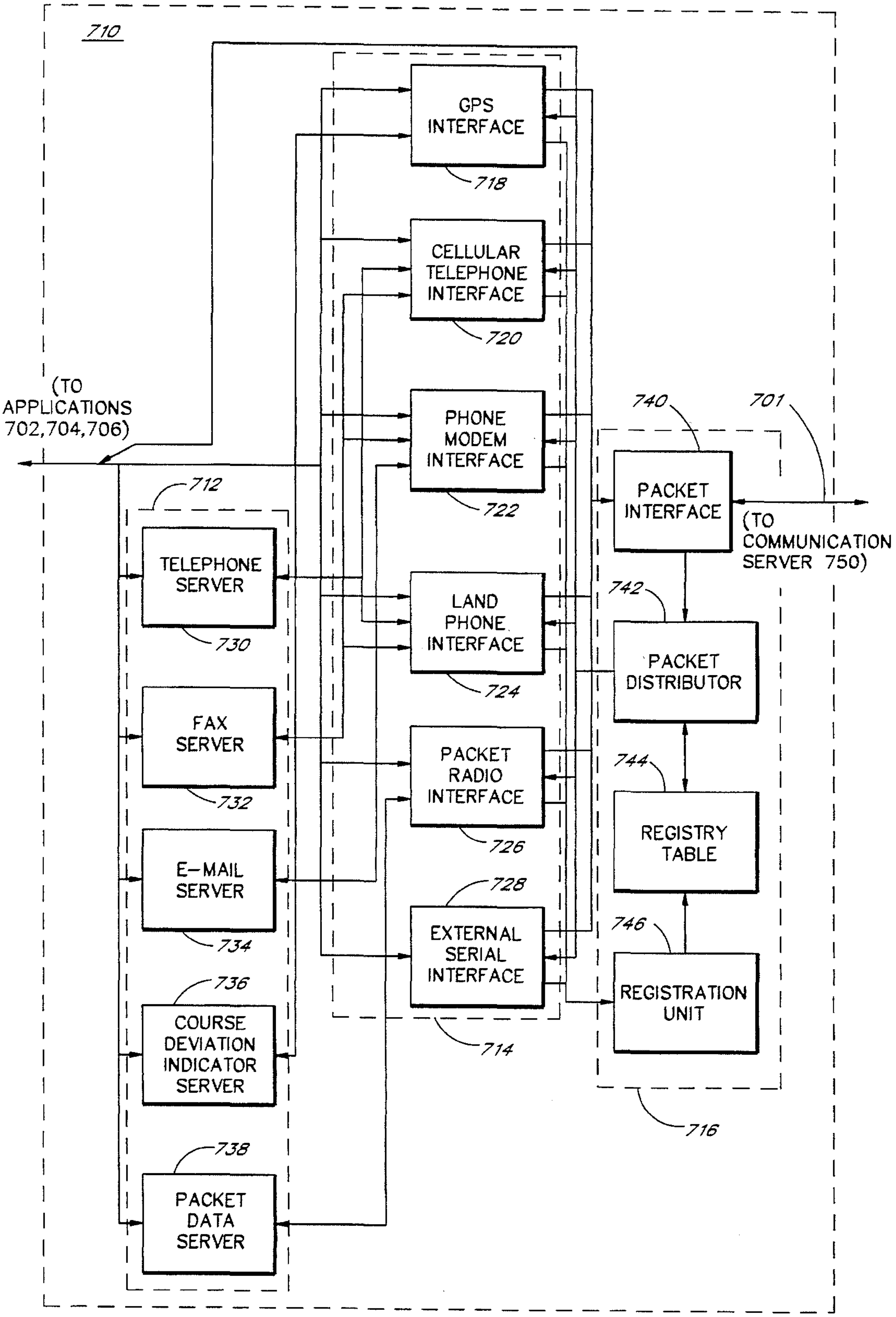

710
GPS INTERFACE
718
CELLULAR TELEPHONE INTERFACE
720
(TO APPLICATIONS 702,704,706)
PHONE MODEM INTERFACE
722
740
701
PACKET INTERFACE
(TO COMMUNICATION SERVER 750)
712
TELEPHONE SERVER
730
LAND PHONE INTERFACE
724
742
PACKET DISTRIBUTOR
FAX SERVER
732
PACKET RADIO INTERFACE
726
744
REGISTRY TABLE
E-MAIL SERVER
734
728
EXTERNAL SERIAL INTERFACE
746
REGISTRATION UNIT
736
COURSE DEVIATION INDICATOR SERVER
714
716
738
PACKET DATA SERVER

FIG. 11

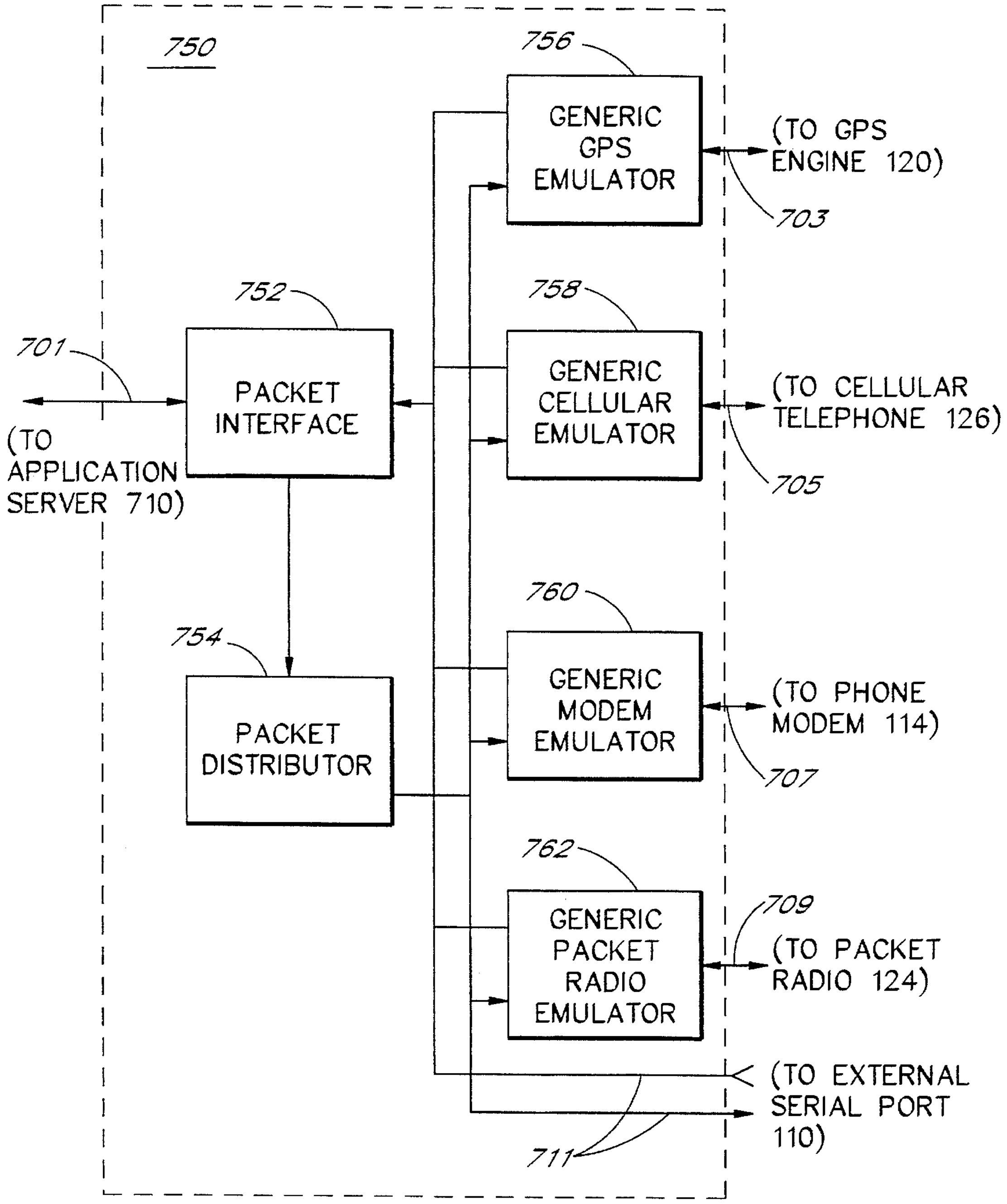

750
756
GENERIC GPS EMULATOR
(TO GPS ENGINE 120)
703
752
758
701
PACKET INTERFACE
GENERIC CELLULAR EMULATOR
(TO CELLULAR TELEPHONE 126)
(TO APPLICATION SERVER 710)
705
760
754
GENERIC MODEM EMULATOR
(TO PHONE MODEM 114)
PACKET DISTRIBUTOR
707
762
709
GENERIC PACKET RADIO EMULATOR
(TO PACKET RADIO 124)
(TO EXTERNAL SERIAL PORT 110)
711

FIG. 12

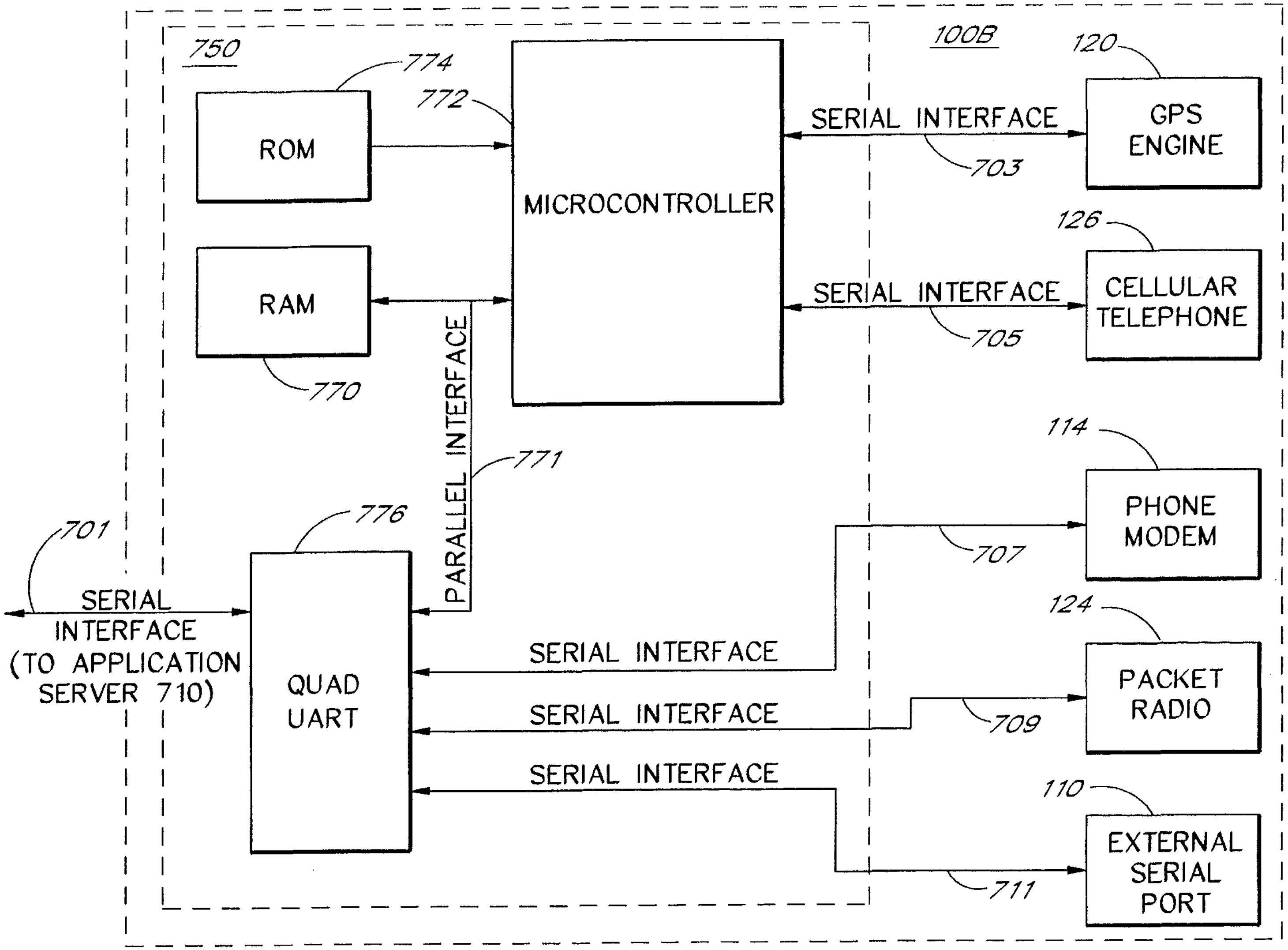

750
774
772
ROM
MICROCONTROLLER
RAM
770
PARALLEL INTERFACE
771
100B
120
GPS ENGINE
SERIAL INTERFACE
703
126
CELLULAR TELEPHONE
SERIAL INTERFACE
705
114
PHONE MODEM
707
124
PACKET RADIO
709
110
EXTERNAL SERIAL PORT
711
701
SERIAL INTERFACE (TO APPLICATION SERVER 710)
776
QUAD UART
SERIAL INTERFACE
SERIAL INTERFACE
SERIAL INTERFACE

FIG. 13

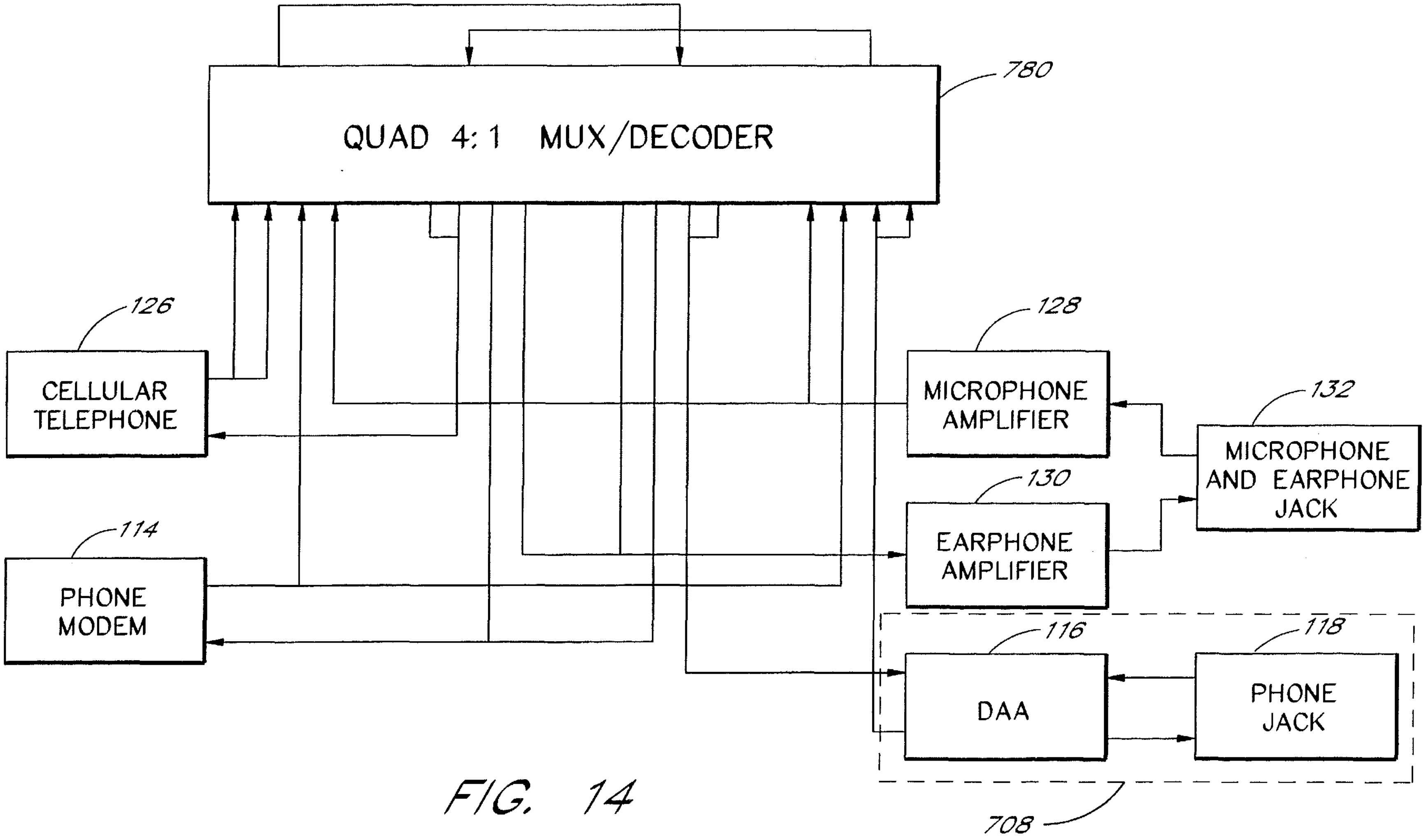

QUAD 4:1 MUX/DECODER
780
126
CELLULAR TELEPHONE
128
MICROPHONE AMPLIFIER
132
MICROPHONE AND EARPHONE JACK
130
EARPHONE AMPLIFIER
114
PHONE MODEM
116
118
DAA
PHONE JACK
708

FIG. 14

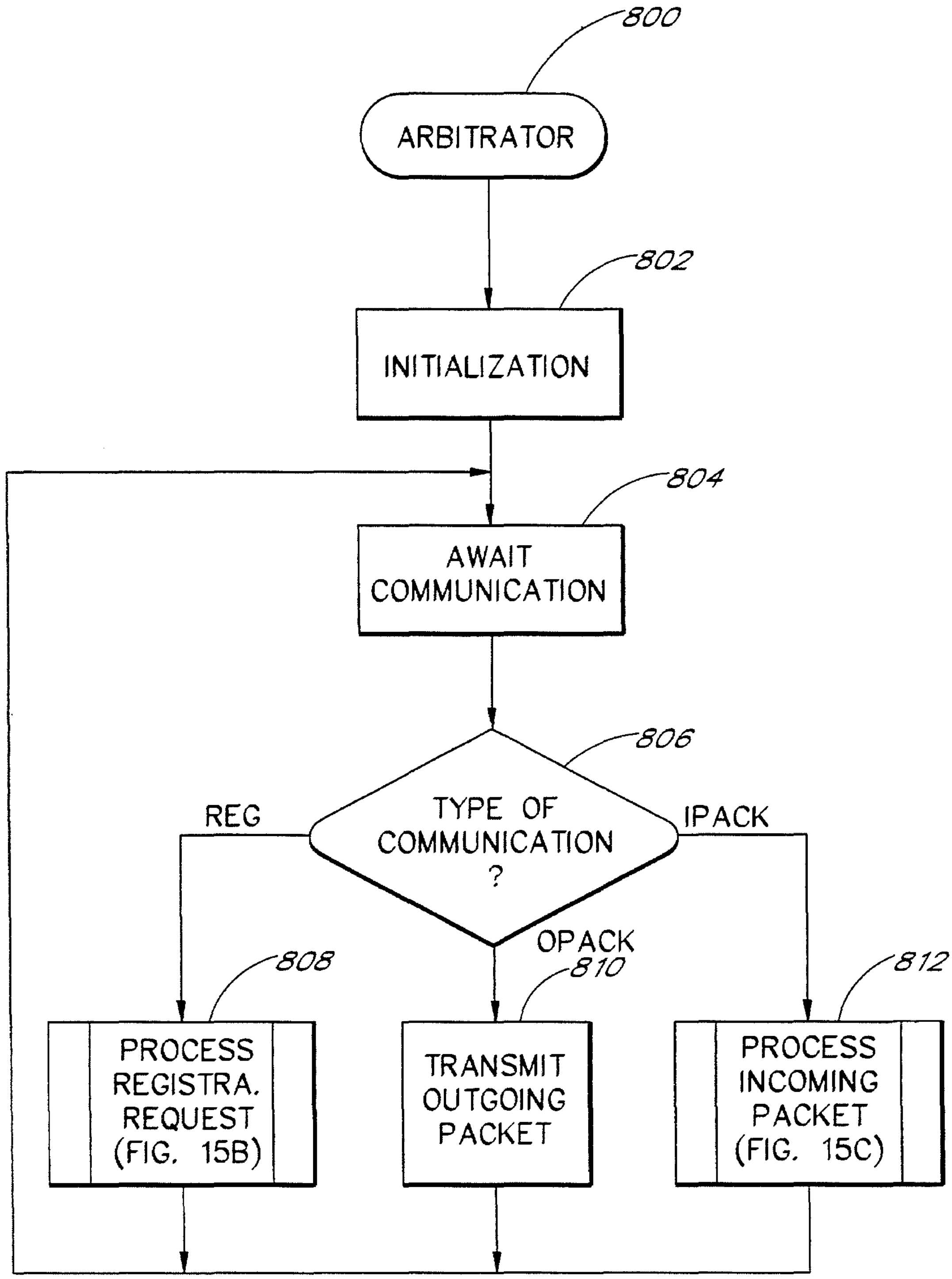

800
ARBITRATOR
802
INITIALIZATION
804
AWAIT COMMUNICATION
806
TYPE OF COMMUNICATION ?
REG
IPACK
OPACK
808
PROCESS REGISTRA. REQUEST (FIG. 15B)
810
TRANSMIT OUTGOING PACKET
812
PROCESS INCOMING PACKET (FIG. 15C)

FIG. 15A

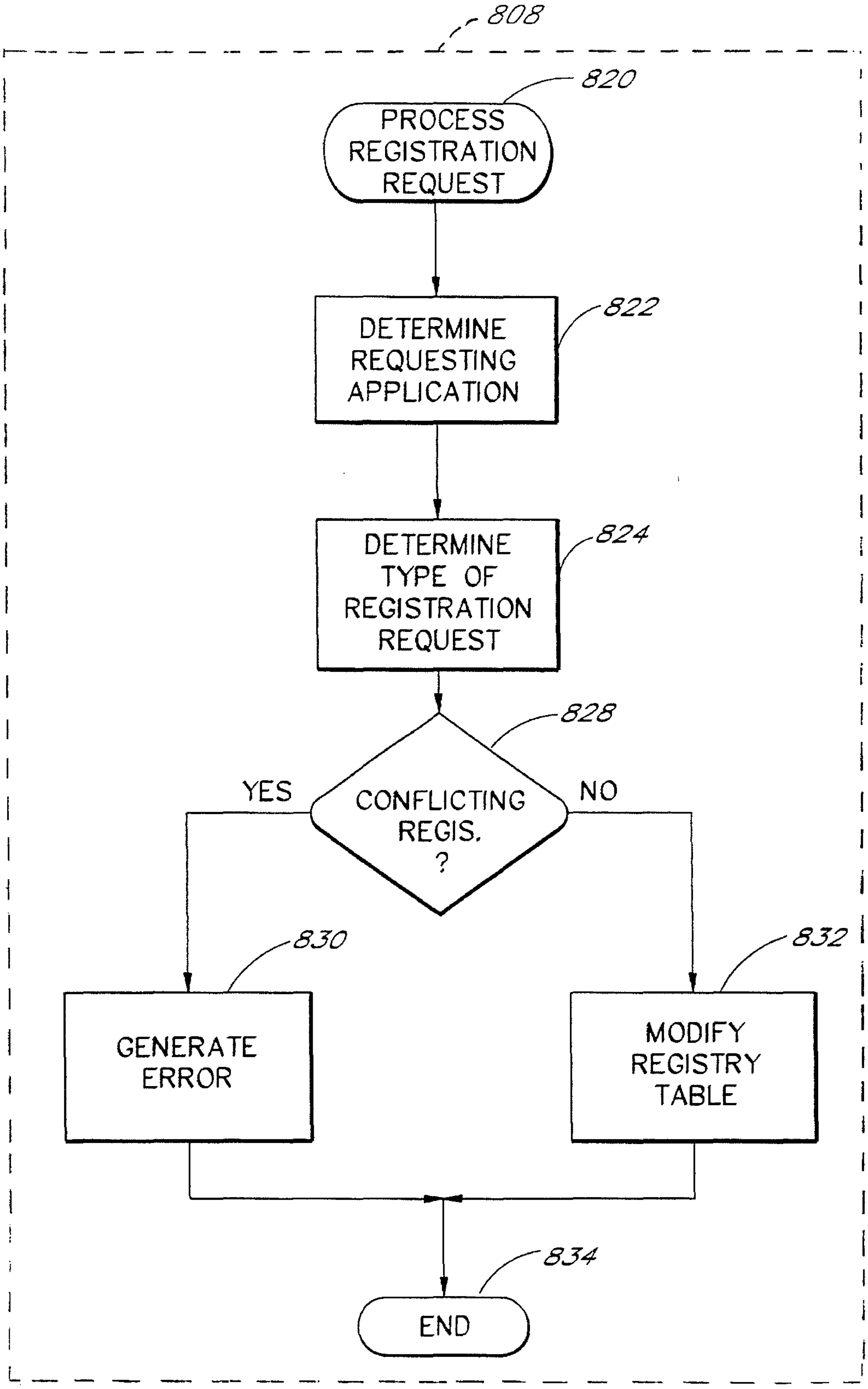

808
820
PROCESS REGISTRATION REQUEST
822
DETERMINE REQUESTING APPLICATION
824
DETERMINE TYPE OF REGISTRATION REQUEST
828
CONFLICTING REGIS. ?
YES
NO
830
GENERATE ERROR
832
MODIFY REGISTRY TABLE
834
END

FIG. 15B

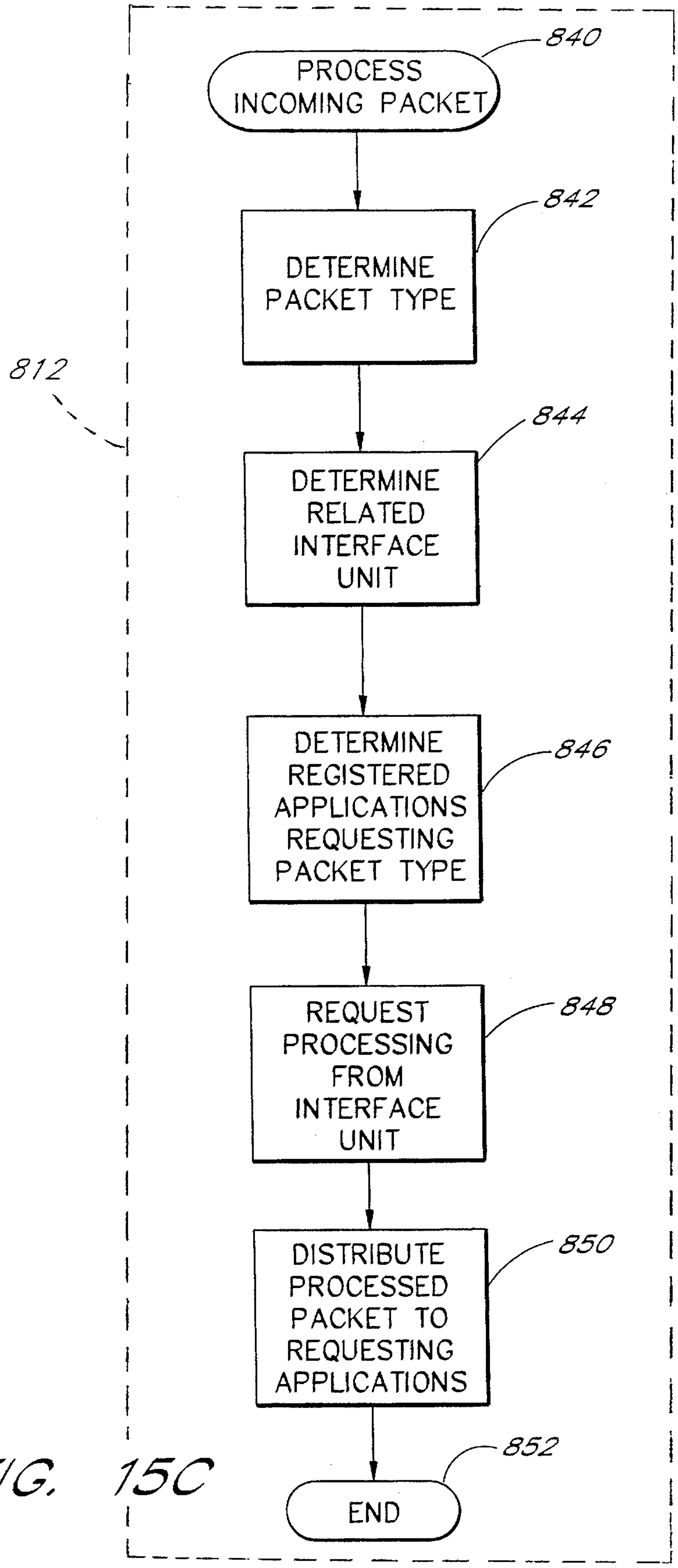

840
PROCESS INCOMING PACKET
842
DETERMINE PACKET TYPE
812
844
DETERMINE RELATED INTERFACE UNIT
846
DETERMINE REGISTERED APPLICATIONS REQUESTING PACKET TYPE
848
REQUEST PROCESSING FROM INTERFACE UNIT
850
DISTRIBUTE PROCESSED PACKET TO REQUESTING APPLICATIONS
852
END

FIG. 15C

# PORTABLE APPARATUS FOR PROVIDING MULTIPLE INTEGRATED COMMUNICATION MEDIA

This is a Continuation-in-part of U.S. patent application Ser. No. 08/152,492, filed Nov. 15, 1993 now abandoned.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention is in the field of portable communication devices for providing a computer with multiple integrated communication media, such as a phone modem, a cellular telephone, a packet radio and a Global Positioning System engine. In particular, the present invention relates to a portable multiple integrated communication device for a palm computer.

### 2. Background Information

Recent advances in the manufacture of integrated circuit components have allowed ever increasing functional capabilities to be performed by fewer integrated circuit components. This increased density of processing power in modern electronic equipment allows for the design of small, portable instruments with impressive processing capabilities. Advances in other technological areas, such as LCD displays, pen-based input devices and handwritten character recognition, have also contributed to a new generation of truly portable computers that are aptly described as palm computers or personal digital assistants (PDAs), but which have sufficient processing capabilities for numerous tasks. Examples of such PDAs include the Apple™ Newton™ and the Sharp™ Expert Pad™. These computers allow a user to take notes, store data, retrieve data, run certain application programs and interface with external devices, such as printers, modems or an Appletalk™ network.

## Summary of the Invention

The present invention connects to and interfaces with a PDA to dramatically increase the functional capabilities of the PDA. The present invention adds multiple integrated communication media to the resources currently available to the PDA, while maintaining a compact, portable size. For example, the combination of the present invention with a PDA can be used to place or receive a cellular telephone call or a land line telephone call, to transmit or receive packet radio data, to obtain three-dimensional location data from the Global Positioning System (GPS) and to send or receive data over a telephone cellular link or over a land line using a built in phone modem. These added communication features greatly enhance the utility of the PDAs. Instead of having a stand-alone PDA, isolated from other data sources, such as a person's office computer network, the combined PDA and multiple integrated communication device provides a powerful processing device with convenient access to vast stores of information over a variety of possible media.

One aspect of the present invention involves a portable communication device. The communication device comprises first and second communication circuits providing first and second differing modes of communication, a first generic emulator coupled to the first communication circuit and a second generic emulator coupled to the second communication circuit, a first interface unit coupled to the first generic emulator and a second interface unit coupled to the second generic emulator, and an application program. The application program accesses the first interface unit to generate a first command to control the operation of the first communication circuit. The application program accesses the second interface unit to generate a second command to control the operation of the second communication circuit. The first interface unit communicates the first command to the first generic emulator. The second interface unit communicates the second command to the second generic emulator. The first generic emulator reformats the first command and communicates the first command to the first communication circuit. The second generic emulator reformats the second command and communicates the second command to the second communication circuit. The first communication circuit executes the first command and the second communication circuit executes the second command.

Additional aspects of the present invention will be apparent in the following detailed description of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a palm computer for use with the portable multiple integrated communication device of the present invention.

FIG. **2** is a perspective view of the communication device of the present invention.

FIG. **3** is a perspective view of a palm computer mounted inside the communication device of the present invention.

FIG. **4** is a general functional block diagram of a first embodiment of the communication device of the present invention, connected to a palm computer.

FIG. **5** is a more detailed functional block diagram of the serial interface between the microcontroller and the pair of serial ports of FIG. **4**.

FIG. **6** is a more detailed functional block diagram of the phone modem interface of FIG. **4**.

FIG. **7** is a more detailed functional block diagram of the GPS engine interface of FIG. **4**.

FIG. **8** is a more detailed functional block diagram of the packet radio interface and the cellular telephone interface of FIG. **4**.

FIGS. **9**A, **9**B and **9**C illustrate a flow chart of a computer program executed by the microcontroller of FIG. **4**.

FIG. **10** is a functional block diagram of a second embodiment of the communication device of the present invention connected to a palm computer that has been programmed to implement an improved interface with the communication device.

FIG. **11** is a functional block diagram of the application server of FIG. **10**.

FIG. **12** is a functional block diagram of the software of the communication server of FIG. **10**.

FIG. **13** is a functional block diagram of the hardware of the communication server of FIG. **10**.

FIG. **14** is a functional block diagram of the interconnections between the cellular telephone, the phone modem, the microphone and earphone jack and the phone jack of the second embodiment.

FIGS. **15**A, **15**B, and **15**C illustrate a flow chart of the method implemented by the arbitrator of FIG. **11**.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** illustrates a palm computer or personal digital assistant (PDA) **102** for use with the present invention. The PDA **102** comprises an LCD display **78**, a light pen **76**, a DC power connector **50** and a serial interface connector **52**. The PDA **102** provides an operator with a variety of data processing and data storage functions in a lightweight, portable device.

First Embodiment

FIGS. **2** to **9C** illustrate a first embodiment 100 of the portable multiple integrated communication device of the present invention. FIG. **2** illustrates a perspective view of the communication device **100**. Externally, the communication device **100** comprises a fixed securing surface **56**, a supporting surface **57**, a movable securing surface **58**, a GPS antenna **123** (FIG. **7**), either a cellular telephone antenna **121** (FIG. **8**) or a packet radio antenna **122**, a microphone and earphone jack **132**, a serial/power interface connector **60**, a serial/power interface cable **62**, a phone jack **118**, a pass-thru serial interface connector **68**, a DC power connector **70** and a set of three LEDs **71**, **72** and **73**. The LEDs **71**, **72** and **73** indicate a low battery, power-on and packet radio transmit condition.

FIG. **3** illustrates the PDA **102** of FIG. **1** inserted into the communication device **100** of FIG. **2**. The PDA **102** is inserted into the communication device **100** by pressing the bottom end of the PDA **102** against the securing surface **58** to rotate the securing surface **58** toward its open position (shown by the phantom lines in FIG. **2**) until the top end of the PDA **102** clears the fixed securing surface **56**, lowering the PDA **102** against the supporting surface **57**, with the orientation of FIG. **3**. The PDA **102** is then released, and a spring (not shown) rotates the securing surface **58** to its closed position, as shown by the solid lines in FIGS. **2** and **3**, pressing the top end of the PDA **102** against the securing surface **56**. Next, the remote serial/power interface connector **60** of the communication device **100** is inserted into both the DC power connector **50** and the serial interface connector **52** of the PDA **102**. The combination of the PDA **102** and the communication device **100** forms a small, lightweight unit that is convenient to carry around and to use.

The structure of the communication device **100** is preferably designed to allow access to connectors and controls of the PDA **102**. For example, the securing surface **56** of the communication device **100** preferably has an opening corresponding to a slot in the top end of the Sharp™ Expert Pad™, for insertion of an IC card into the slot of the Expert Pad™. The packet radio antenna **122** and the cellular telephone antenna **121** (shown in FIG. **8**) of the communication device **100** are preferably mounted so that they can be rotated between an active position and an inactive position. In the active position, the antenna **122** or **123** is generally perpendicular to the main structure of the communication device **100**, as shown in FIG. **3**, to achieve optimal reception. In the inactive position, the antenna **122** or **123** is adjacent to a side of the communication device **100** that is directly opposite the side with the phone jack **118**. The GPS antenna **123** may be mounted on the frame of the communication device **100**, or it may be a separate device.

FIG. **4** illustrates a general functional block diagram of the first embodiment of the portable multiple integrated communication device **100** of the present invention, connected to a PDA **102**. The communication device **100** comprises a primary serial port **106**, a buffer **108**, a pass-thru serial port **110**, a DC power connector **148**, a power supply **146**, a power connector **144**, a microcontroller **104**, a read-only memory (ROM) **134**, a lamp **135**, a decoder/multiplexer **112**, a phone modem **114**, a Data Access Arrangement (DAA) **116**, the phone jack **118**, a Global Positioning System (GPS) engine **120**, the GPS antenna **123**, either a packet radio **124** or a cellular telephone **126**, a microphone amplifier **128**, an earphone amplifier **130**, the microphone and earphone jack **132**, and either the packet radio antenna **122** or the cellular telephone antenna **121**. The decoder/multiplexer **112** comprises a dual 1:4 decoder or demultiplexer **136** and a dual 4:1 multiplexer or selector **138**. In the first embodiment of the present invention, the communication device **100** comprises either the packet radio **124** or the cellular telephone **126**, but not both. In one embodiment, the circuit card implementing the packet radio **124** occupies the same physical space inside the communication device **100** as the circuit card implementing the cellular telephone **126**, thus conserving space and reducing the size of the communication device **100**.

The microcontroller **104** preferably comprises an Intel® 80C320 microcontroller, although numerous other processors could be used. The microcontroller **104** communicates with the PDA **102** through the primary serial port **106**. The serial/power interface cable **62** of FIGS. **2** and **3** is connected to the primary serial port **106** and the power connector **144** of FIG. **4**. The primary serial port **160** is used for the communication of commands and data between the microcontroller **104** and the PDA **102**, as well as for the downloading of program code from the ROM **134** to the PDA **102**. The power connector **144** provides DC power from the power supply **146** to the PDA **102**. The power supply **146** also provides DC power to circuitry in the communication device **100**. The power supply **146** preferably comprises batteries. However, DC power can also be provided by an external source through the DC power connector **148** to the power supply **146**. The microcontroller **104** can cause the power supply **146** to power down, either as a result of a command from the PDA **102** or after a period of inactivity, to conserve battery power.

The communication device **100** also has the separate pass-thru serial port **110** to allow other external devices to communicate with the PDA **102**. Such devices may include printers, phone modems or an Appletalk™ network. The pass-thru serial port **110** is connected to the pass-thru serial interface connector **68** of FIGS. **2** and **3**. The buffer **108** is used to enable or disable the serial port **110**. In the first embodiment, the buffer **108** comprises an LTC1032 component. If the microcontroller **104** needs to transmit data to the PDA **102** or receive data from the PDA **102**, the microcontroller **102** disables the buffer **108**. Otherwise, the buffer **108** is enabled to allow an external device to communicate with the PDA **102** through the serial port **110** and the primary serial port **106**. The serial interfaces between the microcontroller **104**, the PDA **102** and external devices are described in greater detail below with reference to FIG. **5**.

The ROM **134** comprises a 27C1001 128Kx8 ultraviolet erasable EPROM from NEC, or the like, in the first embodiment. The ROM **134** contains code for both the microcontroller **104** and the PDA **102**. The ROM **134** may also contain code for standard external devices. The microcontroller **104** executes code in the ROM **134** to implement the described functions of the communication device **100**. The microcontroller **104** also uploads code from the ROM **134** through the primary serial port **106** into the PDA **102**. The PDA **102** executes this code to provide an interface with the microcontroller **104** and to support and control the functions of the communication device **100**. After the code in the ROM **134** is loaded into the PDA **102**, an operator of the combined PDA **102** and the communication device **100** can utilize the functions provided by both the PDA **102** and the communication device **100** by providing appropriate input commands to the PDA **102**. The PDA **102** sends appropriate commands and data to the microcontroller **104** to control the functions of the communication device **100**, as provided by the code in the ROM **134**. The program executed by the microcontroller **104** is described in greater detail below with reference to FIG. **9**. The microcontroller **104** can also download code to attached external devices.

The first embodiment of the communication device **100** provides the PDA **102** with access to three different communication media through the microcontroller **104** and the decoder/multiplexer **112**. Specifically, the communication media include the phone modem **114**, the GPS engine **120**, and either the packet radio **124** or the cellular telephone **126**. Each of the communication media is implemented in a separate communication circuit. As described above, the decoder/multiplexer **112** comprises a dual 1-to-4 decoder **136** and a dual 4-to-1 multiplexer **138**. In the first embodiment, the decoder comprises a 74HC139 from Texas Instruments, or the like, while the multiplexer **138** comprises a 74HC153, also from Texas Instruments, or the like. The communication device **100** has a separate serial interface from the microcontroller **104**, through the decoder/multiplexer **112** to each of the communication circuits **114**,**120**, **124** and **126**. To implement these serial interfaces, the microcontroller **104** generates a single handshake signal and a single data signal to the decoder **136**. The decoder **136** has four pairs of handshake and data outputs (output pair A, output pair B, output pair C and output pair D), to which the signals from the microcontroller **104** may be connected. The microcontroller **104** generates a pair of select signals on a pair of select lines **140** and **142** to the decoder **136**. The two select signals have logical values of 00, 01, 10, or 11 to control the selection of one of the four output pairs of the decoder **136** to which the input pair is connected. The output pair A is connected to both the packet radio **124** and the cellular telephone **126**; however, as discussed above, only one of the two devices is installed at any particular time in the present embodiment. The output pair B has only one line which is connected to the GPS engine **120**. The output pair C is connected to the phone modem **114**. The output pair D is unconnected in the present embodiment. Thus, the microcontroller **104** can send serial data to any of the installed communication circuits **114**, **120** and either **124** or **126** by selecting the appropriate select signals.

The phone modem **114** also generates a handshake signal and a data signal for a serial interface which is connected to an input pair C on the multiplexer **138**. The GPS engine **120** also generates a handshake signal and a data signal for a serial interface that is connected to an input pair B on the multiplexer **138**. The packet radio **124** also generates a handshake signal and a data signal for a serial interface that is connected to an input pair A on the multiplexer **138**. The cellular telephone **126** also generates a handshake signal and a data signal for a serial interface that is also connected to the input pair A on the multiplexer **138**. The multiplexer **138** also has an output pair to which one of four input pairs is internally connected. This output pair of the multiplexer **138** is connected to the microcontroller **104**. The microcontroller **104** controls the selection of the multiplexer **138** using the same select signals as described above with reference to the decoder **136**. Thus, the microcontroller **104** can select an input pair to receive the serial interface signals from a selected one of the installed communication circuits **114**, **120** and either **124** or **126**.

The select lines from the microcontroller **104** are preferably connected to the decoder **136** and the multiplexer **138** so that the communication circuit **114**, **120**, **124** or **126** selected by the decoder **136** is also selected by the multiplexer at all times. Thus, for example, by controlling the select lines to select input pair C and output pair C, the microcontroller **104** generates a handshake and a data signal for a serial interface that is received by the phone modem **114**. The microcontroller **104** can also receive a handshake and a data signal for a serial interface that are generated by the phone modem **114**. Thus, the decoder/multiplexer **112** allows the microcontroller **104** to select between three different serial interfaces. A first serial interface allows the microcontroller **104** to communicate with the phone modem **114** and is described in greater detail below with reference to FIG. **6**. A second serial interface allows the microcontroller **104** to communicate with the GPS engine **120** and is described in greater detail below with reference to FIG. **7**. A third serial interface allows the microcontroller **104** to communicate with either the packet radio **124** or the cellular telephone **126** and is described in greater detail below with reference to FIG. **8**.

FIG. **5** is a more detailed functional block diagram of the serial interface between the microcontroller **104**, the primary serial port **106** and the pass-thru serial port **110**, shown in FIG. **4**. The microcontroller **104** is connected to the primary serial port **106** and to the buffer **108** by a transmit data line **202**, a handshake-in line **204**, a handshake-out line **208** and a receive data line **210**. The microcontroller **104** is connected to an output port **200** by a set of three address lines **228**, a data line **230** and a write enable line **232**. The output port **200** is connected to the primary serial port **106** and the serial port **110** by a GPI line **206**. The output port **200** is connected to the buffer **108** by a receive enable line **224** and a transmit enable line **226**. The buffer **108** is connected to the serial port **110** by a differential pair of transmit data lines **212** and **214**, a handshake-out line **216**, a handshake-in line **218**, and a differential pair of receive data lines **220** and **222**.

The microcontroller **104** receives an active low signal from the primary serial port **106** on the transmit data line **202** and another signal from the primary serial port **106** on the handshake-out line **208**. The microcontroller **104** also generates an active low signal to the primary serial port **106** on the transmit data line **210** and another signal to the primary serial port **106** on the handshake-in line **204**. A person of skill in the art will understand the use of these handshake and data signals to form a serial interface between the microcontroller **104** and the primary serial port **106**. As described above, a serial port of a PDA **102** is connected to the primary serial port **106**, so that the microcontroller **104** can communicate with the PDA **102** over the serial interface.

The output port **200** constitutes an eight-bit addressable latch, such as a 74HC259 from Texas Instruments, or the like. The output port **200** generates eight output data signals, three of which are applied to the receive enable line **224**, the transmit enable line **226** and the GPI line **206**, respectively. Other output signals of the output port **200** are described below with reference to FIGS. **6**, **7** and **8**. The output port **200** also receives signals on the set of three address lines **228** for selecting among the eight output signals. It also receives signals on the data line **230** and on the write enable line **232**. The microcontroller **104** writes data to the output port **200** one bit at a time by controlling the address lines **228**, the input data line **230** and the write enable line **232**. The output port **200** decodes the signals on the address lines **228** to determine which output signal is written. When the signal on the write enable line **232** is activated, the output port **200** transfers the logic level at the input data line **230** to the corresponding output data signal.

The GPI line **206** is connected to both the primary serial port **106** and the serial port **110**. The PDA **102** can receive a pulse on the GPI line **206** from either the microcontroller **104** through the output port **200** or from an external device through the serial port **110**. Upon receiving a pulse on the GPI line **206**, if the PDA **102** has gone into a sleep mode to conserve battery power, the PDA **102** "wakes up" and becomes fully operational. Either the microcontroller **104** or an external device can wake up the PDA **102** at any time. If the PDA **102** is not in a sleep mode when a pulse is received on the GPI line **206**, the pulse will operate as an interrupt to the PDA **102**. Also, the GPI line **206** can be used to allow the microcontroller **104** to wake up an external device. Thus, if an external device is in a sleep mode, the external device can be activated by receiving a pulse on the GPI line **206** from the microcontroller **104**.

The transmit data line **202** carries an active low TTL signal from the primary serial port **106** to the buffer **108**. The buffer **108** transforms the TTL signal on the transmit data line **202** to a differential signal on the transmit data lines **212** and **214**. The transmit data lines **212** and **214** are connected between the buffer **108** and the serial port **110**. The handshake-out line **208** carries the handshake-out signal from the primary serial port **106** to the buffer **108**. The buffer **108** generates a signal on the handshake-out line **216** in response to the signal on the handshake-out line **208**. The handshake-out line **216** is connected between the buffer **108** and the serial port **110**. The output port **200** generates a signal on the transmit enable line **226**, which is connected to the buffer **108**. This signal enables or disables the gates in the buffer **108** that generate the signals on the transmit data lines **212** and **214** and on the handshake-out line **216**. Thus, the serial port **110** receives the active low transmit data signal and the handshake-out signal from the primary serial port **106** only if the signal on the transmit enable line **228** is active.

If an external device is connected to the serial port **110**, the external device applies a signal through the serial port **110** to the handshake-in line **218**. The handshake-in line **218** is connected between the serial port **110** and the buffer **108**. The buffer **108** generates a signal on the handshake-in line **204** in response to the signal on the handshake-in line **218**. The handshake-in line **204** is connected between the buffer **108** and the primary serial port **106**. If an external device is connected to the serial port **110**, the external device generates a differential signal through the serial port **110** to the receive data lines **220** and **222**. The receive data lines **220** and **222** are connected between the serial port **110** and the buffer **108**. The buffer **108** generates a TTL signal on the receive data line **210** in response to the differential signal on the receive data lines **220** and **222**. The output port **200** generates a signal on the receive enable line **224**, which is connected to the buffer **108**. This signal enables or disables the gates in the buffer **108** that generate the signals on the handshake-in line **204** and on the receive data line **210**. Thus, by controlling the signal on the receive enable line **224**, the microcontroller **104** can determine whether the handshake-in signals and the receive data signals from an external device are communicated through to the primary serial port **106**. A person of skill in the art will understand the operation of the handshake and data signals between the serial port **110** and the primary serial port **106** for providing a serial interface between an external device and the PDA **102**.

If the microcontroller **104** needs to use the serial interface between the microcontroller **104** and the PDA **102**, the microcontroller **104** causes the signals on the transmit enable line **226** and on the receive enable line **224** to become inactive. This disables the serial interface between the external device at the serial port **110** and the PDA **102** at the primary serial port **106**. Whenever the microcontroller **104** does not need to use the serial interface with the PDA **102**, the microcontroller **104** sets the signals on the transmit enable line **226** and on the receive enable line **224** to active levels. This enables the buffer **108** and the serial interface between the external device at the serial port **110** and the PDA **102** at the primary serial port **106**.

FIG. **6** is a more detailed functional block diagram of the interface between the microcontroller **104** and the phone modem **114**. This interface comprises the microcontroller **104**, the decoder/multiplexer **112**, the phone modem **114**, the DAA **116**, the phone jack **118**, the output port **200**, a sound transducer **330**, a lightning suppressor **300**, the set of three address lines **228**, the data line **230**, the write enable line **232**, a set of two handshake-out lines **302** and **310**, a set of two transmit data lines **304** and **312**, a set of two handshake-in lines **306** and **314**, a set of two receive data lines **308** and **316**, a transmit line **318**, a receive line **320**, an off-hook line **322**, a set of two ring indicator lines **324** and **332**, a tip line **326**, a ring line **328**, an audio line **336** and an enable modem line **334**.

The microcontroller **104** generates signals on the handshake-out line **302** and on the transmit data line **304**. The microcontroller **104** also receives signals on the handshake-in line **306** and on the receive data line **308**. The handshake-out line **302**, the transmit data line **304**, the handshake-in line **306** and the receive data line **308** are connected between the microcontroller **104** and the decoder/multiplexer **112**. As described above with reference to FIG. 4, if the phone modem **114** is selected for communication with the microcontroller **104**, the decoder/multiplexer **112** transfers the signal on the handshake-out line **302** to the handshake-out line **310**; it transfers the signal on the transmit data line **304** to the transmit data line **312**; it transfers a signal on the handshake-in line **314** to the handshake-in line **306**; and it transfers a signal on the receive data line **316** to the receive data line **308**. The handshake-out line **310** is connected between the decoder/multiplexer **112** and a ready-to-send input of the phone modem **114**. The transmit data line **312** is connected between the decoder/multiplexer **112** and a transmit data input of the phone modem **114**. The handshake-in line **314** is connected between a clear-to-send output of the phone modem **114** and the decoder/multiplexer **112**. The receive data line **316** is connected between a receive data output of the phone modem **114** and the decoder/multiplexer **112**. A person of skill in the art will understand that the handshake-out lines **302, 310**, the transmit data lines **304, 312**, the handshake-in lines **306, 314** and the receive data lines **308, 316** form a serial interface between the microcontroller **104** and the phone modem **114**.

In the preferred embodiments, the phone modem **114** comprises a Rockwell SM224ATF single-chip modem. This phone modem **114** can perform standard facsimile and modem functions and is controlled using a standard Hayes® compatible protocol. In an alternative embodiment, the phone modem **114** also generates and receives a pair of analog audio signals. These audio signals can be applied to lines connected between the phone modem **114** and the cellular telephone **126**. In this alternative embodiment, information can be transferred between the cellular telephone **126** and the microcontroller **104** and between the cellular telephone **126** and the phone modem **114**.

The transmit line **318**, the receive line **320**, the off-hook line **322** and the ring indicator line **324**, are connected between the phone modem **114** and the DAA **116**. The phone modem **114** applies data to the transmit line **318**, while the DAA **116** applies received data to the receive line **320**. The DAA **116** activates a signal on the ring indicator line **324** to alert the phone modem **114** to an incoming phone call. The phone modem **114** activates the signal on the off-hook line **322** to cause the DAA **116** to activate the telephone connection. A person of skill in the art will understand the operation of the interface between the phone modem **114** and the DAA **116**, as well as the operation of the DAA **116**.

The ring indicator line **332** is connected between the phone modem **114** and the microcontroller **104**. The phone modem **114** activates a signal on the ring indicator line **332** in response to an active signal on the ring indicator line **324** from the DAA **116**. The microcontroller **104** receives the signal on the ring indicator line **332** at a modem ring indicator input of the microcontroller **104**. The modem enable line **334** is connected between a DTR input of the phone modem **114** and one of the eight output signals generated by the output port **200**. As described above, the microcontroller **104** controls the output signals of the output port **200** by controlling the set of three address lines **228**, the data line **230** and the write enable line **232**. The microcontroller **104** activates the signal on the modem enable line **334** to enable the phone modem **114** to send or receive data. The audio line **336** is connected between the phone modem **114** and the sound transducer **330**. The phone modem **114** generates a signal on the audio line **336** to activate the sound transducer **330** to provide audio indicators to the user of the PDA **102**. The tip line **326** and the ring line **328** are each connected between the DAA **116**, the phone jack **118** and the surge suppressor **300**. A person of skill in the art will understand the operation of the tip and ring signals for incoming and outgoing calls. The lightning suppressor **300** protects the DAA **116** from voltage spikes on the telephone lines caused by lightning. The phone jack **118** is mounted at an outside surface of the communication device **100**, as illustrated in FIGS. **2** and **3**.

FIG. **7** is a more detailed functional block diagram of the interface between the microcontroller **104** and the GPS engine **120**. This interface comprises the microcontroller **104**, the decoder/multiplexer **112**, the GPS engine **120**, the GPS antenna **123**, the output port **200**, the set of three address lines **228**, the data line **230**, the write enable line **232**, the transmit data line **304**, a transmit data line **400**, the handshake-in line **306**, a handshake-in line **402**, the receive data line **308**, a receive data line **404**, a GPS antenna line **406** and an enable GPS line **408**.

The microcontroller **104** generates a signal on the transmit data line **304**, which is connected between the microcontroller **104** and the decoder/multiplexer **112**. The microcontroller **104** also receives signals on the handshake-in line **306** and on the receive data line **308**, which are also connected between the microcontroller **104** and the decoder/multiplexer **112**. As described above with reference to FIG. **4**, if the GPS **120** is selected for communication with the microcontroller **104**, the decoder/multiplexer **112** transfers the signal on the transmit data line **304** to the transmit data line **400**; it transfers a signal on the handshake line **402** to the handshake-in line **306**; and it transfers a signal on the receive data line **404** to the receive data line **308**. The transmit data line **400** is connected between the decoder/multiplexer **112** and a transmit data input of the GPS engine **120**. The handshake-in line **402** is connected between a time mark output of the GPS engine **120** and the decoder/multiplexer **112**. The receive data line **404** is connected between a receive data output of the GPS engine **120** and the decoder/multiplexer **112**. A person of skill in the art will understand that the transmit data lines **304**, **400**, the handshake-in lines **306**, **402** and the receive data lines **308**, **404** form a serial interface between the microcontroller **104** and the GPS engine **120**.

The GPS engine **120** comprises a Rockwell NavCore® VI MicroTracker™ Global Positioning System circuit card. The GPS engine **120** receives commands from the microcontroller **104** over the transmit data lines **304** and **400**. The microcontroller **104** can use these commands to control a number of aspects of the operation of the GPS engine **120**, such as a selection of the satellites utilized for computing the location of the communication device **100** and the frequency at which the GPS engine **120** makes this computation. The GPS antenna **123** receives electromagnetic signals transmitted from GPS satellites. The GPS antenna **123** applies these signals to the GPS antenna line **406** connected between the GPS antenna **123** and the GPS engine **120**. The GPS engine **120** utilizes the signals received from the satellites to calculate the location of the communication device **100** in terms of longitude, latitude and altitude. The GPS enable line **408** is connected between the output port **200** and the GPS engine **120**. The output port **200** applies one of its eight output signals to the GPS enable line **408**. As described above with reference to FIG. 4, the microcontroller **104** controls the GPS enable line **408** by controlling the set of three address lines **228**, the data line **230** and the write enable line **232**. The microcontroller **104** enables the GPS engine **120** to send commands to the GPS engine **120** or receive data back from the GPS engine **120**.

FIG. **8** is a more detailed functional block diagram of the interface between the microcontroller **104** and either the packet radio **124** or the cellular telephone **126**, whichever communication circuit is inserted. This interface comprises the microcontroller **104**, the decoder/multiplexer **112**, the packet radio **124**, the cellular telephone **126**, the packet radio antenna **122**, the cellular telephone antenna **121**, the microphone amplifier **128**, the earphone amplifier **130**, the microphone and earphone jack **132**, the output port **200**, the set of three address lines **228**, the data line **230**, the write enable line **232**, the handshake-out line **302**, a handshake-out line **500**, the transmit data line **304**, a transmit data line **502**, the handshake-in line **306**, a handshake-in line **504**, the receive data line **308**, a receive data line **506**, a packet radio antenna line **508**, a ring indicator line **510**, a cellular telephone antenna line **514**, a cellular telephone/packet radio enable line **512**, a set of two microphone audio lines **516** and **522**, an LPS control line **518**, and a set of two earphone audio lines **520** and **524**.

The microcontroller **104** generates signals on the handshake-out line **302** and on the transmit data line **304**, which are connected between the microcontroller **104** and the decoder/multiplexer **112**. The microcontroller **104** also receives signals on the handshake-in line **306** and on the receive data line **308**, which are also connected between the microcontroller **104** and the decoder/multiplexer **112**. As described above with reference to FIG. **4**, if the packet radio **124** or the cellular telephone **126** is selected for communication with the microcontroller **104**, the decoder/multiplexer **112** transfers the signal on the handshake-out line **302** to the handshake-out line **500**; it transfers the signal on the transmit data line **304** to the transmit data line **502**; it transfers a signal on the handshake-in line **504** to the handshake-in line **306**; and it transfers a signal on the receive data line **506** to the receive data line **308**. The handshake-out line **500** is connected between the decoder/multiplexer **112** and a ready-to-send input of the packet radio **124**. The transmit data line **502** is connected between the decoder/multiplexer **112** and a transmit data input of the packet radio **124** or a DTMS input of the cellular telephone **126**. The handshake-in line **504** is connected between a clear-to-send output of the packet radio **124** or an SWDC5 output of the cellular telephone **126** and the decoder/multiplexer **112**. The receive data line **506** is connected between a receive data output of the packet radio **124** or a DFMS output of the cellular telephone **126** and the decoder/multiplexer **112**. A person of skill in the art will understand that the handshake-out lines **302**, **500**, the transmit data lines **304**,**502**, the handshake-in lines **306**,**504** and the receive data lines **308**, **506** form a serial interface between the microcontroller **104** and either the packet radio **124** or the cellular telephone **126**.

In the preferred embodiments, the packet radio **124** comprises a GE/Ericson Moby Pack. The packet radio **124** is connected to the antenna **122** by the packet radio line **508**. The microcontroller **104** sends control commands and packets of data to the packet radio **124** over the above-described serial interface. The packet radio **124** generates a signal on the antenna line **508** to the antenna **122** to transmit the data to a base unit, as is well-known in the art. The antenna **122** also receives data from base units and applies the data to the antenna line **508**. The packet radio **124** receives this data and relays the data to the microcontroller **104** over the above-described serial interface. When the packet radio **124** initially receives data from a remote source, the packet radio **124** activates a ring indicator output signal. The ring indicator output signal is applied to the ring indicator line **510** connected between the packet radio **124** and the microcontroller **104**. This signal alerts the microcontroller **104** to receive the incoming data.

The cellular telephone/packet radio enable line **512** is connected between the output port **200** and a DTR input of the packet radio **124** or an ON SRQ input of the cellular telephone **126**. The DTR input of the packet radio **124** is active low, while the ON SRQ input of the cellular telephone **126** is active high. Thus, when the signal on the cellular telephone/packet radio enable line **512** is low, the packet radio **124** is enabled and the cellular telephone **126** is disabled. Conversely, when the signal is high, the packet radio **124** is disabled and the cellular telephone **126** is enabled. Thus, it is necessary for the microcontroller **104** to send the correct enable signal to whichever communication circuit (either the packet radio **124** or the cellular telephone **126**) is installed in order to activate the installed circuit. This helps preclude having the wrong software attempt to operate the installed circuit. This signal is one of the eight output signals of the output port **200**. As described above, the microcontroller **104** can control this signal by controlling the set of address lines **228**, the data line **230** and the write enable line **232**. Thus, the microcontroller **104** can enable the desired communication circuit **124** or **126**.

In the preferred embodiments, the cellular telephone **126** comprises a GE/Ericson Mary Beth circuit card. The microphone and earphone jack **132** is mounted at an outside surface of the communication device **100**, as illustrated in FIGS. **2** and **3**. An external microphone and earphone set can be plugged into the microphone and earphone jack **132** to allow a telephone conversation between the user of the PDA **102** and a remote party, using the cellular telephone **126**. The external microphone applies an audio signal to the audio line **522**, through the microphone and earphone jack **132**. The audio line **522** is connected between the earphone amplifier **128** and the microphone and earphone jack **132**. The microphone amplifier **128** receives the signal on the audio line **522** and amplifies the signal to generate a signal on the audio line **516**. The audio line **516** is connected between the microphone amplifier **128** and the cellular telephone **126**. The cellular telephone **126** then receives the audio signal from the audio line **516**.

The cellular telephone **126** generates a signal on the cellular telephone antenna line **514** that is connected to the antenna **121**, for transmission to a cellular cell site. The signal generated by the cellular telephone **126** on the antenna line **514** represents audio signals received from the microphone and earphone jack **132**.

The antenna **121** also receives signals from the cellular cell site and applies these signals to the antenna line **514**. The cellular telephone **126** receives the signal on the line **514** and, in response thereto, generates an audio signal on the earphone audio line **520**. The audio line **520** is connected between the cellular telephone **126** and the earphone amplifier **130**. The earphone amplifier **130** amplifies the signal on the audio line **520** and generates a new signal on the audio line **524**. The audio line **524** is connected between the earphone amplifier **130** and the microphone and earphone jack **132**. The signal on the audio line **524** drives the external earphone connected to the microphone and earphone jack **132** to allow the user of the PDA **102** to listen to a remote party.

The cellular telephone **126** receives commands from the microcontroller **104** over the transmit data lines **302** and **502** to control the operation of the cellular telephone **126**. The cellular telephone **126** also communicates information to the microcontroller **104** via the above-described serial interface.

The LPS control line **518** is connected to the microphone amplifier **128**, the earphone amplifier **130** and the ring indicator line **510**. The cellular telephone **126** activates a signal on the LPS control line **518** in response to either a command from the microcontroller **104** or in response to receiving an incoming telephone call. An active signal on the LPS control line **518** enables the amplifiers **128** and **130**. In addition, an active signal on the LPS control line **518** is received at a ring indicator input of the microcontroller **104**, over the ring indicator line **510**. Thus, the cellular telephone **126** alerts the microcontroller **104** upon receiving an incoming call.

FIGS. **9A**, **9B** and **9C** illustrate a flow chart representing the software that is executed by the microcontroller **104** of the communication device **100**. When the communication device **100** is initially powered up, the microcontroller **104** begins executing at a block **600**, as shown in FIG. **9A**. At a process block **602**, the microcontroller **104** accesses the ROM **134** and loads small portions of the software into random access memory (RAM) inside the microcontroller **104**. Preferably, the software routines that are loaded into internal RAM are the routines that are generally executed most frequently. The microcontroller **104** executes routines that are not loaded into RAM by directly accessing the ROM **134**.

At a process block **604**, the microcontroller **104** sends messages over each of the above-described serial interfaces between the microcontroller **104** and the communication circuits **114**, **120**, **124**, **126**. The microcontroller **104** waits for a response from each of the communication circuits **114**, **120**, **124**, **126**. This exchange of messages allows the microcontroller **104** to determine which of the communication circuits **114**, **120**, **124**, **126** have been installed inside the communication device **100**.

At a process block **606**, the microcontroller **104** sends a message to the PDA **102** over the primary serial port **106**. The response from the PDA **102** indicates whether software must be uploaded to the PDA **102**. Upon receiving this response from the PDA **102**, the microcontroller **104** proceeds to a process block **608**. At the process block **608**, the microcontroller **104** reads code from the ROM **134** and transfers it to the PDA **102** over the primary serial port **106**, if the previous response from the PDA **102** indicated that an upload was necessary. The required software can be uploaded to the PDA **102** by an appropriate method, as required by the PDA **102**. For example, the Apple™ Newton™ has a well-defined method for uploading software from its serial port. As described above, the software that is uploaded to the PDA **102** provides the user of the PDA **102** with access to the functions provided by the communication device **100**. The software uploaded into the PDA **102** provides an interface with the hardware and the software of the communication device **100**.

At a process block **610**, the microcontroller **104** sends messages to any attached external devices through the pass-thru serial port **110**. Each of the attached external devices, if any, responds to the microcontroller **104** through the pass-thru serial port **110**. These responses allow the microcontroller **104** to determine the types of external devices that are attached to the pass-thru serial port **110**.

The microcontroller **104** proceeds to a process block **612**. As described above, the ROM **134** may contain code that can be downloaded to external devices through the pass-thru serial port **110**. If the ROM **134** contains code for one or more of the attached external devices, and one or more of those attached external devices require a software download, the microcontroller **104** reads the appropriate code from the ROM **134** and transfers it to the appropriate external devices through the pass-thru serial port **110**.

At a process block **614**, the microcontroller **104** initializes each of the installed communication circuits **114**, **120**, **124**,**126**, as required. For example, the microcontroller **104** may initiate a warm start in the GPS engine **120** by sending an appropriate command over the serial interface connecting the microcontroller **104** with the GPS engine **120**. This warm start allows the GPS engine **120** to respond more quickly to a request from the PDA **102** for location data. As another example, the microcontroller **104** may send appropriate commands to program the cellular telephone **126**, if the cellular telephone **126** has not yet been programmed.

At a process block **616**, as shown in FIG. **9B**, the microcontroller **104** powers up the phone modem **114** by activating the signal on the modem enable line **334**, as shown in FIG. **6**. At a process block **618**, the microcontroller **104** causes the decoder/multiplexer **112** to select the phone modem **114** for on-line operation by applying appropriate signals to the select lines **140** and **142**, as shown in FIG. **4**.

At a process block **620**, the microcontroller **104** enters a monitor mode. In the monitor mode, the microcontroller **104** emulates a modem and relays data between the PDA **102** and the communication circuit **114**, **120**, **124**, **126** that is currently on-line, while monitoring the communication stream generated by the PDA **102** for escape codes. The microcontroller **104** continues to relay data between the PDA **102** and the on-line communication circuit **114**, **120**, **124**, **126**, until it receives either an escape code from the PDA **102** or an interrupt from one of the communication circuits **114**, **120**, **124** or **126** that is not selected for on-line operation. The phone modem **114** can interrupt the microcontroller **104** by applying an active signal to the ring indicator line **332**, as shown in FIG. **6**. Either the packet radio **124** or the cellular telephone **126** can interrupt the microcontroller **104** by activating the signal on the ring indicator line **510**. Upon receiving either an escape code from the PDA **102** or an interrupt from an off-line communication circuit **114**, **120**, **124** or **126**, the microcontroller **104** advances to a decision block **622**.

At the decision block **622**, the microcontroller **104** determines whether it received an escape code or an interrupt. If the microcontroller **104** received an escape code, then the microcontroller **104** advances to a process block **624**. Otherwise, the microcontroller **104** advances to a decision block **628**, as shown on FIG. **9C**. At the process block **624**, the microcontroller **104** reports any prior interrupts that have not yet been reported to the PDA **102**. Specifically, the microcontroller **104** sends a message to the PDA **102** indicating which communication circuits **114**,**120**,**124** or **126** have interrupted the microcontroller **104**. After reporting the prior interrupts, the microcontroller **104** advances to a process block **626**.

At the process block **626**, the microcontroller **104** enters a command mode. In this mode, the PDA **102** can send a series of commands to the microcontroller **104** for controlling the communication circuits **114**, **120**, **124** and **126**. Examples of possible commands that can be sent to the microcontroller **104** include commands to power off the communication device **100**, to wake up the PDA **102** upon receipt of an incoming cellular call, to select a communication circuit **114**, **120**, **124**, **126** for on-line operation, to idle at low power and to check different status conditions. The microcontroller **104** continues to execute commands received from the PDA **102** until the microcontroller **104** has selected a communication circuit **114**, **120**, **124** or **126** for on-line operation in response to a command from the PDA **102**. At this point, the microcontroller **104** returns to the process block **620**.

At the decision block **628**, the microcontroller **104** checks the service response code for the communication circuit **114**, **120**, **124** or **126** that generated the interrupt. The service response code indicates whether there are any actions that the microcontroller **104** should automatically perform in response to the interrupt. If the service response code indicates that the interrupt does not require service, then the microcontroller **104** advances to a decision block **636**. If the service response code indicates that the interrupt does require servicing, then the microcontroller **104** advances to a process block **630**.

At the process block **630**, the microcontroller **104** disables the serial interface between the PDA **102** and the communication circuit **114**,**120**, **124** or **126** that is currently selected for on-line operation. The microcontroller **104** disables this interface using the handshake lines **204**, **208**, **302** and **306**, as is well known in the art. At a decision block **632**, the microcontroller **104** performs the appropriate steps to service the current interrupt from the communication circuit **114**,**120**, **124** or **126**. The steps performed during the process block **632** depend on the particular communication circuit **114**, **120**, **124** or **126** generating the interrupt and on the instructions that have been previously received from the PDA **102** related to the particular communication circuit **114**, **120**, **124** or **126**. For example, the cellular telephone **126** generates an interrupt to the microcontroller **104** on the ring indicator line **510** upon receiving an incoming call. If the PDA **102** has previously set the cellular telephone **126** to an automatic answering mode inside the microcontroller **104**, the microcontroller **104** causes the cellular telephone **126** to answer the incoming call during the process block **632**. Specifically, the microcontroller **104** temporarily disables the interface between the PDA **102** and the communication circuit **114**, **120** or **124** that has been selected for on-line operation and causes the decoder/multiplexer **112** to select the cellular telephone **126**. The microcontroller **104** then generates appropriate commands to cause the cellular telephone **126** to answer the incoming call. The user of the PDA **102** can then begin a telephone conversation with the remote caller using an external microphone and earphone connected to the microphone and earphone jack **132**. After controlling the cellular telephone **126** to answer the incoming call, the microcontroller **104** controls the decoder/multiplexer **112** to again select the communication circuit **114**, **120** or **124** that had previously been selected for on-line operation. At a process block **634**, the microcontroller **104** again enables the interface between the PDA **102** and the communication circuit **114**,**120**, **124** or **126** by controlling the handshake lines **204**,**208**, **302** and **306**. After the process block **634**, the microcontroller **104** advances to the decision block **636**.

At the decision block **636**, the microcontroller **104** checks the interrupt response code corresponding to the communication circuit **114**,**120**,**124** or **126** that generated the interrupt. The interrupt response code has been previously set by the PDA **102** by a command to the microcontroller **104**. The interrupt response code indicates whether the microcontroller **104** should immediately interrupt the PDA **102**, whether it should cause a delayed interrupt of the PDA **102**, or whether it should not interrupt the PDA **102** at all. If the interrupt response code indicates that the microcontroller **104** should not interrupt the PDA **102**, the microcontroller **104** returns to the process block **620**. If the interrupt response code indicates that the microcontroller **104** should immediately interrupt the PDA **102**, then the microcontroller **104** advances to a process block **640**. If the interrupt response code indicates that the microcontroller **104** should perform a delayed interrupt, the microcontroller **104** advances to a process block **638**. At the process block **638**, the microcontroller **104** monitors the communication stream between the PDA **102** and the communication circuit **114**, **120**,**124** or **126** that has been selected for on-line operation. When the microcontroller **104** detects a break in the communication stream, the microcontroller **104** advances to the process block **640**. At the process block **640**, the microcontroller **104** activates the GPI line **206**, illustrated in FIG. **5**, to cause an interrupt to the PDA **102**. The response of the PDA **102** to the interrupt on the GPI line **206** depends on the application program running on the PDA **102**, if any. After the process block **640**, the microcontroller **104** returns to the process block **620** of FIG. **9B**.

As discussed above, the PDA **102** executes software that allows the PDA **102** to interface with and control the communication device **100**. This software sends commands to the microcontroller **104** when the microcontroller **104** is in the command mode, and it sends data to the on-line communication circuit **114**, **120**, **124**, **126** when the microcontroller **104** is in the monitor mode. The format and the content of the data sent to the different communication circuits **114**,**120**,**124**,**126** complies with the requirements of the particular communication circuits **114**, **120**, **124**, **126**. For example, the data sent to the phone modem **114** complies with the standard Hayes® format for modems.

As described above, the communication software for the PDA **102** is uploaded to the PDA **102** from the ROM **134**, and the software extends the capabilities of the PDA **102**. As an example, the software is described in terms of using an Apple™ Newton® as the PDA **102**. In this case, the system preferences are extended to provide user access to the functions of the communication device. For example, the standard functions of Print, Fax, Mail and Call are modified to operate the communication circuits **114**, **120**, **124**, **126** of the communication device **100**. Thus, the Call function places a cellular telephone call if the cellular telephone **126** is currently on-line. Alternatively, the Fax function sends a facsimile over the phone modem **114** if the phone modem is currently on-line. The system preferences are also extended to display information about the communication device **100**. For example, if a packet of data is received at the packet radio **124**, the In Box of the PDA **102** reflects the reception of this message.

Although extending the Newton system preferences provides a powerful interface with the communication device **100**, not all of the functions of the communication device **100** can be conveniently controlled by this method. Consequently, one or more application programs are also provided that allow more complete control of the functions of the communication device **100**. For example, one application program can be used to control different functions of the cellular telephone **126**, such as programming the cellular telephone **126** or placing a phone call.

The Intelligent Assistant™ of the Newton is also extended to understand commands for the communication device **100**. Thus, for example, a user can write the phrase "Where am I?" on the LCD display **78** using the light pen **76**. The extended Intelligent Assistant™ understands this as a command to activate the GPS engine **120** to determine the current location of the communication device **100**. The PDA **102** generates the appropriate commands to the communication device **100** to obtain the requested data from the GPS engine **120**. The Intelligent Assistant™ preferably utilizes the above-described application programs to control many functions of the communication device **100**.

The software uploaded to the PDA **102** also includes proto end points, as defined by Apple™ specifications, that facilitate interfacing with the communication device **100** and controlling the operation of the communication device **100**. These proto end points can be used by other application programs to access the communication device **100**.

The portable multiple integrated communication device **100** of the present invention provides versatile utilization of the communication circuits **114**, **120**, **124**, **126**. Data is channeled from a communication circuit **114**, **120**, **124** or **126**, through the microcontroller **104**, to the PDA **102**. The data can then be rerouted to any of the other communication circuits **114**, **120**, **124**, **126**. This data flow versatility allows the different functions of the communication device **100** to be utilized in various combinations to provide numerous more complex functions. For example, the GPS engine **120** can be used in conjunction with the packet radio **124** to form an automated tracking system. The GPS engine **120** can periodically generate location data to the PDA **102**. This information can automatically be transmitted to an office computer using the packet radio **124**, providing personnel at the office with continuous access to data indicating the location of the communication device **100**, and consequently, the person using it. Also, in the alternative embodiment described above, involving a phone modem **114** that has analog audio input and output capabilities, data can be transferred directly between the cellular telephone **126** and the phone modem **114**, further expanding the possibilities. For example, digital data can be transmitted over the cellular interface by routing the data from the PDA **102**, through the microcontroller **104** and the phone modem **114**, to the cellular telephone **126**. The phone modem **114** converts the digital data into a format that is compatible with cellular technology.

The communication device **100** of the present invention can also be implemented with other optional devices or features. For example, an optional lamp **135**, as illustrated in FIG. **4**, can be controlled by the microcontroller **104** to illuminate the LCD display **78**. Also, other units can be used to replace the communication circuits **114, 120, 124, 126** of the present embodiment. These other units need not be communication circuits, either.

## Second Embodiment

FIGS. **10** to **15C** illustrate a second embodiment 100B of the portable multiple integrated communication device of the present invention. Many of the implementation details that have been described above with respect to the first embodiment 100 also apply to the second embodiment 100B. As a result, the present description of the second embodiment 100B focuses on differences between the two embodiments. A person of skill in the art can apply the more specific teachings described above with respect to the first embodiment 100 to the more general teachings described below with respect to the second embodiment 100B to fully implement the second embodiment 100B. For example, the communication device **100B** has a power supply that is similar to the power supply **146** of the communication device **100**, although FIGS. **10–15C** do not illustrate a power supply.

FIG. **10** illustrates a functional block diagram of the second embodiment communication device **100B** connected to a PDA **102B**. The PDA **102B** is the same as the PDA **102**, except that the program executed in the PDA **102B** to interface with the communication device **100B** is different in some respects from the program executed in the PDA **102** to interface with the communication device **100**.

The PDA **102B** comprises one or more application programs and an application server **710**. FIG. **10** illustrates a first application program **702**, a second application program **704** and a third application program **706**. Each of the application programs **702, 704, 706** is coupled to the application server **710**.

The communication device **100B** comprises a communication server **750**, the GPS engine **120**, the cellular telephone **126**, the phone modem **114**, a land phone **708**, the packet radio **124**, and the pass-thru or external serial port **110**. The application server **710** of the PDA **102B** is coupled to the communication server **750** of the communication device **100B** by a serial interface **701**. The serial interface **701** between the application server **710** and the communication server **750** corresponds to the serial interface between the PDA **102** and the primary serial port **106** of the first embodiment communication device **100**, as illustrated in FIG. **4**. The communication server **750** is coupled to the GPS engine **120** by a serial interface **703**. The communication server **750** is coupled to the cellular telephone **126** by a serial interface **705**. The communication server **750** is coupled to the phone modem **114** by a serial interface **707**. The communication server **750** is coupled to the packet radio **124** by a serial interface **709**. The communication server **750** is coupled to the external serial port **110** by a serial interface **711**. The phone modem **114** is also coupled to the land phone **708** and to the cellular telephone **126**.

Generally, the communication circuits **114, 120, 124, 126**, as well as the external serial port **110** are utilized for the same purposes as in the first embodiment communication device **100**. Each application program **702, 704, 706** can generally utilize any of the functions of the communication circuits **114, 120, 124, 126**. For example, the first application **702** may utilize the GPS engine **120** and the packet radio **124**, while the second application **704** utilizes the phone modem **114**. In the second embodiment communication device **100B**, the cellular telephone **126** and the packet radio **124** can be installed simultaneously. Thus, the second embodiment communication device **100B** includes both a cellular telephone antenna **121** and a packet radio antenna **122** (See FIG. 4). In fact, all of the communication circuits **114, 120, 124, 126** can be installed simultaneously.

To utilize the communication functions of the communication circuits **114, 120, 124, 126**, the applications **702, 704, 706** cause one or more data packets to be generated and communicated to the communication circuits **114,120,124, 126**. The data packets can contain commands to control the operation of the communication circuits **114, 120, 124, 126**, or the data packets can contain requests for data, or the data packets can contain data for transmission by an appropriate communication circuit **114,120,124,126**, such as the phone modem **114**, the packet radio **124**, or a device connected to the external serial port **110**. Each data packet also contains an address identifying the destination of the data packet. The destination can be any of the communication circuits **114, 120, 124,126**, or the external serial port **110**. The application server **710** generates data packets in response to function calls by the applications **702, 704, 706**. The application server **710** then transmits the data packets to the communication server **750**. The communication server **750** modifies the data packets before distributing the data packets to the appropriate communication circuits **114, 120, 124, 126**, or to the external serial port **110**. For example, the application **704** may cause the application server **710** to generate a data packet that requests positional data from the GPS engine **120**. The application server **710** transmits the data packet to the communication server **750**. The communication server **750** modifies the data packet before forwarding the data packet to the GPS engine **120**.

The communication circuits **114, 120, 124, 126** and devices connected to the external serial port **110** also generate data packets for transmission to one or more of the applications **702, 704, 706**. Each of the data packets identifies the type of data contained therein. The packet radio **124**, for example, may generate a data packet containing data that has been received from a remote source. The communication circuits **114, 120, 124, 126** and the external serial port **110** transmit the data packets to the communication server **750**. The communication server **750** modifies the data packets and transmits them to the application server **710**, which also modifies the data packets. The application server **710** also determines which applications **702,704, 706** have requested data of the type contained in a data packet, and sends the data packet to the appropriate applications **702, 704, 706**.

As an additional example of the general operation of the PDA **102B** and the communication device **100B**, suppose that a user of the PDA **102B** wants to send data to a remote location using the phone modem **114** and the land phone **708**. The user can control one of the application programs **702, 704, 706**, such as the first application **702** to control the phone modem **114**. The first application **702** first generates one or more data packets to initialize the phone modem **114** and to dial the desired phone number through the land phone **708**. Next, the first application **702** sends one or more additional data packets containing the data to be transmitted. The application server **710** transmits each of the data packets to the communication server **750**, which modifies the data packets and routes them to the phone modem **114**. The phone modem **114** responds to the data packets to establish the requested communication with the remote location using the land phone **708**. The phone modem **114** then transmits the supplied data.

FIG. **11** is a functional block diagram of the application server **710** of FIG. **10**. The application server **710** comprises a set of service routines **712**, a set of interface units **714**, and an arbitrator **716**. The set of service routines **712** comprises a telephone server **730**, a fax server **732**, an e-mail server **734**, a course deviation indicator server **736**, and a packet data server **738**. The set of interface units **714** comprises a GPS interface **718**, a cellular telephone interface **720**, a phone modem interface **722**, a land phone interface **724**, a packet radio interface **726**, and an external serial interface **728**. The arbitrator **716** comprises an application packet interface **740**, an application packet distributor **742**, a registry table **744**, and a registration unit **746**.

Each of the applications **702, 704, 706** is coupled to each of the service routines **730, 732, 734, 736, 738** and to each of the interface units **718, 720, 722, 724, 726, 728**. The telephone server **730** is coupled to the cellular telephone interface **720** and the land phone interface **724**. The fax server **732** is coupled to the cellular telephone interface **720**, the phone modem interface **722**, and the land phone interface **724**. The e-mail server **734** is coupled to the phone modem interface **722**. The course deviation indicator server **736** is coupled to the GPS interface **718**. The packet data server **738** is coupled to the packet radio interface **726**. Each of the interface units **718, 720, 722, 724, 726, 728** is coupled to the application packet interface **740**, the application packet distributor **742**, and the registration unit **746**. The registration unit **746** is coupled to the registry table **744**, which is coupled to the application packet distributor **742**. The application packet distributor **742** is coupled to the application packet interface **740**, which is coupled to the communication server **750** by the serial interface **701**. The application packet distributor **742** is also coupled to each of the applications **702, 704, 706**.

FIG. **12** illustrates a software functional block diagram of the communication server **750** of FIG. **10**. The communication server **750** comprises a communication packet interface **752**, a communication packet distributor **754**, a generic GPS emulator **756**, a generic cellular emulator **758**, a generic modem emulator **760**, and a generic packet radio emulator **762**. The communication packet interface **752** is coupled to the application server **710**, and, more specifically, to the application packet interface **740** by the serial interface **701**. The communication packet interface **752** is also coupled to the communication packet distributor **754**. The communication packet interface **752** is coupled to the generic GPS emulator **756**, the generic cellular emulator **758**, the generic modem emulator **760**, and the generic packet radio emulator **762**. The communication packet distributor **754** is also coupled to the generic GPS emulator **756**, the generic cellular emulator **758**, the generic modem emulator **760**, and the generic packet radio emulator **762**. The communication packet interface **752** and the communication packet distributor **754** are also coupled to the external serial port **110** by the serial interface **711**. The generic GPS emulator **756** is coupled to the GPS engine **120** by the serial interface **703**. The generic cellular emulator **758** is coupled to the cellular telephone **126** by the serial interface **705**. The generic modem emulator **760** is coupled to the phone modem **114** by the serial interface **707**. The generic packet radio emulator **762** is coupled to the packet radio **124** by the serial interface **709**.

Each generic emulator **756, 758, 760, 762** provides a common software interface to the application server **710** regardless of the specific model of communication circuit **114, 120, 124, 126** that implements a given communication function. For example, the generic GPS emulator **756** provides the same software interface to the application server **710** whether the GPS engine **120** is a Rockwell NavCore® VI MicroTracker™ GPS circuit card, or some other GPS circuit card, made by Rockwell or another manufacturer. The application server **710** can send the same format data packets to the generic GPS emulator **756** no matter which model of GPS engine **120** is utilized. The generic GPS emulator **756** determines the model of GPS engine **120** that is attached to the communication device **100B** and reformats received data packets to conform to the format required by the attached model. Similarly, the generic cellular emulator **758**, the generic modem emulator **760**, and the generic packet radio emulator **762** reformat received data packets to conform to the requirements of the specific models of communication circuits **126, 114, 124** that are attached.

The communication packet interface **752** receives data packets from the application packet interface **740** over the serial interface **701** and transfers the data packets to the communication packet distributor **754**. The communication packet distributor **754** reads the destination address of the data packets and transfers each of the data packets to the appropriate generic emulator **756, 758, 760, 762,** or to the external serial port **110**. For example, if the destination address of a data packet identifies the packet radio **124**, the communication packet distributor **754** transfers the data packet to the generic packet radio emulator **762**. If the destination address identifies a device connected to the external serial port **110**, the communication packet distributor **754** transfers the data packet to the external serial port **110**. The generic emulators **756, 758, 760, 762** reformat any received data packets before transferring them to the addressed communication circuits **114, 120, 124, 126**.

The generic emulators **756, 758, 760, 762** also receive data packets from the corresponding communication circuits **114, 120, 124, 126**. The data packets received from the communication circuits **114,120, 124,126** are in formats that are specific to the particular models of communication circuits **114, 120, 124, 126** that are attached to the communication device **100B**. Each of the generic emulators **756, 758, 760, 762** reformats the received data packets into a generic format. For example, the Rockwell NavCore® VI MicroTracker™ GPS circuit card generates data packets that have a format that may be unique to that particular model of GPS engine **120**. The generic GPS emulator **756** reformats data packets received from the Rockwell NavCore® VI MicroTracker™ GPS circuit card into the same pre-defined generic format that is used for other models of the GPS engine **120**. Thus, the formats of the data packets generated by the generic emulators **756, 758, 760, 762** are independent of the particular models of communication circuits **114, 120, 124, 126** that are attached to the communication device **100B**. The communication packet interface **752** receives data packets from each of the generic emulators **756,758, 760,762** and from the external serial port **110** and transmits the data packets to the application packet interface **740** over the serial interface **701**.

The interface units **718, 720, 722, 724, 726, 728** generate data packets in response to user control of the applications **702, 704, 706** directly, or through the set of service routines **730, 732, 734, 736, 738**. The data packets generated by the interface units **718, 720, 722,724,726,728** conform to the requirements of corresponding generic emulators **756, 758, 760, 762** or to the requirements of devices connected to the external serial port **110**. Specifically, the GPS interface **718** generates data packets according to the requirements of the generic GPS emulator **756**, the cellular telephone interface **720** generates data packets according to the requirements of the generic cellular emulator **758**, the phone modem interface **722** and the land phone interface **724** generate data packets according to the requirements of the generic modem emulator **760**, the packet radio interface **726** generates data packets according to the requirements of the generic packet radio emulator **762**, and the external serial interface **728** generates data packets according to the requirements of the devices that are connected to the external serial port **110**. The data packets that are generated by the interface units **718**, **720**, **722**, **724**, **726**, **728** are sent to the application packet interface **740**, which transmits the data packets to the communication packet interface **752**, over the serial interface **701**.

The applications **702**, **704**, **706** can interact directly with the interface units **718**, **720**, **722**, **724**, **726**, **728** to cause the interface units **718**, **720**, **722**, **724**, **726**, **728** to generate the desired data packets. For example, the application **704** can call a routine or method within the cellular telephone interface **720** that causes the cellular telephone interface **720** to generate a data packet to cause the cellular telephone **126** to dial a specified telephone number. Alternatively, the applications **702**, **704**, **706** can utilize the service routines **730**, **732**, **734**, **736**, **738** to assist in the control of the communication circuits **114**, **120**, **124**, **126**. The service routines **730**, **732**, **734**, **736**, **738** implement many of the same functions that are provided directly from the interface units **718**, **720**, **722**, **724**, **726**, **728**. However, the functions of the service routines **730**, **732**, **734**, **736**, **738** are arranged in a functional manner for the convenience of the user. For example, a user can select a function to dial a phone number from the telephone server **730**, and the telephone server **730** either causes the cellular telephone interface **720** to generate a data packet for the cellular telephone **126**, or it causes the land phone interface **724** to generate a data packet for the land telephone **708**, depending on which type of telephone has been previously selected for operation.

Also, as described above, the application packet interface **740** receives generic data packets from the communication packet interface **752**. The application packet interface **740** provides the received data packets to the application packet distributor **742**. As described in greater detail below, with reference to FIGS. **15A** to **15C**, the application packet distributor **742** requests that the appropriate interface units **718**, **720**, **722**, **724**, **726**, **728** process the generic data packets to extract data required by the applications **702**, **704**, **706**. The application packet distributor **742** refers to the registry table **744** to determine which applications should receive the data packets after the data packets have been processed by the appropriate interface units **718**, **720**, **722**, **724**, **726**, **728**. The application packet distributor **742** sends the processed data packets directly to the appropriate applications **702**, **704**, **706**.

The telephone server **730** can be used to process incoming and outgoing phone calls using either the cellular telephone interface **720** or the land phone interface **724**, depending on which type of telephone interface has been previously selected. The telephone server **730** provides various functions to the applications **702**,**704**,**706**, such as allowing for the selection of a type of telephone interface for subsequent operations, dialing a telephone number, answering a call, terminating a phone connection, determining the current signal strength, redialing the last dialed number, setting the volume level for an attached earphone, setting a volume level for the ringer of the selected telephone **126**, **708**, sending tones from the selected telephone **126**, **708**, determining the air time that has been consumed, determining the battery level of the communication device **100B**, determining the current roam state, and determining the current service state.

Similarly, the fax server **732** can be used to send and receive data using the phone modem interface **722** and either the cellular telephone interface **720** or the land phone interface **724**. The fax server **732** also provides functions such as allowing for the selection of a type of telephone interface for subsequent operations, powering on or off the phone modem **114**, dialing a telephone number, answering a call, sending or receiving a fax, controlling the phone modem **114** to automatically receive a fax, and terminating a phone connection.

The e-mail server **734** can be used to send and receive data using the phone modem interface **722**. The e-mail server **734** also provides functions such as powering on or off the phone modem **114**, sending or receiving an e-mail, and controlling the phone modem **114** to automatically receive an e-mail.

The course deviation indicator server **736** can be used to determine a user's current location or to obtain directions to a desired location using the GPS interface **718**. The course deviation indicator server **736** also provides functions such as determining whether a GPS engine **120** is present, powering on or off the GPS engine **120**, determining or setting the current operating state of the GPS engine **120**, and requesting periodic position data from the GPS engine **120**.

The packet data server **738** can be used to send and receive data using the packet radio interface **726**. The packet data server **738** also provides functions such as determining whether a packet radio **124** is attached to the communication device **100B**, powering on or off the packet radio **124**, causing the packet radio **124** to execute a cold start, determining and setting the operating mode of the packet radio **124**, determining the number of packets waiting to be read or transmitted, determining the signal strength, determining status results regarding the data packet link or regarding a specific transmission or reception, setting a channel for transmission or reception, and setting the packet radio **124** to automatically receive data packets.

The GPS interface **718** can be used to control the GPS engine **120** to determine the location of the PDA **102B** and the communication device **100B** to within **25** meters. The GPS interface **718** provides a number of functions, such as determining whether a GPS engine **120** is present, powering on or off the GPS engine **120**, determining the current battery level of the communication device **100B**, determining or setting the power management mode of the GPS engine **120**, determining or setting the current operating state of the GPS engine **120**, requesting periodic position data from the GPS engine **120**, requesting satellite information from the GPS engine **120**, and initiating a self test in the GPS engine **120**.

The cellular telephone interface **720** can be used for incoming and outgoing cellular phone calls. The cellular telephone interface **720** can also be used in conjunction with the phone modem interface **722** to send and receive data over a cellular link. The cellular telephone interface **720** provides functions such as determining whether a cellular telephone **126** is attached to the communication device **100B**, dialing a telephone number, answering a call, terminating a phone connection, determining the current signal strength, redialing the last dialed number, setting the volume level for an attached earphone, setting a volume level for the ringer of the cellular telephone **126**, sending tones from the cellular telephone **126**, determining the air time that has been consumed, determining the battery level of the communication device **100B**, determining the current roam state, determining the current service state.

The phone modem interface **722** is used in conjunction with either the cellular telephone interface **720** or the land phone interface **724** to send and receive data. The phone modem interface **722** also provides functions such as allowing for the selection of a type of telephone interface for subsequent operations, determining the battery level of the communication device **100B**, powering on or off the phone modem **114**, sending data or receiving data, sending a fax or receiving a fax, controlling the phone modem **114** to automatically receive data or a fax, providing a special escape sequence to cause the phone modem **114** to exit an on-line mode and return to a command mode, and generating AT commands to the phone modem **114**.

The land phone interface **724** is primarily used in conjunction with the phone modem interface **722** to send and receive data, and for voice calls. The land phone interface **724** also provides functions such as determining whether a land phone **708** is attached to the communication device **100B**, dialing a telephone number, answering a call, terminating a phone connection, determining the current signal strength, redialing the last dialed number, setting the volume level for an attached earphone, setting a volume level for the ringer of the land phone **708**, sending tones from the land phone **708**, determining the air time that has been consumed, and determining the battery level of the communication device **100B**.

The packet radio interface **726** provides access to the packet radio **124**, and implements functions such as determining whether a packet radio **124** is attached to the communication device **100B**, powering on or off the packet radio **124**, causing the packet radio **124** to execute a cold start, determining the battery level of the communication device **100B**, determining and setting the power management mode of the packet radio **124**, determining and setting the operating mode of the packet radio **124**, determining the number of packets waiting to be read or transmitted, determining the signal strength, determining status results regarding the data packet link or regarding a specific transmission or reception, setting a channel for transmission or reception, and setting the packet radio **124** to automatically receive data packets.

The external serial interface **728** provides access to devices connected to the external serial port **110**, and implements functions such as determining the battery level of the communication device **100B** and determining the state of the external serial port **110**.

Each of the interface units **718,720, 722,724,726,728** can also set the corresponding communication circuit **114, 120, 124, 126** or the external serial port **110** into a native mode that allows the communication circuits **114, 120, 124, 126** and the external serial port **110** to receive and execute commands that are similar to those that are described above with reference to the first embodiment communication device **100**.

FIG. **13** illustrates a hardware functional block diagram of the communication server **750** of FIG. **10**, along with the GPS engine **120**, the cellular telephone **126**, the phone modem **114**, the packet radio **124**, and the external serial port **110**. The communication server **750** comprises a RAM **770**, a microcontroller **772**, a ROM **774**, and a quad universal asynchronous receiver transmitter (quad UART) **776**. The quad UART 776 is coupled to the application packet interface **740** by the serial interface **701**. The quad UART **776** is connected to both the microcontroller **772** and the RAM **770** by a parallel interface **771**. The quad UART 776 is connected to the phone modem **114** by the serial interface **707**. The quad UART 776 is connected to the packet radio **124** by the serial interface **709**. The quad UART 776 is connected to the external serial port **110** by the serial interface **711**. The microcontroller **772** is connected to the ROM **774**. The microcontroller **772** is connected to the GPS engine **120** by the serial interface **703**. The microcontroller **772** is connected to the cellular telephone **126** by the serial interface **705**.

The microcontroller **772** preferably comprises an Intel® 80C320 microcontroller. The quad UART 776 preferably comprises a Startech ST16C454 quad UART. The RAM **770** preferably comprises a Fujitsu MB84256A 32Kx8 static RAM, or a similar device. The ROM **774** preferably comprises a Texas Instruments 29F010 128Kx8 flash memory, or a similar device.

The communication packet interface **752**, the communication packet distributor **754**, and the generic emulators **756, 758, 760, 762** are implemented in software inside the ROM **774** that is executed by the microcontroller **772**. The quad UART 776 effectively provides the microcontroller **772** with four additional serial ports. The microcontroller **772** receives data packets directly from the GPS engine **120** and the cellular telephone **126** via the serial interfaces **703, 705**. Generally, the slower communication circuits **114, 120, 124, 126** are connected directly to the microcontroller **772**. When the GPS engine **120** or the cellular telephone **126** transmits a data packet to the microcontroller **772**, the transmitting communication circuit **120, 126** generates a vectored interrupt to the microcontroller **772**. In response to the vectored interrupt, the microcontroller **772** receives the incoming data packet and stores the data in the RAM **770**. The microcontroller **772** processes the stored data packet and transfers the data packet to the quad UART 776 over the parallel interface **771** for transmission to the application packet interface **740** over the serial interface **701**.

The quad UART 776 receives data packets from the application packet interface **740** over the serial interface **701**, from the phone modem **114** over the serial interface **707**, from the packet radio **124** over the serial interface **709**, and from the external serial port **110** over the serial interface **711**. The quad UART 776 receives a single interrupt signal in connection with the receipt of any of the received data packets. The quad UART 776 polls the serial ports to determine which port has received a data packet. The quad UART 776 receives the data packet and transfers the data packet to the microcontroller **772**. The quad UART 776 interrupts the microcontroller **772** with a vectored interrupt indicative of the serial port that received the data packet. Thus, if the quad UART 776 receives a data packet from the packet radio **124** over the serial interface **709**, the quad UART **776** interrupts the microcontroller **772** using a vector that indicates to the microcontroller **772** that the data packet was received from the packet radio **124**. The microcontroller **772** processes data packets received from the phone modem **114**, the packet radio **124** and the external serial port **110** before returning the data packets to the quad UART 776 for transmission to the application packet interface **740** over the serial interface **701**.

The microcontroller **772** also processes data packets that have been received by the quad UART 776 over the serial interface **701**. After processing such a data packet, if the data packet is addressed to the GPS engine **120**, the microcontroller **772** transmits the data packet directly to the GPS engine **120** over the serial interface **703**. If the data packet is addressed to the cellular telephone **126**, the microcontroller **772** transmits the data packet directly to the cellular telephone **126** over the serial interface **705**. If the data packet is addressed to the phone modem **114**, the microcontroller **772** transfers the data packet to the quad UART 776 over the parallel interface **771**, which subsequently transmits the data packet to the phone modem **114** over the serial interface **707**. If the data packet is addressed to the packet radio **124**, the microcontroller **772** transfers the data packet to the quad UART 776 over the parallel interface **771**, which subsequently transmits the data packet to the packet radio **124** over the serial interface **709**. If the data packet is addressed to the external serial port **110**, the microcontroller **772** transfers the data packet to the quad UART 776 over the parallel interface **771**, which subsequently transmits the data packet to the external serial port **110** over the serial interface **711**. Data packets can also be addressed to the microcontroller **772** to control different aspects of the operation of the microcontroller **772**. For example, a data packet can be sent to the microcontroller **772** to control the selection of an interconnection between the cellular telephone **126**, the phone modem **114**, the microphone and earphone jack **132**, and the land phone **708**, as described in greater detail below with reference to FIG. **14**.

FIG. **14** illustrates a functional block diagram of the interface between the cellular telephone **126**, the phone modem **114**, the microphone and earphone jack **132**, and the land phone **708**. The land phone **708** comprises the DAA **116** and the phone jack **118**. FIG. **14** also illustrates a quad 4-to-1 multiplexer/decoder **780**, the microphone amplifier **128**, and the earphone amplifier **130**. In the second embodiment, the functionality of the quad 4-to-1 multiplexer/decoder **780** is implemented with a 74HC4053 multiplexer and a number of 74HC4066 electronic switches.

An output of the cellular telephone **126** is connected to a first input and a second input of a first 4:1 multiplexer of the multiplexer/decoder **780**. An output of the phone modem **114** is connected to a third input of the first multiplexer of the multiplexer/decoder **780**. An output of the microphone amplifier **128** is connected to a fourth input of the first multiplexer of the multiplexer/decoder **780**. An output of the first multiplexer of the multiplexer/decoder **780** is connected to an input of a first 1:4 decoder of the multiplexer/decoder **780**. A first output of the first decoder of the multiplexer/decoder **780** is connected to an input of the earphone amplifier **130**. A second output of the first decoder of the multiplexer/decoder **780** is connected to an input of the phone modem **114**. A third output and a fourth output of the first decoder of the multiplexer/decoder **780** are connected to an input of the DAA **116**.

The output of the microphone amplifier **128** is connected to a first input of a second 4:1 multiplexer of the multiplexer/decoder **780**. The output of the phone modem **114** is connected to a second input of the second multiplexer of the multiplexer/decoder **780**. An output of the DAA **116** is connected to a third input and a fourth input of the second multiplexer of the multiplexer/decoder **780**. An output of the second multiplexer of the multiplexer/decoder **780** is connected to an input of a second 1:4 decoder of the multiplexer/decoder **780**. A first output and a second output of the second decoder of the multiplexer/decoder **780** are connected to an input of the cellular telephone **126**. A third output of the second decoder of the multiplexer/decoder **780** is connected to the input of the phone modem **114**. A fourth output of the second decoder of the multiplexer/decoder **780** is connected to the input of the earphone amplifier **130**.

As in the first embodiment of the present invention, an output of the earphone amplifier **130** is connected to an input of the microphone and earphone jack **132**, an output of the microphone and earphone jack **132** is connected to an input of the microphone amplifier **128**, an output of the DAA **116** is connected to an input of the phone jack **118**, and an output of the phone jack **118** is connected to an input of the DAA **116**.

In functional terms, the microcontroller **772** controls the operation of the multiplexer/decoder **780** by the use of two select lines. The same two select lines are connected to each of the multiplexers and each of the decoders of the multiplexer/decoder **780** in the same manner, so that corresponding inputs of the multiplexers and outputs of the decoders are always selected simultaneously. For example, if the second input of the first multiplexer is selected, the second input of the second multiplexer, the second output of the first decoder and the second output of the second decoder are also selected.

If the microcontroller **772** selects the first inputs and outputs of the multiplexer/decoder **780**, the cellular telephone **126** is coupled to the microphone and earphone jack **132**. In this mode, a user can use an attached microphone and earphone to communicate to a remote party using a cellular system.

If the microcontroller **772** selects the second inputs and outputs of the multiplexer/decoder **780**, the cellular telephone **126** is coupled to the phone modem **114**. In this mode, data can be sent from the PDA **102B** to a remote destination or received at the PDA **102B** from a remote source, through the phone modem **114**, again using a cellular system. To use the communication device **100B** in this mode, the microcontroller **772** must first control the cellular telephone **126** directly to dial the desired number and establish the cellular link. After the link is established, the microcontroller **772** can send data through the phone modem **114** to the cellular telephone **126** to be transmitted over the cellular link to a remote location, or data can be transmitted from a remote location to the cellular telephone **126**, which sends the data through the phone modem **114** to the microcontroller 772. In this latter event, the phone modem **114** generates a data packet to be transmitted to the application packet interface **740**.

If the microcontroller **772** selects the third inputs and outputs of the multiplexer/decoder **780**, the phone modem **114** is coupled to the land phone **708**. In this mode, data can be sent from the PDA **102B** to a remote destination or received at the PDA **102B** from a remote source, through the phone modem **114**, using a land-based telephone line.

If the microcontroller **772** selects the fourth inputs and outputs of the multiplexer/decoder **780**, the microphone and earphone jack **132** is coupled to the land phone **708**. In this mode, a user can use an attached microphone and earphone to communicate to a remote party using a land-based telephone line.

In this second embodiment, only one of the four above-described connections can be established at a time. However, a person of skill in the art will understand that an alternative interconnection could be used that would allow multiple connections to be established simultaneously. For example, an alternative embodiment can allow data to be transferred over a cellular system using the phone modem **114** and the cellular telephone **126**, while a user talks over a land-based telephone line using an attached microphone and earphone and the land phone **708**.

FIGS. **15**A, **15**B, and **15**C illustrate a method performed by the arbitrator **716** during operation of the PDA **102B** and the communication device **100**B. The method begins at an initial block **800** of FIG. **15**A.

At a process block **802**, the arbitrator **716** initializes the application server **710** and the serial interface **701**. The serial interface **701** is initialized by transmitting an initialization data packet to the communication server **750**. The communication server **750** receives the initialization data packet and transmits a response data packet back to the arbitrator **716** to verify initialization of the serial interface **701**. Either the arbitrator **716** or the communication server **750** can also initialize the serial interface **701** at other times, as required, by a similar process. If the communication server **750** initializes the serial interface **701**, the communication server **750** transmits the initialization data packet, and the arbitrator **716** transmits the response data packet.

At a process block **804**, the arbitrator **716** awaits communication from other functional units. The arbitrator **716** may receive a request for registration from an application **702, 704,706** through one of the interface units **718, 720, 722,724, 726, 728**. A request for registration is received by the registration unit **746**. Alternatively, the arbitrator **716** may receive an outgoing data packet (opack) from an application **702, 704, 706**, again through one of the interface units **718, 720, 722, 724, 726, 728**. An outgoing data packet is received by the application packet interface **740**. Alternatively, the arbitrator **716** may receive an incoming data packet (ipack) from the communication server **750** over the serial interface **701**. An incoming data packet is also received by the application packet interface **740**.

At a decision block **806**, the arbitrator **716** determines which type of communication has been received. If a registration request has been received, the arbitrator **716** advances to a process block **808**. If an outgoing data packet has been received, the arbitrator **716** advances to a process block **810**. If an incoming data packet has been received, the arbitrator **716** advances to a process block **812**.

At the process block **808**, the arbitrator **716** processes the registration request. The method for processing a registration request is described in greater detail below with reference to FIG. **15**B. After the process block **808**, the arbitrator **716** advances to the process block **804** to await further communication.

At the process block **810**, the arbitrator **716** transmits the outgoing data packet to the communication server **750** over the serial interface **701**. After the process block **810**, the arbitrator **716** also advances to the process block **804**.

At the process block **812**, the arbitrator **716** processes the incoming data packet. The method for processing an incoming data packet is described in greater detail below with reference to FIG. **15**C. After the process block **812**, the arbitrator **716** also advances to the process block **804**.

FIG. **15**B illustrates the method performed by the registration unit **746** at the process block **808** of FIG. **15**A to process a registration request. The method of FIG. **15**B begins at an initial block **820**.

At a process block **822**, the registration unit **746** determines which application **702, 704, 706** requested the registration. This information is provided by the requesting application **702, 704, 706** in the registration request.

At a process block **824**, the registration unit **746** determines the type of registration request that has been received. The registration request can specify a request to either establish or cancel a registration. The registration request also identifies a particular type of data packet. For example, a requesting application **702, 704, 706** may request to receive a data packet generated by the GPS engine **120** containing positional data related to the PDA **102**B. The requesting application **702,704,706** can also request either a one-shot registration or a continuous registration. A one-shot registration is canceled after a first data packet is received by the arbitrator **716** that matches the type of data packet requested by the requesting application **702,704,706**. If the registration unit **746** registers a continuous registration request, the requesting application **702, 704, 706** continues to receive incoming data packets that match the requested type until the registration is canceled.

At a decision block **828**, the registration unit **746** checks for a conflict between the current registration request and the registered requests in the registry table **744**. A conflict may occur, for example, if there is no registered request in the registry table **744** that matches a current request to cancel a registration. A conflict may also occur if a request to establish a registration matches a previously registered request, or under other circumstances. If the registration unit **746** detects a conflict, the method advances to a process block **830**. Otherwise, the method advances to a process block **832**.

At the process block **830**, the registration unit **746** generates an error indication and advances to a terminal block **834**.

At the process block **832**, the registration unit **746** modifies the registry table **744** according to the registration request. If the request seeks to cancel a registered request, the registration unit **746** deletes the entry in the registry table **744** that corresponds to the current request. If the request seeks to register a new request, the registration unit **746** generates a new entry in the registry table **744** identifying the type of registration requested. After the process block **832**, the registration unit **746** advances to the terminal block **834**, at which the method ends.

FIG. **15**C illustrates the method performed by the application packet distributor **742** at the process block **812** of FIG. **15**A to process an incoming data packet. The method of FIG. **15**C begins at an initial block **840**. Incoming data packets are received by the application packet interface **740**, which stores the received data packets in the memory of the PDA **102**B. The application packet interface **740** then notifies the application packet distributor **742** of the location of the data packets in memory.

At a process block **842**, the application packet distributor **742** determines the type of data packet that has been received. A data packet can contain specific data that has been requested by an application **702, 704, 706**, it can contain incoming data from one of the communication circuits **114, 120, 124, 126** or from the external serial port **110**, or it can contain information reflecting changes in the communication device **100**B.

At a process block **844**, the application packet distributor **742** determines which interface unit **718, 720, 722, 724, 726, 728** is related to the incoming data packet. For example, if the data packet contains positional data from the GPS engine **120**, the related interface unit **718, 720,722, 724, 726, 728** is the GPS interface **718**.

At a process block **846**, the application packet distributor **742** searches the registry table **744** to determine which applications **702,704,706** have registered requests for the type of data packet that has been received. The application packet distributor **742** also deletes entries in the registry table **744** that identify one-shot requests that correspond to the type of data packet that has been received.

At a process block **848**, the application packet distributor **742** requests that the related interface unit **718, 720, 722,**

**724, 726, 728** process the incoming data packet, as required, to extract the data that is desired by each of the applications **702, 704, 706** that have registered requests for the type of data that has been received. After the related interface unit **718,720, 722,724,726,728** has processed and repackaged the data packet, the method advances to a process block **850.**

At the process block **850,** the application packet distributor **742** distributes the processed data packet to each of the applications **702, 704, 706** that has registered a request for the type of data that has been received.

After the process block **850,** the application packet distributor **742** advances to the terminal block **852,** at which the method ends.

As an example of the operation of the second embodiment communication device **100B** in conjunction with the PDA **102B**, suppose that a user wants to send a document that is stored in the PDA **102B** to a remote destination via facsimile, over a land-based telephone line. Assume that the user executes the application program **702** to facilitate sending the fax. The application **702** allows the user to enter the phone number to which the fax should be sent, and it allows the operator to identify the file to be transmitted. The application **702** may also allow the user to set other parameters of the facsimile transmission.

Generally, the application **702** calls one or more functions in the fax server **732** to establish the telephone link with the remote destination. The fax server **732** may call one or more functions in the phone modem interface **722** and the land phone interface **724** to generate one or more data packets for transmission to the phone modem **114**. For example, the application **702** may call a function in the fax server **732** to dial the user-specified phone number. The fax server **732** calls a corresponding function in the land phone interface **724**. The land phone interface **724** generates a data packet that instructs the phone modem **114** to dial the user-specified phone number. The data packet generated by the land phone interface **724** is directed to a generic phone modem **114**, so that it may not be compatible with the phone modem **114** that is actually installed in the communication device **100B**. The generic modem emulator **760** modifies the generic modem data packet to conform to the requirements of the phone modem **114** that is actually installed in the communication device **100B**. The generic modem emulator **760** then transmits the modified data packet to the phone modem **114**, which dials the user-specified phone number.

Next, the application **702** calls one or more functions in the fax server **732** to send the file to the remote destination. The fax server **732** calls one or more functions in the phone modem interface **722** and the land phone interface **724** to generate one or more data packets containing the data in the file. The generic modem emulator **760** again modifies the data packets, and transmits them to the phone modem **114**. The phone modem **114** transmits the file to the remote destination.

Next, the application **702** calls one or more functions in the fax server **732** to terminate the connection with the remote destination. Again, the fax server **732** calls one or more functions in the phone modem interface **722** and the land phone interface **724** to generate one or more data packets to terminate the connection. The generic modem emulator **760** again modifies the data packets, and transmits them to the phone modem **114**. The phone modem **114** proceeds to terminate the connection with the remote destination, and the process of transmitting the selected file via facsimile is completed.

The invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is therefore indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within that scope.

I claim:

**1.** A portable communication system comprising:

a palm computer comprising at least one application program and an application server, wherein said application server is coupled in communication with said application program and generates data packets in response to requests issued by said at least one application program; and

a cradle for releasable retaining said palm computer therein, said cradle comprising:

a communication server coupled to said application server via an interface, said communication server having a packet interface which receives data packets transferred by said application server, said communication server further having a packet distributor coupled to said packet interface which receives data packets from said packet interface, and a plurality of generic emulators coupled to said packet distributor, wherein said packet distributor transfers said data packets received from said packet interface to an appropriate one of said generic emulators; and

a plurality of integral communications devices, each of said integral communication devices coupled to a corresponding one of said plurality of generic emulators, wherein said generic emulators reformat said data packets received from said packet distributor in accordance with specific requirements of said communication device coupled thereto, and wherein said generic emulators transfer said reformatted data packets to said corresponding communication device.

**2.** The portable communications system of claim **1**, wherein said data packets contain commands to control the operation of said communication devices.

**3.** The portable communications system of claim **1**, wherein said data packets contain requests for data from said communication devices.

**4.** The portable communications system of claim **1**, wherein said data packets contain data for transmission by an appropriate communication device.

**5.** The portable communications system of claim **1**, wherein said data packets contain address information identifying a destination of said data packets.

**6.** The portable communications system of claim **1**, wherein said communication devices further generate data packets for transmission to one or more of said application programs.

**7.** The portable communications system of claim **6**, wherein said data packets generated by said communication devices identify the type of data contained therein.

**8.** A palm computer communications cradle which provides alternative communication capabilities for a palm computer releasably retained therein, said communications cradle comprising:

a communication server coupled to said palm computer via an interface, wherein said communication server receives data packets generated by said palm computer; and

a plurality of integral communications circuits, each of said integral communication circuits coupled to said communication server, wherein said communication server reformats said data packets received from said palm computer in accordance with specific requirements of said communication circuits coupled thereto, and wherein said communication server transfers said reformatted data packets to an appropriate one of said communication circuits.

**9**. The palm computer communications cradle of claim **8**, wherein said communications circuits further generate data packets for transmission to said palm computer.

**10**. The palm computer communications cradle of claim **8**, wherein said communications circuits comprise at least two of a global positioning satellite system, a modem, a packet radio system, a land phone coupled to said modem, and a cellular phone coupled to said modem.

**11**. The portable communications system of claim **8**, wherein said data packets contain commands to control the operation of said communication devices.

**12**. The portable communications system of claim **8**, wherein said data packets contain request for data from said communication devices.

**13**. The portable communications system of claim **9**, wherein said data packets contain data for transmission by an appropriate communication device.

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