(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 January 2001 (11.01.2001)

PCT

(10) International Publication Number
WO 01/03315 A1

(51) International Patent Classification[7]: H04B 1/56, H04L 5/14

(21) International Application Number: PCT/US00/17593

(22) International Filing Date: 27 June 2000 (27.06.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/346,434 1 July 1999 (01.07.1999) US

(71) Applicant: MOTOROLA INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(72) Inventors: USKALI, Robert, G.; 1504 Coventry Road, Schaumburg, IL 60195 (US). KINDINGER, Peter, A.; 75 Briargate Road, Cary, IL 60013 (US).

(74) Agents: BOSE, Romi, N. et al.; Motorola Inc.,, Intellectual Property Dept., 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

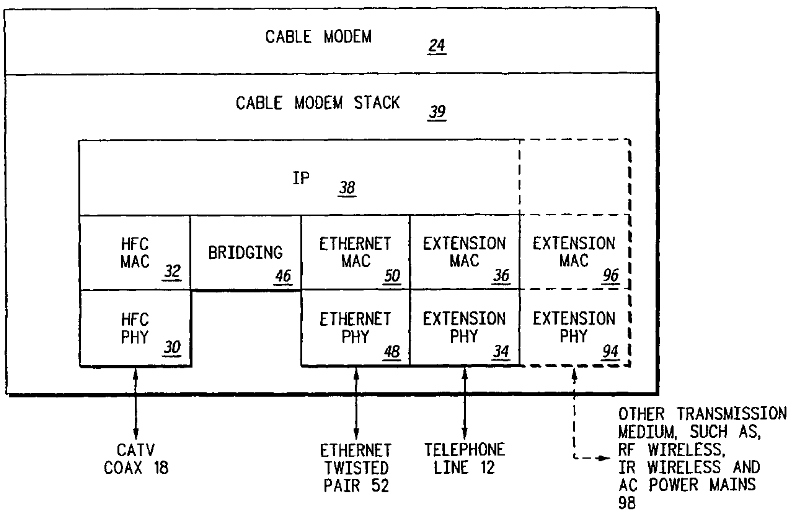
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

[Continued on next page]

(54) Title: HIGH-SPEED DATA EXTENSION INTERFACE FOR A MODEM



(57) Abstract: A modem (24) provides Internet access via an Internet service provider (ISP) network connection (18) within an ISP network (22) and a telephone line (12) within a public switched telephone network (16). An ISP network physical (PHY) layer (30) and an ISP network media access control (MAC) layer (32) are coupleable to the ISP network connection (18). An extension PHY layer (34) and an extension MAC layer (36) are coupleable to the telephone line (12). A single Internet protocol (IP) layer (38) couples the ISP network PHY and MAC layers (30, 32) to the extension PHY and MAC layers (34, 36). The single IP layer (38) transfers an IP datagram between the ISP network connection (18) via the ISP network PHY and MAC layers (30, 32) and the telephone line (12) via the extension PHY and MAC layers (30, 32) without manipulating the IP datagram over any additional PHY and MAC layers therebetween.

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HIGH-SPEED DATA EXTENSION INTERFACE FOR A MODEM

Field of the invention

The present invention relates generally to a high-speed data extension interface for a modem.

Background of the Invention

Typically, installations of cable modems today, as shown in FIG. 1, involve a cable modem that is connected directly to the cable system coaxial cable through the use of a splitter or directional coupler. This same coaxial feed is also used to supply CATV channels and programming to a TV or set-top box as shown. A 10BaseT Ethernet connection between an Internet access device, typically a personal computer (PC), and the cable modem is used to route upstream and downstream data between the computer and cable modem to ultimately provide an Internet connection.

If a second Internet access device is to be added to the system to take advantage of the Internet connection through the cable modem, an Ethernet hub may be used to create a star network topology as shown in FIG 2. In this case, twisted pair wiring is routed to one or more "extension" computers. In a typical subscriber premise environment, routing twisted pair wiring for the purposes of an Ethernet extension is costly and in some cases impractical.

Another method of sharing Internet connections throughout the subscriber premise is illustrated in FIG 3. This method leverages the use of an installed local network that operates over existing telephone lines within the subscriber premise. Telephone use is unaffected by the addition of the high-speed data signaling even when high-speed data is present. This is possible by frequency multiplexing the high-speed data signal allowing it to coexist with the baseband telephone signal. A high-speed Internet access device, such as the cable modem shown in FIG. 3, provides the Internet connection for the system. A disadvantage to this method is that it requires a host PC to manage the data traffic between the cable modem and the telephone line interface device. With this configuration, even if Internet access is only desired at the remote access point (Internet Access Device #2 in FIG. 3), a host computer must be present, turned on and continuously running appropriate bridging or proxy server software. If the host computer has a problem, such that it quits running, then the connection to the remote devices is broken.

A further disadvantage of this method is continuous manipulation of the Internet protocol (IP) datagrams through the Host PC interface. In order for the datagrams to be sent between the telephone line interface and the Internet access device, all data must be passed through the Host PC as shown in FIG. 3. Each time the data is processed through a physical medium, addition data processing is required which in turn increases the risks of introducing data errors and losing data while potentially adding transmission latencies. In addition, costly hardware and wiring is required to perform this physical layer and host computer processing.

Thus, there exists a need to provide a reliable, high-speed data network connection for cable modems without the disadvantages of high cost, limiting data rates, additional wiring of the premise, or requirement of a dedicated host computer.

Brief Description of the Drawings

A preferred embodiment of the invention is now described, by way of example only, with reference to the accompanying drawings in which:

FIG. 1 (prior art) illustrates a diagram of a cable modem installation;

FIG. 2 (prior art) illustrates a diagram of a cable modem using an Ethernet hub within a subscriber premise to connect more than one Internet access device to the Internet;

FIG. 3 (prior art) illustrates a diagram of a cable modem using a host personal computer to connect more than one Internet access device to the Internet;

FIG. 4 illustrates an example of the system employing a cable modem extension in accordance with the preferred embodiment of the present invention;

FIG. 5 illustrates protocol level diagram of the internal architecture of the cable modem in accordance with the preferred embodiment of the present invention;

FIG. 6 illustrates a spectrum allocation chart plotting frequency versus amplitude for the cable modem Ethernet extension in accordance with the preferred embodiment of the present invention;

FIG. 7 illustrates an alternative spectrum allocation chart plotting frequency versus amplitude for the cable modem Ethernet extension in accordance with the preferred embodiment of the present invention; and

FIG. 8 illustrates a hardware block diagram of the internal architecture of the cable modem in accordance with the preferred embodiment of the present invention.

Detailed Description of the Preferred Embodiment

The preferred embodiment of the present invention provides a high-speed data extension interface for modems with low cost and high data rates in a unitary device. The present invention allows one or more remote Internet access devices within a subscriber premise (e.g., the home, the office, etc.) to access the Internet via a single modem. The Internet access device is a personal computer, a personal digital assistant, a set-top box, an Internet appliance or any other device capable of accessing the Internet or the World Wide Web.

The present invention allows each Internet access device present within the subscriber premise to be connected directly to the telephone line through the use of an adapter. The present invention does not require a host Internet access device to be coupled directly to the modem or a dedicated Internet service provider (ISP) network connection (e.g., a cable television (CATV) coaxial cable) or a dedicated twisted pair wire to be coupled to each Internet access device.

FIG. 4 illustrates a preferred implementation of a modem in accordance with the preferred embodiment of the present invention. Typically, a subscriber premise 10 comprises a subscriber premise telephone line 12 connected to a public switched telephone network (PSTN) 16 and an ISP network connection 18 connected to the ISP network 22. The ISP network can be, but is not limited to, a CATV network, an integrated services digital network, an asynchronous transfer mode network, etc. The ISP network connection can be wired, wireless or a combination thereof. For ease of explanation and understanding, the following description assumes that the ISP network is a CATV network.

The telephone line 12 connects plain old telephone service (POTS) equipment 14 (e.g., telephones, facsimiles, etc.) to the PSTN 16 and a CATV coaxial cable 18 connects a television 20 to the CATV network 22 (possibly via a set-top box (not shown)). In addition, the preferred embodiment of the present invention allows a cable modem 24 to provide Internet access to at least one Internet access device 26 via the existing telephone line 12 and CATV coaxial cable 18. The cable modem 24 utilizes the telephone wiring 12 to route data packets to and from the Internet access device 26.

The cable modem 24 is connected to the CATV coaxial cable 18 extending from the CATV coaxial cable drop location 28. The internal architecture of the cable modem 24 is illustrated in FIG. 5. Of particular importance to the preferred embodiment of the present invention, the cable modem 24 comprises a hybrid fiber coaxial (HFC) physical (PHY) layer 30, a HFC media access control (MAC) layer 32, an extension PHY layer 34, and extension MAC layer 36 and a single Internet protocol (IP) layer 38. The

HFC PHY and MAC layers 30, 32 are coupleable to the CATV coaxial cable 18. The extension PHY and MAC layers 34, 36 are coupleable to the telephone line 12. The single IP layer 38 couples the HFC PHY and MAC layers 30, 32 to the extension PHY and MAC layers 34, 36. Thus, the HFC PHY and MAC layers 30, 32 and the extension PHY and MAC layers 34, 36 interface between the CATV network 22 and the telephone line 12 via the single IP layer 38 of the cable modem 24. The single IP layer 38 transfers IP datagrams between the CATV coaxial cable 18 via the HFC PHY and MAC layers 30, 32 and the telephone line 12 via the extension PHY and MAC layers 34, 36 without manipulating the IP datagram (e.g., packing and unpacking the IP datagram, etc.) over any additional PHY and MAC layers therebetween.

In particular, the extension PHY layer 34 performs both modulation and demodulation functions. The downstream data (data originating from the CATV network 22 and terminating at the Internet access device 26) is modulated by the extension PHY layer 34 in a predetermined format, such as, frequency shift keying (FSK), quadrature amplitude modulation (QAM), quadrature phase shift keying (QPSK), code division multiple access (CDMA), etc. The downstream data is then transmitted by employing communication system transmission circuits known to those skilled in the art of digital communication systems design within the modem extension channel 40 of FIG. 6 and FIG. 7 on the telephone line 12. The downstream data is transmitted in a non-interfering means avoiding the POTS channel 42 and/or any other channel present in the spectrum allocation (e.g., the xDSL channel 44) by using frequency multiplexing.

The upstream data (data originating from the Internet access device 26 and terminating at the CATV network 22) is extracted from the frequency multiplexed composite signal residing on the telephone line 12. By employing communication systems receiver circuits, upstream data within the modem extension channel 40 of FIG. 6 and FIG. 7 is recovered as readily known by one skilled in the art of digital communication systems receiver design by the extension PHY layer 34. Again, one of many modulation/demodulation formats, such as, FSK, QAM, QPSK, CDMA, etc. may be used to encode the upstream data. It is noted that the modulation/demodulation format of the upstream data need not be the same format as the downstream data. In addition, the modulation/demodulation format of the upstream and downstream data within the modem extension channel 40 need not be the same as that used within the CATV network 22. Also the upstream and downstream data within the modem extension 40 channel avoid interference with each other by frequency multiplexing.

The extension MAC layer 36 provides the necessary interfaces to manage upstream and downstream data transfers between the extension PHY layer 34 and the IP layer 38. The extension MAC layer 36 independently provides upstream and downstream functions as well as other miscellaneous control, such as memory management. Data received by the extension MAC layer 36 from the extension PHY layer 34 is processed by performing functions such as, but not limited to, frame and header extraction, frame and header processing, message filtering, data decryption, synchronizing messaging, and cyclic redundancy check (CRC) processing. Data received by the extension MAC layer 36 from the IP layer 38 to be transmitted by the extension PHY layer 34 is also processed within the extension MAC layer 36 by performing functions such as, but not limited to, data encryption, message and data packet forwarding, time slot management and data queuing.

The cable modem 24 further comprises a bridging mechanism within a bridging layer 46. The single IP layer 38 couples the bridging layer 46 to the HFC PHY and MAC layers 30, 32 and to the extension PHY and MAC layers 34, 36. The bridging layer 46 assists in transferring IP datagrams between the HFC MAC layer 32 and the extension MAC layer 36.

The cable modem 24 can also comprise a high-speed interface PHY layer 48 and a high-speed interface MAC layer 50 (e.g., Ethernet PHY and MAC layers). If the high-speed interface PHY and MAC layers 48, 50 are present, the high-speed interface PHY and MAC layers 48, 50 are coupleable to a high-speed interface twisted pair wire 52. The single IP layer 38 further couples the high-speed interface PHY and MAC layers 48, 50 to the HFC PHY and MAC layers 30, 32 and to the extension PHY and MAC layers 34, 36.

The preferred embodiment of the present invention provides a means for distributing Internet connections to Internet access device residing in locations where POTS connections (access points) 54 are available but CATV coaxial cable connections 56 are not. All Internet access devices 26 within the subscriber premise 10, even if only one, can access the Internet via the cable modem 24 by connecting the Internet access device 26 to a POTS connection 54. The present invention does not require any additional hosting devices (e.g., a dedicated PC coupled to the cable modem via a high-speed interface (e.g. Ethernet), external to the cable modem 24, to provide the Internet connection.

Turning to FIG. 8, the hardware components of the internal architecture of the cable modem 24 is shown. As shown in FIG. 8, the HFC PHY layer 30 comprises a HFC PHY layer circuit 58 (e.g., a HFC modem) having a HFC modulator 60 and demodulator 62. The extension PHY layer 34 comprises an extension PHY layer circuit 64 (e.g., an extension modem) having an extension modulator 66 and demodulator 68. The high-speed interface (e.g., Ethernet) PHY layer 48 comprises a high-speed interface PHY layer circuit 70 (e.g., an Ethernet modem) having a high-speed interface modulator 72 and demodulator 74. The functions and controls of the MAC layers 32, 36 and 50, the single IP layer 38 and the higher protocol layers of the cable modem stack 39 are implemented in a processing element 76 (e.g., a microprocessor, an application specific integrated circuit (ASIC) or other logic circuit). The processing element 76 is coupled to the HFC PHY layer circuit 58 for control thereof by the HFC MAC layer functions 78, to the extension PHY layer circuit 64 for control thereof by the extension MAC layer functions 80 and to the high-speed interface PHY layer circuit 70 for control thereof by the high-speed interface MAC layer functions 82. The processing element 76 further comprises IP buffering functions 84 (i.e., an IP buffer) common to the MAC layer functions 78, 80 and 82 for buffering IP datagrams between the PHY layer circuits 58, 64 and 70 in a common buffer 84.

First, let's discuss when the cable modem 24 transmits downstream data to the Internet access device 26 from the CATV network 22. At the HFC PHY layer circuit 58, a first signal is retrieved from the CATV coaxial cable 18. The HFC PHY layer circuit 58 demodulates the first signal in the HFC demodulator 62 resulting in a first data packet. The HFC demodulator 62 demodulates the first signal by using any of a variety of known techniques, such as, FSK, QAM, QPSK, CDMA, etc. The HFC demodulator 62 then transfers the first data packet to the processing element 76.

The processing element 76 implements the HFC MAC layer functions 78 by receiving the first data packet from the HFC demodulator 62 and decoding the first data packet resulting in an IP datagram. The IP datagram is then stored in an IP buffer 84.

Implementing the functions of the extension MAC layer 80, the processing element 76 retrieves the IP datagram from the IP buffer 84 and encodes the retrieved IP datagram into a second data packet. The second data packet is then transferred to the extension PHY layer circuit 64.

At the extension modulator 66, the second data packet is received from the processing element 76 and modulated into a second signal using known techniques, such as, FSK, QAM, QPSK, CDMA, etc. Once modulated, the extension modulator 66 transmits the signal onto the modem extension channel 40 of the telephone line 12.

Now let's discuss when the cable modem 24 transmits upstream data from the Internet access device 26 to the CATV network 22. At the extension PHY layer circuit 64, a first signal is retrieved from the telephone line 12. The extension PHY layer circuit 64 demodulates the first signal in the extension demodulator 68 resulting in a first data packet. The extension demodulator 68 demodulates the first signal by using any of a variety of known techniques, such as, FSK, QAM, QPSK, CDMA, etc. The extension demodulator 68 then transfers the first data packet to the processing element 76.

The processing element 76 implements the extension MAC layer functions 80 by receiving the first data packet from the extension demodulator 68 and decoding the first data packet resulting in an IP datagram. The IP datagram is then stored in an IP buffer 84.

Implementing the functions of the HFC MAC layer 78, the processing element 76 retrieves the IP datagram from the IP buffer 84 and encodes the retrieved IP datagram into a second data packet. The second data packet is then transferred to the HFC PHY layer circuit 58.

At the HFC modulator 60, the second data packet is received from the processing element 76 and modulated into a second signal using known techniques, such as, FSK, QAM, QPSK, CDMA, etc. Once modulated, the HFC modulator 60 transmits the signal onto the CATV coaxial cable 18 of the CATV network 22.

Referring back to FIG. 4, an Internet access device 26' can optionally be connected directly to the cable modem 24 via a high-speed interface and protocol 90 (e.g., Ethernet, universal serial bus (USB), etc.). However, directly connecting the Internet access device 26' to the cable modem 24 via the high-speed interface 90 is not optimal if the CATV coaxial cable drop location 28 is in an undesirable location (e.g., located in the middle of a living room next to the television 20). If an Internet access device 26' is connected directly to the cable modem 24, additional Internet access devices 26 can also access the Internet by connecting to the telephone line 12 without acquiring a connection through the Internet access device 26' connected to the cable modem 24 via the high-speed interface 90. Thus, the present invention provides the flexibility of routing all data packets through the telephone wiring 12 within the subscriber premise 10 by connecting the Internet access device 26 to the cable modem 24 via a POTS connection 54 with only an adapter 86 (described below) therebetween. Being able to connect all Internet access devices 26 to the cable modem 24 via the POTS connection 54 with only an adapter 86 therebetween avoids the disadvantages of high costs and inconvenience associated with providing a host Internet access device and/or installing dedicated high-speed wiring, such as twisted pair Ethernet or additional CATV coaxial cable within the subscriber premise 10.

The adapter 86, referred to above, is coupled to or installed within each Internet access device 26 connected to the Internet via POTS connection 54. The adapter 86 filters out undesired signaling, e.g., POTS voice signaling 42 (as shown in FIGS. 6 and 7), present on the telephone line 12 from reaching the Internet access device 26. The adapter 86 performs both modulation and demodulation functions. The downstream data within the modem extension channel 40 is extracted from the frequency multiplexed composite signal residing on the telephone line 12. The extracted data is then converted into high-speed interface packets (e.g., Ethernet packets). The adapter 86 selectively removes signals not of interest to the Internet access device 26 on the telephone line 12, such as POTS 42, xDSL 44, and upstream data, with either analog or digital filtering operations. The remaining spectrum containing downstream data is further processed by the adapter 86 to extract the baseband downstream data. For example, with respect to FIG. 6, the adapter 86 filters out all signaling transmitted below F1 and above F2. With respect to FIG. 7, the adapter 86 filters out all signaling transmitted below F2 and above F3.

The upstream data originating from the Internet access device 26 is modulated and transmitted within the modem extension channel 40 on the telephone line 12 in a modulation format and frequency spectrum allocation which is pre-determined and expected by the extension PHY layer 34. Using techniques known to one skilled in the art of digital communication system design, these transmitter and receiver functions (not shown) are performed within the adapter 86. Given known transmission upstream and downstream frequency allocations within the modem extension channel 40 of FIG. 6 and FIG. 7, known modulation formats and known communication protocols, a two-way communication link between the adapter 86 and the extension PHY and MAC layers 34, 36 of the cable modem 24 is established.

Also included within the adapter 86 are PHY and MAC layers (collectively referred to as an interface 87). The adapter MAC layer (not shown individually) manages data transmission to and from the Internet access device 26 and the adapter PHY layer (not shown individually). The type of high-speed data interface 88 between the adapter 86 and the Internet access device 26 is not limited to any particular implementation, but may be one such as Ethernet, USB, RS-232, parallel port, internal data bus, or any other connection that provides Internet access to an Internet access device 26. For example, an industry standard architecture (ISA) or a peripheral component interconnect (PCI) bus network interface card (NIC) may be used to provide the high-speed data interface to the desired Internet access device 26. The NIC includes the telephone line, adapter components, and data port jack (e.g., RJ11). In the case of Internet appliances, a fully integrated adapter, and computing device may be desired and possible with the present invention.

The present invention also allows configurations other than that shown in FIG. 4. Additional remote Internet access devices can be added to the system. In this example, the "base" configuration as shown in FIG. 4 does not change and additional remote Internet access devices are simply added anywhere in the subscriber premise 10 having an appropriate POTS connection 54.

In the preferred embodiment of the present invention, the cable modem 24 (i.e., the high-speed Internet connection) doubles as a stand-alone base unit supporting features such as, but not limited to, a dynamic host configuration protocol (DHCP) client to obtain an IP address and a DHCP server with network address translation (NAT) to assign IP addresses to the Internet access devices 26 within the subscriber premise 10. In addition, the cable modem 24 may also support firewall capability to provide secure access to the telephone line 12 from the CATV network 22.

Another function that may be included within the cable modem 24 is a unified messaging server (UMS). The UMS provides storage, retrieval and creation capability for voice and email messages. The primary function of the UMS is to provide a central point for the collection of all subscriber premise 10 messages with an ability to browse, reply and forward, including some intelligent filtering and automation. Email messages are collected from the Internet service provider (ISP) account(s) by the UMS. The UMS provides a visual indication of the receipt of email (e.g., flashing LED). Email can be viewed on a display contained on the cable modem if so desired. Voice mail playback functionality may also be included in the cable modem 24. In other words, a computer, or like device, is not necessary to receive or respond to email or voice mail messages. Alternately, email and voice mail messages can be retrieved through remote access to the UMS. The messages can be browsed and replies can be generated. The user can be connected locally on the telephone line 12 or remotely. Remote users, however, must be authenticated through the firewall.

All of the above mentioned features are implemented without the use of a dedicated host Internet access device being present, turned on and continuously running with appropriate software installed and operational.

Low pass filters (LPFs) 92 are installed at each POTS equipment connection 54 as well as at the POTS entry point in the subscriber premise 10. The LPFs 92 protect and block the high-speed Internet data signals from interfering with the POTS signaling 42, telephone lines 12 or any POTS equipment 14 connected to the telephone line 12 internal and/or external to the subscriber premise 10. For example, referring back to the frequency spectrum allocation illustrated in FIGS. 6 and 7, the LPF 92 corner frequency is predetermined based on the known spectral characteristics of the POTS signaling 42 and attenuates to an acceptable level all other unwanted signaling not within the POTS bandwidth (e.g., all signaling present above F1).

Thus, the LPFs 92 and the adapters 86 allow POTS equipment 14 and the Internet access devices 26 to be used without any impairments or restrictions by allowing POTS signals 42 and high-speed data signals 40 to coexist on a common telephone line 12. Using frequency-multiplexing techniques over the telephone line 12, simultaneous non-interfering use of POTS equipment 14 and Internet access devices 26 is possible.

In a first alternative embodiment of the invention, the cable modem 24 of FIG. 4 is replaced with another high-speed modem device. This high-speed modem device has the same basic architecture of the cable modem of FIG. 5 except an alternate MAC/PHY interface replaces the HFC MAC/PHY such as one that is used with an integrated services digital network (ISDN) or an asynchronous transfer mode (ATM) interface modem. Since a common IP layer is still shared with this architecture, the same benefits and features that are gained with the cable modem-based implementation apply.

In a second alternative embodiment of the invention, the extension PHY and MAC layers 34, 36 of the cable modem 24 shown in FIG. 5 are configured (resulting in a modified extension PHY and MAC layer 34, 36) to allow the signals residing on the modem extension channel 40 to be transmitted wirelessly (e.g. via industrial, scientific and medical (ISM) band transceivers, infrared data association (IrDA) transceivers, etc.). The modified extension PHY layer 34 provides the appropriate radio circuits to modulate and transmit downstream high-speed data as well as radio circuits to receive and demodulate the upstream high-speed data within the modem extension channel. The modem extension channel 40 is appropriately allocated by use of frequency multiplexing, within the wireless frequency spectrum, in a way which minimizes interference from any other communication signals. The modified extension PHY and MAC layers 34, 36 support a wireless transmission link between the cable modem 24 and modified adapters 86. In this second alternative embodiment, the modified adapters 86 contain a radio transceiver PHY/MAC interface 87' in place of the telephone line interface 87. The modified adapter PHY layer (not shown) incorporates corresponding radio circuits that receive and demodulate high-speed downstream data and modulate and transmit high-speed upstream data. This modified adapter 86' is coupled to the Internet access device 26 to provide the desired Internet connection. In the second embodiment, a wireless Internet connection is established without the use or need of the telephone line 12 and/or any other wiring.

In a third alternative embodiment of the invention, the extension PHY and MAC layers 34, 36 of the cable modem 24 shown in FIG. 5 is configured (resulting in modified extension PHY and MAC layers 34', 36') to allow the modem extension channel 40 to be transmitted over the subscriber premise alternating current (AC) power mains. The modified extension PHY layer 34' provides the appropriate communication circuits to modulate and transmit downstream high-speed data as well as communication circuits to receive and demodulate the upstream high-speed data within the modem extension channel 40. The modem extension channel 40 is appropriately allocated within the frequency spectrum of the AC power mains in a way that minimizes interference with any other existing communication or AC power signals. The modified extension PHY and MAC layers 34, 36 support an AC power line transmission link between the cable modem 24 and the modified adapters 86. In the third alternative embodiment, the modified adapters 86 contain a power line transceiver PHY/MAC interface 87' in place of the telephone line interface 87. The modified adapter PHY layer (not shown) incorporates corresponding communication circuits that receive and demodulate high-speed downstream data and modulate and transmit high-speed upstream data. This modified adapter 86 is coupled to the Internet access device 26 to provide the desired Internet connection. In the third alternative embodiment, access to the Internet is established over the existing AC power mains without the use or need of the telephone line 12.

In a fourth alternative embodiment of the present invention, the cable modem 24 contains the elements as shown in the architecture diagram of FIG. 5 with an added PHY layer 94 and MAC layer 96 (collectively referred to as "an additional PHY/MAC interface"). This additional PHY/MAC interface allows for an alternate transmission medium 98 in addition to the telephone line 12 to transmit the modem extension channel 40. The additional PHY/MAC interface supports a transmission link between the cable modem 24 and Internet access devices 26, and alternate transmission mediums 98, other than the telephone line 12, such as, but not limited to, a wireless radio frequency link, a wireless infrared link, and an AC power main link. Internet access devices 26 may be connected to the Internet via the telephone line 12 or via the alternate transmission medium 98.

CLAIMS

We claim:

1. A modem (24) for providing Internet access via an Internet service provider (ISP) network and a subscriber premise telephone line (12) within a public switched telephone network (16), comprising, in a unitary device:

an ISP network physical (PHY) layer (30) and an ISP network media access control (MAC) layer (32) coupleable to an ISP network connection (18);

an extension PHY layer (34) and an extension MAC layer (36) coupleable to the subscriber premise telephone line (12); and

a single Internet Protocol (IP) layer (38) coupling the ISP network PHY and MAC layers (30, 32) to the extension PHY and MAC layers (34, 36), wherein an IP datagram is transferred between the ISP network connection (18) via the ISP network PHY and MAC layers (30, 32) and the subscriber premise telephone line (12) via the extension PHY and MAC layers (34, 36) without manipulating the IP datagram over any additional PHY and MAC layers therebetween.

2. The modem (24) in accordance with claim 1 further comprising an high-speed interface PHY and MAC layers (48, 50), wherein the single IP layer (38) further couples the high-speed interface PHY and MAC layers (48, 80) to the ISP network PHY and MAC layers (30, 32) and the extension PHY and MAC layers (34, 36).

3. The modem (24) in accordance with claim 1 wherein the single IP layer (38) further couples a bridging layer (46) to the ISP network PHY and MAC layers (30, 32) and to the extension PHY and MAC layers (34, 36), and wherein the bridging layer (46) assists in transferring the IP datagrams between the ISP network MAC layer (32) and the extension MAC layer (36) across the single IP layer (38).

4. The modem (24) in accordance with claim 1 wherein the subscriber premise telephone line (12) has at least one access point (54) in which at least one Internet access device (26) is connected thereto via an adapter (86).

5. The modem (24) in accordance with claim 1 wherein the ISP network PHY and MAC layers (30, 32) and the extension PHY and MAC layers (34, 36) comprise communication system transmission circuits for transmitting IP datagrams to the ISP network connection (18) and to the subscriber premise telephone line (12), respectively.

6. The modem (24) in accordance with claim 1 further comprising an additional extension PHY and MAC layers (94, 96) coupleable to an alternate transmission medium (98), wherein the single IP layer (38) couples the additional extension PHY and MAC layers (94, 96) to the ISP network PHY and MAC layers (30, 32) and to the extension PHY and MAC layers (34, 36).

7. The modem (24) in accordance with claim 1 wherein:

at the ISP network PHY layer (30):

retrieving a first signal from the ISP network connection (18); demodulating the first signal resulting in a first data packet; and transferring the first data packet to the ISP network MAC layer (32),

at the ISP network MAC layer(32):

receiving the first data packet from the ISP network PHY layer (30);

decoding the first data packet resulting in the IP datagram; and transferring the IP datagram to an IP buffer (84) residing on the single IP layer (38),

at the extension MAC layer (36):

retrieving the IP datagram from the IP buffer (84); encoding the IP datagram into a second data packet; and transferring the second data packet to the extension PHY layer(34),

at the extension PHY layer (34):

receiving the second data packet from the extension MAC layer (36);

modulating the second data packet into a second signal; and transmitting the second signal onto the subscriber premise telephone line (12).

8. The modem (24) in accordance with claim 1 wherein:

at the extension PHY layer (34):

retrieving a first signal from the subscriber premise telephone line (12);

demodulating the first signal resulting in a first data packet; and

transferring the first data packet to the extension MAC layer (36),

at the extension MAC layer (36):

receiving the first data packet from the extension PHY layer (34);

decoding the first data packet resulting in the IP datagram; and

transferring the IP datagram to an IP buffer (84) residing on the single IP layer (38),

at the ISP network MAC layer (32):

retrieving the IP datagram from the IP buffer (84);

encoding the IP datagram into a second data packet; and

transferring the second data packet to the ISP network PHY layer (30),

at the ISP network PHY layer (30):

receiving the second data packet from the ISP network MAC layer (32);

modulating the second data packet into a second signal; and

transmitting the second signal onto the ISP network connection (18).

9. A modem (24) for providing Internet access comprising, in a unitary device:

a Internet service provider (ISP) network physical (PHY) layer (30) and a ISP network media access control (MAC) layer (32) coupleable to an ISP network via an ISP network connection (18);

an extension PHY layer (34) and an extension MAC layer (36) coupleable to an adapter (86) via a wireless transmission link; and

a single Internet Protocol (IP) layer (38) coupling the ISP network PHY (30) and MAC layers (32) to the extension PHY and MAC layers (34, 36), wherein IP datagrams are transferred between the ISP network connection (18) via the ISP network PHY and MAC layers (30, 32) and the wireless transmission link via the extension PHY and MAC layers (34, 36) without manipulating the IP datagrams over any additional PHY and MAC layers therebetween.

10. A modem (24) for providing Internet access via an Internet service provider (ISP) network connection (18) within an ISP network and a subscriber premise telephone line (12) within a public switched telephone network (16), comprising, in a unitary device:

a first physical (PHY) layer (30) circuit coupleable to the subscriber premise telephone line (12);

a second PHY layer circuit (34) coupleable to the ISP network connection (18); and

a processing element (76) having first media access control (MAC) layer functions and second MAC layer functions, the processing element (76) coupled to the first PHY layer circuit (58) for control thereof by the first MAC layer functions and to the second PHY layer circuit (64) for control thereof by the second MAC layer functions, and having Internet protocol layer buffering functions common to the first and second MAC layer functions, for buffering IP datagrams between the first PHY layer circuit (58) and the second PHY layer circuit (64).

11. A method for providing Internet access via an Internet service provider (ISP) network connection within an ISP network and a subscriber premise telephone line within a public switched telephone network, comprising, in a unitary device:

coupling an ISP network physical (PHY) layer and an ISP network media access control (MAC) layer to the ISP network connection;

coupling an extension PHY layer and an extension MAC layer to the subscriber premise telephone line; and

coupling the ISP network PHY and MAC layers to the extension physical and MAC layers via a single Internet Protocol (IP) layer, wherein IP datagrams are transferred between the ISP network connection via the ISP network PHY and MAC layers and the subscriber premise telephone line via the extension PHY and MAC layers without manipulating the IP datagrams over any additional PHY and MAC layers therebetween.

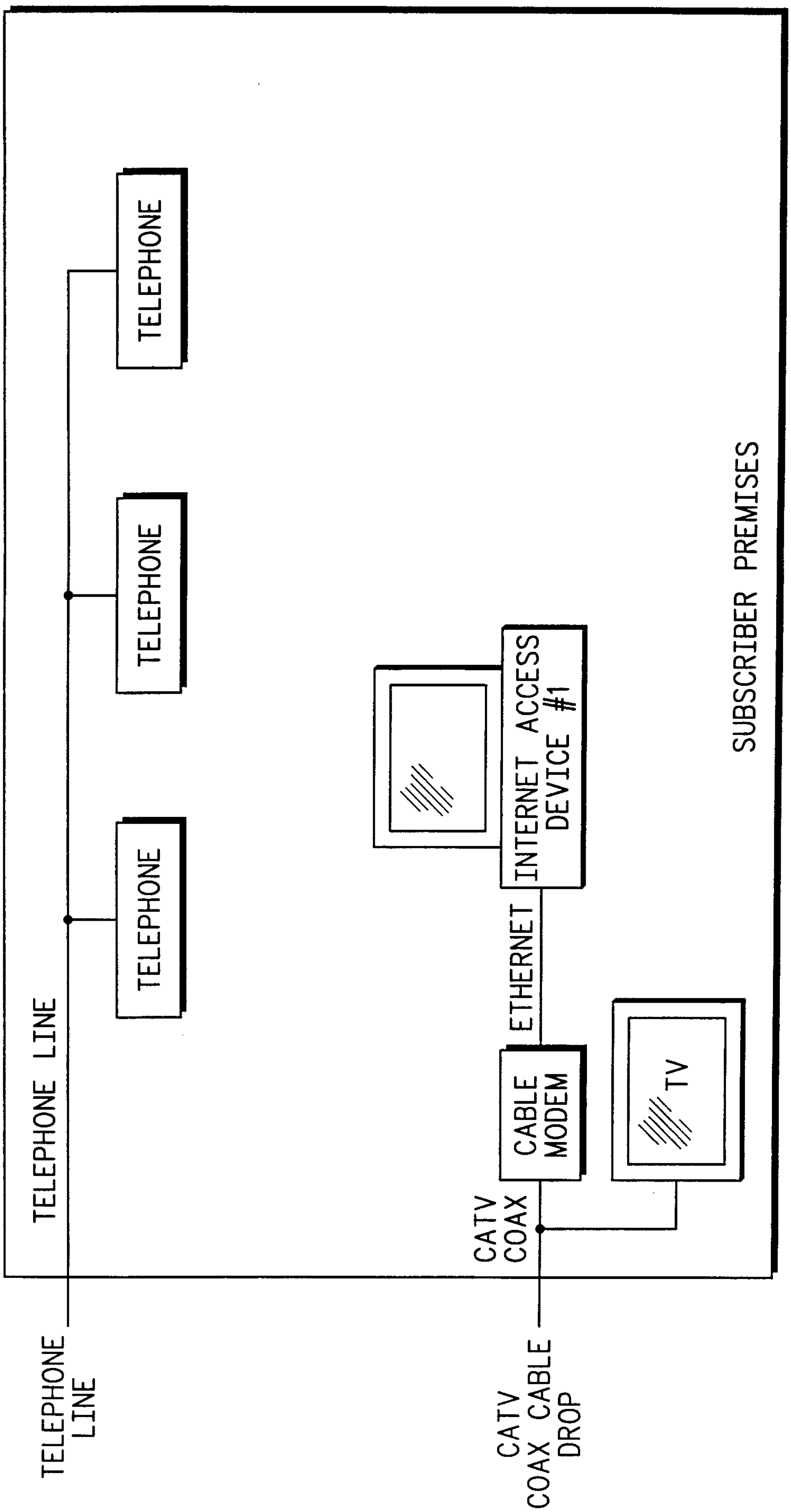

FIG.1
-PRIOR ART-

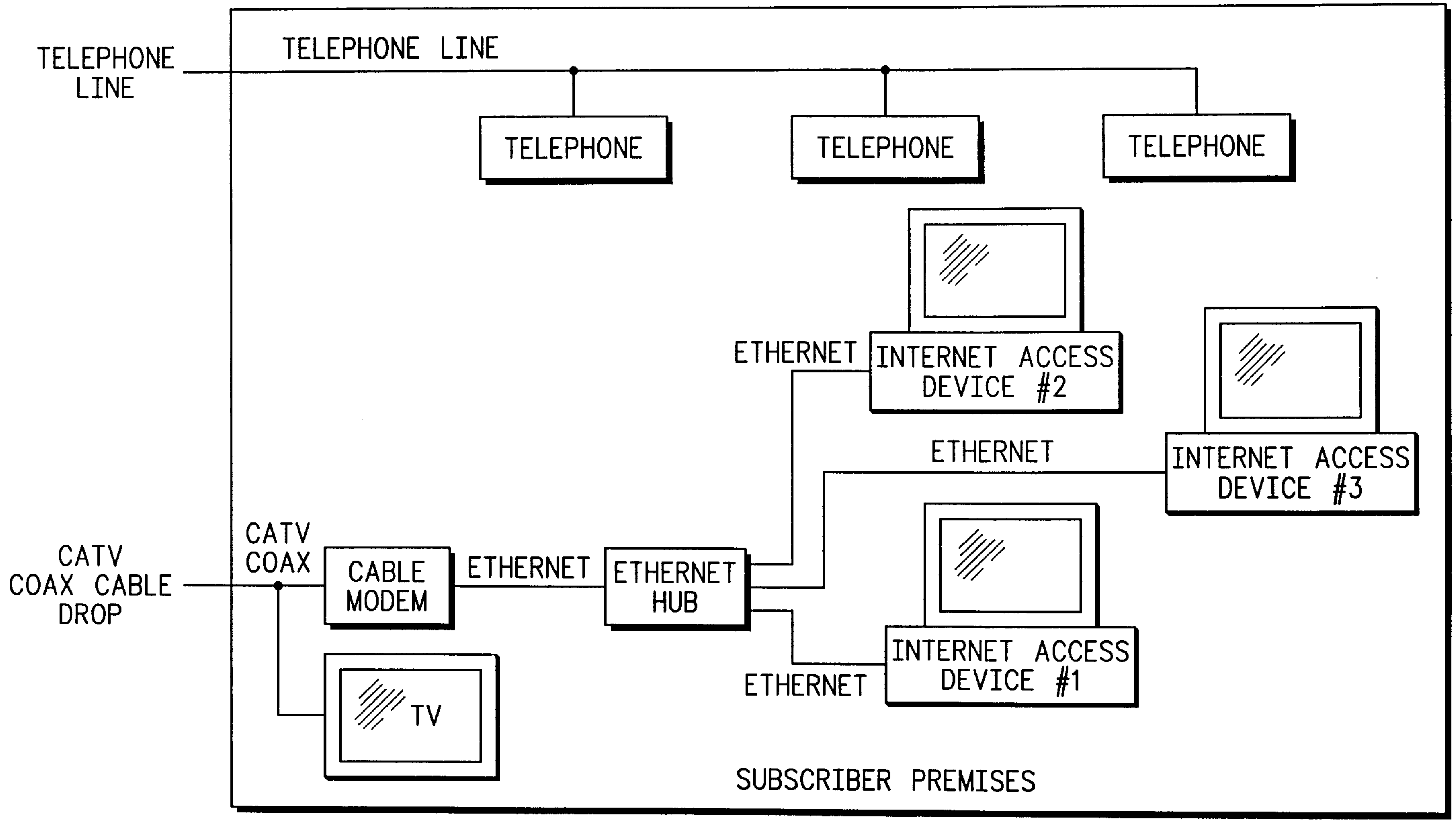

FIG.2
-PRIOR ART-

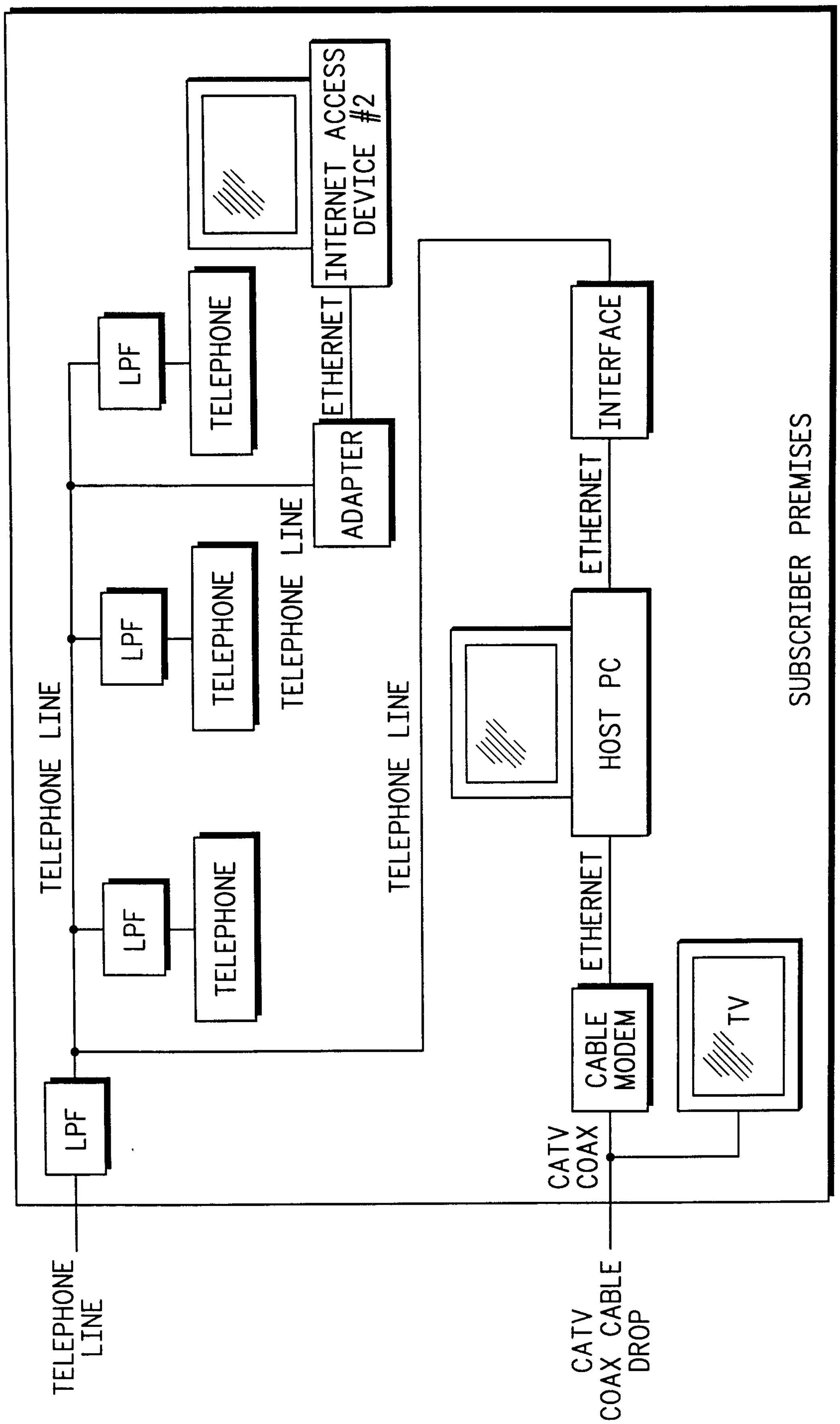

FIG.3
-PRIOR ART-

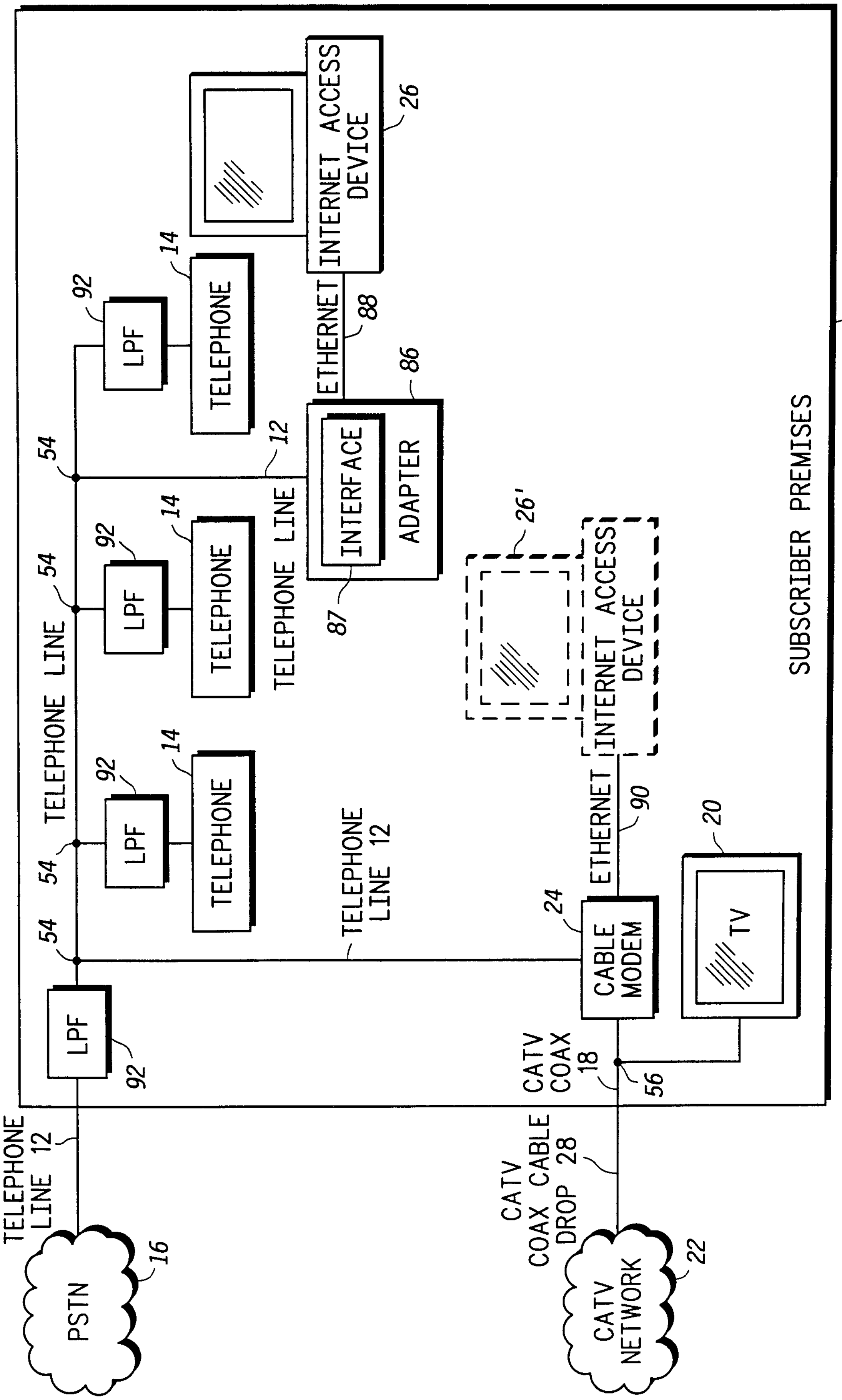
INTERNET ACCESS DEVICE
26
92
LPF
14
TELEPHONE
ETHERNET
88
86
INTERFACE
ADAPTER
12
54
TELEPHONE LINE
87
26'
INTERNET ACCESS DEVICE
SUBSCRIBER PREMISES
10
TELEPHONE LINE 12
ETHERNET
90
20
TV
24
CABLE MODEM
CATV COAX 18
56
TELEPHONE LINE 12
CATV COAX CABLE DROP 28
PSTN
16
CATV NETWORK
22

FIG. 4

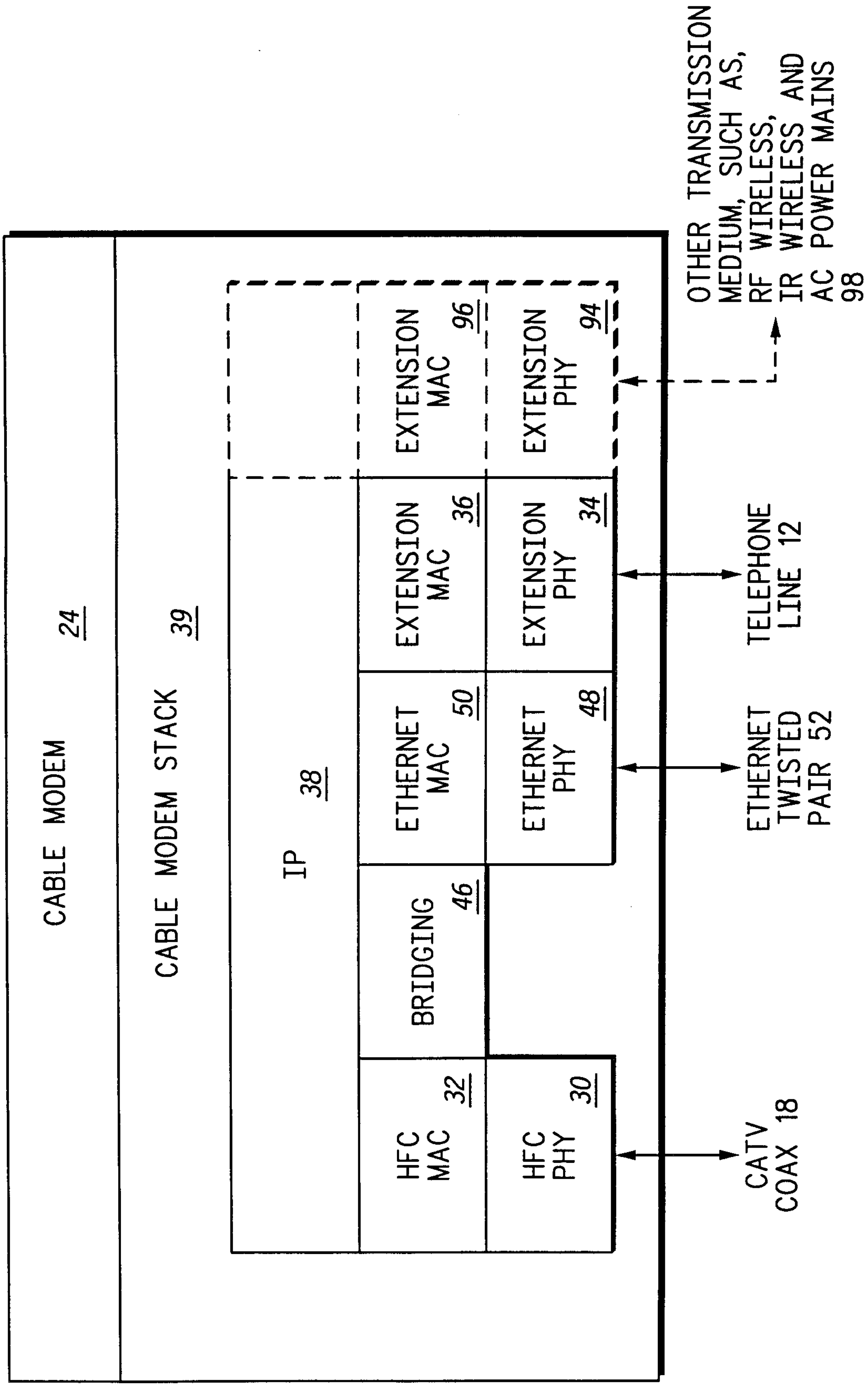
CABLE MODEM 24
CABLE MODEM STACK 39
IP 38
HFC MAC 32
HFC PHY 30
BRIDGING 46
ETHERNET MAC 50
ETHERNET PHY 48
EXTENSION MAC 36
EXTENSION PHY 34
EXTENSION MAC 96
EXTENSION PHY 94
CATV COAX 18
ETHERNET TWISTED PAIR 52
TELEPHONE LINE 12
OTHER TRANSMISSION MEDIUM, SUCH AS, RF WIRELESS, IR WIRELESS AND AC POWER MAINS 98

FIG.5

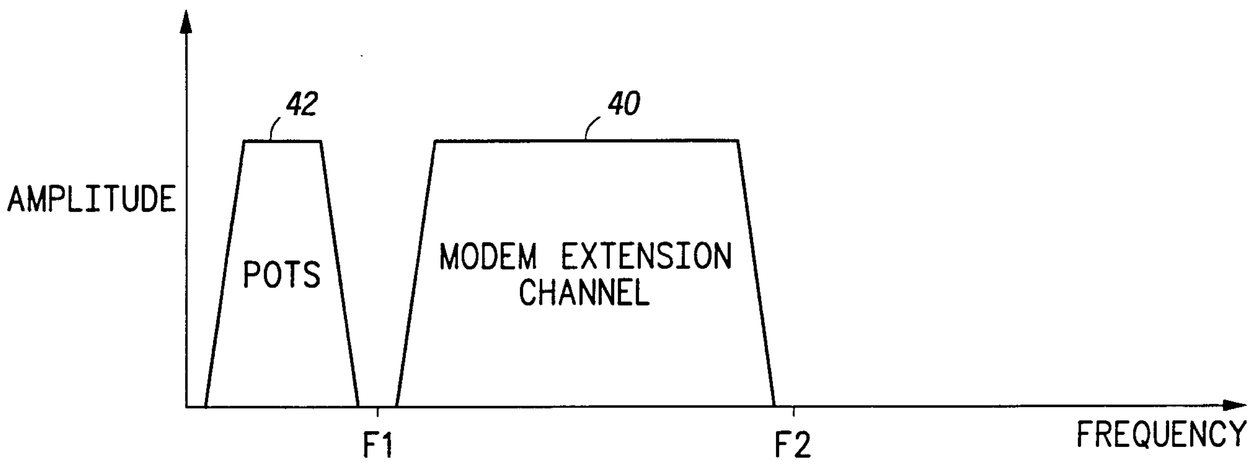
AMPLITUDE
42
40
POTS
MODEM EXTENSION CHANNEL
F1
F2
FREQUENCY

FIG.6

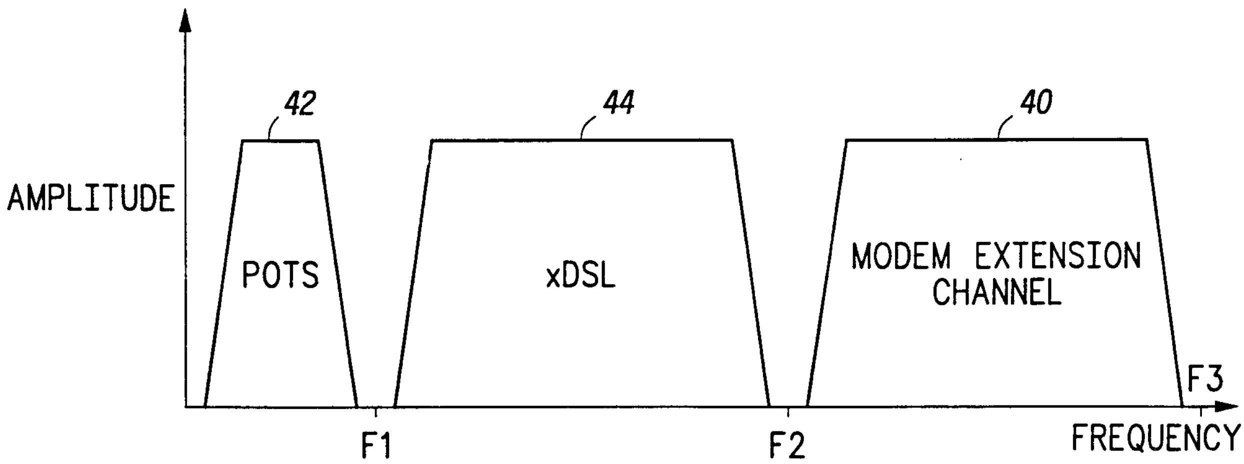
AMPLITUDE
42
44
40
POTS
xDSL
MODEM EXTENSION CHANNEL
F1
F2
F3
FREQUENCY

FIG.7

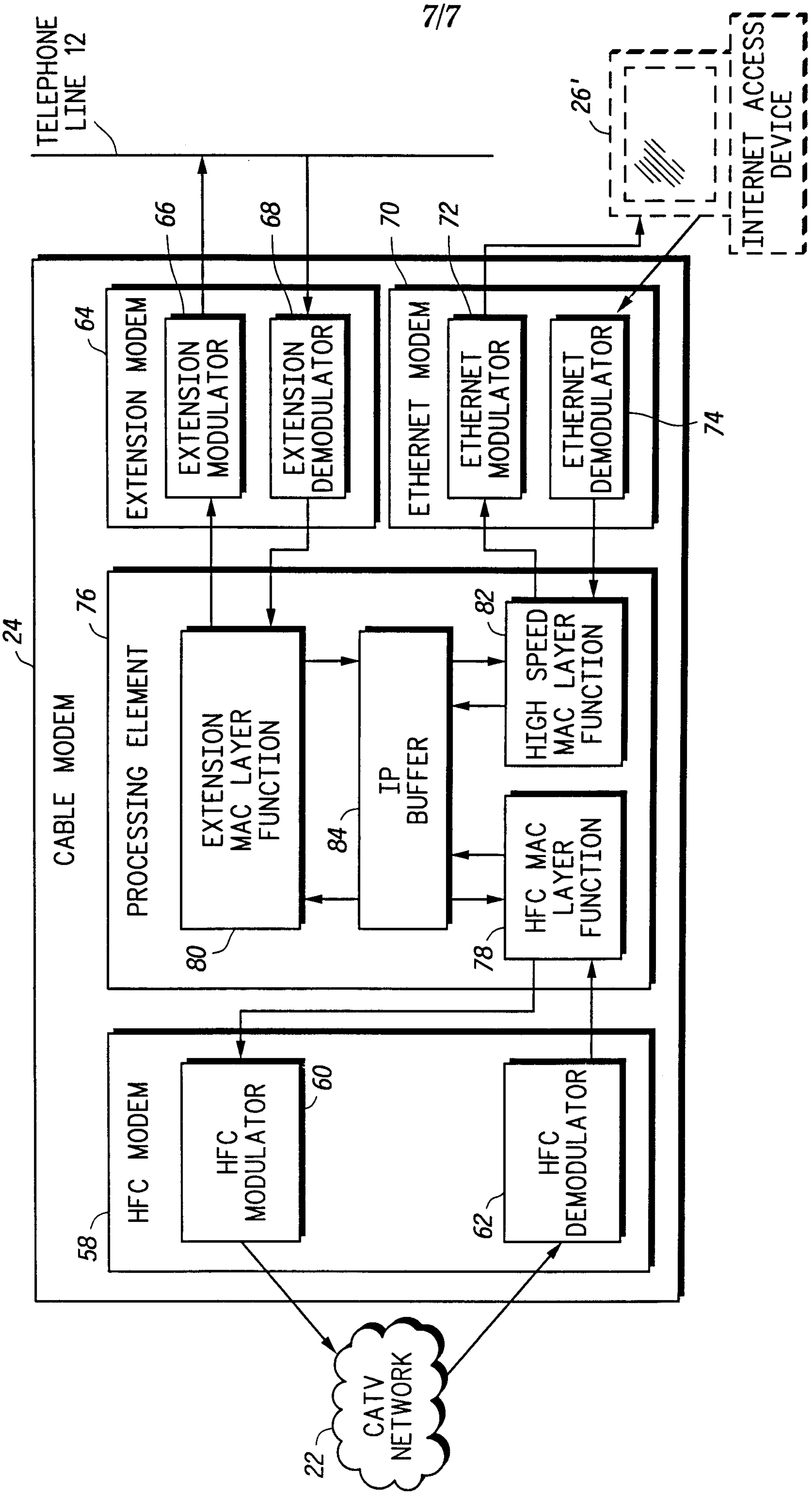
TELEPHONE LINE 12
66
68
70
72
26'
INTERNET ACCESS DEVICE
64
EXTENSION MODEM
EXTENSION MODULATOR
EXTENSION DEMODULATOR
ETHERNET MODEM
ETHERNET MODULATOR
ETHERNET DEMODULATOR
74
24
CABLE MODEM
76
PROCESSING ELEMENT
EXTENSION MAC LAYER FUNCTION
IP BUFFER
84
82
HIGH SPEED MAC LAYER FUNCTION
HFC MAC LAYER FUNCTION
80
78
HFC MODEM
58
HFC MODULATOR
60
HFC DEMODULATOR
62
CATV NETWORK
22

FIG.8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/17593

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H04B 1/56; H04L 5/14
US CL :370/276
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/276, 280, 285, 294, 351, 352, 353, 354, 356, 359, 360, 395, 396, 401, 412, 413, 415, 417, 419, 442, 465, 473

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,P	US 6,075,787 A (BOBECK et al) 13 June 2000, see Figs. 1, 23-25, col. 5, lines 23-55, col. 6, lines 57-67, col. 7, lines 1-15, col. 27, lines 9-41, col. 28, lines 1-67, and col. 29, lines 1-27.	1-6 and 9-11
Y,P	US 6,065,061 A (BLAHUT et al) 16 May 2000, see Figs. 1-2, col. 3, lines 16-67, and col. 4, lines 1-42.	1-6 and 9-11

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 AUGUST 2000	30 AUG 2000

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	PHIRIN SAM
Facsimile No. (703) 305-3230	Telephone No. (703) 308-9294