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(72) Inventeurs/Inventors:
CRUDER, OLIVER, CA;
LABBE, SAMUEL M., CA

(73) Propriétaire/Owner:
SASKTEL, CA

(74) Agent: SWABEY OGILVY RENAULT

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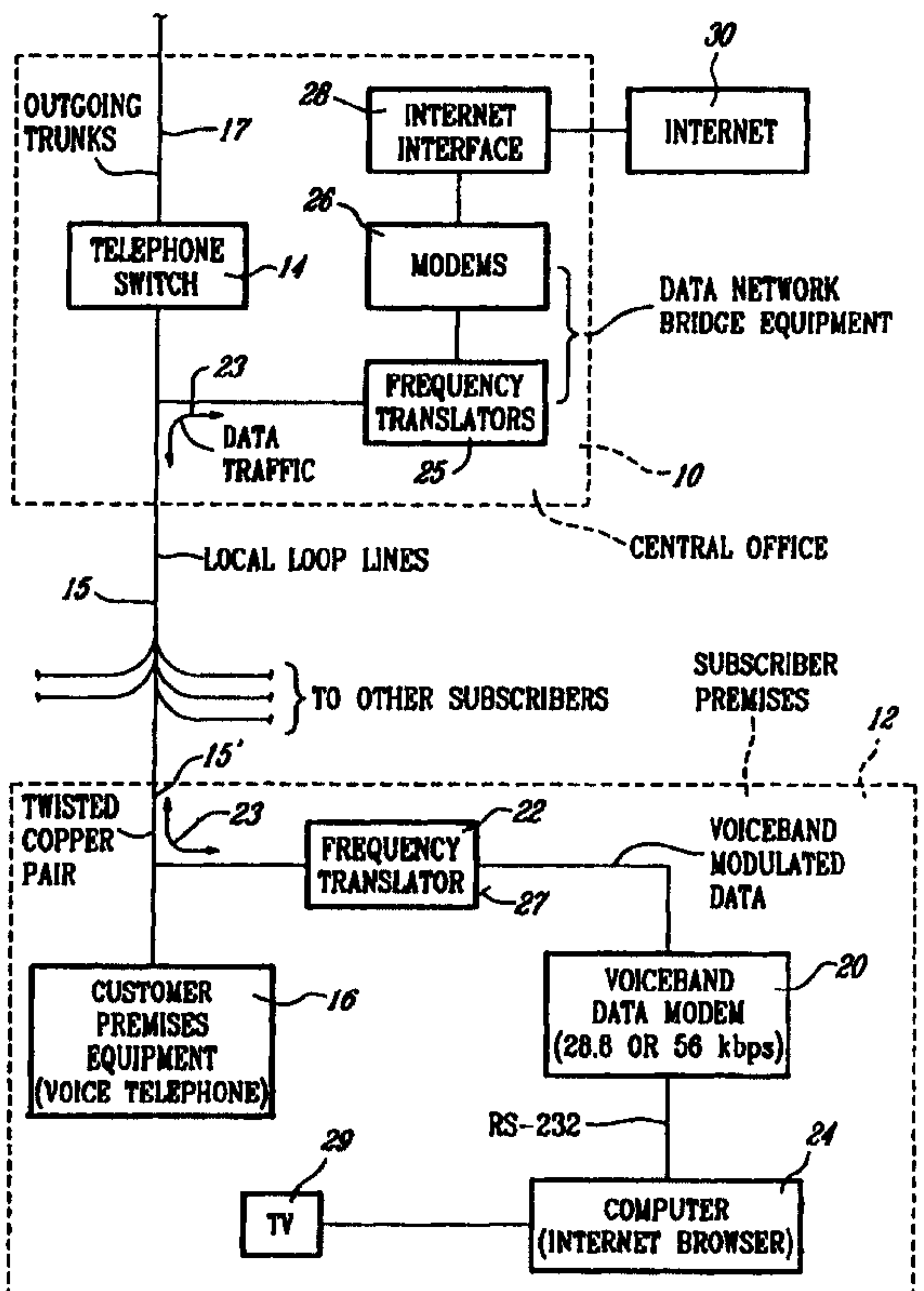
(54) Title: INTERNET ACCESS SYSTEM USING VOICEBAND MODEMS AND OUT-OF-BAND TRANSMISSION OVER LOCAL LOOP LINES



(57) Abrégé/Abstract:
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(57) Abrégé(suite)/Abstract(continued):

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(71) Applicant *(for all designated States except US)*: SASKTEL [CA/CA]; 2121 Saskatchewan Drive, Regina, Saskatchewan S4P 3Y2 (CA).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: CRUDER, Oliver [CA/CA]; Apartment 502, 611 University Drive, Saskatoon, Saskatchewan S7N 3Z1 (CA). LABBÉ, Samuel, Mark [CA/CA]; 314 Brightwater Crescent, Saskatoon, Saskatchewan S7J 5H9 (CA).

(74) Agents: ANGLEHART, James et al.; Swabey Ogilvy Renault, Suite 1600, 1981 McGill College Avenue, Montreal, Québec H3A 2Y3 (CA).

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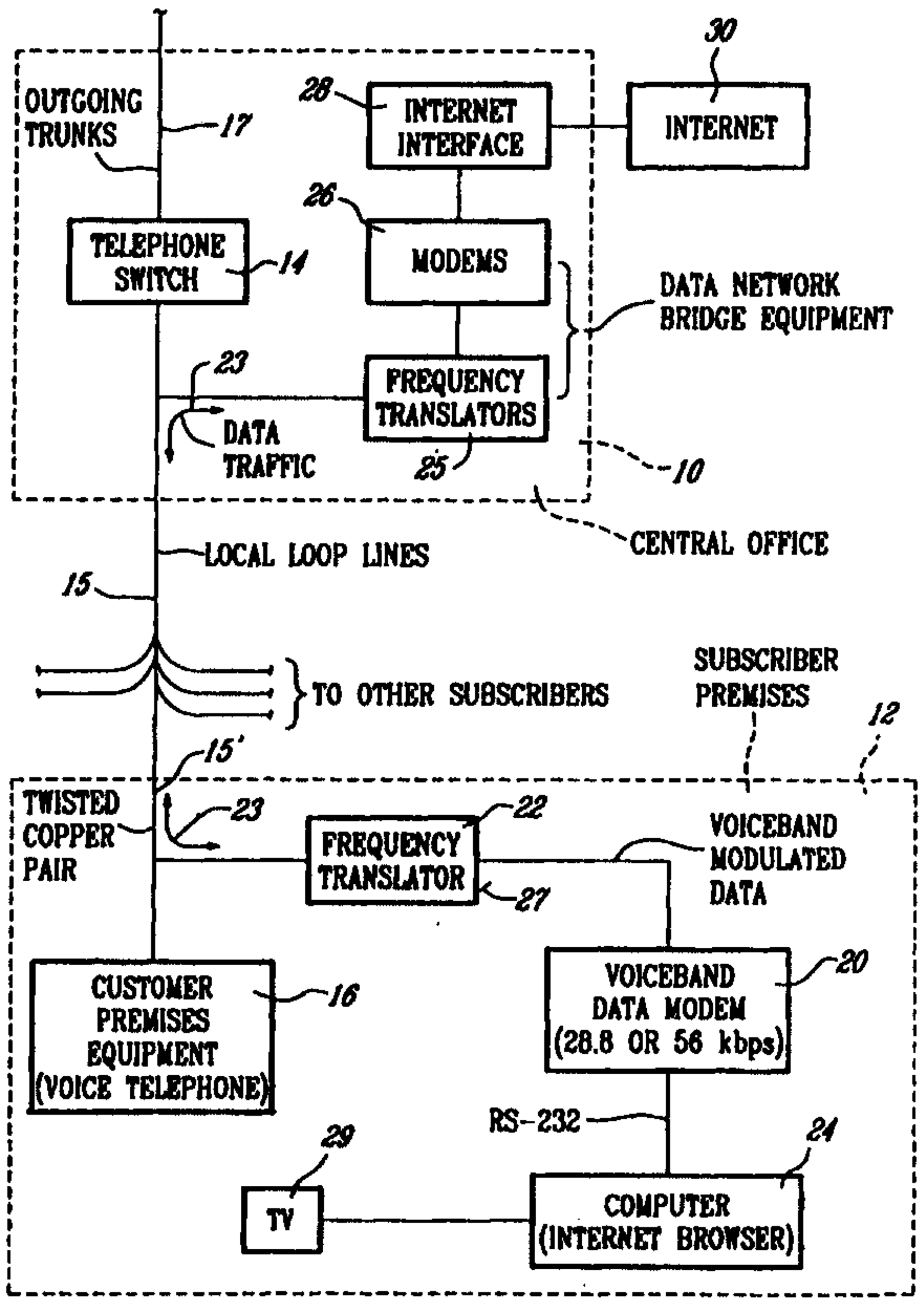
(54) Title: INTERNET ACCESS SYSTEM OVER LOCAL LOOP LINES

(57) Abstract

Telephone service subscribers who are connected to a telephone network via local loop lines to local telephone switches are also connected to a data network without communication through the local telephone switches. The system has frequency translator devices for translating send and receive voiceband frequency signals used by voiceband data modems to different frequency bands above the voiceband used by the telephone network. The voiceband modems at the subscriber premises maintain a connection in the presence of transient signals caused by on-hook and off-hook activity of voiceband subscriber equipment. The system also has data network bridge equipment connected between the local loop lines and the data network for bidirectionally converting the translated voiceband frequency modem signals into digital data signals and bidirectionally relaying the digital data signals to the data network. Internet access is made possible using conventional voiceband modems at the subscriber premises and using out-of-band transmission over the local loop lines so as to provide the Internet access without loading the local telephone switches and without preventing use of voice telephone service at a same time as Internet access is in progress.



INTERNET ACCESS SYSTEM USING VOICEBAND MODEMS AND OUT-OF-BAND TRANSMISSION OVER LOCAL LOOP LINES

Field of the Invention

The present invention relates generally to data communications and, in particular, to data communications over local loop telephone lines useful for residential and commercial Internet access. The present invention involves a data communications network and system using voiceband modems at the subscriber end of local loop lines in which the modem voiceband communication signals are frequency shifted above voiceband frequencies, transmitted over the local loop lines to terminal equipment prior to entering and co-located with the local telephone switch or private branch exchange (PBX).

Background of the Invention

The Internet has grown exponentially in recent years as more and more homes and businesses invest in the basic equipment required to connect, typically using the telephone network and voiceband modems, to Internet Service Providers (ISP's). The telephone network has been able to absorb the increased usage as a result of Internet access, however, continued growth could result in three foreseeable difficulties. Traffic through local switches (which may not be non-blocking) can result in telephone network congestion. For each Internet browser computer connected to the Internet, a local telephone line is used to connect the telephone network and another line is used to connect the ISP to the Internet browser computer through the telephone network. Use of telephone lines for Internet access occupies local loop lines and requires installation of additional local loop lines if voice telephony service is required simultaneously. The installation of additional local loop telephone access lines only increases the proliferation of telephone numbers which, in North America, is threatening to exceed the capacity of the conventional number plan system.

Voiceband modems are internal or external computer peripherals which commonly operate at data transmission rates of 28.8k to 56k bits per second (kbps) using various symbol encoding techniques to transmit digital data over analog voiceband telephone lines. Voiceband modems are universal standard equipment purchased with most home computers and can be connected to any telephone line and provide for modest data transmission rates via the telephone network.

Patent Application WO 96/29808 filed on March 14, 1996 teaches how to network computers via shared use of voice telephone lines. It provides simultaneous communication of data and voice on a common telephone line.

Digital subscriber lines (DSL) have come into use in recent years. Also known as asymmetric DSL or ADSL (in the case that the download speed is greater than the upload speed), this service provides high bandwidth data communications at speeds in the order of 100 to 1000 kbps over local loop telephone lines. DSL is thus able to provide "fast" Internet connections suitable for low and medium bandwidth multi-media applications. The subscriber is provided with a DSL modem which operates above voiceband frequencies and communicates with a personal computer much like conventional external voiceband modems. The DSL connection operates without disrupting regular voice telephone service while sharing the local loop lines. The local loop lines are twisted copper pairs and can handle a bandwidth well above normal voice transmission bandwidth. With DSL, the connection to the ISP is made using equipment connected directly to the local loop lines prior to entering the local telephone switch. The local telephone switch will of course ignore the data communications signals which are at frequencies well above voiceband frequencies.

In the case of rural telephone service, the local loop lines run much farther than in urban and suburban areas. Such long local lines are not able to support the bandwidth required for DSL, and installing additional lines is very costly.

DSL, when feasible, has the disadvantage that the subscriber equipment is costly and can only be used over telephone lines which have been equipped for DSL connections. Relatively few service areas in the North American telephone network have implemented DSL, and thus a DSL subscriber may need to stop using the DSL service and modem when moving to a new area. Since the DSL subscriber modem is dedicated to DSL, it is either difficult to have subscribers invest in purchasing the equipment, or the service provider must invest in purchasing the subscriber equipment to in turn rent it to subscribers. Both are impediments to growth in implementing DSL.

With both DSL and voiceband modems, there is commonly a problem that the local loop lines are of poor quality and thus force the modems to operate at a reduced speed. Such poor quality may be due to bends in twisted pair conductors, splices or the like, which cause reflections.

Summary of the Invention

It is an object of the present invention to provide an Internet access system using conventional voiceband modems and out-of-band transmission over local loop lines so as to provide Internet access without loading local telephone switches or PBX's and without preventing use of voice communication at the same time as Internet access is in progress.

It is a further object of the invention to provide an Internet access system using voiceband modems which does not interfere with regular voiceband use of the same local loop lines.

It is yet another object of the invention to provide Internet access over local loop lines using voiceband modems in which problems associated with poor quality local loop lines are reduced.

According to the invention, there is provided data transmission system for transmitting data between a data network and telephone service subscribers connected to a telephone network by local loop lines connected to local telephone switches. The data transmission system comprises frequency translator devices for translating voiceband frequency signals used by voiceband data modems to a frequency band above the voiceband used by the telephone network, the frequency translator devices being provided at a premises of the telephone service subscribers and being connected between the voiceband data modems and the local loop lines; and data network bridge equipment, preferably located near the telephone switch, and connected between the local loop lines and the data network for bidirectionally converting the translated voiceband frequency modem signals into digital data signals and bidirectionally relaying the digital data signals to the data network.

The invention provides a method of providing Internet access to telephone service subscribers connected to a telephone network by local loop lines connected to local telephone switches, the method comprising the steps of:

providing conventional voiceband modems at premises of the subscribers, the modems being connected to computing devices for Internet browsing;

providing frequency translator devices for translating voiceband frequency signals used by voiceband data modems to a frequency band above a voiceband used by the telephone network;

connecting the frequency translator devices between the voiceband data modems and the local loop lines;

providing data network bridge equipment for bidirectionally converting the modem signals into digital data signals and bidirectionally relaying the digital data signals to the Internet;

connecting the data network bridge equipment between the local loop lines and the Internet; and

establishing data communication between the conventional voiceband modems and the data network bridge equipment.

The data network bridge equipment preferably makes use of frequency translators, conventional voiceband modems and ISP modem bank/Internet interface equipment. Specially designed modems could be used at the data network equipment end to operate directly in the translated frequency range of the subscriber premises frequency translator signals.

The invention also provides a data transmission system for transmitting data between a data network and telephone service subscribers connected to a telephone network by local loop lines connected to a telephone switch. The data transmission system comprises frequency translator devices for translating send and receive voiceband frequency signals used by voiceband data modems to different frequency bands above the voiceband used by the telephone network, the frequency translator devices being provided at a premises of the telephone service subscribers and being connected between the voiceband data modems and the local loop lines; and data network bridge equipment, preferably located near the telephone switch, and connected between the local loop lines and the data network for bidirectionally converting the translated voiceband frequency modem signals into digital data signals and bidirectionally relaying the digital data signals to the data network.

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connecting the frequency translator devices between the voiceband data modems and the local loop lines;

providing data network bridge equipment for bidirectionally converting the modem signals into digital data signals and bidirectionally relaying the digital data signals to the Internet;

connecting the data network bridge equipment between the local loop lines and the Internet; and

establishing data communication between the conventional voiceband modems and the data network bridge equipment.

The subscriber equipment may comprise a single device including both frequency translator and modem circuits, with a view to facilitate compatibility with the network bridge equipment. The subscriber equipment may also comprise frequency translator devices connecting to the subscriber's own voiceband modem. By maintaining the same modem at a subscriber, no configuration changes are required at the subscriber's computer.

Brief Description of the Drawings

The invention will be better understood by way of the following detailed description of a preferred embodiment, with reference to the appended drawings, in which:

Fig. 1 is a schematic block diagram data transmission system according to a first embodiment for transmitting data between the Internet and telephone service subscribers connected to a telephone network by local loop lines connected to a local telephone switch;

Fig. 2 is a block diagram of the frequency translator device according to the first embodiment;

Fig. 3 is a detailed block diagram of the subscriber side device according to the preferred embodiment;

Fig. 4 is a detailed block diagram of the central office side device according to the preferred embodiment; and

Fig. 5 is a circuit diagram of the Hilbert transform device according to the preferred embodiment.

Detailed Description of the Preferred Embodiment

As illustrated in Fig. 1, the data transmission system has a plurality of subscriber premises 12 connected to a central office (CO) 10 via a local loop twisted copper pair line 15' of a local loop line group 15. The local loop lines 15 run between the CO switch 14 and the subscriber premises 12, where regular telephone equipment 16 is connected. Regular customer premises equipment may comprise conventional analog telephones, facsimile machines and other communication devices making use of voiceband frequencies. The telephone switch 14 is also connected to outgoing trunks 17 to connect regular voice and data telephone calls to other points in the telephone network.

According to the first embodiment of the invention, the customer premises 12 are provided with a frequency translator 22 connected to the local loop line 15' and to a voiceband data modem 20. The modem 20 is a conventional modem operating at (presently conventional) speeds of 28.8 to 56kbps and is either external or internal to a personal computer 24. The computer 24 is provided with Internet browser software. In the embodiment of Fig. 1, the modem 20 is external to computer 24 via a serial interface connection, denoted RS-232 in Fig. 1.

The frequency translator device 22 is similar to a circuit whose design is known to those skilled in the art of telephony. The circuit which has been installed in the past in certain service areas as part of the "add-a-line" service. In homes requiring an additional telephone line, the "add-a-line" service allowed a single twisted copper pair to carry an additional telephone voice signal at a frequency range above the normal frequency range for voice communications. At the customer premises, the telephone or telephones using the additional "line" are connected via a frequency translator device to the twisted copper pair. At the CO, another frequency translator is used to return the voice signals in the shifted frequency band back to regular voiceband frequencies and connect the regular voiceband signals to the switch into a port for a different telephone number.

When the local loop line 15' is a long line, as is often the case in rural telephone service, line loading circuit elements, if present, need to be changed to allow the above voiceband signals to be carried, since the line loading circuit elements severely attenuate frequencies above voice band.

In the first embodiment, device 22 is powered by a small amount of DC power derived from an AC/DC adapter plugged into the power mains at the subscriber premises 12. Fig. 2 illustrates a power adapter integrated into a housing of device 22, although an external power adapter may also be used. Device 22 is a small device contained in a housing with first and second standard telephone jacks. The first jack is for connecting to the twisted pair and the second jack is for connecting to the modem 20. The device 22 is preferably a small portable device kept near the modem and personal computer. Alternatively, the device 22 may be installed in premises 12, for example near the telephone entry box within the premises 12, and a built-in line within premises 12 may be dedicated to data. Device 22 takes the voiceband signals from modem 20 and translates them into above voice frequency band signals 23.

To make device 22 more adaptable to a variety of uses, it is provided, in the first embodiment, with a by-pass switch 27 (see Fig. 2) allowing modem 20 to be connected to line 15' without frequency translation. Switch 27 is preferably a physical switch provided on the housing of device 22 and, in the by-pass state, simply connects the "modem in" jack directly to the "telephone line in" jack while disconnecting the frequency translating circuitry. The by-pass state allows the modem to make regular dial-up connections to bulletin board services, other user modems directly through the telephone network, and regular telephone service ISP's (as a back-up Internet service, or so as not to completely abandon one's ISP and e-mail account during a switch over period to the service according to the first embodiment). In the bypass state, of course, use of the regular voiceband POTS (plain old telephone service) lines 15' prevents regular voice telephone service from being used while modem 20 is in operation. As an alternative to a physical switch, device 22 could be more sophisticated and comprise a microprocessor and tone detector circuitry. In this configuration, the translator 22 could be commanded to switch between the frequency shifted data line and the regular voiceband POTS line. The command may be, for example, a '9' to by-pass and reach the "outside" regular POTS voiceband line.

The above voice frequency band data signals 23 are transmitted between translator 22 and one of a number of translators 25 over the twisted copper pair 15'. The frequency translators 25 include frequency translating circuits which are, in the first embodiment, the same as the circuit in device 22. In the first embodiment, there is one frequency translator in the frequency translator group 25 that is assigned to each subscriber. In the preferred embodiment, there is one modem in modem group 26 which is assigned to each subscriber modem 20. For establishing the connection between the modem 20 and the one modem 26, two basic possibilities exist.

The modems 26 may be programmed and controlled to go into a state in which they emit a connect tone continuously. The connect tone initiates a handshaking sequence in accordance with standard modem handshaking protocols when responded to by the modem 20. If the modems 26 are programmed to time out when the connect tone fails to result in handshaking and a connection, the modems may be controlled to repeatedly emit the connect tone and connect after brief idle periods between connect attempts.

Modem 20 is connected to one of modems 26 by having the software in computer 24 command modem 20 to go off-hook, dial a fictitious number, listen for the connect tone and proceed with handshaking to establish a connection. If the particular modem 20 requires detecting a dial tone, dialing a number, detecting a ringback signal and an answer before allowing handshaking to proceed, it may be necessary to use the by-pass switch 27 (when the regular voiceband line in not in use) to by-pass the frequency translator circuitry and connect to the voiceband line. The computer 24 could then command modem 20 to dial a predetermined number which either terminates through switch 14 to an answering device or is handled directly by switch 14 to automatically answer. The number dialed answers and holds without emitting any tones. The number dialed may also be an incomplete number, such as the single digit '2', which causes switch 14 to hold and wait for additional digits. If the modem's internal programming believes that a complete number has been dialed and proceeds to a state in which a connection is awaited, further digits need not be dialed. The user may then use the physical switch 27 to switch over modem 20 to the data line to receive data signals 23 comprising the connect tone. The modem 20 will then proceed with handshaking and establish a connection with one of modems 26. The number dialed and connected to at switch 14 can be automatically dropped, and the voiceband line is made available for regular voice or fax service.

In the second basic possibility for establishing a connection between one of modems 26 and modem 20, the modems 26 are placed in an answer mode. Preferably, the modems 26 are configured to answer when they detect not just a ring signal but also any signal generated by modem 20, such as for example the signal generated when commanded to go off-hook and/or dial any digit. Since the modems 26 are selected or built to specification for the central office, special configuration to answer in response to detecting an off-hook or any signal on the line is feasible. In the case that modems 26 require a ring signal to answer, the system is a little more complicated. Since modem 20 cannot be expected to generate a ring signal, circuitry is provided either to generate a ring signal in frequency translator 22 or 25 or at modems 26 in response to a tone generated by modem 20, such as one or more DTMF tones, or to directly generate an answer enable signal fed to the circuitry of modems 26 in response to detecting signal coming from modem 20 on data path 23. Likewise the circuitry in modems 26 listen to signals from modem 20 on data path 23 and signal a hang-up when no signals are transmitted during a predetermined time period. Modification of the circuitry of modems 26 is not inconvenient because they are telco or ISP equipment and may be of a proprietary design, whereas modem 20 may be of any manufacture or design compliant with ITU specifications. Since this second, and preferred, possibility simplifies action at the subscriber end modem 20, namely it is merely commanded to go off-hook, dial a number and connect, while the modem 26 responds to the signals by answering and emitting the connect tone.

Although there is no need to end communication over the data path 23, a hang-up at modem 20 will result in an end to signals being transmitted to modem 26, and the modem 26 will detect the "hang-up" and itself end communication. The modem 26 will then respond to a future detection of signals from modem 20 by answering and connecting.

Alternatively, the modem 20 may operate with the line connected to translator 22 as if the modem were connected to a regular voiceband telephone line for POTS service. Translator 22 may be provided with a microprocessor as mentioned above, and the translator may emulate a telephone dial tone and answering before connecting to the frequency translator circuitry.

The subscriber modem 20 interfaces with data communication software in computer 24 which also interfaces with a television receiver 29 and provides Internet access in addition to normal television programming.

As will be appreciated, the subscriber data transmission system according to the invention uses a single wire pair to connect the subscriber's premises to the central office of a telephone system. The system simultaneously provides for the bidirectional communication of voice between the subscriber and the voice telephony network together with bidirectional digital data communication between the subscriber data terminal equipment, which form part of computer 24, and a central data communication network, which connects to the Internet. The subscriber data transmission system comprises central and remote subsystems, the central subsystem being located at the central office of the telephone system and the remote subsystem being located on the premises of the subscriber.

The remote subsystem comprises the following elements. A subscriber data terminal 24 for producing and receiving digital data in binary form. A commonly available voiceband modem 20 connected between the subscriber data terminal and the subscribers' end of the wire pair connecting the subscriber's premises 12 to the central office 10. The modem uses a carrier frequency near the center of the voice frequency range and the modem meets ITU standards for bidirectional voiceband data transmission on dialup telephone lines. A frequency translation means 22 shifts the transmit signal of the voiceband modem to a range of frequencies which is higher than the frequency range of voice transmission so that the data signal from the modem can be communicated on the wire pair without interfering with the voice communication signal, and it also shifts the data signal received from the wire pair to the voiceband frequency range for reception by the voiceband modem.

The central subsystem, located at the central office, enables data communication for one wire pair, and comprises the following elements. Data communication equipment 28 for communicating digital data in binary form with the Internet and with other subscriber data terminal equipment. A commonly available answer only voiceband modem 26 connected between said data communication equipment and the central end of the wire pair connecting said subscriber's premises to said central office. The modem 26 uses a carrier frequency near the center of the voice frequency range and meets ITU standards for voiceband data transmission. A frequency translation means 25 shifts the transmit signal of the voiceband modem to a range of frequencies which is higher than the frequency range of voice transmission so that the data signal from the modem can be communicated on the wire pair without interfering with the voice communication signal, and it also shifts the data signal received from the wire pair to the voiceband frequency range for reception by the voiceband modem 26. This conbination of frequency translation means 25 and voiceband modem equipment 26 forms data network bridge equipment.

The subscriber subsystem also includes a conventional telephone set connected to the subscriber's end of the wire pair connecting the subscriber's premises to the central office. Each frequency translator employs amplitude modulation which permits echo reflection signals from the wire pair to be accurately communicated to the voiceband modem in which the modem's internal echo canceller can remove the echo reflection signals and thereby avoid interference with the received data signal. Each frequency translator employs single sideband amplitude modulation and each frequency translator employs a carrier signal which is approximately the same frequency as that in the other frequency translator, such that the carrier signal frequency is not required to be synchronized in frequency and in phase with the carrier signal in the other frequency translator. Up to 7 Hz of frequency difference can be tolerated by modems which conform to ITU standards. Each frequency translator employs a hybrid coupler to separate the transmit and receive signals from the subscriber's wire pair so that unidirectional amplifiers and frequency translation components may be used and a second hybrid coupler is used to recombine the translated transmit and received signals onto a single wire pair for connection to the modem. The frequency translation means in each subsystem shifts the transmit signal of the voiceband modem to a range of frequencies that is higher than that of human hearing so that the data signal from the modem can be communicated on the wire pair without interfering with the human perception of the voice signal. Alternatively, the voiceband modem signal is shifted to a range of frequencies that is within the range of human hearing yet higher than the frequency range of telephone voice transmission and each telephone set is connected to the wire pair through a lowpass filter that effectively eliminates the higher frequency data signal so as to minimize the interference of data signals on the voice communication.

Each of the subscriber and central office subsytems include a highpass filter to effectively pass data signals and simultaneously eliminate voice signals from the frequency translator so as to minimize the effects of low frequency voice signal interference on the data transmission. Preferably, each telephone set is connected to the wire pair through a lowpass filter that effectively eliminates the higher frequency data signal so as to minimize the interference of data signals on the voice communication and the central office voice switch is similarly connected to the wire pair through a lowpass filter. Preferably, a single lowpass filter is used to connect a plurality of telephone sets to the single wire pair connecting the subscriber's premises to the central office of the telephone system.

In the preferred embodiment, the modem is always connected and is always communicating with the central data network. The subscriber modem preferably initiates and establishes a connection with the central office modem using the same procedure as for dialing through the switched telephone network to one of a group of modems on the premises of an Internet service provider.

As can be appreciated, it may be desirable to provide switching equipment between lines 15 and translators 25 or between translators 25 and modems 26 so as to the need to provide a translator and modem at the CO 10 for every subscriber using the service according to the invention. The switching equipment may be controlled by sensing signals sent from modem 20 over data traffic path 23. Alternatively, the voiceband line may be used to place a call through switch 14 to control equipment which in turn can command the switching equipment to connect one of modems 26 to data path 23. After signaling the connection, the voiceband line is dropped and made available for regular use. For example, a user could use a regular handset to call a predetermined number to request his or her Internet connection. Either by automatic ANI or using DTMF commands, the request handler would receive the request to connect the user to the data network. At this point, either the modem 26 goes into a connect tone emitting state directly, or the modem 26 "calls" the user, i.e. a ringing signal is sent, and the computer 24 is used to command modem 20 to answer. It will also be appreciated that the frequency translators 25 may be integrated with modem 26 at the circuit level, i.e. modems 26 could be designed to modulate and demodulate signals in the above voiceband frequency range of the translated data signals 23.

In the preferred embodiment, the subscriber equipment 12 includes a combined modem 20 and frequency shifter device 22. Furthermore, the frequency shifter device according to the preferred embodiment implements two features which improve performance over the first embodiment: separate frequency bands are used for send and receive signals; and automatic gain control is applied to received signals. These two features may be individually applied, even if the modem and frequency translator are separate units.

As illustrated in Fig. 3, the frequency translator device comprises a Hilbert transform circuit 30, as is illustrated in detail in Fig. 5, the output of which is fed to mixers 31 and 32 operating at 46.88 kHz. The Txa wire pair carries a signal and its complement (180° out of phase). This wire pair is fed into the Hilbert transform block. This block is designed to produce two differential waveforms that are separated by 90° at all frequencies in the modem band. The differential inphase components are I+ and I-. The differential quadrature components are Q+ and Q-. I+ with respect to I- is 90° out of phase with Q+ with respect to Q-. Within the modem frequency band (~150Hz – 3.75kHz), the phase error of the differential pairs is within ±0.5°. The Hilbert Transform module 30 was designed to have a minimal impact on the integrity of the signal, and as can be appreciated, uses circuit elements preferably having good tolerance.

The cosine and sine upconverted signals are combined by a combiner 33. Since the waveforms from the Hilbert Transform circuit have been multiplied by square waves, they contain higher order frequency components that should be removed before transmission. A low pass filter is used for this purpose, and does not have to be very sharp since the telephone line inherenty attenuates these high frequency components. The output of the low pass filter is fed to a 5^{th} order Butterworth filter to remove signals from the baseband (0 - 4kHz). On the receive path, signals from the central office data network bridge equipment arrive in the 23.44 kHz band, and are filtered and then amplified by a variable gain amplifier 34 before being downconverted by mixer 35 to the regular voiceband (receive signal labeled Rxa in Fig. 3). The integrated modem 20 receives the downconverted voiceband signals. Modem 20 also generates the output voiceband signal Txa.

The telephone line 15 carries both the incoming and outgoing signals on a 2-wire pair. Since the modem 20 operates using a 4-wire interface (two input lines and two output lines), a conversion stage is required. A hybrid circuit performs the 2-4 wire conversion: it couples the outgoing signal onto the telephone line and extracts the incoming signal from the total, passing it to the demodulator input. The hybrid circuit has two legs. It consists of a transformer and two resistors. The circuit-interface (primary) side of the transformer has two coils, and the telephone-line (secondary) side has one. Each of the two legs of the hybrid is a series combination of one primary coil and one resistor. At the modulating frequency, the impedance seen from the line side of the transformer is approximately 135Ω. From each coil on the circuit side, this impedance translates to about 30Ω. The transformer passes frequencies in the range of 10–50kHz with less than 0.25dB transformer loss. It has a turns ratio of 1.5 : 1 from the line side to each coil on the circuit side.

The central office data network bridge equipment comprises corresponding circuit elements as shown in Fig. 4. The upconverter mixers 31' and 32' operate at 23.44 kHz and the downconverter mixer 35' likewise at 46.88 kHz. By using different bands for the send and receive signals, the deleterious effects of reflections and other sources of noise due to poor quality of the local loop line 15 are greatly reduced. Since the lower band at 23.44 kHz has better transmission characteristics, it is used for receiving from the data network bridge equipment because most Internet traffic is from the Internet to the subscriber.

In the preferred embodiment, the modems 20,26 comprise the Rockwell R6764-67 chipset which operates at up to 33.6 kbps modulating and demodulating data at the baseband (~150Hz – 3.75kHz) using QAM. The modem interfaces with the rest of the system through two pairs of wires: Txa and Rxa. The signals on Txa are fed into the Hilbert Transform block 30 and the signals to Rxa come from the demodulation stage 35, 35'. The subscriber modem connects to the RS-232 port on a PC, and the data network bridge edquipment modem connects to an access server Ethernet interface through RS-232. Some commercially available modems have been found to be disrupted (i.e. they disconnect) when they receive the transient signals generated when the regular voiceband customer premises equipment 16 goes off-hook and on-hook. The mentioned Rockwell chipset provides a conventional voiceband modem which is not disrupted by such transient signals. This is important since disruption due to normal use of standard voiceband telephony equipment would be unacceptable.

For the purposes of enhancing signal transmission quality up to distances of 5 km over conventional twisted pairs, a variable gain amplifier 34 is provided. As shown in Fig. 3, a comparator 41 is provided which compares a probe signal to a reference. The microprocessor 40 determines the level of gain required to bring the probe signal up to the desired signal strength, and sets the gain control signal accordingly. For transmitting the probe signal, the microprocessor 40 outputs a probe control signal to switch 42. The probe signal may be a type of dial tone signal.

The microprocessor 40 at the subscriber end may be programmed to detect the probe signal or dial tone signal sent from the central office end, and in response thereto (after adjusting the gain) send the probe signal so that the central office end can adjust its gain. Then microprocessor 40 generates a ring command output for modem 20. Modem 20 can be configured to initiate communications in response to the ring command. At the central office side, the modem 26 is configured to allow communications to be established in response to the signals sent from the modem 20.

Whether it is the modem 20 or the modem 26 that initiates communications is not important, however, it is preferred that communications be automatically initiated and be maintained without interruption. This provides for an "always connected" system. As discussed above with respect to the various possibilities for establishing the connection between the modem 26 and modem 20, in the preferred embodiment, the equipment is adapted to generate tones and automatically recognize the presence of the other end with the object of establishing a connection without prompting by the subscriber.

Although the invention has been described above with reference to the preferred embodiment and to specific alternative embodiments, it is to be understood that other embodiments are contemplated within the scope of the present invention, as defined by the appended claims.

What is claimed is:

1. A data transmission system for transmitting data between a data network and telephone service subscribers connected to a telephone network by local loop lines connected to local telephone switches, the system comprising:

frequency translator devices for translating send and receive voiceband frequency signals used by voiceband data modems to different frequency bands above a voiceband used by the telephone network, the frequency translator devices being provided at a premises of the telephone service subscribers and being connected between the voiceband data modems and the local loop lines; and

data network bridge equipment connected between the local loop lines and the data network for bidirectionally converting the translated voiceband frequency modem signals into digital data signals and bidirectionally relaying the digital data signals to the data network, whereby

Internet access is made possible using conventional voiceband modems at the subscriber premises and using out-of-band transmission over the local loop lines so as to provide the Internet access without loading the local telephone switches and without preventing use of voice telephone service at a same time as Internet access is in progress.

2. The system as claimed in claim 1, said frequency translator devices comprise a Hilbert transform circuit for converting an input transmit voiceband signal to a pair of QAM signals prior to upconversion.

3. The system as claimed in claim 1 or 2, wherein said frequency translator devices comprise a gain control circuit for adjusting a gain of received signals prior to downconverting to voiceband.

4. The system as claimed in claim 1,2 or 3, wherein said data network bridge equipment comprises a central office frequency translator and a central office modem connected to each one of said local loop lines using said system.

5. The system as claimed in claim 4, wherein said central office modem provides continuously a connect tone on said local loop line.

6. The system as claimed in one of claims 1 to 5, said frequency translator devices each comprise portable devices powered by AC mains power from the subscriber premises, the portable devices including a voiceband modem, a standard telephone jack connector for connecting to the local loop line at the subscriber premises, and a connector for connecting to a subscriber terminal bus at the subscriber premises, said voiceband modem maintaining a connection in the presence of transient signals caused by on-hook and off-hook activity of voiceband subscriber equipment.

7. The system as claimed in one of claims 1 to 6, said frequency translator devices comprise a connection controller circuit for outputting a probe tone signal and for detecting a received probe tone signal for automatically initiating communications between said voiceband data modems and said data network bridge equipment.

8. The system as claimed in one of claims 1 to 7, wherein said data network bridge equipment comprises modems similar to said voiceband data modems and frequency translator circuits similar to said frequency translator devices.

9. The system as claimed in one of claims 1 to 8, wherein said different frequency bands are approximately 23.44 kHz and 46.88 kHz, said 23.44 kHz band being used for transmission from said data network bridge equipment to said subscriber.

10. A method of providing Internet access to telephone service subscribers connected to a telephone network by local loop lines connected to local telephone switches, the method comprising the steps of:

providing conventional voiceband modems at premises of the subscribers, the modems being connected to computing devices for Internet browsing;

providing frequency translator devices for translating send and receive voiceband frequency signals used by voiceband data modems to different frequency bands above a voiceband used by the telephone network;

connecting the frequency translator devices between the voiceband data modems and the local loop lines, said voiceband modems maintaining a connection in the presence of transient signals caused by on-hook and off-hook activity of voiceband subscriber equipment;

providing data network bridge equipment for bidirectionally converting the modem signals into digital data signals and bidirectionally relaying the digital data signals to the Internet;

connecting the data network bridge equipment between the local loop lines and the Internet, the data network bridge equipment by-passing the local telephone switches; and

establishing data communication between the conventional voiceband modems and the data network bridge equipment.

11. The method according to claim 10, wherein said step of establishing comprises:

continuously providing a connect tone from the data network bridge equipment on the local loop lines; and

causing the voiceband modems at the subscriber premises automatically to initiate communications with the data network bridge equipment in response to said connect tone.

12. The method according to claim 10, wherein said frequency translator devices converting an input transmit voiceband signal to a pair of QAM signals prior to upconversion and then combine the pair of upconverted QAM signals together for transmission on said local loop line.

13. The method according to claim 10,11 or 12, wherein a gain of received signals is adjusted prior to downconverting to voiceband.

14. The method according to one of claims 10 to 13, wherein said different frequency bands are approximately 23.44 kHz and 46.88 kHz, said 23.44 kHz band being used for transmission from said data network bridge equipment to said subscriber.

15. The method according to one of claims 10 to 14, wherein said data network bridge equipment comprises modems similar to said voiceband modems at the subscriber premises.

16. The method according to one of claims 10 to 15, wherein said data communication is automatically established and maintained for as long as both the voiceband modems at the subscriber premises and the data network bridge equipment are powered to operate.

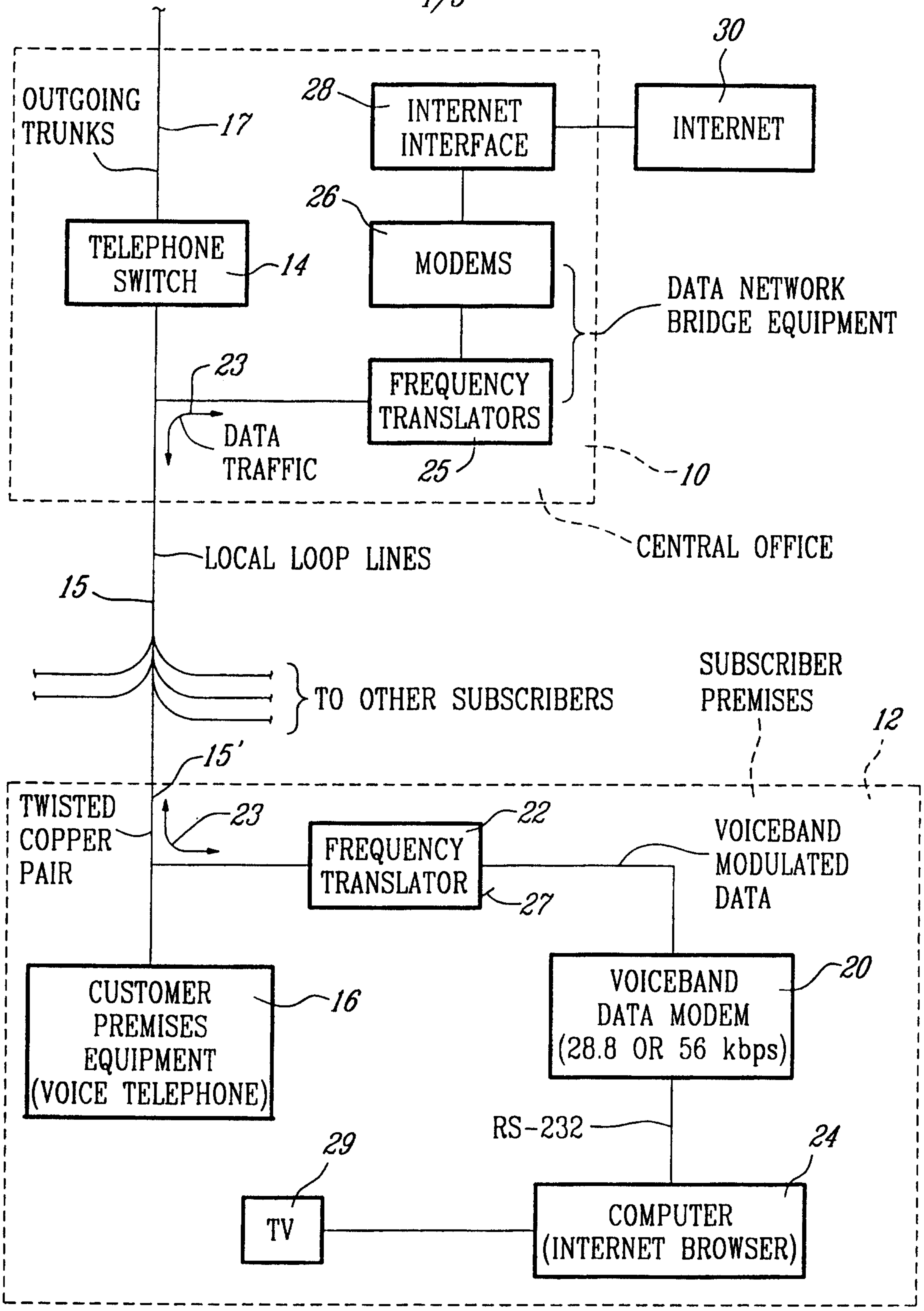

30
28
INTERNET INTERFACE
INTERNET
OUTGOING TRUNKS
17
26
MODEMS
TELEPHONE SWITCH
14
DATA NETWORK BRIDGE EQUIPMENT
23
FREQUENCY TRANSLATORS
DATA TRAFFIC
25
10
CENTRAL OFFICE
LOCAL LOOP LINES
15
TO OTHER SUBSCRIBERS
SUBSCRIBER PREMISES
12
15'
TWISTED COPPER PAIR
23
FREQUENCY TRANSLATOR
22
27
VOICEBAND MODULATED DATA
CUSTOMER PREMISES EQUIPMENT (VOICE TELEPHONE)
16
VOICEBAND DATA MODEM (28.8 OR 56 kbps)
20
RS-232
29
24
TV
COMPUTER (INTERNET BROWSER)

FIG. 1

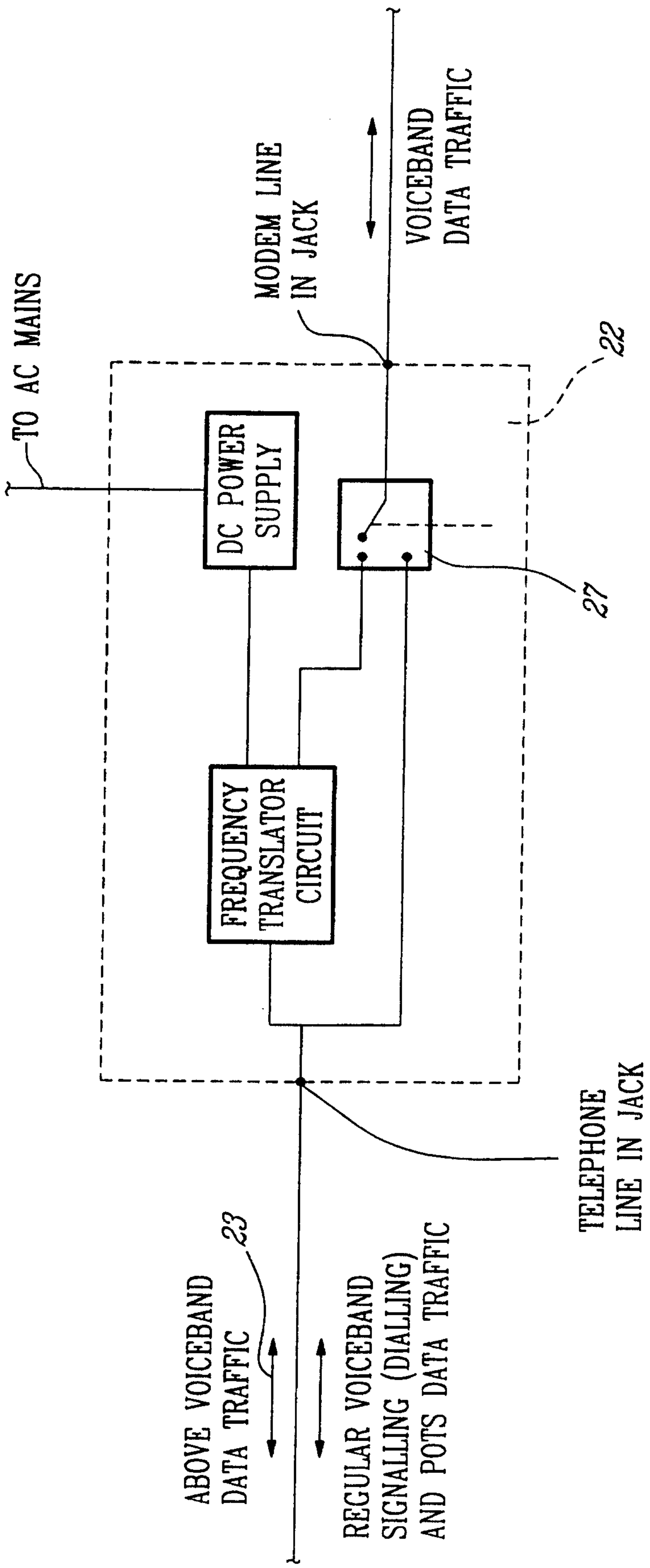

TO AC MAINS
DC POWER SUPPLY
FREQUENCY TRANSLATOR CIRCUIT
MODEM LINE IN JACK
VOICEBAND DATA TRAFFIC
22
27
TELEPHONE LINE IN JACK
23
ABOVE VOICEBAND DATA TRAFFIC
REGULAR VOICEBAND SIGNALLING (DIALLING) AND POTS DATA TRAFFIC

FIG-2

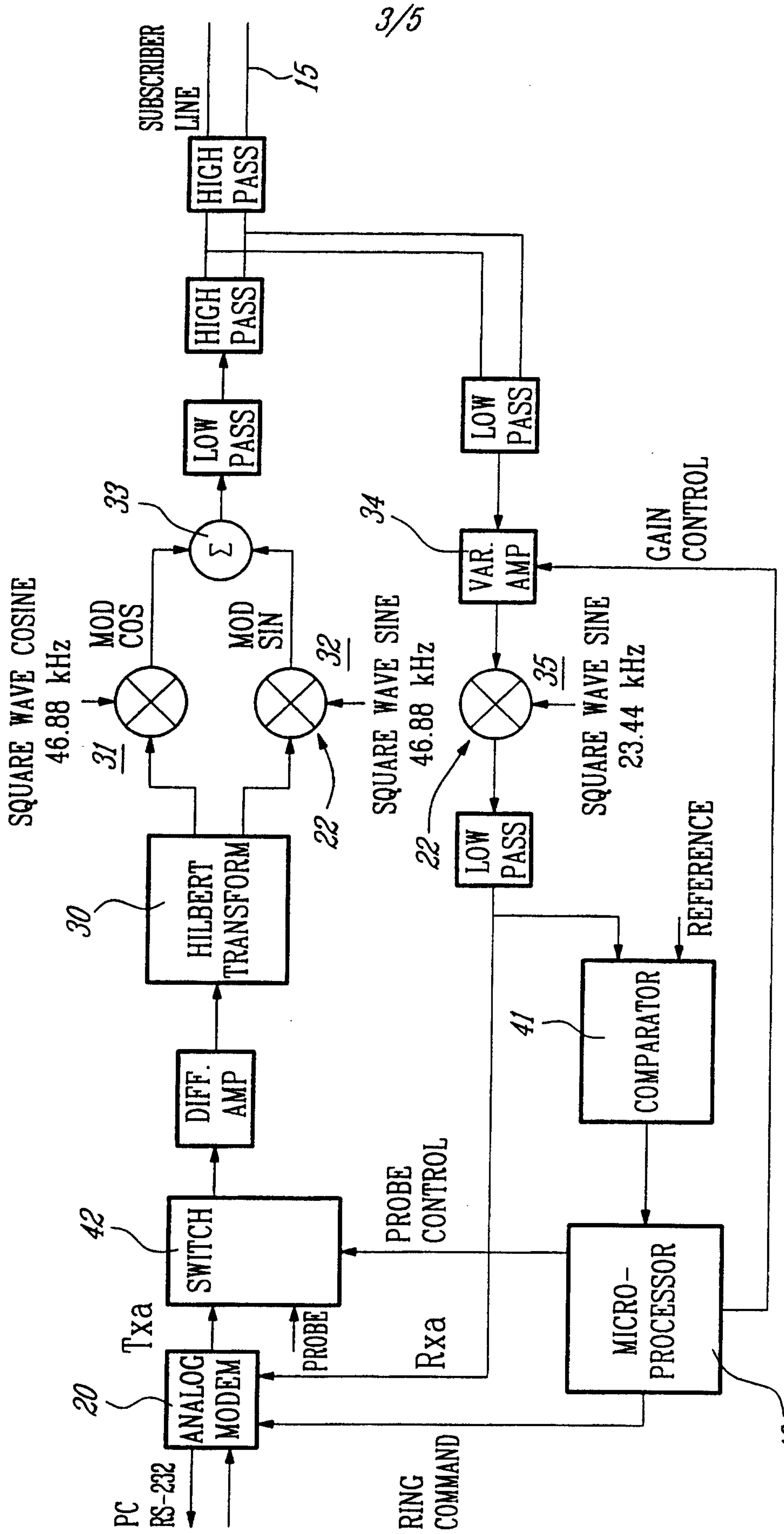

SUBSCRIBER LINE
15
HIGH PASS
HIGH PASS
LOW PASS
LOW PASS
33
Σ
34
VAR. AMP
GAIN CONTROL
SQUARE WAVE COSINE 46.88 kHz
MOD COS
MOD SIN
31
32
22
SQUARE WAVE SINE 46.88 kHz
35
SQUARE WAVE SINE 23.44 kHz
22
LOW PASS
30
HILBERT TRANSFORM
REFERENCE
41
COMPARATOR
DIFF. AMP
PROBE CONTROL
42
SWITCH
MICRO-PROCESSOR
Txa
PROBE
Rxa
20
ANALOG MODEM
40
PC RS-232
RING COMMAND

FIG. 3

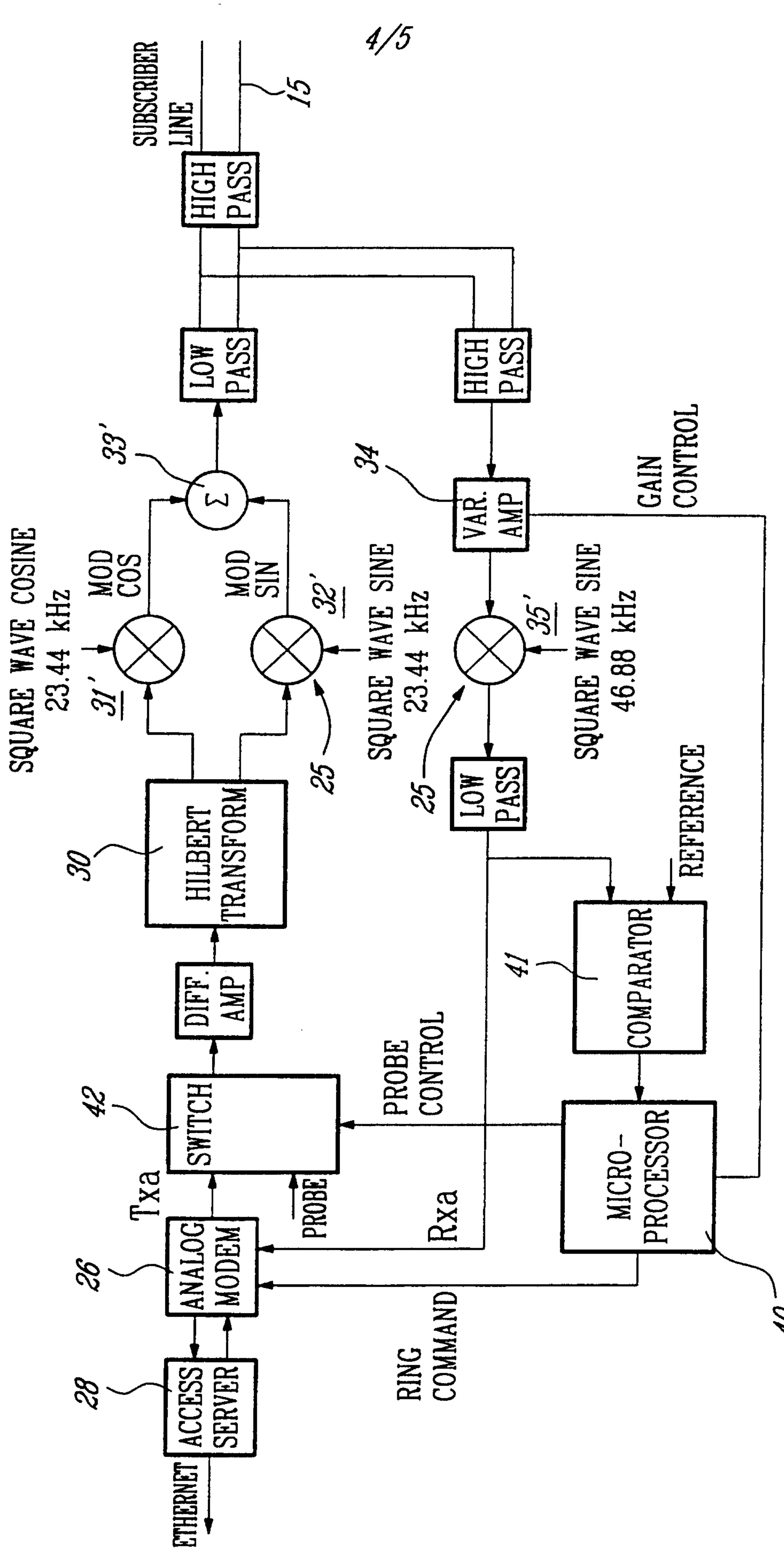

SUBSCRIBER LINE
15
HIGH PASS
LOW PASS
HIGH PASS
33'
Σ
34
VAR. AMP
GAIN CONTROL
SQUARE WAVE COSINE 23.44 kHz
MOD COS
MOD SIN
31'
32'
SQUARE WAVE SINE 23.44 kHz
35'
SQUARE WAVE SINE 46.88 kHz
25
25
LOW PASS
30
HILBERT TRANSFORM
REFERENCE
41
COMPARATOR
DIFF. AMP
PROBE CONTROL
42
SWITCH
PROBE
Txa
Rxa
MICRO-PROCESSOR
26
ANALOG MODEM
40
RING COMMAND
28
ACCESS SERVER
ETHERNET

FIG. 4

5/5

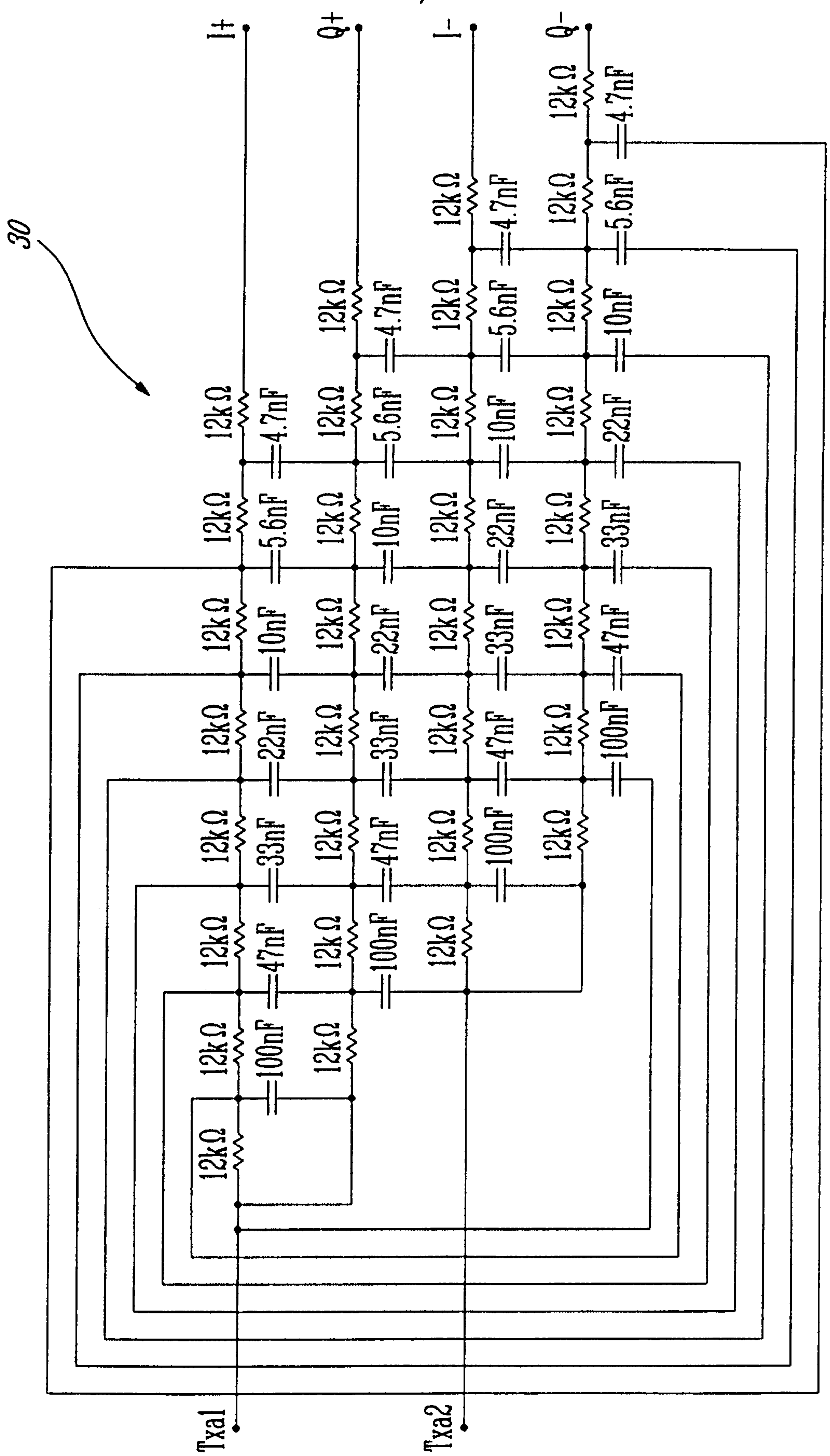
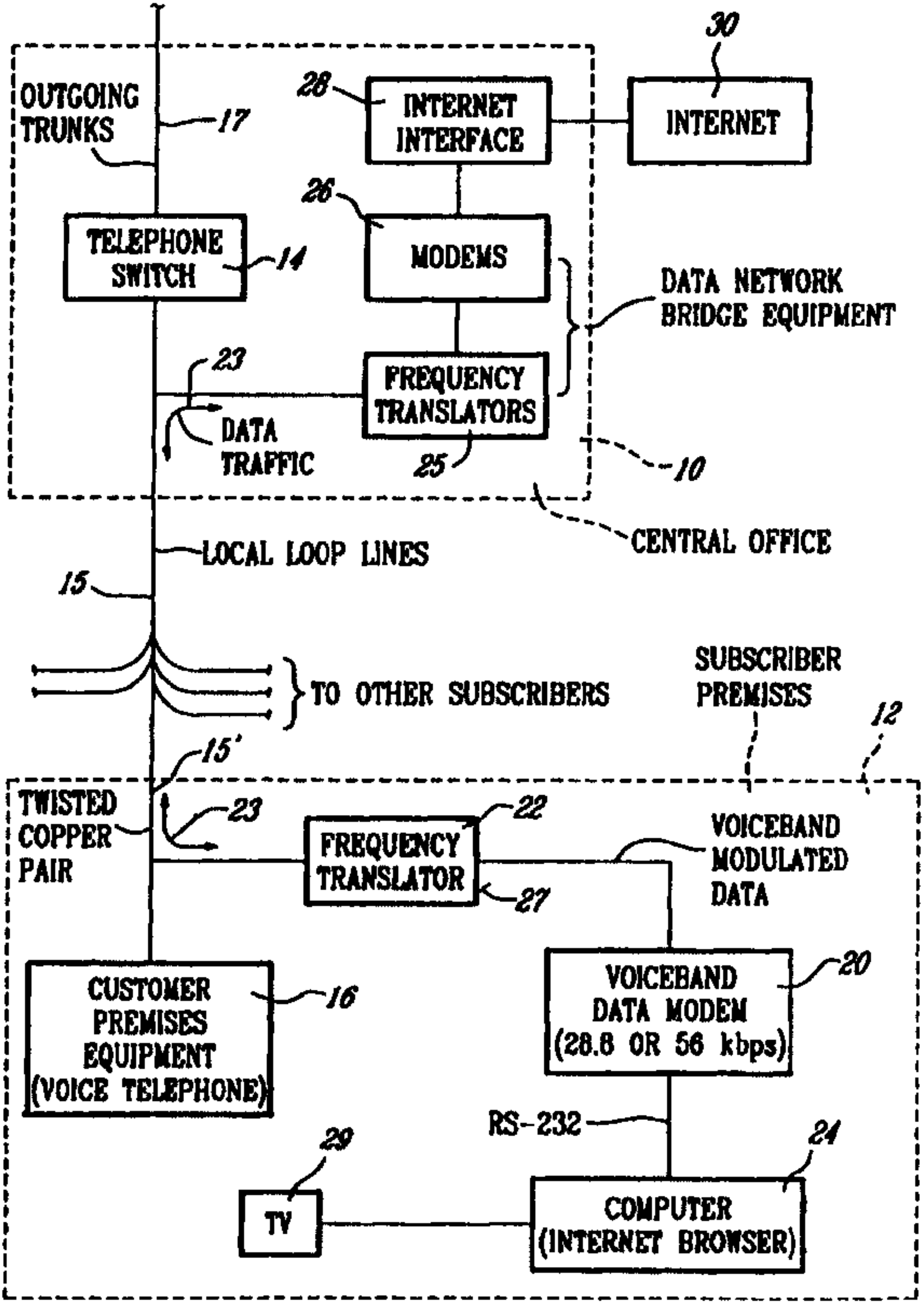


FIG. 5


30
28
INTERNET INTERFACE
INTERNET
OUTGOING TRUNKS
17
26
TELEPHONE SWITCH
14
MODEMS
DATA NETWORK BRIDGE EQUIPMENT
23
FREQUENCY TRANSLATORS
DATA TRAFFIC
25
10
CENTRAL OFFICE
LOCAL LOOP LINES
15
TO OTHER SUBSCRIBERS
SUBSCRIBER PREMISES
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VOICEBAND MODULATED DATA
CUSTOMER PREMISES EQUIPMENT (VOICE TELEPHONE)
16
VOICEBAND DATA MODEM (28.8 OR 56 kbps)
20
RS-232
29
24
TV
COMPUTER (INTERNET BROWSER)