US 20070036169A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2007/0036169 A1**

Walkoe, JR. et al. (43) **Pub. Date: Feb. 15, 2007**

(54) **TELECOMMUNICATION SYSTEM, METHOD AND SUBSCRIBER UNIT FOR USE THEREIN**

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(21) Appl. No.: **11/478,856**

(22) Filed: **Jun. 30, 2006**

Related U.S. Application Data

(63) Continuation of application No. 09/533,263, filed on Mar. 17, 2000, which is a continuation-in-part of application No. 08/742,164, filed on Nov. 1, 1996, now abandoned, and which is a continuation-in-part of application No. 09/119,094, filed on Jul. 20, 1998, now Pat. No. 6,370,149.

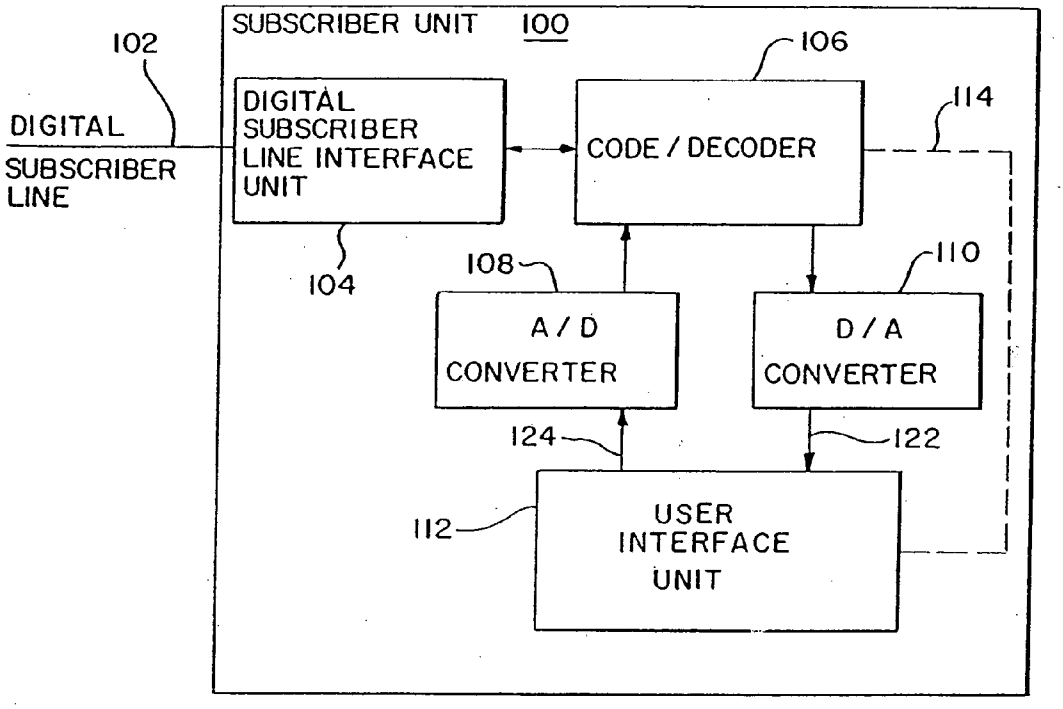
Publication Classification

(51) **Int. Cl.**
H04L 12/56 (2006.01)

(52) **U.S. Cl.** **370/419**; 370/463

(57) **ABSTRACT**

A telecommunication system includes a digital switch, a local loop coupling the digital switch to a subscriber location, wherein a segment of the local loop includes copper twisted pair and wherein an asymmetrical digital subscriber line is carried by the local loop, the asymmetrical digital subscriber line including a plurality of data packets capable of carrying a plurality of derived digital telephone lines. The telecommunication system further includes a subscriber unit coupled to the asymmetrical digital subscriber line. The subscriber unit monitors the content of at least one of the plurality of data packets, receives an off-hook signal in response to an action of a user, and initiates a first derived digital telephone line of the plurality of derived digital telephone lines in response to the off-hook signal. A telephone communication system including an analog telephone providing a plain old telephone service (POTS) analog voice channel on a subscriber loop with a digital data line sharing the same subscriber loop. In addition to the analog voice line, the digital data line provides an additional digital voice channel for placing telephone voice calls.



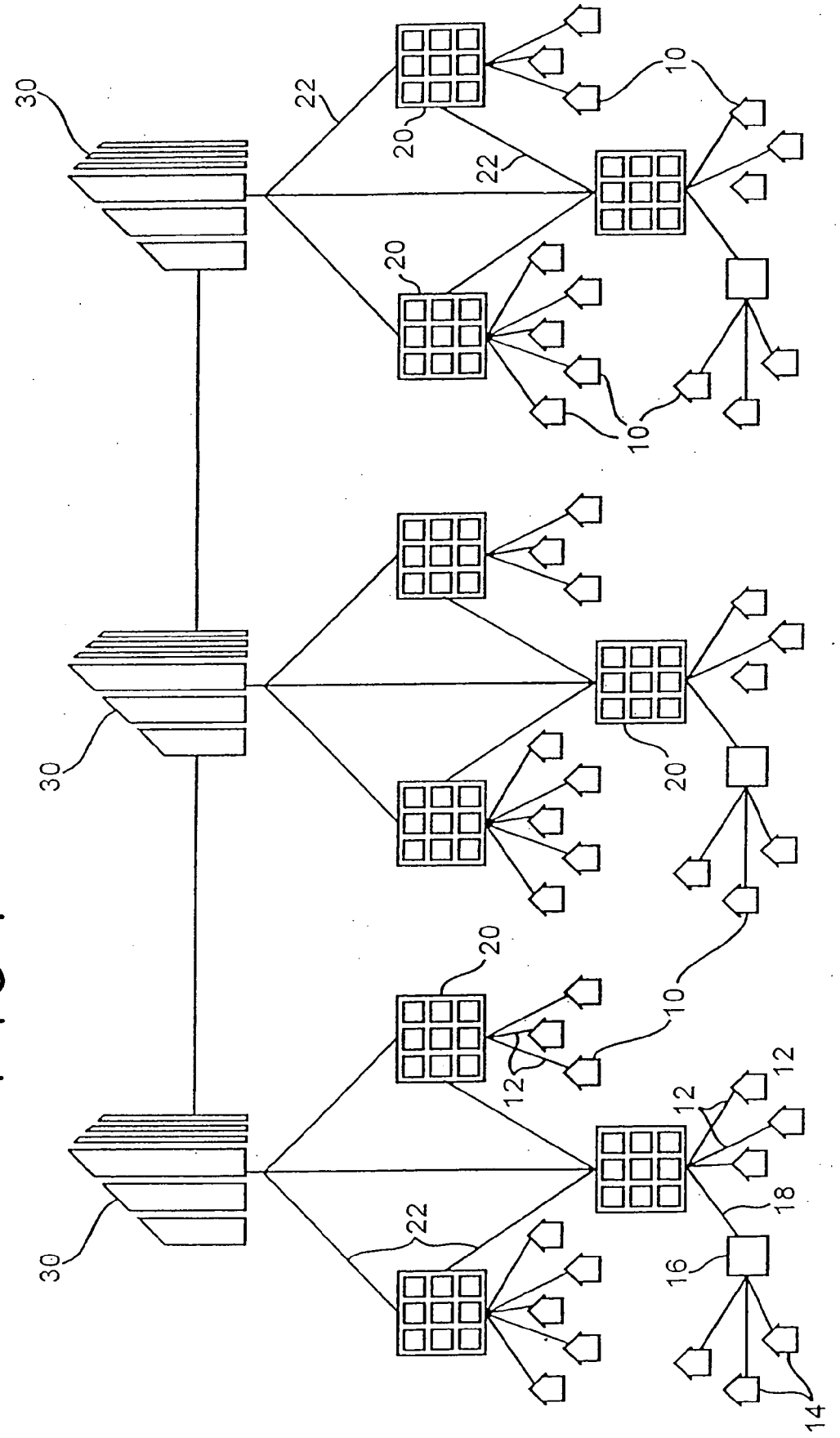


FIG. 1

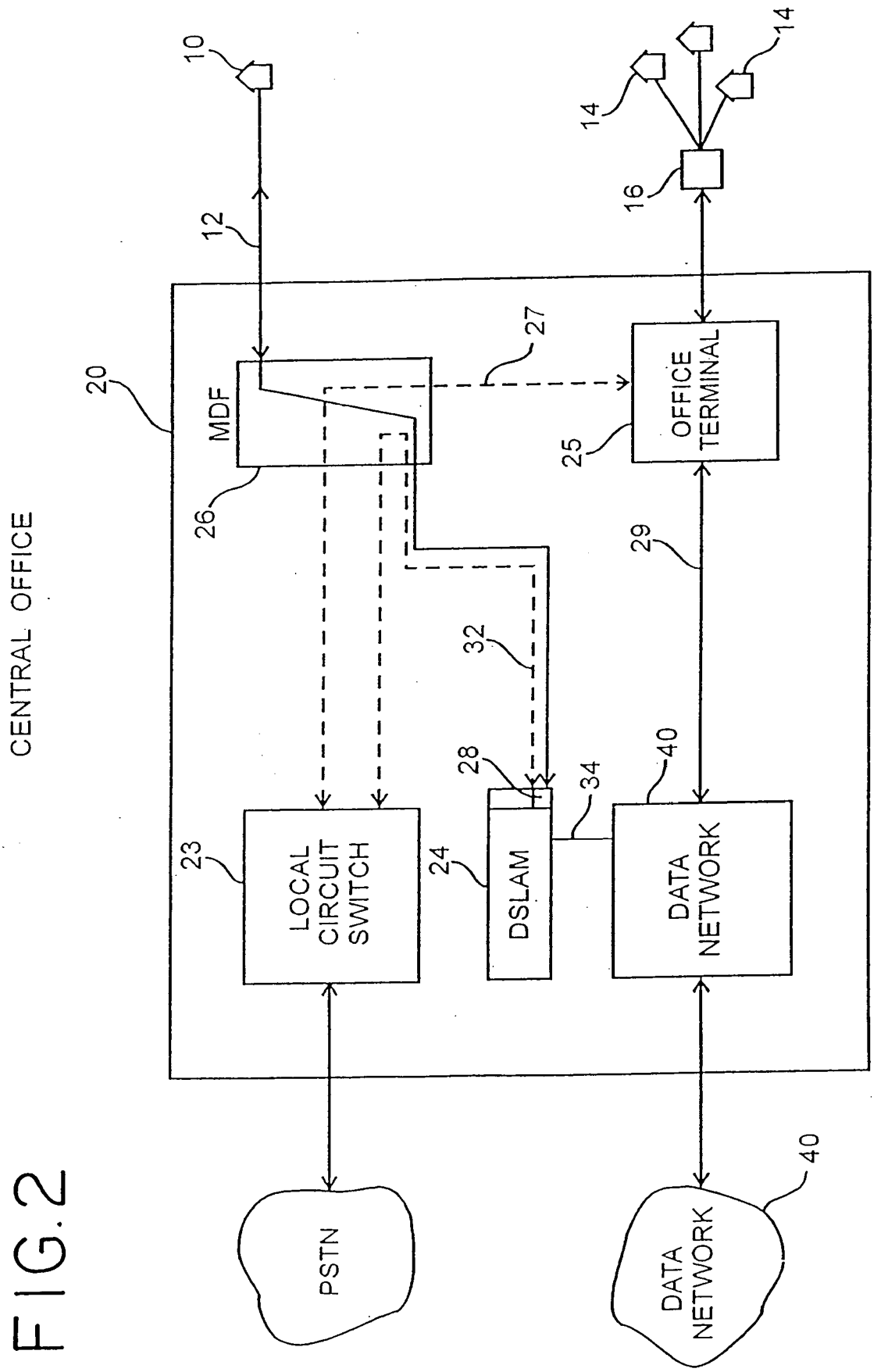
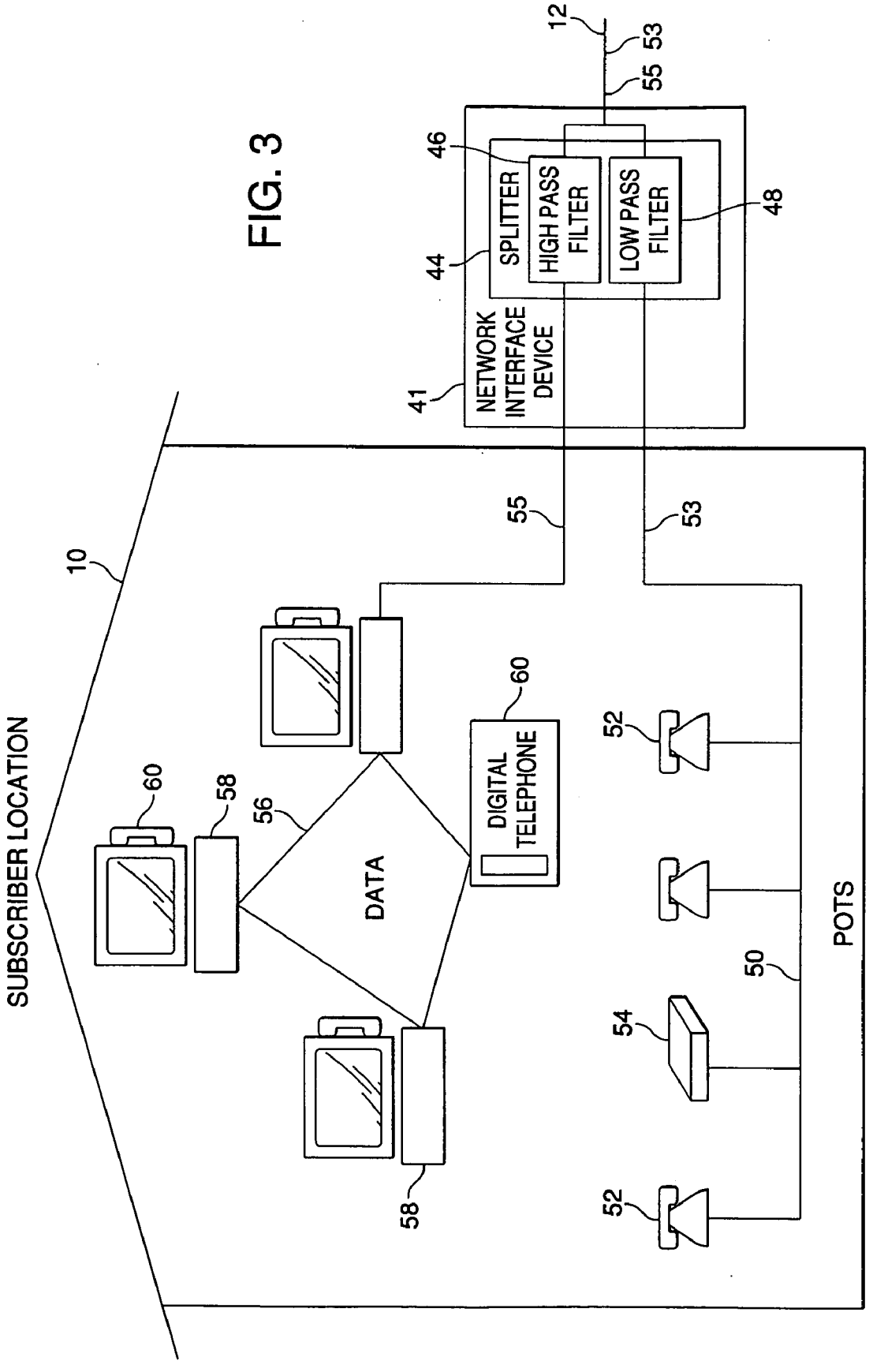

CENTRAL OFFICE
10
12
14
14
16
20
MDF
27
OFFICE TERMINAL
25
26
29
32
28
34
40
23
LOCAL CIRCUIT SWITCH
24
DSLAM
DATA NETWORK
PSTN
DATA NETWORK
40

FIG.2

FIG. 3


12
53
55
46
SPLITTER
HIGH PASS FILTER
LOW PASS FILTER
48
44
NETWORK INTERFACE DEVICE
41
10
SUBSCRIBER LOCATION
55
53
60
DIGITAL TELEPHONE
52
60
58
56
DATA
50
POTS
54
58
52

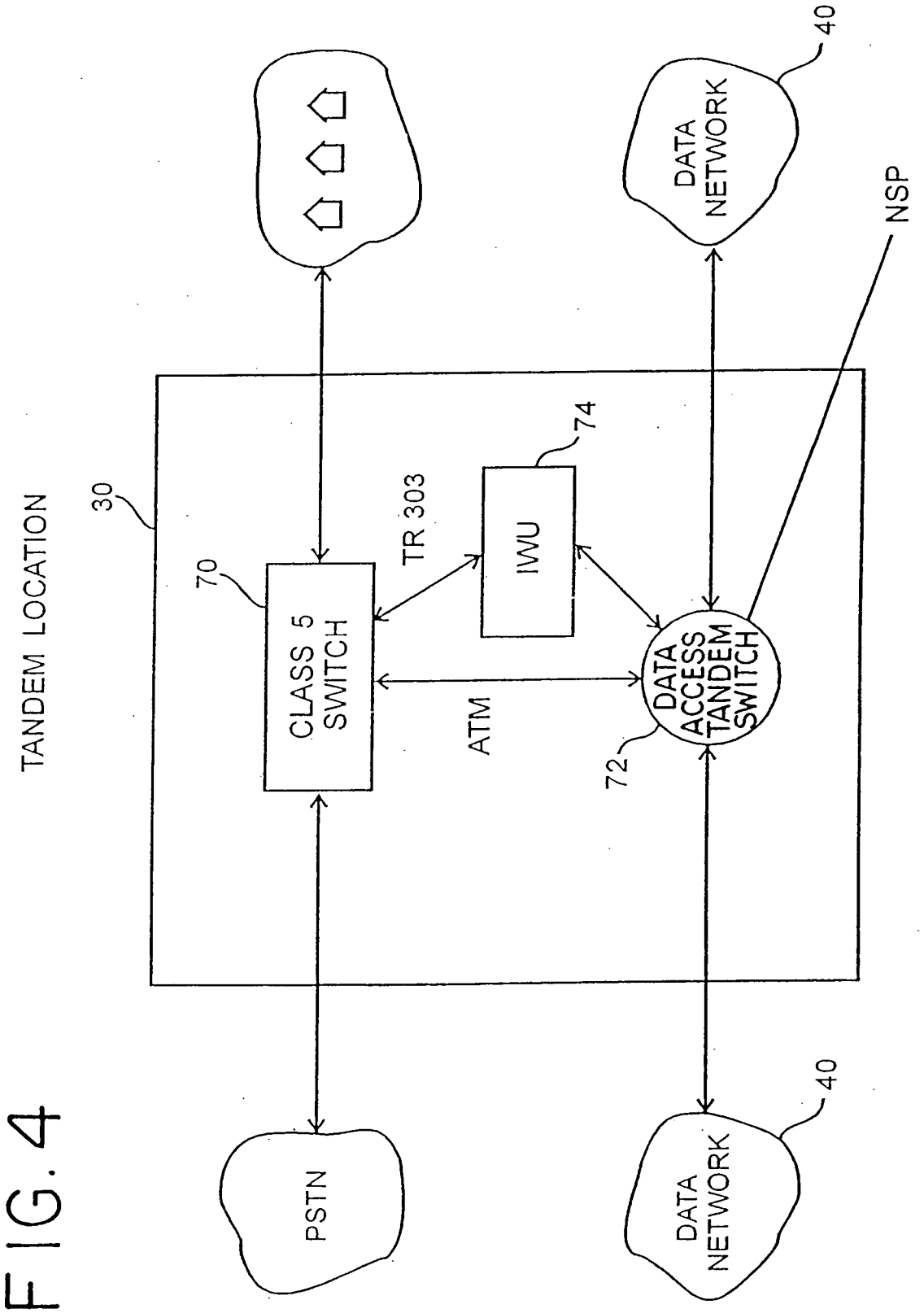

TANDEM LOCATION
30
70
CLASS 5 SWITCH
TR 303
IWU
74
ATM
DATA ACCESS TANDEM SWITCH
72
NSP
DATA NETWORK
40
PSTN
DATA NETWORK
40

FIG. 4

FIG. 5

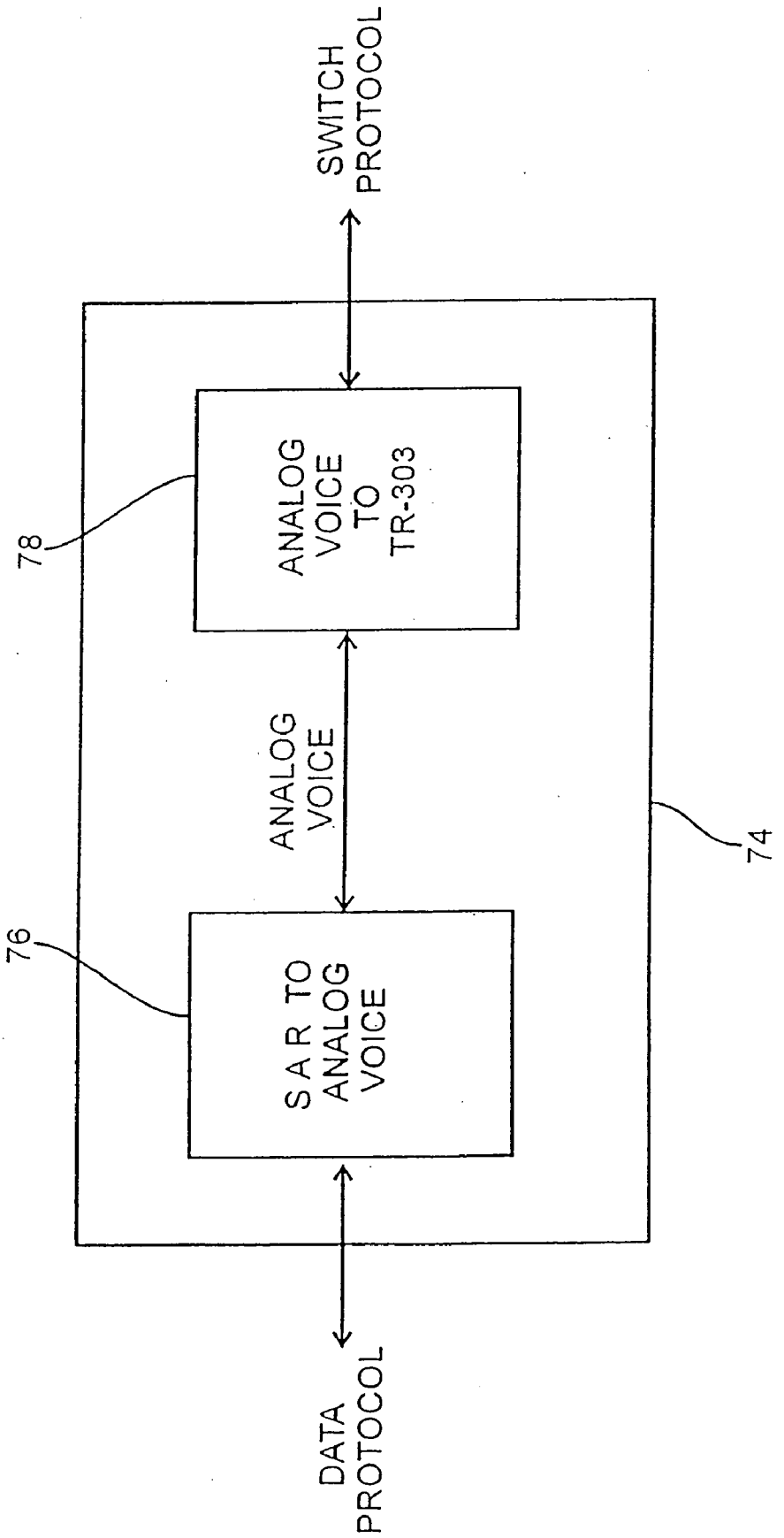
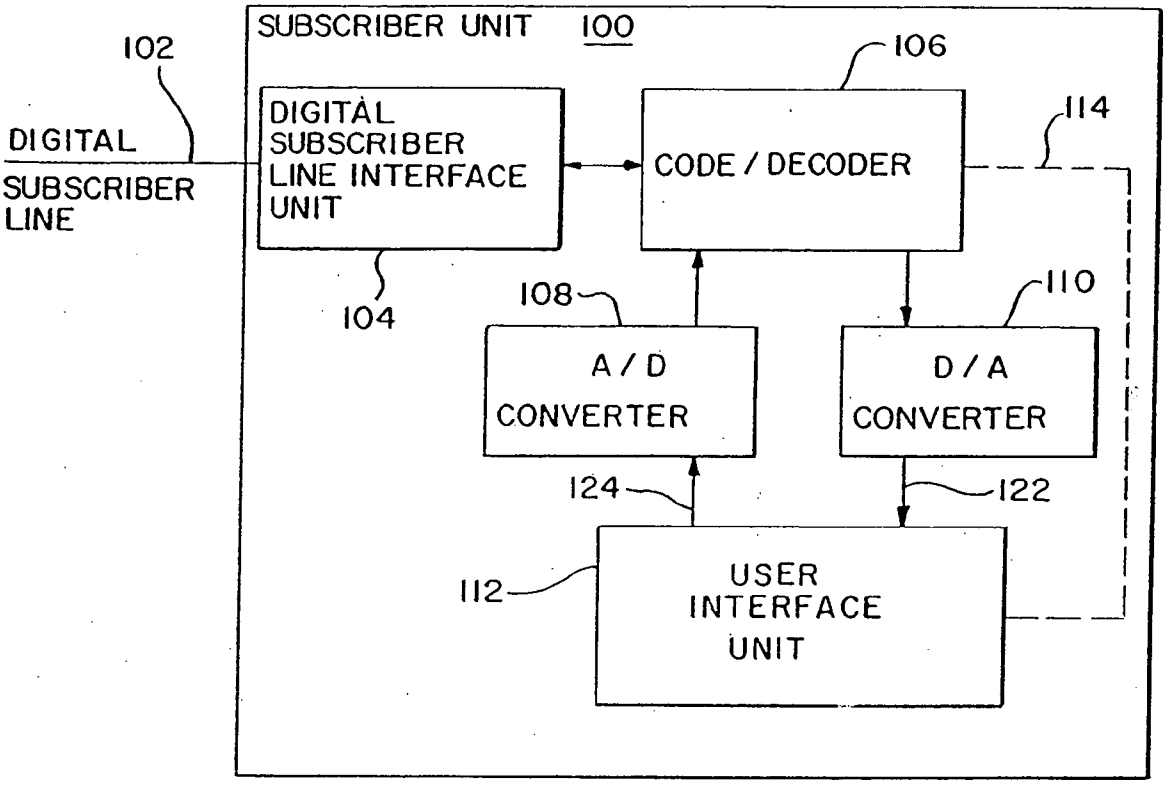

SWITCH PROTOCOL
ANALOG VOICE TO TR-303
78
ANALOG VOICE
SAR TO ANALOG VOICE
76
74
DATA PROTOCOL

FIG. 6


SUBSCRIBER UNIT 100
102
DIGITAL SUBSCRIBER LINE
DIGITAL SUBSCRIBER LINE INTERFACE UNIT
104
106
CODE / DECODER
114
108
A / D CONVERTER
110
D / A CONVERTER
124
122
112
USER INTERFACE UNIT

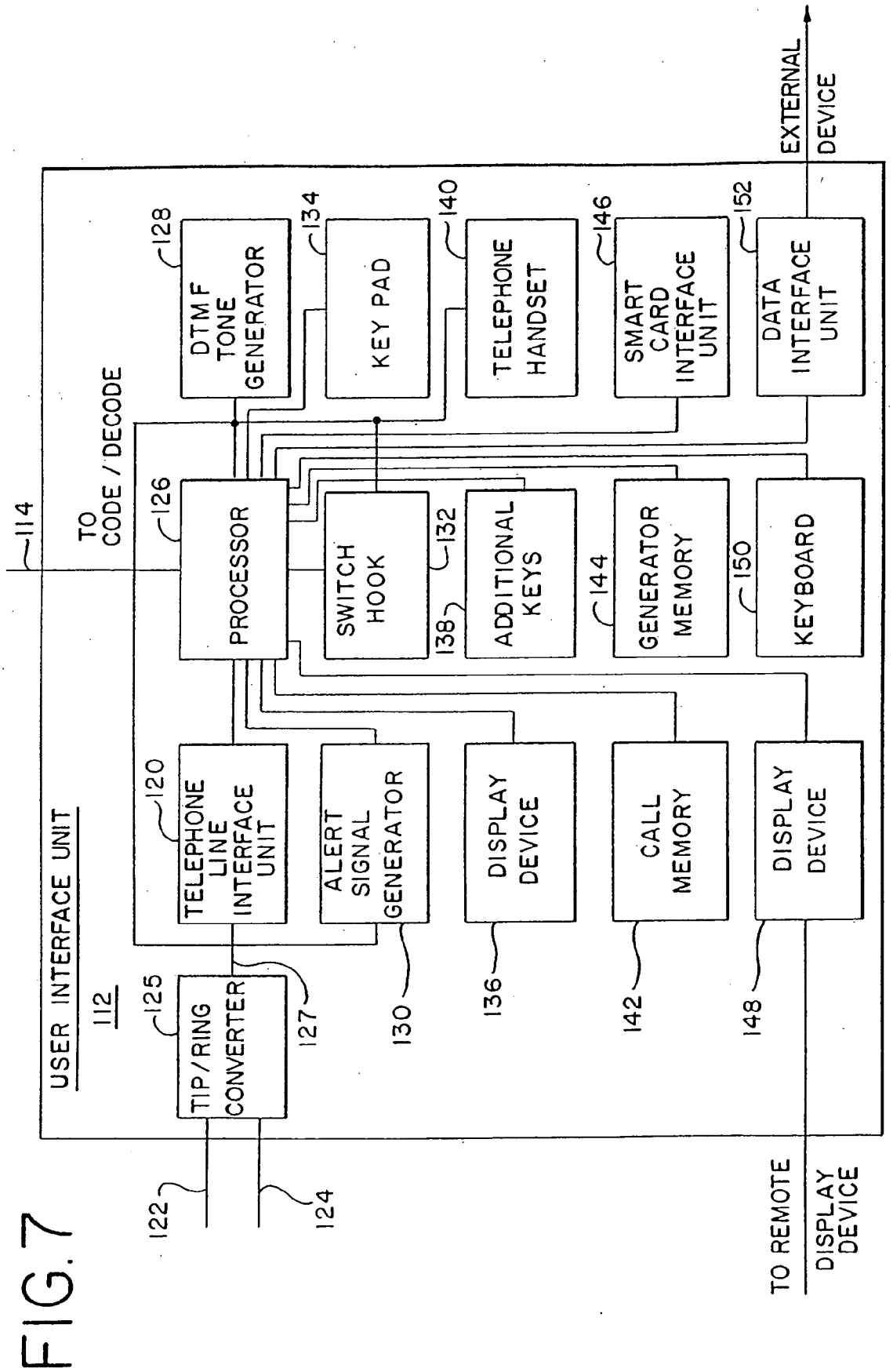

USER INTERFACE UNIT
112
114
TO CODE / DECODE
126
PROCESSOR
128
DTMF TONE GENERATOR
134
KEY PAD
140
TELEPHONE HANDSET
146
SMART CARD INTERFACE UNIT
152
DATA INTERFACE UNIT
EXTERNAL DEVICE
SWITCH HOOK
132
138
ADDITIONAL KEYS
144
GENERATOR MEMORY
150
KEYBOARD
120
TELEPHONE LINE INTERFACE UNIT
ALERT SIGNAL GENERATOR
DISPLAY DEVICE
CALL MEMORY
DISPLAY DEVICE
125
TIP/RING CONVERTER
127
130
136
142
148
122
124
TO REMOTE DISPLAY DEVICE

FIG. 7

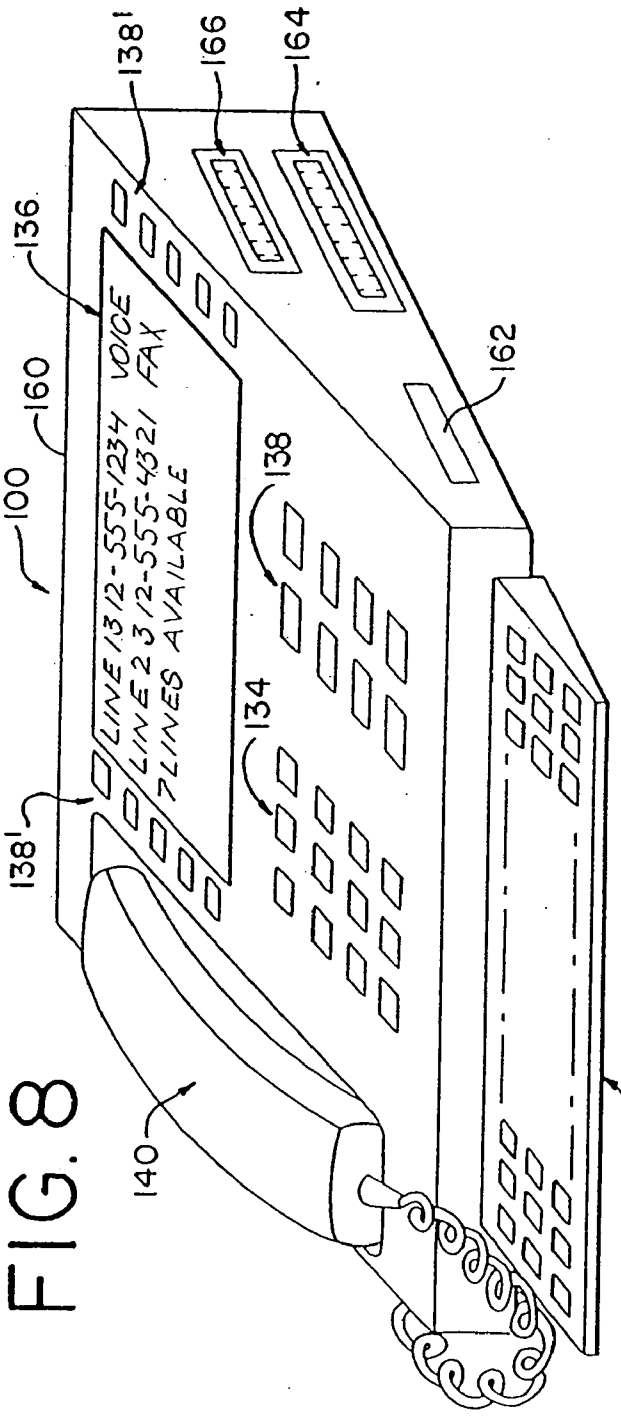

LINE 1 312-555-1234 VOICE
LINE 2 312-555-4321 FAX
7 LINES AVAILABLE
100
136
160
138'
166
164
138
162
134
140
150

FIG. 8

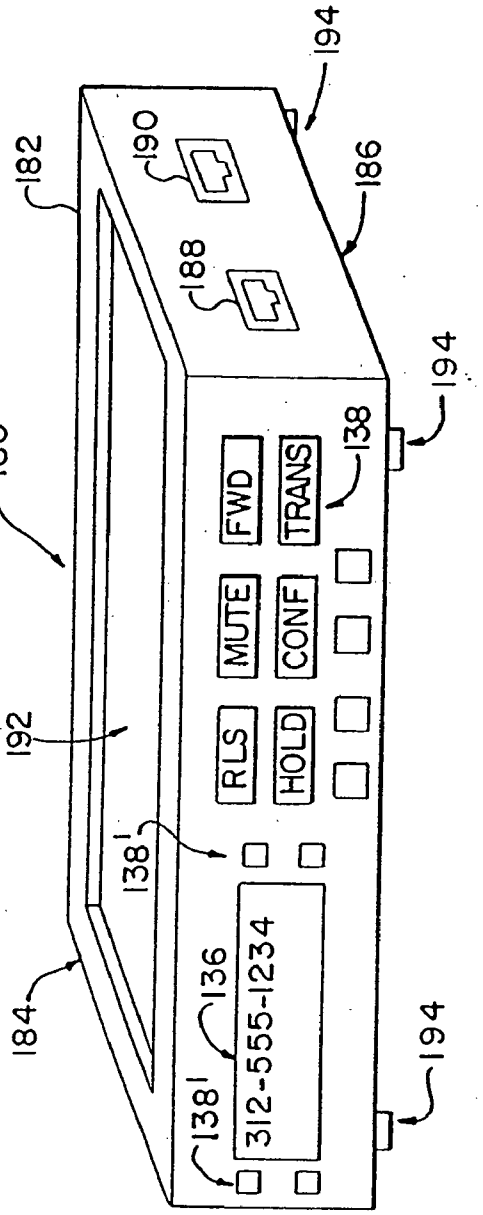

194
182
190
186
188
180
FWD
TRANS
MUTE
CONF
RLS
HOLD
138
192
138'
184
136
312-555-1234

FIG. 9

FIG. 10

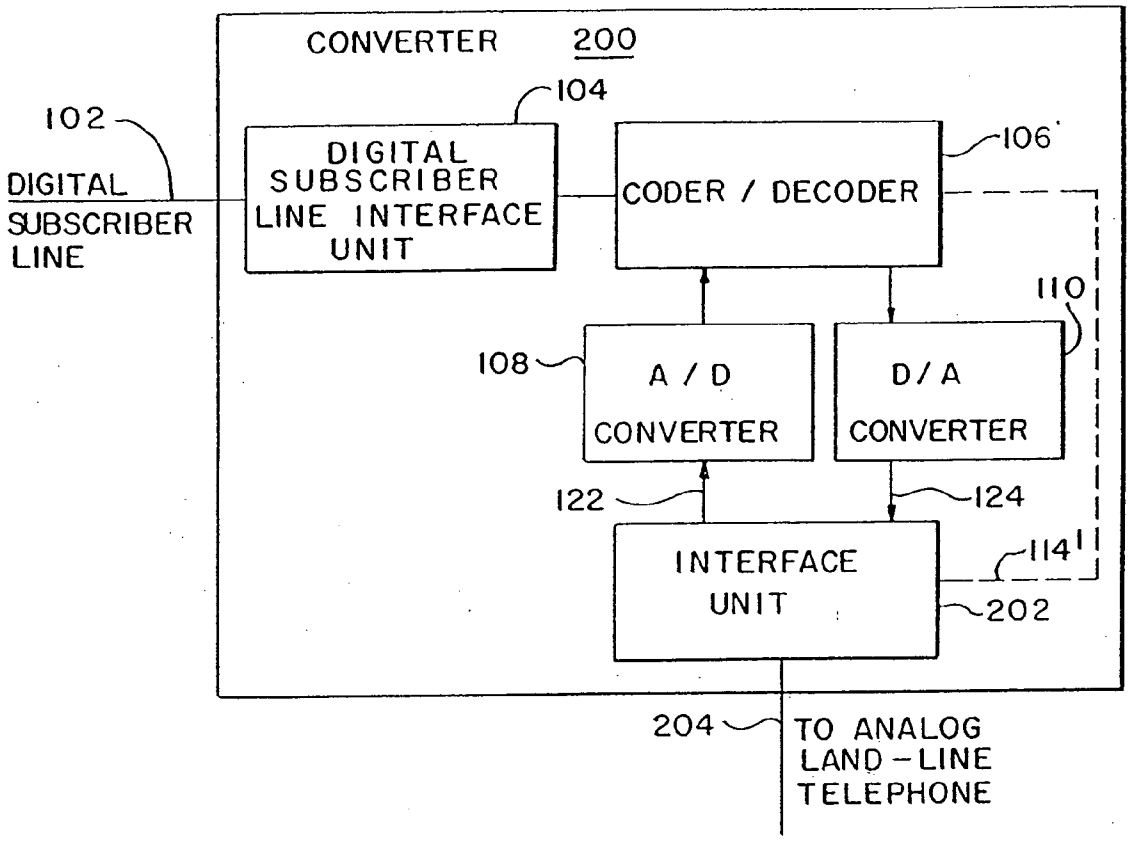
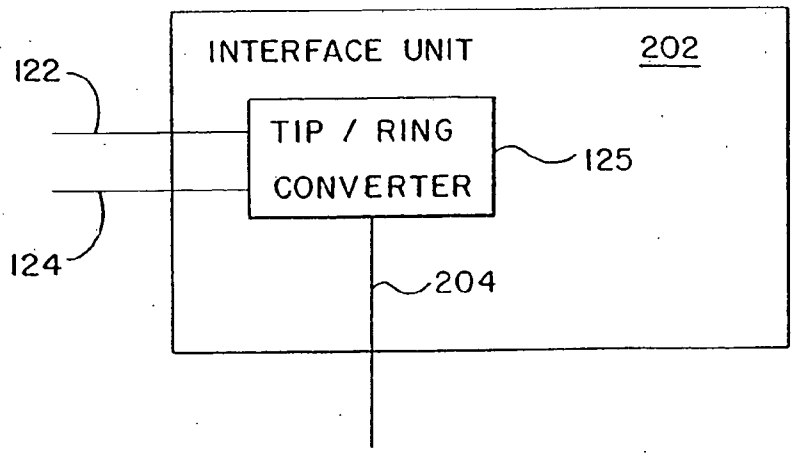

CONVERTER 200
104
102
DIGITAL SUBSCRIBER LINE
DIGITAL SUBSCRIBER LINE INTERFACE UNIT
CODER / DECODER
106
110
108
A / D CONVERTER
D / A CONVERTER
122
124
INTERFACE UNIT
114
202
204
TO ANALOG LAND-LINE TELEPHONE

FIG. 11


INTERFACE UNIT 202
122
TIP / RING CONVERTER
125
124
204

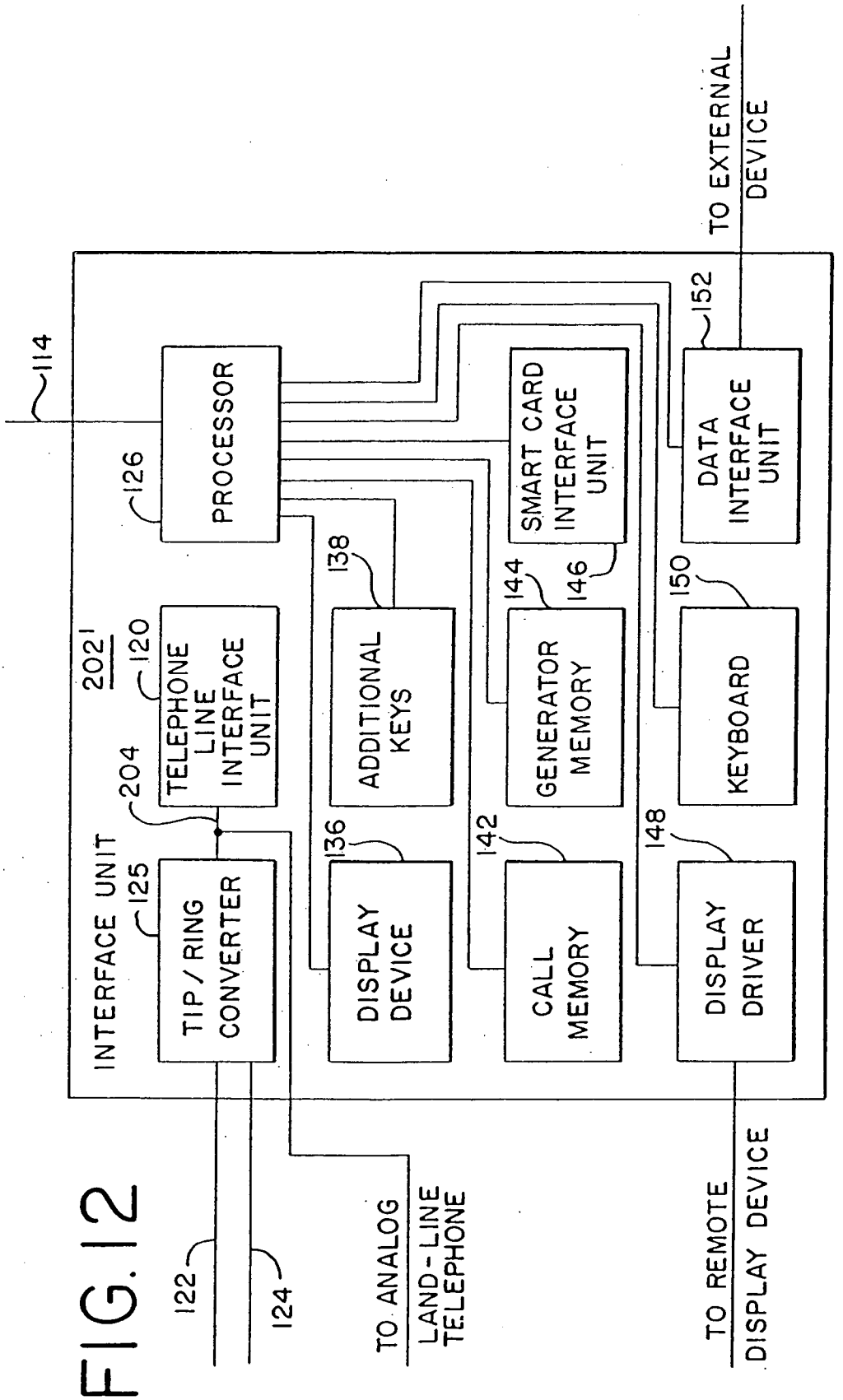

INTERFACE UNIT
202'
114
PROCESSOR
126
TELEPHONE LINE INTERFACE UNIT
120
204
TIP / RING CONVERTER
125
ADDITIONAL KEYS
138
DISPLAY DEVICE
136
SMART CARD INTERFACE UNIT
GENERATOR MEMORY
144
146
CALL MEMORY
142
DATA INTERFACE UNIT
152
KEYBOARD
150
DISPLAY DRIVER
148
TO EXTERNAL DEVICE
TO REMOTE DISPLAY DEVICE
TO ANALOG LAND-LINE TELEPHONE
122
124

FIG. 12

FIG. 13

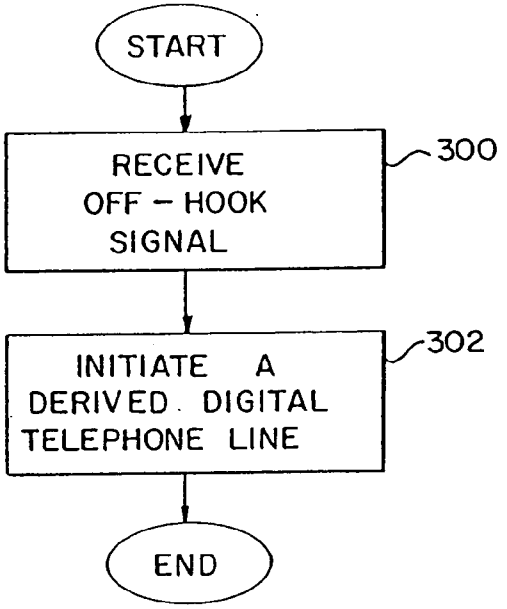

START
RECEIVE OFF – HOOK SIGNAL
300
INITIATE A DERIVED DIGITAL TELEPHONE LINE
302
END

FIG.14

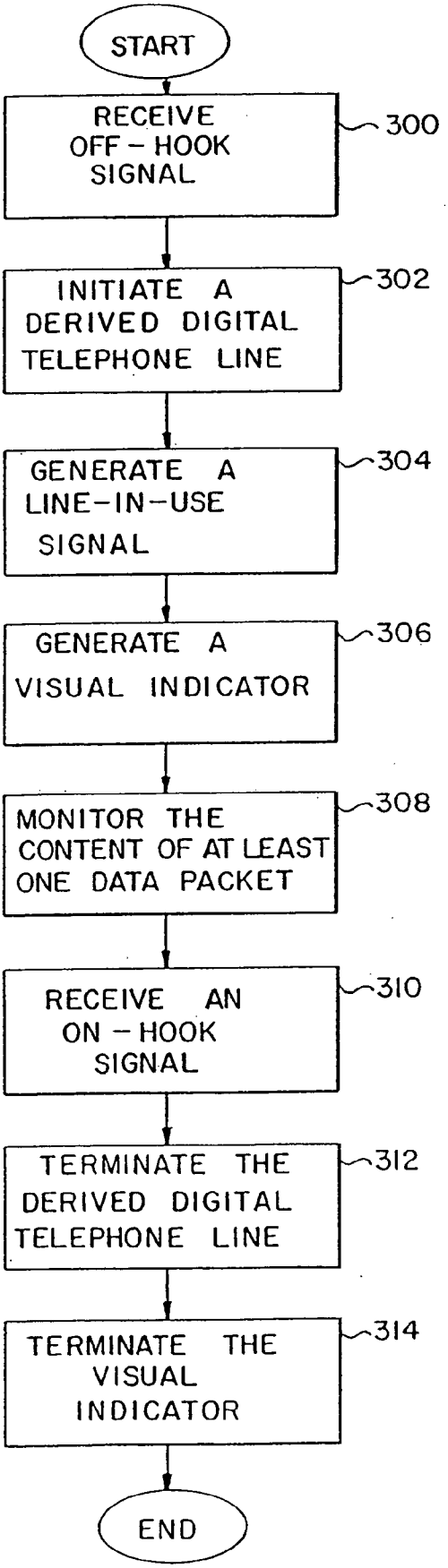

START
RECEIVE OFF – HOOK SIGNAL
300
INITIATE A DERIVED DIGITAL TELEPHONE LINE
302
GENERATE A LINE–IN–USE SIGNAL
304
GENERATE A VISUAL INDICATOR
306
MONITOR THE CONTENT OF AT LEAST ONE DATA PACKET
308
RECEIVE AN ON – HOOK SIGNAL
310
TERMINATE THE DERIVED DIGITAL TELEPHONE LINE
312
TERMINATE THE VISUAL INDICATOR
314
END

FIG. 15

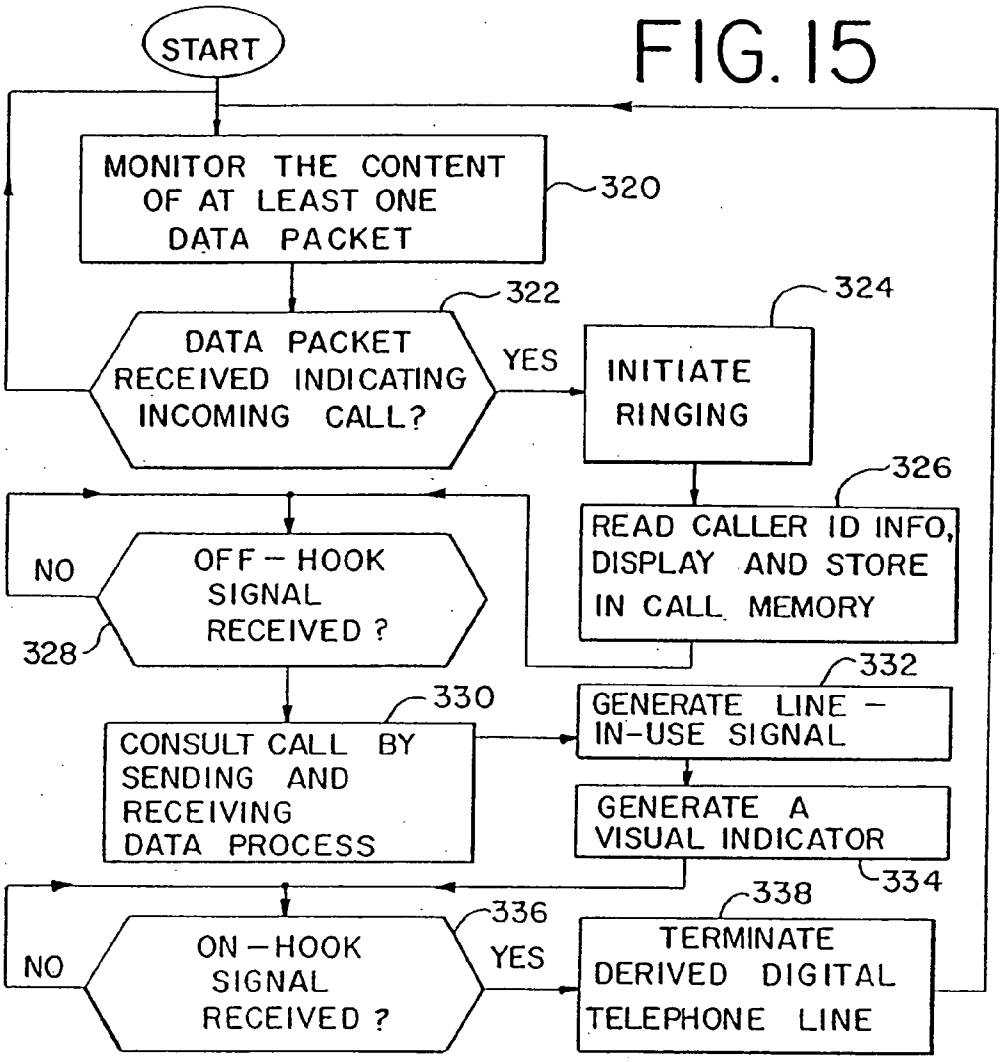

START
MONITOR THE CONTENT OF AT LEAST ONE DATA PACKET
320
DATA PACKET RECEIVED INDICATING INCOMING CALL?
322
YES
INITIATE RINGING
324
READ CALLER ID INFO, DISPLAY AND STORE IN CALL MEMORY
326
NO
OFF-HOOK SIGNAL RECEIVED ?
328
CONSULT CALL BY SENDING AND RECEIVING DATA PROCESS
330
GENERATE LINE-IN-USE SIGNAL
332
GENERATE A VISUAL INDICATOR
334
NO
ON-HOOK SIGNAL RECEIVED ?
336
YES
TERMINATE DERIVED DIGITAL TELEPHONE LINE
338

FIG. 16

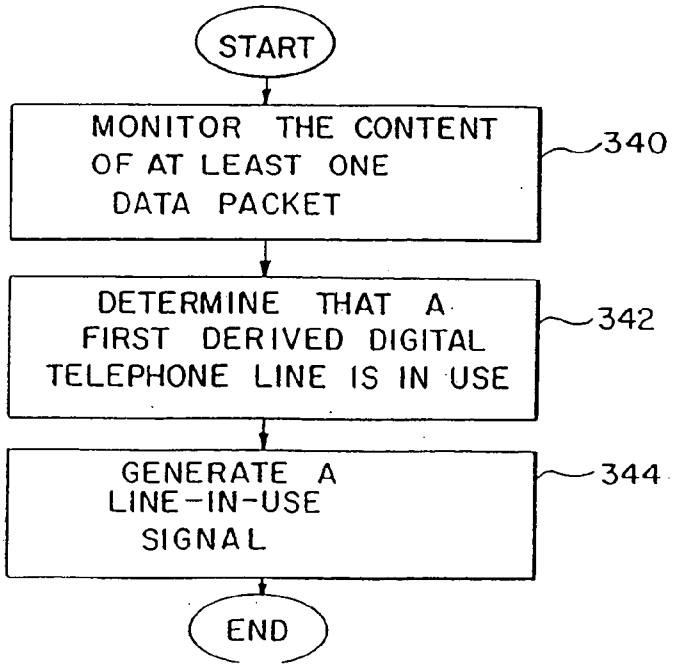
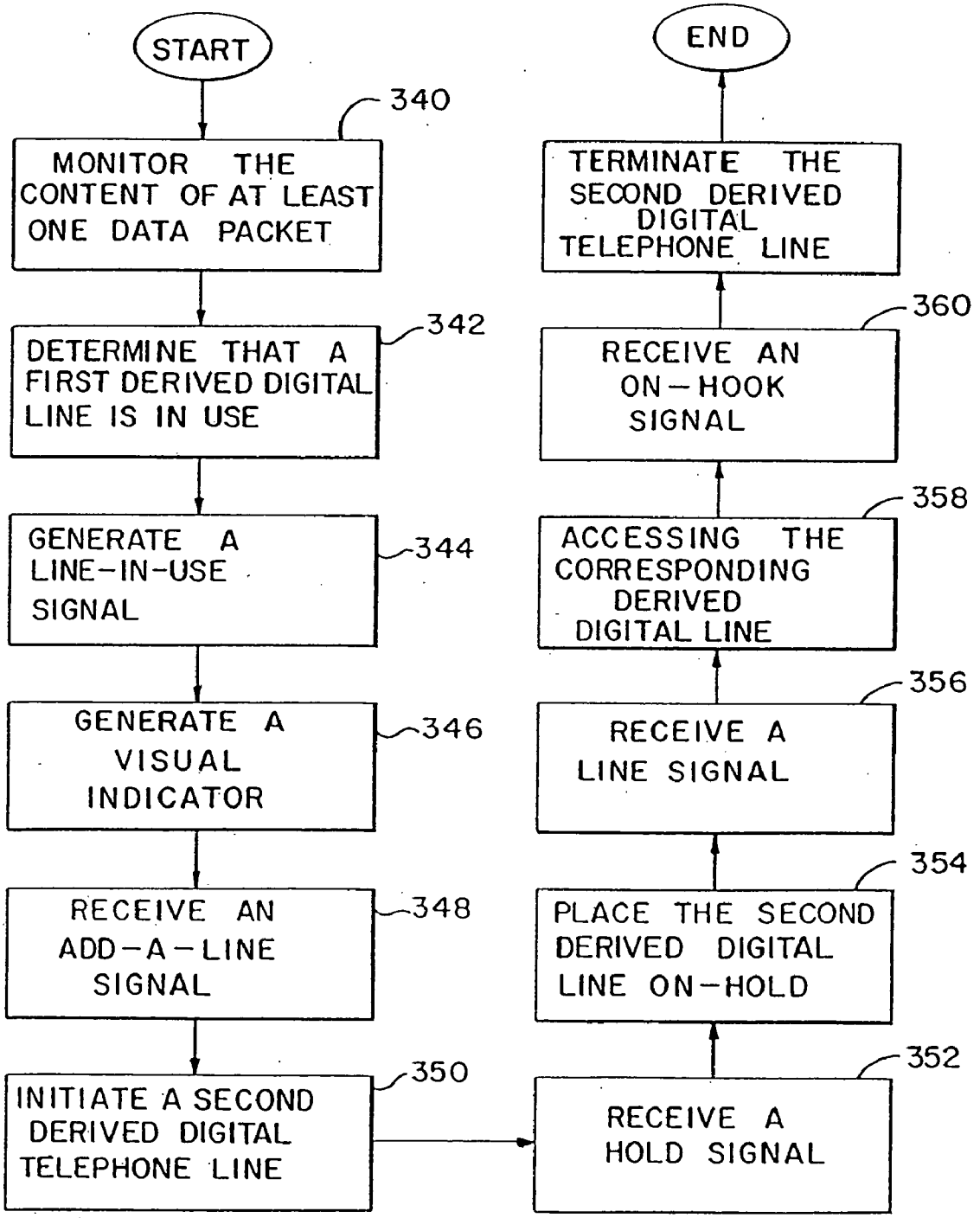

START
MONITOR THE CONTENT OF AT LEAST ONE DATA PACKET
340
DETERMINE THAT A FIRST DERIVED DIGITAL TELEPHONE LINE IS IN USE
342
GENERATE A LINE-IN-USE SIGNAL
344
END

FIG. 17


START
340
MONITOR THE CONTENT OF AT LEAST ONE DATA PACKET
342
DETERMINE THAT A FIRST DERIVED DIGITAL LINE IS IN USE
344
GENERATE A LINE-IN-USE SIGNAL
346
GENERATE A VISUAL INDICATOR
348
RECEIVE AN ADD-A-LINE SIGNAL
350
INITIATE A SECOND DERIVED DIGITAL TELEPHONE LINE
352
RECEIVE A HOLD SIGNAL
354
PLACE THE SECOND DERIVED DIGITAL LINE ON-HOLD
356
RECEIVE A LINE SIGNAL
358
ACCESSING THE CORRESPONDING DERIVED DIGITAL LINE
360
RECEIVE AN ON-HOOK SIGNAL
TERMINATE THE SECOND DERIVED DIGITAL TELEPHONE LINE
END

TELECOMMUNICATION SYSTEM, METHOD AND SUBSCRIBER UNIT FOR USE THEREIN

RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 08/742,164 entitled "Method and Apparatus for Providing a Derived Digital Telephone Voice Channel" filed Nov. 1, 1996 and of U.S. patent application Ser. No. 09/119,094 entitled "Telecommunication System, Method and Subscriber Unit for Use Therein" filed Jul. 20, 1998. The subject matter of each of these applications is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to telecommunication systems, and in particular to subscriber units and methods for interfacing with digital lines.

BACKGROUND

[0003] Most telephone service subscribers today use familiar analog Plain Old Telephone Service ("POTS") for placing ordinary voice telephone calls. POTS is typically delivered over a subscriber loop of copper wires installed between each subscriber location, such as a home or office, and the local telephone company ("telco") central office. Over the pair of copper wires, voice signals are transmitted between subscribers and the telco central office. The central office then provides circuit-switching equipment to establish connections between subscribers. In such a circuit-switched system, a circuit connection is established for each call and is maintained for the duration of the call.

[0004] Recently, on-line computer services, such as the Internet, have changed the way subscribers use their telephones. On-line computer services typically make a dial-up telephone number available for users with a modem to access the service. Many users of on-line computer services now spend several hours each day on the telephone connected to services such as the Internet. Such a usage pattern ties up the telephone for incoming calls and causes a strain for other members of the household who wish to place calls. In response, households have added a second telephone line for computer data traffic. To provide a second telephone line, a second pair of copper wires is usually provided between the subscriber's location and the telco central office. In addition to more copper wiring, a second telephone line also requires additional central office connection and transmission equipment.

[0005] Recently, higher capacity data transmission services have become available to carry a subscriber's computer data to remote computer systems. Such data transmission services often carry data on the same copper pair utilized by POTS. To allow simultaneous data and POTS service and provide greater bandwidth, higher capacity data services operate at frequencies above the 1 KHz to 4 KHz voice frequency band used by POTS. For example, such data services may operate in the frequency range around 80 KHz or higher.

[0006] The growing popularity of on-line computer services has also challenged the assumptions upon which the telephone network was constructed. The public switched telephone network (PSTN) is designed with the assumption that only about 10% of residential users and 20% of business users are using the telephone at any given time. The PSTN telephone line and associated circuit-switching equipment are thus designed to be shared by only the fraction of subscribers actually using the telephone at any time. Now, many households use the telephone for several hours each day to carry data traffic to computer services. Using a POTS circuit-switched telephone call to carry data traffic inefficiently consumes hardware resources, since a dedicated circuit connection is consumed for the entire duration of the call.

[0007] More recently, packet-switched data networks have been established to carry high-speed data traffic between distributed computer systems. In addition to providing higher data rates, packet-switched networks are more hardware efficient than circuit-switched networks for carrying data. A packet-switched network establishes a virtual circuit connection which uses transmission resources only when data is actually transmitted. Such a virtual connection is well suited for users of computer services who are connected for long periods of time and spend a relatively small proportion of time actually transmitting and receiving data.

[0008] Despite the change in communication needs and usage patterns, most data traffic from homes or small offices is carried by POTS voice lines.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The invention is pointed out with particularity in the appended claims. However, other features of the invention will become apparent and the invention will be best understood by referring to the following detailed description in conjunction with the accompanying drawings in which:

[0010] FIG. **1** shows a schematic diagram of a telephone network in accordance with the present invention.

[0011] FIG. **2** shows a block diagram of the telco central office **20** of FIG. **1** in accordance with the present invention.

[0012] FIG. **3** shows a schematic diagram of a telephone subscriber location **10** such as a typical home or small office in accordance with the present invention.

[0013] FIG. **4** shows a block diagram of a tandem location in accordance with the present invention.

[0014] FIG. **5** presents a block diagram representation of an example interworking unit in accordance with the present invention.

[0015] FIG. **6** presents a block diagram of a subscriber unit in accordance with the present invention.

[0016] FIG. **7** presents a block diagram representation of an user interface unit in accordance the present invention.

[0017] FIG. **8** presents a perspective view of a subscriber unit in accordance with the present invention.

[0018] FIG. **9** presents a perspective view of a subscriber interface unit in accordance with the present invention.

[0019] FIG. **10** presents a block diagram representation of a converter in accordance with the present invention.

[0020] FIG. **11** presents a block diagram representation of an interface unit in accordance with the present invention.

[0021] FIG. **12** presents a block diagram representation of an interface unit in accordance with the present invention.

[0022] FIG. **13** presents a flowchart representation of a method in accordance with the present invention.

[0023] FIG. **14** presents a flowchart representation of a method in accordance with the present invention.

[0024] FIG. **15** presents a flowchart representation of a method in accordance with the present invention.

[0025] FIG. **16** presents a flowchart representation of a method in accordance with the present invention.

[0026] FIG. **17** presents a flowchart representation of a method in accordance with the present invention.

DETAILED DESCRIPTION OF PRESENTLY PREFERRED EMBODIMENTS

[0027] The various embodiments of the present invention yield several advantages over the prior art. In several embodiments, the telecommunication system of the present invention includes a subscriber unit, and methods for use therewith, for accessing one or more derived digital telephone lines carried over a digital subscriber line. Other embodiments of the present invention are directed toward a subscriber interface unit that provides similar functionality to a standard analog telephone set.

[0028] FIG. **1** shows a schematic diagram of a telephone network in accordance with the present invention. Telephone subscribers **10** are typically serviced by analog telephone lines carried to the central office **20** by a subscriber loop **12** including twisted pairs of copper wires. A number of subscribers **14** may also be connected by subscriber loops to a remote terminal **16** which combines a number of subscribers **14** onto a digital multiplexed data line **18** for transmission to the central office **20**. For example, a 24 channel multiplexed T1 line is commonly used in North America for the data line **18**.

[0029] Typically, a number of central offices **20** are connected by direct trunk circuits **22** or through tandem locations **30**. The tandem locations **30** provide trunk circuits **22** to connect two central offices or other tandem locations **30**. The tandem locations **30** can thus provide connections between central offices which do not have direct interconnecting trunks. It is to be understood that telephone switching networks may have multiple levels of tandem switching or other network topologies. The unique features of the present invention will be identified with respect to the features of the components of the network and their unique configuration.

[0030] FIG. **2** shows a block diagram of the telco central office **20** of FIG. **1** in accordance with the present invention. The central office **20** preferably includes a means to provide analog telephone lines such as conventional POTS. Conventional POTS is typically handled by the local-telephone switching device **23**. Local telephone switching devices such as a Northern Telecom DMS-100 or Lucent No. 5 ESS are well known to those skilled in the art. In alternative embodiments, an analog telephone line may also be provided by a Centrex type service or private branch exchange (PBX). As known to those skilled in the art, an analog telephone service may also be provided by a digital carrier system such as a T1 carrier or other type of concentrator.

[0031] In addition to POTS service, the central office may also include a means to provide a digital data line. For example, a digital data line may be implemented by a digital subscriber line access multiplexer (DSLAM) **24** to multiplex traffic from digital subscriber loops. Digital subscriber loops or digital carrier systems provided by remote terminal **16** and office terminal **25** provide digital data lines which enable subscribers **10** (FIG. **1**) to transmit large amounts of digital multiplexed data traffic over the POTS twisted pair telephone line. The digital subscriber loop is preferably an Asymmetric Digital Subscriber Line (ADSL). ADSL typically implements a digital subscriber line with a maximum data rate from the central office **20** to the subscriber **10** which is higher than the maximum available data rate from the subscriber **10** to the central office **20**. For example, ADSL typically provides an asymmetric data rate of 1.5 megabits-per-second (mbs) to the subscriber from the central office and about 400 kilobits-per-second (kbs) from the subscriber location to the central office. Most preferably, ADSL implements an ATM data transmission protocol between the subscriber **10** (FIG. **1**) and the central office **20**. Of course, other types of data transmission protocols may be utilized. In alternate embodiments, the digital data line may be provided by other types of digital carrier systems such as a SONET based digital systems.

[0032] As shown in FIG. **2**, the subscriber loop pairs **12** carrying both analog voice and digital data traffic from subscribers **10** to the central office **20** are terminated at a main distribution frame (MDF) **26**. From the MDF **26**, the subscriber loops **12** are connected to a means for separating POTS voice **32** frequencies from digital data traffic **34** such as a splitter **28**, for example. Preferably, the splitter **28** is implemented by the DSLAM **24**. The internal operation of the splitter **28** will be described later in more detail in connection with a splitter at the subscriber **10**.

[0033] The splitter **28** preferably has two outputs: one for POTS signals and another for data traffic. From the splitter **28**, the separated POTS voice signals **32** are connected back to the MDF **26** and onto the local switching device **23** handling POTS telephone calls. The data traffic output of the splitter **28** is directed to the DSLAM **24** to multiplex the digital data into a format suitable for transport on a data network **40**. Preferably, the DSLAM **24** multiplexes and packages a number of lower signal rate digital data lines to a SONET OC-3 or a DS-1 rate signal which is carried by a fiber optic network. Depending on the data network **40**, the DLSAM **24** may operate at higher bit rates such as those appropriate for SONET OC-12. It should be understood that the data network **40** may be of many different topologies. Preferably, the data network **40** is connected to a tandem location **30** to allow access to other central offices.

[0034] In the case of subscriber loops that are connected to the central office through a digital loop carrier system (i.e., a remote terminal **16** and an office terminal **25**), the DSLAM **24** and its splitter **28** are preferably placed at the remote terminal **16**. The data and voice signals are separated with the splitter **28**, as described above. The voice signals are carried on the digital loop carrier system to the office terminal **25** where they are connected through the MDF **26** to the local circuit switch **23**. Preferably, the data signals are carried on a separate optical fiber or SONET frame in the carrier system so that they can easily be separated from the

voice signals in the office terminal **25**. These signals are transmitted from the office terminal to the data network **40**.

[**0035**] FIG. **3** shows a schematic diagram of a telephone subscriber location **10** such as a typical home or small office in accordance with the present invention. A network interface device (NID) **41** connects the subscriber to the public switched telephone network (PSTN). The subscriber loop **12** between the subscriber **10** and the central office **20** is terminated at the NID **41**. Customer premise equipment (CPE) such as a standard telephone set **52** or other CPE equipment such as a key system, PBX, or computer network **56** to access the PSTN is connected at the NID **41**. Voice signals from an analog telephone line **53** and data signals from a digital data line **55** are typically carried to the subscriber **10** on the same subscriber pair **12**.

[**0036**] In the preferred embodiment of the invention, the NID **41** includes a means for separating voice frequency signals from data signals. Preferably, a splitter **44** separates voice frequency signals from the data traffic sharing the subscriber loop **12** wire pair. For example, to separate POTS from data traffic, the splitter **44** typically includes a high-pass filter **46** and a low-pass filter **48**. To separate POTS voice signals, the low-pass filter **48** blocks high frequency signals, for example signals above 5 KHZ, passing only lower voice frequency signals on a conventional CPE POTS loop **50**. The voice signals on the CPE POTS loop **50** are connected to standard telephone **52** such as a Bell **103** set providing conventional POTS service. It should be noted that a conventional computer modem **54** can also utilize the conventional CPE POTS loop **50**.

[**0037**] To recover data traffic, the high-pass filter **46** blocks low frequency signals, for example signals below 5 KHz, leaving only high frequency data traffic signals to be sent out on a separate CPE data network loop **56**. The CPE data network loop **56** is connected to CPE equipped to access data traffic, for example, a network of personal computers. In the preferred embodiment, the CPE data network **56** implements an asynchronous transfer mode network (ATM). Each of the personal computers **58** is equipped with a ATM network interface card (NIC) to allow the computer to access the CPE data network **56**. The NIC **41** preferably also includes data segmentation and reassembly (SAR) capability to packetize data for transmission on the data network **56**. Of course, other types of computer networks, such as an Ethernet network, may also be implemented.

[**0038**] Preferably, the CPE data network **56** is also equipped with one or more digital telephones **60** capable of interfacing the data network **56** to allow a subscriber to place a voice telephone call over the CPE data network **56**. For example, a digital telephone **60** may be implemented with one of the personal computers **58** on the data network **56** by adding a telephone handset and an appropriate NIC with telephony functions. The telephone handset transmits and receives analog voice signals similar to a conventional handset. The computer/NIC provides SAR capability for converting analog voice to a digital packet stream for transmission over the CPE data network **56**. The data network **56** also carries the basic telephony signaling functions. One such system capable of providing such a digital telephone is an ATM network based telephone system from Sphere Communications in Lake Bluff, Ill.

[**0039**] Using the CPE data network **56**, the subscriber **10** can place a voice call using a telephone line derived from the digital data line. POTS service operates as a usual over the POTS wiring **50** to provide regular telephone service such as a telephone line carrying analog voice signals. In addition, the data network **56** with digital telephone **60** also has the capability to place voice telephone calls using one or more derived voice lines implemented through the data network, as will be explained below in more detail.

[**0040**] FIG. **4** shows a block diagram of a tandem location in accordance with the present invention. The Class 5 local switch **70** typically connects local subscriber loops to the telephone network, while a separate tandem voice switch (not shown) provides conventional circuit-switched connections for directing POTS traffic between central offices **20** (FIG. **1**) of the PSTN. Class 5 local switches such as the Lucent 5 ESS and the Nortel DMS 100, and tandem voice switches such as the Lucent 4 ESS and the Nortel DMS 250 are known to those skilled in the art. In comparison, the means for providing data access to data networks is preferably a packet switch handling digital data traffic. For example, a data access tandem switch **72** provides access to data networks carrying digital data traffic. Preferably, the data networks are equipped to accept ATM packet-switched connections. The data access tandem switch **72** is an ATM fabric switch configured to provide virtual connections on demand between end users and providers of data networks and services. The data access tandem switch **72** may connect end users to various network service providers (NSPs) such as UUNet, MCI, Sprintnet, and AADS.

[**0041**] The tandem location **30** may also include a means to interface the data access tandem **72** and the Class 5 switch. For example, an interworking unit (IWU) **74** may implement an interface between the data access tandem switch **72** and the Class 5 switch **70** of the PSTN. The IWU **74** enables voice telephone calls carried by the data network **40** to access the PSTN through the Class 5 switch **70**. The IWU **74** is capable of converting a voice telephone call in the data network protocol from the data access tandem switch **72** into the circuit-switch protocol of the Class 5 switch **70**. Preferably, the IWU **74** interfaces an ATM packet data stream to a multiplexed circuit-switch protocol with dynamic allocation of voice channels such as TR-303.

[**0042**] FIG. **5** presents a block diagram representation of an example interworking unit in accordance with the present invention. In particular, the IWU **74** performs the SAR **76** of voice data from an ATM stream into a analog voice signal. The analog voice signal is then converted **78** into the data protocol such as a TR-303 protocol. More preferably, as seen in FIG. **4**, the IWU **74** converts the packetized ATM voice streams to a digital PCM format which is then converted to the desired TR-303 protocol. It should be noted that the local switch **70** may also be directly connected to a data access tandem **72** without the IWU interface **74**. Newer generation digital switches may be capable of directly interfacing with the data transfer protocol of the data access tandem **72**. For example, new generation circuit-switches may directly accept an ATM data stream for switching into the PSTN without the need for an IWU.

[**0043**] While a TR-303 protocol is described above, other protocols may likewise be used in accordance with the present invention. In particular, other protocols including a

PRI protocol, TR-08 protocol or a TR-57 protocol could likewise be used within the scope of the present invention.

[0044] With the system of FIGS. **1-5**, a derived voice telephone line using the data network can be implemented and utilized in conjunction with the methods and systems that follow.

[0045] A caller places a digital voice call similar to an ordinary telephone call using the digital telephone **60** of FIG. **3**. The SAR function of the digital telephone **60** converts the caller's analog voice signals to a packetized digital data stream for transport over the subscriber data network **56**. Preferably, the packetized data stream is in an ATM format.

[0046] The subscriber data network **56** carries the derived telephone line data stream to the subscriber loop **12** where it is transported on a digital data line to the central office **20** along with POTS traffic. Note, the derived telephone line uses the digital data line of the subscriber data network **56**, leaving the POTS telephone line available for analog telephone voice calls.

[0047] At the central office **20** shown in FIG. **2**, the splitter **28** separates the derived telephone line data stream from POTS traffic. The derived telephone line data stream is multiplexed by the DSLAM **24** together with a number of data streams or derived telephone line data streams from other subscribers. For example, the DSLAM **24** may combine data streams from a number of different subscribers into a higher rate digital signal such as a DS-3 or OC-3 signal. The telephone line data stream is then carried by the OC-3 signal over the data network **40** to the tandem location **30**.

[0048] At the tandem location **30** shown in FIG. **4**, the derived telephone line and data sessions are switched by the data access tandem **72**. Preferably, data sessions to a NSP are directly switched by the data access tandem **72** to the desired NSP without entering the PSTN. For voice calls which must enter the PSTN, the data access tandem **72** directs the derived telephone line data streams to the IWU **74**.

[0049] The IWU **74** preferably converts the derived telephone line data stream to a voice signal in a TR-303 format which can be switched by the Class 5 telephone switch **70**. Through the Class 5 switch **70**, the derived voice call enters the PSTN and is switched as a POTS call. If needed, a separate tandem switch establishes a circuit connection to the desired central office **20**.

[0050] FIG. **6** presents a block diagram of a subscriber unit in accordance with the present invention. In particular, a subscriber unit **100** allows connection with a public switched telephone network. The public switched telephone network has at least one switch and at least one digital subscriber line **102**, such as described in FIGS. **1-5**, in communication with the switch. In accordance with the present invention, the subscriber unit **100** is operable to send and receive voice calls over the public switched telephone network.

[0051] While the various embodiments of the present invention have been described in conjunction with a public switched telephone network, these embodiments could similarly apply to voice communications over other communication networks. In particular, telephone calls, within the scope of the present invention, can be transmitted using a data communications network such as the Internet as a transport medium for a least a portion of a call. In these embodiments of the present invention the functionality of an analog local switch or digital switch could be performed by a server and router corresponding to a local Internet service provider or could include an IP gateway in combination with a central office switch. Further the switch of the present invention could be a central office circuit switch or a packet switch depending on the nature of the network.

[0052] The subscriber unit **100** includes a digital subscriber line interface unit **104** receives the plurality of data packets from the digital subscriber line **102** and identifies selected ones of the plurality of received data packets corresponding to a received data stream Of a first derived digital telephone. The subscriber unit **100** is further operable to transmit, on the digital subscriber line, a plurality of transmitted data packets corresponding to a transmitted data stream of the first derived digital telephone line.

[0053] In one embodiment of the present invention data packets are formatted in accordance with the Asynchronous Transfer Mode (ATM) protocol. Further, a hierarchical protocol structure could likewise be used encompassing, for instance, an Ethernet protocol carried by ATM or an internet protocol (IP) such as TCP/IP carried by ATM. However, other packet data protocols and hierarchical structures and combinations could likewise be implemented within the scope of the present invention.

[0054] Packets received by the subscriber unit **100**, destined for receipt by subscriber unit **100** include an address, consistent with the particular protocol or protocols used for formatting the data packets, that corresponds to either the subscriber unit **100** or to a corresponding subscriber. In accordance with an embodiment of the present invention whereby an IP is used, data packets directed to the subscriber unit **100** could be identified based on a particular IP node address or URL corresponding to either the particular subscriber unit **100** or to a particular subscriber using subscriber unit **100**. Alternatively, an ATM address could be used for the same purpose in an ATM protocol environment.

[0055] The subscriber unit **100** further includes a coder/decoder **106**. The coder/decoder **106** receives the transmitted data stream from analog-to-digital (A/D) converter **108** and codes the transmitted data stream into the plurality of transmitted data packets. The coder/decoder **106** also receives the plurality of received data packets from the digital subscriber line interface unit **104** and decodes the plurality of received data packets into a received data stream to be transmitted to the digital-to-analog (D/A) converter **110** on line **122**.

[0056] Analog-to-digital converter **108** converts a transmitted analog signal from user interface unit **112** into the transmitted data stream. Digital-to-analog converter **110** converts the received data stream into a received analog signal for transmission to the user interface unit **112** on line **124**.

[0057] In this fashion, digital subscriber line interface unit **104**, coder/decoder **106**, A/D converter **108** and D/A converter **110** operate in concert to send and receive basic telephony signaling between the digital subscriber line **102** and an user interface unit **112**. This user interface unit **112** provides the basic functionality of a standard analog tele-

phone set. In particular, the user interface unit **112** provides an interface to a user of the subscriber unit and, at a minimum, generates the transmitted analog signal sent to A/D converter **108** and generates an acoustic signal based on at least a portion of the received analog signal.

[**0058**] In an alternative embodiment of the present invention, a direct data path **114** is provided for communicating with the user interface unit **112**. This data path could carry the transmitted data stream, the received data stream or both. In embodiments of the present invention where the user interface unit **112** includes a processor, data path **114** is advantageous to allow direct digital communication without need for the conversion to analog and then back to digital data.

[**0059**] FIG. **7** presents a block diagram representation of an user interface unit in accordance with the present invention. In particular, user interface **112** of FIG. **6** is shown in more detail in accordance with various alternative embodiments.

[**0060**] User interface unit **112** optionally includes a telephone tip/ring converter **125** that converts the analog signal line **122** from the D/A converter **110** to appear as a typical tip/ring pair **127** to telephone line interface unit **120**. In particular, tip/ring converter **125** adds a voltage bias and provides any necessary generation or conversion of signal levels from line **122** to appear as a standard analog telephone line, even though the analog signals such as voice and ringing signals on line **122** where transported over a packet data line. In various embodiments of the present invention, the functionality of D/A converter **108**, A/D converter **110** and tip/ring converter **125** perform the functions of a line card used in conjunction with a digital central office switch.

[**0061**] Optional telephone line interface unit **120** provides an interface between processor **126** and tip/ring converter **125** by converting basic telephony signals such as on-hook, off-hook, and ring signals for detection by the processor or for generation by the processor to the tip/ring pair **127**. In this embodiment, keypad **134** and DTMF tone generator **128**, switch hook **132**, alert signal generator **130** and telephone handset **140** are further coupled to the tip/ring pair **127** for directly responding to, and/or for generating, the basic telephony signals carried by tip/ring pair **127** in a manner familiar to those skilled in the art.

[**0062**] While the present invention is described as including a switch hook, other similar devices could likewise be used, including a flash key or a receive button, within the scope of the present invention.

[**0063**] However, processor **126**, including a plurality of interface ports (not specifically shown) and general memory **144**, is likewise capable of responding to and/or directly generating the basic telephony signals in a similar manner. In this fashion, dialed numbers can be recorded and stored for redialing or speed dialing purposes, conditions requiring distinctive ringing patterns can be detected and distinctive rings can be generated, stored voice signals can be generated and received voice signals can be analyzed, and on-hook and off-hook signaling can be generated without the use of the switch hook.

[**0064**] In an alternative embodiment of the present invention the functionality supplied by tip/ring converter **125** and telephone interface unit **120** could be supplemented or supplanted by direct digital connection **114** to processor **126**. The plurality of interface ports (not specifically shown) of processor **126** could provide the appropriate conversion from the analog devices such as keypad **134** and DTMF tone generator **128**, switch hook **132**, alert signal generator **130** and telephone handset **140**.

[**0065**] In various embodiments of the present invention the user interface unit advantageously includes a display unit. In various embodiments, this display unit is a liquid crystal display (LCD) capable of displaying information relating to incoming and outgoing calls in additional to command and control information for the operation of the subscriber unit. In particular, a graphical user interface (GUI) for operation of the telephone is implemented using the processor **126**, the display device **136** and additional keys **138**.

[**0066**] In a further embodiment of the present invention the additional are distributed adjacent to the display unit, the plurality of keys operable by the user to activate selected ones of a plurality of call control options displayed on the display device adjacent thereto. In this fashion, a plurality of call control options such as call transfer, hold, redial, conferencing, forwarding, speed dialing, hands free, line release, line selection, etc., can be implemented by a user by the presentation of a menu of commands and by pressing the key adjacent to the displayed command on the display device.

[**0067**] The display device **136** is further capable of displaying a plurality of data relating to an outgoing call, for instance, by monitoring the digits dialed by the user and by displaying destination telephone number reflected by these digits. The processor further is operable to time the duration of the call from the time the telephone line is off-hook and displaying the duration on the display device **14**. Call memory **142** is available for storing the plurality of data relating to an outgoing call for a plurality of outgoing calls. This data can be retrieved and reviewed by the user or can be downloaded to an external device coupled to the subscriber unit through data interface unit **152**.

[**0068**] Processor **126** is further capable of receiving and decoding caller identification data relating to the identity of an incoming caller and the display unit is capable of displaying a plurality of data relating an incoming call. In this fashion, caller ID signals received during the silent interval between the first and second rings of an incoming telephone call can be decoded and displayed to the user before the corresponding line is taken off-hook.

[**0069**] Similarly, for a subscriber to a caller ID/call waiting service who is engaged in a conversation with a first caller, the processor **126** can receive the caller ID information corresponding to a second caller and display it to a user for determination if the first caller should placed on hold and the second call should be answered. Additionally, the call disposition features corresponding a caller ID/call waiting deluxe could likewise be implemented using the display and either the keys of keypad **134** or the additional keys **138**.

[**0070**] Call memory **142** is likewise available for storing a plurality of data relating to an incoming call for a plurality of incoming calls. The plurality of data relating the incoming call includes caller ID information of the calling party, the duration of the call (if the call was completed), and data

indicating if the incoming call includes a facsimile message. In this embodiment of the present invention the stored data can be retrieved and displayed or downloaded as discussed earlier in conjunction with outgoing call data.

[0071] While many of the forgoing discussions have addressed the accessing of a single line, in various embodiments of the present invention the subscriber unit **100** is capable of monitoring and accessing multiple telephone lines, at least one of which is a derived digital telephone line. In these embodiments the display device **136** is capable of showing the status a plurality of lines, and the user is capable of accessing and placing calls on any one of a plurality of lines.

[0072] Further, the subscriber unit **100**, through the use of processor **126** and in response to a signal generated by the user interface unit **112** and in response to an action of the user, is capable of initiating a connection to a remote central office on one or more derived digital telephone lines carried by the digital subscriber line. In this embodiment of the present invention the processor **126**, coupled to the coder/decoder **106**, digital subscriber line interface **104** and coder/decoder **106**, is capable of accepting data corresponding to a second derived digital telephone line in addition to a first derived digital telephone line, and the processor **126** is further capable of monitoring the status of the second derived digital telephone line. More generally, the subscriber unit **100**, in response to a signal generated by the user interface unit **112** in response to an action of the user, is capable of initiating up to N additional derived digital telephone lines, where N is greater than 2.

[0073] In an additional embodiment of the present invention the user interface unit **112** further comprises a smart card interface unit **146** capable of accepting and communicating with a smart card (not specifically shown). Preferably, smart card interface unit **146** is compatible with PCMCIA standards and can accept any of a wide variety of such smart cards. In one such embodiment, the smart card inserted into the smart card interface unit **146** stores a plurality of data associated with the user and wherein the processor **126** is capable of downloading a plurality of smart card data from a smart card so that the use of the subscriber unit **100** can be personalized to the particular user.

[0074] In one embodiment of the present invention the plurality of smart card data includes a protocol address such as a IP node address or an ATM address corresponding to the user. In this fashion, the address of the telephone could change or be overridden by the address of the user downloaded from the smart card so that calls directed to the user could be sent to the particular subscriber unit **100** over a derived digital telephone line. Once the data was downloaded from the smart card, the subscriber unit can automatically register the presence of the subscriber at the location of the particular subscriber unit **100** by sending a data message to the remote central office over the digital subscriber line. Alternatively, the registration of the presence of the user at the particular subscriber unit **100** containing the smart card could be optionally effectuated only upon activation of the user either in response to a query by the subscriber unit, such as in response to a message displayed on the display device **136** or by action of the user in the absence of such a query.

[0075] In a further embodiment of the present invention the smart card data contains other personal options of the user including custom set-up and command options for the subscriber unit. These set-up and command options could include device macros for performing a series of commands on the subscriber unit at the touch of a single button and could also include a user's speed dial list.

[0076] In another embodiment of the present invention the user interface unit **112** further includes a keyboard **150** and wherein the subscriber unit is capable of communication with a first data service over the digital subscriber loop. In this fashion the subscriber unit **100** can operate as a PC or network computer to access data services such as internet or world wide web services from the subscriber unit **100**. In one such embodiment the communication with the first data service over the digital subscriber loop could use data packets that do not correspond to a derived digital telephone line. However, one or more derived digital lines could, nevertheless, be used for this purpose. In this embodiment the user interface unit **112** further includes a display driver **148** for driving a remote display device. In an applications where communicating with a first data service the device driver **148** allows the use of a larger display than might be integrated in the subscriber unit itself.

[0077] In a further embodiment of the present invention, the subscriber unit **100** specifically includes the functionality of a fax modem. In the fashion, the subscriber unit **100** is operable to send a receive a plurality of fax messages. In this embodiment a received fax message or fax message to be sent could be communicated to/from the subscriber unit using the data interface unit **152** in combination with a document scanner or a printer or other specific device.

[0078] In an additional embodiment of the present invention, the subscriber unit, under the control of processor **126**, performs the functionality of a answering machine where greetings are stored and played to incoming callers, and messages from callers are stored in a memory device such as general memory **144**.

[0079] FIG. **8** presents a perspective view of a subscriber unit in accordance with the present invention. In particular, a subscriber unit **100** is presented that incorporates the various features and options presented in conjunction with the descriptions of FIG. **6** and FIG. **7**. Housing **160** includes an integral display device **136**, keypad **134** and telephone handset **140**. Additional keys **138** (that are not adjacent to the display device **136**) and additional keys **138'** that are adjacent to the display device **136** provide access to advanced controls and features of the subscriber unit **100**. Smart card slot **162** corresponds to smart card interface unit **146** disposed within the housing. Display device jack **166** is coupled to display driver **148** within the housing **160** and data interface jack **164** is coupled to data interface unit **152** also disposed within the housing **160**.

[0080] FIG. **9** presents a perspective view of a subscriber interface unit in accordance with the present invention. In particular, FIG. **9** presents a subscriber interface unit for use in a telecommunication system including a switch, a local loop coupling the switch to a subscriber location. In this embodiment, a segment of the local loop includes copper twisted pair and the asymmetrical digital subscriber line is carried by the local loop. Further, the asymmetrical digital subscriber line carries a plurality of derived digital telephone lines as described in conjunction with FIGS. **1-5**. The

subscriber interface unit of FIG. **9** advantageously couples the asymmetrical digital subscriber line to an analog land-line telephone.

[**0081**] Subscriber interface unit **180** includes a housing **182** having a top surface **184** and a bottom surface **186** substantially coplanar to the top surface. An electrical coupler **188** provides a connection to a cable capable of carrying the asymmetrical digital subscriber line. An RJ-11 jack **190** provides a connection to a cable of the analog telephone (not specifically shown). A converter **200**, disposed within the housing, coupled to the electrical coupler **188** and to the RJ-11 jack **190**, converts the first analog signals generated by the analog telephone into a first plurality of data packets for transmission to a selected one of the plurality of derived digital telephone lines and converts a second plurality of data packets received from the selected one of the plurality of derived digital telephone lines into a second analog signal for transmission to the analog telephone.

[**0082**] In a particular embodiment of the present invention the subscriber interface unit **180** includes several optional features that correspond to features described in conjunction with the subscriber unit **100**. Components that are common with subscriber unit **100** are assigned common reference numerals. In addition, subscriber unit **180** includes a first indented portion **192** of top surface **184** for accepting the analog telephone on top thereof. A plurality of non-skid feet are coupled to the bottom surface **186** of the housing **182**.

[**0083**] While an RJ-11 jack **190** is shown for coupling to the analog land-line telephone, many other electrical connections including other plug and jack combinations are possible within the scope of this embodiment of the present invention. In a one embodiment of the present invention the digital subscriber line is carried by the standard telephone wiring within a home. In this embodiment, electrical coupler **188** is also implemented using an RJ-11 jack, however, like the RJ-11 jack **190**, other electrical connection options are possible within the broad scope of the present invention.

[**0084**] FIG. **10** presents a block diagram representation of a converter in accordance with the present invention. In particular, a converter **200** is presented for use with the subscriber interface unit **180** of FIG. **9**. Digital subscriber line **102** is attached to electrical coupler **188**. An analog land-line telephone is coupled to the converter via line **204** connected to RJ-11 jack **190**. Components that are common with subscriber unit **100** are assigned common reference numerals. Converter **200** operates in a manner similar to subscriber unit **100**, however, some of the components of subscriber unit **100** are supplied by an analog land-line telephone that is attached to the unit. In other words, the functionality of user interface unit **112** is supplied by interface unit **202** in combination with the analog land-line telephone. For the purposes of this disclosure the term "subscriber unit" should include the various embodiments of subscriber unit **100** as well as the various embodiments of subscriber interface unit **180** in combination with an analog land-line telephone.

[**0085**] In accordance with the present invention a multi-line analog telephone can be coupled to the subscriber interface unit **180**. In a manner similar to subscriber unit **100**, the combination of subscriber interface unit **180** and the multi-line analog land-line telephone is capable of accessing and monitoring the plurality of telephone lines and is further capable of selecting one of the plurality of telephone lines for conducting a voice call. The converter **200** further is capable of converting a third plurality of data packets received from an additional one of the plurality of derived digital telephone lines into a third analog signal for transmission to the analog telephone.

[**0086**] FIG. **11** presents a block diagram representation of an interface unit in accordance with the present invention. In particular, user interface unit **202** is shown for use in accordance with one embodiment of the converter **200** of FIG. **10**. Lines **122** and **124** from the A/D converter **108** and D/A converter **110** are coupled to tip/ring converter **125** as described in conjunction with several embodiments of subscriber unit **100**. The output **204** appears as a standard tip and ring pair to the analog land-line telephone.

[**0087**] The user interface unit **202** of FIG. **11** presents minimal functionality. The inclusion of additional functions for subscriber interface unit **180** can be desirable. In particular, many of the additional functions described in conjunction with subscriber unit **100** can likewise be included in subscriber interface unit **202** in accordance with the present invention. While the subscriber interface unit **180** of FIG. **9** does not present each of these additional functions, these functions may, nevertheless be included as described in conjunction with an alternative embodiment for interface unit **202** presented in FIG. **12**.

[**0088**] FIG. **12** presents a block diagram representation of an interface unit in accordance with the present invention. In particular, an alternative embodiment of interface **202** designated by reference numeral **202'** is presented. In this embodiment, numerous features of subscriber unit **100** are included. Components that are common with subscriber unit **100** are assigned common reference numerals. The output **204** of tip/ring converter **125** is coupled to the analog land-line telephone as well as to telephone line interface unit **120**. Processor **126**, display device **136**, additional keys **138**, call memory **142**, general memory **144**, smart card interface unit **146**, display driver **148**, keyboard **150** and data interface unit **152** function as previously described in conjunction with user interface unit **112**.

[**0089**] FIG. **13** presents a flowchart representation of a method in accordance with the present invention. In particular, a method for initiating a call is presented for use with various embodiments of the subscriber unit **100** or the various embodiments of subscriber interface unit **180** in combination with an analog land-line telephone.

[**0090**] The method begins in step **300** receiving an off-hook signal, generated by the subscriber unit in response to an action of a user. In one embodiment of the present invention this signal would be generated by the switch hook of a subscriber unit responding to the handset going off-hook. In other embodiments, an off-hook signal could be generated by the user selecting an additional key of the subscriber unit such as a "handsfree" key used to initiate a call using a speakerphone function of the subscriber unit or a "send" key commonly used by cellular telephones to initiate a call.

[**0091**] The method continues in step **302** by initiating a first derived digital telephone line of the plurality of derived digital telephone lines in response to the off-hook signal. In particular, the off-hook signal is converted to data in a

transmitted data stream that is converted to a transmitted data packet that is transmitted along the digital subscriber line to a switch through an interworking unit. This begins a data packet exchange between the switch and the subscriber unit carrying the basic telephony signals corresponding to the derived digital telephone line. In one embodiment of the present invention the data packet is addressed to an interworking unit where it is converted to a signaling protocol for interface to the switch.

[0092] FIG. **14** presents a flowchart representation of a method in accordance with the present invention. In particular, a method for initiating and terminating a call is presented for use with various embodiments of the subscriber unit **100** or the various embodiments of subscriber interface unit **180** in combination with an analog land-line telephone.

[0093] Steps **300** and **302** proceed as described in conjunction with the method described in FIG. **12**. The method continues in step **304** by generating a line-in-use signal, at the subscriber unit, indicating a first derived digital telephone line is in use. In step **306**, a visual indicator is generated at the subscriber unit in response to the line-in-use signal. In a preferred embodiment of the present invention, the visual indicator includes a display, on display device **136**, of the destination telephone number and of the duration of the call. Optionally, the visual display includes an indicator of an assigned number for the derived digital line. Thus, in a multi-line environment, a visual designator such as "line 1" can be displayed as well.

[0094] The method continues in step **308** by monitoring, at the subscriber unit, the content of at least one of the plurality of data packets of the digital subscriber line. In a preferred embodiment of the present invention, each of the incoming packets is continuously monitored by the subscriber unit to determine if any of the plurality of incoming data packets has an address corresponding to the subscriber unit. If so, the data payload from each such packet is transformed to the received data stream for transfer to the user interface unit to conduct the call. Further the transmitted data stream would be converted into a plurality of data packets addressed to the switch.

[0095] In step **310**, an on-hook signal is received, generated by the subscriber unit in response to an action of a user. In one embodiment of the present invention this signal would be generated by the switch hook of a subscriber unit responding to the handset being placed on-hook. In other embodiments, an on-hook signal could be generated by the user selecting an additional key of the subscriber unit such as a "line release" key used to terminate a call using a speakerphone function of the subscriber unit.

[0096] In step **312** the derived digital telephone line is terminated in response to the on-hook signal. In particular, the call is terminated when the on-hook signal is transmitted to the switch and the subscriber unit stops creating a transmitted data stream and transmitted data packets. The exchange of data packets between the switch and the subscriber unit corresponding to the derived digital telephone line ends.

[0097] In step **314**, the visual display indicating the line is use is also terminated with the termination of the call.

[0098] FIG. **15** presents a flowchart representation of a method in accordance with the present invention. In particular, a method for responding to an incoming call is presented for use with various embodiments of the subscriber unit **100** or the various embodiments of subscriber interface unit **180** in combination with an analog land-line telephone. One of ordinary skill in the art will recognize, based on the disclosure herein, that this method may be used in conjunction with the other methods of the present invention described herein.

[0099] The method begins is step **320** by monitoring the content of at least one data packet to detect an incoming call. As previously discussed, in a preferred embodiment of the present invention the step of monitoring is performed continuously. Prior to the initiation of an outgoing call or the receipt of an incoming call, the step of monitoring is important to both the detection of usage of other derived digital lines and the detection of an incoming call for the particular subscriber unit. During a call the step of monitoring is important to identifying data packets that correspond to the call in progress.

[0100] The method continues in step **322** by determining if a received packet indicates an incoming call. After receiving a data packet addressed to the particular subscriber unit, the data portion of the packet is translated to a received data stream—the data indicating a ring signal from the central office. In response, the method initiates ringing as shown in step **324**. In step **326**, caller ID information, that is, in a preferred embodiment, transmitted between the silent interval between the first and second ringing signals, is decoded, displayed on the display device, and is stored in a call memory.

[0101] The method proceeds in step **328** to determine if an off-hook signal is received. If an off-hook signal is received, the call is conducted in step **330** by continuously sending and receiving data packets corresponding to a derived digital telephone line between the subscriber unit and the central office for the duration of the call. In step **332**, a line-in-use signal is generated in response to the off-hook signal and in step **334** a visual indicator is generated and displayed to the user. In a preferred embodiment of the present invention this visual indicator includes the duration of the call and the received caller ID data. The visual indicator may optionally include a line designator indicating the line number of the line in use.

[0102] In step **336** the method proceeds by determining if an on-hook signal is generated in response to an action of the user. In step **338**, in response to the detection of an on-hook signal the derived digital line is terminated. The method continues by returning to step **320** and continuing to monitor the content of the incoming data packets for the initiation of an incoming call.

[0103] In a further embodiment of the present invention, when the remote party engaged in a telephone call on a derived digital telephone line goes on-hook, the subscriber unit generates an on-hook signal a predetermined time later to terminate the line in cases where the remote party has hung-up.

[0104] FIG. **16** presents a flowchart representation of a method in accordance with the present invention. In particular, a method for indicating the use of a derived digital telephone line by another subscriber unit is presented for use with various embodiments of the subscriber unit **100** or the

various embodiments of subscriber interface unit **180** in combination with an analog land-line telephone. One of ordinary skill in the art will recognize, based on the disclosure herein, that this method may be used in conjunction with the other methods of the present invention described herein.

[**0105**] The method begins in step **340** by monitoring, at the subscriber unit, the content of at least one of the plurality of data packets corresponding to the digital subscriber line. The method continues in step **342** by determining that a first derived digital telephone line is in use based on the content of the at least one of the plurality of data packets.

[**0106**] In this embodiment of the present invention, the subscriber unit monitors the traffic of data packets to determine the presence of incoming and outgoing calls by other subscriber units that share the same digital subscriber line. In one such embodiment the addresses of the other subscriber units is recorded in the particular subscriber unit of interest so that packets addressed to the other subscriber units can be read. In an alternative embodiment of the present invention all incoming data packets are monitored for the presence of basic telephony signals to determine if other derived digital telephone lines are in use.

[**0107**] In step **344** a line-in-use signal is generated, at the subscriber unit, indicating a first derived digital telephone line is in use. This line-in-use signal can be used in the subscriber unit to display information on the status of one or more additional lines that are use by other subscriber units connected to the same digital subscriber line.

[**0108**] In operation, the present invention allows a plurality of subscriber units to be advantageously connected to a single subscriber line. The nature of the derived digital telephone line allows additional telephone lines to be added on demand up to the bandwidth limits of the digital subscriber loop. All of these lines can be monitored and accessed by a single subscriber unit connected to the digital subscriber line. The subscriber unit of the present invention is capable of performing the advanced features of a multi-line centrex-based system without the necessity of the additional hardware. For instance, each subscriber unit can perform three-way calling, call transfer, call forwarding, call holding etc.

[**0109**] FIG. **17** presents a flowchart representation of a method in accordance with the present invention. In particular, a more detailed method for indicating the use of a derived digital telephone line by another subscriber unit is presented for use with various embodiments of the subscriber unit **100** or the various embodiments of subscriber interface unit **180** in combination with an analog land-line telephone. One of ordinary skill in the art will recognize, based on the disclosure herein, that this method may be used in conjunction with the other methods of the present invention described herein.

[**0110**] Steps **340**, **342** and **344** correspond to similar steps presented in conjunction with FIG. **16**. Step **346** proceeds by generating a visual indicator in response to the line-in-use signal. In a preferred embodiment of the present invention this visual indicator includes the duration of the call, the received caller ID data. The visual indicator further includes a line designator indicating the line number of the line in use.

[**0111**] In step **348** an add-a-line signal is received, generated in response to an action by the user. In one embodiment of the present invention, this signal is generated by an off-hook signal where a line is currently in use. In this fashion the subscriber unit defaults to adding a new line rather than adding the user to a call on an existing line when the receiver is picked-up during a period when another derived digital telephone line is in use. In this embodiment, an existing call would be accessed by a user by pressing another key, such as a soft key, adjacent to the portion of display indicating that an call is progress. In an alternative embodiment the functions could be reversed and an off-hook signal would default to joining an existing call and an additional key could be used to generate an add-a-line signal.

[**0112**] The method proceeds in step **350** by initiating a second derived digital line by setting up two-way packet data communication with the local central office. Optional steps **352** and **354** correspond to receiving a hold signal generated by the action of the user, such a pressing a hold button, and placing the second derived digital line on "hold". Optional steps **356** and **358** correspond to receiving a signal based on the action of a user indicating one of a plurality of derived digital lines that are currently active and accessing the corresponding one of the plurality of derived digital lines.

[**0113**] In step **360** an on-hook signal is received and in step **362**, the second derived digital line is terminated in response to the on-hook signal. These steps are similar in scope to steps described in conjunction with the methods of FIGS. **14** and **15**.

[**0114**] While various embodiments of the present invention have been described as having a single address or single telephone number that corresponds to a subscriber unit. The subscriber unit of the present invention could likewise respond to a plurality of derived digital lines corresponding to multiple IP node addresses, URLs, ATM addresses or telephone numbers. In this fashion, multiple derived digital lines may be directed to a single subscriber unit via multiple addresses or multiple telephone numbers.

[**0115**] The various methods described herein, in a preferred embodiment, are intended for operation as software programs running on a computer processor. One of ordinary skill in the art will recognize that other hardware implementations such as application specific integrated circuits, programmable logic arrays and other hardware devices could likewise be constructed to implement the methods described herein. In should also be noted that the various methods of the present invention could be stored on a tangible storage medium such as a magnetic or optical disk, read-only memory or random access memory and be produced as an article of manufacture.

[**0116**] Thus, there has been described herein a concept, as well as several embodiments including a preferred embodiment, of a telecommunication system, method and subscriber unit for use therewith. The various embodiments of methods and systems, by enabling telecommunications services over a derived digital telephone line of a digital subscriber line, provide a significant improvement over the prior art. Additionally, the various embodiments of the present invention herein-described have other features that distinguish the present invention from the prior art.

[**0117**] It will be apparent to those skilled in the art that the disclosed invention may be modified in numerous ways and

may assume many embodiments other than the preferred forms specifically set out and described above. Accordingly, it is intended by the appended claims to cover all modifications of the invention which fall the true spirit and scope of the invention.

1.-**36**. (canceled)

37. A telephone communication system comprising:

means for providing a telephone line having analog voice signals carried by a subscriber loop; and

means for providing a digital data line sharing said subscriber loop with said subscriber loop with said telephone line, said digital line providing a digital voice channel for placing telephone voice calls.

38. The invention of claim 37 wherein said means for providing a telephone line comprises a central office switch.

39. The invention of claim 37 wherein said means for providing a digital data line include a digital carrier system.

40. The invention of claim 37 further comprising a means for separating analog voice signals from digital data signals.

41. The invention of claim 40 wherein said means of separating analog voice signals includes a splitter comprising a high-pass and a low-pass filter.

42.-**61**. (canceled)

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