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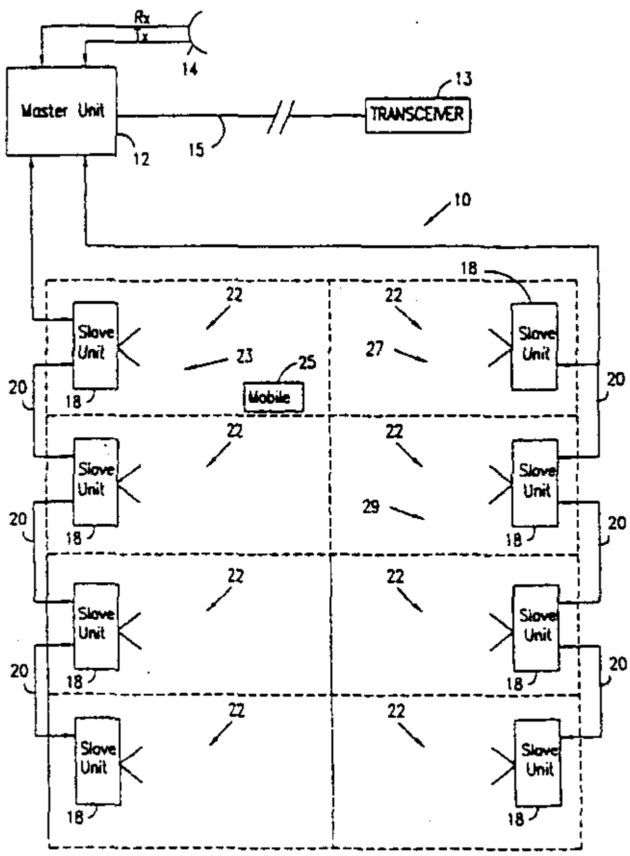

(57) Abstract: Repeater apparatus for conveying a radio-frequency (RF) signal into an environment closed-off to the RF signal, including a master transceiver unit having a master port which receives the RF signal, a local oscillator (LO), which generates a LO signal at a LO frequency, and a frequency divider which divides the LO frequency of the LO signal by an integer to produce a divided LO signal. The master transceiver unit also includes a master mixer coupled to the master port and the divider which generates an intermediate-frequency (IF) signal responsive to the RF signal and the LO signal. The apparatus includes one or more slave transceiver units, each unit positioned within the environment closed-off to the RF signal and including a frequency multiplier which generates a recovered LO signal at the LO frequency by multiplying the frequency of the divided LO signal by the integer, a slave mixer coupled to the multiplier which generates a recovered RF signal responsive to the recovered LO signal and the IF signal, and a slave port coupled to the slave mixer which receives the recovered RF signal therefrom and transmits the recovered RF signal into the closed-off environment. The apparatus further includes one or more cables coupled between the master transceiver unit and the one or more slave transceiver units which convey the IF signal and the divided LO signal between the master transceiver unit and the one or more slave transceiver units.

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IN-BUILDING RADIO-FREQUENCY COVERAGE

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates generally to cellular communication systems, and specifically to cellular communication systems for areas where radio-frequency signals have difficulty entering.

II. Description of the Related Art

In cellular communications systems there are typically regions where the coverage is difficult or incomplete, for example, within metal-framed structures and underground. One of the reasons for the difficult coverage is Faraday-cage type shielding, wherein radio frequency (RF) signals have difficulty penetrating an effectively closed conducting structure. Another reason is Rayleigh fading, which is generated by a signal traversing multiple paths between a transmitter and a receiver. Typically the multiple paths are caused by reflections and/or refractions of the signal by objects between the transmitter and the receiver. The multiple paths followed by the signal generate interference effects at the receiver, which effects manifest themselves as differences in measured signal strength at the receiver, the measured signal strength being a function of the different paths followed by the signal. Methods for improving the coverage in regions where Faraday-cage type shielding and Rayleigh fading occur are known in the art.

U. S. patent 5,404,570, to Charas et al, whose disclosure is incorporated herein by reference, describes a repeater system used between a base transceiver station (BTS) which is able to receive signals and a closed environment such as a tunnel, wherein the environment is closed off to transmissions from the BTS. The system down-converts a high radio-frequency (RF) signal from the BTS to an intermediate-frequency (IF) signal, which is then radiated by a cable and an antenna in the closed environment to a receiver therein. The receiver up-converts the IF signal to the original

RF signal. Systems described in the disclosure include a vehicle moving in a tunnel, so that passengers in the vehicle who would otherwise be cut off from the BTS are able to receive signals.

U. S. patent 5,603,080 to Kallandar et al., whose disclosure is incorporated herein by reference, describes a plurality of repeater systems used between a plurality of BTSs and a closed environment, wherein the environment is closed off to transmissions from the BTSs. Each system down-converts an RF signal from its respective BTS to an IF signal, which is then transferred by a cable in the closed environment to one or more respective receivers therein. Each receiver up-converts the IF signal to the original RF signal. Systems described in the disclosure include a vehicle moving between overlapping regions in a tunnel, each region covered by one of the BTSs via its repeater system. Thus passengers in the vehicle who would otherwise be cut off from one or more of the BTSs are able to receive signals from at least one of the BTSs throughout the tunnel.

U. S. patent 5,765,099, to Georges et al., whose disclosure is incorporated herein by reference, describes a system and method for transferring an RF signal between two or more regions using a low bandwidth medium such as twisted pair cabling. In a first region the RF signal is mixed with a first local oscillator to produce a down-converted IF signal. The IF signal is transferred to a second region via the low bandwidth medium, wherein the signal is up-converted to the original RF signal using a second local oscillator. The local oscillators are each locked by a phase locked loop (PLL) in each region to generate the same frequency, the locking being performed in each loop by comparing the local oscillator frequency with a single low frequency stable reference signal generated in one region. The reference signal is transferred between the regions via the low bandwidth medium.

One of the methods for overcoming Rayleigh fading, is to use a plurality of spatially-diverse receiving antennas, relying on the fact that statistically the chance of destructive interference occurring at all the antennas for a given signal is small. Using a plurality of antennas (in many cases two antennas are sufficient) enables a corresponding diversity of received signals to be analyzed, and typically the strongest signal is chosen. In the case of two antennas, the received signals are referred to as main and diversity signals.

U. S. patent 5,513,176, to Dean et al., whose disclosure is incorporated herein by reference, describes a distributed antenna array within a region where reception is difficult. The performance of the antenna array is enhanced by utilizing the signal diversity which is generated by the antennas being spatially distributed. Each antenna has a differential time delay applied to signals received by the antennas, so that the diverse signals are also separated in time. The differentially-delayed signals are preferably down-converted to an intermediate frequency and are combined, and the combined signal is then transferred out of the region via a cable.

SUMMARY OF THE INVENTION

It is an object of some aspects of the present invention to provide methods and apparatus for improved coverage in regions where cellular communication is inherently difficult.

In preferred embodiments of the present invention, repeater apparatus for use in a cellular communications system comprises a master transceiver unit, which communicates, preferably over the air or alternatively via a cable, with a base transceiver station using master radio-frequency (RF) signals. The master transceiver unit is coupled by one or more cables to one or more slave transceiver units, which are situated in an environment substantially closed off electromagnetically from the environment wherein the base transceiver station is situated. The slave units comprise respective slave antennas, by means of which the slave units communicate with mobile cellular transceivers using slave RF signals. Most preferably, the slave units are located in a region where the master RF signals are not able to penetrate, such as within a building. Signals between the master unit and the slave units are transferred at intermediate frequencies (IF) via the cables.

In both master and slave units, the IF signals are generated by down-converting the respective RF signals, and the RF signals are recovered by up-converting the IF signals. The up-conversion and down-conversion are performed using the same local oscillator (LO) frequency in the master and the slave units. In order to generate the same LO frequency in all units, one local oscillator in the master unit generates the LO frequency, and the generated LO frequency is divided by an integer in the master unit. The divided LO signal is transferred by the cable to the slave units, wherein the divided LO signal is multiplied by the same integer to recover the LO frequency.

Transferring an integer-divided LO frequency throughout the system, for use as a reference, enables recovery of the undivided LO frequency by multiplying by the same integer. Furthermore, the integer-divided LO signal can be distributed with low loss over conventional, inexpensive cable. Thus, one local oscillator supplies the entire system with the same LO frequency, so that problems which might be caused by LO frequency differences within the system are obviated.

In some preferred embodiments of the present invention, the RF signals comprise code division multiple access (CDMA) signals, which include one or more pilot signals associated with cellular channels over which the mobile transceivers are to communicate. The slave units comprise respective transmission delay elements which add a differential time delay to signals transmitted from the master unit to the respective slave units. The differential time delay effectively adds diversity to the signals received by the slave units, so that reception of pilot tone signals transmitted by the master unit is improved. In some preferred embodiments of the present invention, the slave units comprise respective receive delay elements, which add a differential time delay to signals received by the master unit from the respective slave units, so that reception of signals from the slave units is improved.

In some preferred embodiments of the present invention, the local oscillator generating the particular LO frequency is not necessarily a high-stability oscillator, since any variations in the LO frequency are transferred throughout the system.

In some preferred embodiments of the present invention, a plurality of master units communicate with a respective plurality of groupings of one or more slave units, each master and slave grouping operating substantially as described hereinabove. Preferably, the plurality of master units (and their respective slave units) utilize the same LO frequency to generate the IF frequencies used for master-slave communication. Alternatively, each master unit and its respective slave units utilize different LO frequencies. By dividing the slave units among the master units, an overall noise figure of the system is reduced. Most preferably, at least some of the slave units provide signals which are used as diverse receive signals, so that overall reception by the slave units is improved.

In some preferred embodiments of the present invention, the system operates as a channelized repeater system transferring channelized signals between the master and slave units. Most preferably, one or more filters are placed within the one or more slave units or one or more master units for the purpose of filtering out unwanted signals, for example signals outside specific channels which are designated to be transferred between the master and slave units.

There is therefore provided, in accordance with a preferred embodiment of the present invention, repeater apparatus for conveying a radio-frequency (RF) signal into an environment closed-off to the RF signal, including:

a master transceiver unit, including:

a master port which receives the RF signal;

a local oscillator (LO), which generates a LO signal at a LO frequency;

a frequency divider which divides the LO frequency of the LO signal by an integer to produce a divided LO signal; and

a master mixer coupled to the master port and the divider which generates an intermediate-frequency (IF) signal responsive to the RF signal and the LO signal;

one or more slave transceiver units, each unit positioned within the environment closed-off to the RF signal and including:

a frequency recovery circuit, preferably a frequency multiplier, which generates a recovered LO signal at the LO frequency by multiplying the frequency of the divided LO signal by the integer;

a slave mixer coupled to the multiplier which generates a recovered RF signal responsive to the recovered LO signal and the IF signal; and

a slave port coupled to the slave mixer which receives the recovered RF signal therefrom and transmits the recovered RF signal into the closed-off environment; and

one or more cables coupled between the master transceiver unit and the one or more slave transceiver units which convey the IF signal and the divided LO signal between the master transceiver unit and the one or more slave transceiver units.

Preferably, the master port is a two-way port, and each slave port is a two-way port through which the respective slave transceiver unit receives an RF slave signal from the closed-off environment and mixes the RF slave signal with the recovered LO signal to produce a slave IF signal which is conveyed by the one or more cables to the master transceiver unit, wherein a recovered slave RF signal is generated and is conveyed to the master port for transmission therefrom.

Preferably, each slave transceiver unit includes a respective IF signal reverse path wherein the reverse path comprises a delay element which delays the IF signal in the reverse path by a predetermined time.

Preferably, the master transceiver unit includes an antenna which receives the RF signal from a base transceiver station and transfers the received RF signal to the master port.

Preferably, the master port receives the RF signal via a cable coupled to a base transceiver station.

Further preferably, each slave unit includes one or more antennas coupled to the respective slave port which transmit the recovered RF signal into the closed-off environment.

Preferably, the master unit transceiver includes a DC power supply which generates a DC level that is conveyed over the one or more cables to power the one or more slave transceiver units.

Preferably, the master unit transceiver includes a controller which controls the operation of the master transceiver unit and the one or more slave transceiver units.

Further preferably, the repeater apparatus includes a remote control unit which transfers control signals between the controller and an operator of the apparatus.

Further preferably, the controller generates modulated control signals which are conveyed by the one or more cables between the master transceiver unit and the one or more slave transceiver units.

Preferably, the apparatus operates in a cellular communications network at frequencies substantially in the range 800 MHz to 1900 MHz.

Preferably, the IF signal corresponds to one or more predetermined channels of a multiple-access communications network.

Preferably, the one or more slave transceiver units include a plurality of slave transceiver units coupled to the master transceiver unit in one or more daisy-chain topologies.

Further preferably, the one or more slave transceiver units include a plurality of slave transceiver units coupled to the master transceiver unit in one or more star topologies.

Preferably, the one or more slave transceiver units include a plurality of slave transceiver units coupled to the master transceiver unit in one or more hybrid star-daisy-chain topologies.

Preferably, each slave transceiver unit includes a respective IF signal forward path, wherein the forward path includes a delay element which delays the IF signal in the forward path by a predetermined time.

There is further provided, in accordance with a preferred embodiment of the present invention, a method for conveying a radio-frequency (RF) signal into an environment closed-off to the RF signal, including:

receiving the RF signal at a master port;

providing a local oscillator (LO) signal operating at a LO frequency in a vicinity of the master port;

dividing the LO frequency of the LO signal by an integer to produce a divided LO signal;

generating an intermediate frequency (IF) signal responsive to the RF signal and the LO signal;

conveying the IF signal and the divided LO signal to the closed-off environment;

multiplying the frequency of the divided LO signal by the integer to generate a recovered LO signal having the LO frequency;

mixing the recovered LO signal and the IF signal to generate a recovered RF signal;

coupling the recovered RF signal to a slave port; and

transmitting the recovered RF signal into the closed-off environment from the slave port.

Preferably, the method includes:

receiving a slave RF signal from the closed-off environment at the slave port;

mixing the slave RF signal and the LO signal to produce a slave IF signal;

recovering the slave RF signal by mixing the slave IF signal with the LO signal; and

transmitting the slave RF signal from the master port.

Preferably, receiving the RF signal includes receiving a cellular communications transmission at a frequency in the range 800 MHz to 1900 MHz.

Preferably, generating the IF signal includes producing an IF signal having a frequency substantially less than the frequency of the RF signal.

Further preferably, generating the IF signal includes producing an IF signal having a frequency substantially less than the LO frequency.

Further preferably, generating the IF signal includes producing an IF signal to correspond to one or more predetermined channels of a multiple-access communications network.

Preferably, conveying the IF signal to the closed-off environment includes delaying the IF signal by a predetermined time.

Preferably, mixing the slave RF signal and the LO signal to produce a slave IF signal includes delaying the slave IF signal by a predetermined time.

There is further provided, in accordance with a preferred embodiment of the present invention a communications repeater system that includes a plurality of slave units, which receive a main radio frequency (RF) signal and a diversity RF signal transmitted by one or more mobile communication units in a vicinity of the slave units and which generate, responsive to the received RF signals, a respective main intermediate frequency (IF) signal and diversity IF signal, apparatus for converting the IF signals to respective recovered main and recovered diversity radio-frequency (RF) signals, including:

a main master unit, including:

a main IF port which receives the main IF signal;

a local oscillator which generates a local oscillator (LO) signal;

a reference signal generator, coupled to the local oscillator, which generates a reference signal responsive to the LO signal;

a main mixer coupled to the main IF port and the local oscillator which generates the recovered main RF signal responsive to the main IF signal and the LO signal; and

a main RF port coupled to the main mixer which transmits the recovered main RF signal; and

a diversity master unit, including:

a diversity intermediate frequency (IF) port which receives the diversity IF signal;

a receiver which generates a recovered LO signal from the reference signal received from the main master unit;

a diversity mixer coupled to the diversity IF port and the receiver which generates a recovered diversity RF signal responsive to the diversity IF signal and the recovered LO signal; and

a diversity RF port coupled to the diversity mixer which transmits the recovered diversity RF signal.

Preferably, the reference signal generator includes a frequency divider, which divides a frequency of the LO signal by an integer to produce a divided LO signal, and the receiver includes a multiplier which multiplies the divided LO signal by the integer to generate the recovered LO signal.

Preferably, the reference signal includes the LO signal, and the receiver includes a splitter which receives the LO signal and splits the LO signal to generate the recovered LO signal.

Preferably, each slave unit includes a respective IF signal forward path, wherein the forward path includes a delay element which delays the IF signal in the forward path by a predetermined time.

Further preferably, each slave unit includes a respective IF signal reverse path, wherein the reverse path includes a delay element which delays the IF signal in the reverse path by a predetermined time.

Preferably, the plurality of slave units includes:

one or more main slave units coupled to the main IF port which receive the main RF signal and generate the main IF signal responsive to the LO signal and the main RF signal; and

one or more diversity slave units coupled to the diversity RF port which receive the diversity IF signal and generate the diversity IF signal responsive to the LO signal and the diversity RF signal.

Preferably, the one or more main slave units are separated sufficiently in position from the one or more diversity slave units so that the main RF signal received by the one or more main slave units and the diversity RF signal received by the one or more diversity slave units are distinguishable from each other by the one or more main slave units and the one or more diversity slave units.

Preferably, the system includes an antenna coupled to the main RF port and the diversity RF port which radiates the main recovered RF signal and the diversity recovered RF signal.

Further preferably, the system includes a cable coupled to the main RF port and the diversity RF port which conveys the main recovered RF signal and the diversity recovered RF signal to a base transceiver station.

There is further provided, in accordance with a preferred embodiment of the present invention, a communications repeater system that includes a plurality of slave units, which receive a main radio frequency (RF) signal and a diversity RF signal transmitted by one or more mobile communication units in a vicinity of the slave units and which generate, responsive to the received RF signals, a respective main intermediate frequency (IF) signal, and diversity IF signal, a method for converting the main and diversity IF signals to respective recovered main and recovered diversity radio-frequency (RF) signals, including:

receiving the main IF signal generated responsive to the main RF signal in a main IF port;

generating a local oscillator (LO) signal;

mixing the main IF signal and the LO signal to generate a recovered main RF signal;

transmitting the recovered main RF signal from a main RF port;

receiving the diversity IF signal generated responsive to the diversity RF signal at a diversity IF port;

generating a reference responsive to the LO signal;

receiving the reference to generate a recovered LO signal;

mixing the diversity IF signal and the recovered LO signal to generate a recovered diversity RF signal; and

radiating the recovered diversity RF signal from a diversity RF port.

Preferably, generating the reference includes dividing a frequency of the LO signal by an integer to produce a divided LO signal, and receiving the reference includes multiplying the frequency of the divided LO signal by the integer.

There is further provided, in accordance with a preferred embodiment of the present invention, repeater apparatus, including:

first and second master units, which communicate with respective first and second wireless communication networks operating on respective first and second frequency bands;

a combiner, in wired communication with the first and second master units, so as to receive therefrom and convey thereto communication signals that are transmitted over the first and second networks; and

a plurality of slave units, coupled to the combiner, and located at a plurality of different, respective locations within a generally closed environment, so as to communicate with mobile wireless units operating on the first and second frequency bands.

Preferably, the first frequency band includes frequencies substantially in a range 800 MHz to 900 MHz and the second frequency band includes frequencies substantially in a range 1800 MHz to 1900 MHz.

Preferably, the plurality of slave units includes at least one slave unit operating on the first frequency band and at least one slave unit operating on the second frequency band.

Preferably, the repeater apparatus includes one or more antennas coupled at least to the first or the second master unit via which the respective master unit communicates with the respective wireless communication network.

Further preferably, the repeater apparatus includes a cable coupled to at least the first or the second master unit via which the respective master unit communicates with the respective wireless communication network.

Preferably, the first wireless communication network includes a cellular network, and the second wireless communication network includes a Personal Communication Services (PCS) network.

The present invention will be more fully understood from the following detailed description of the preferred embodiments thereof, taken together with the drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic block diagram of an in-building repeater system, according to a preferred embodiment of the present invention;

Fig. 2 is a schematic block diagram of a cellular master unit comprised in the system of Fig. 1, according to a preferred embodiment of the present invention;

Fig. 3 is a schematic block diagram of a cellular slave unit comprised in the system of Fig. 1, according to a preferred embodiment of the present invention;

Fig. 4 is a schematic block diagram of a repeater system installed in a building, according to an alternative preferred embodiment of the present invention;

Fig. 5 is a schematic diagram showing signals passing through a splitter/combiner comprised in the system of Fig. 4, according to a preferred embodiment of the present invention;

Fig. 6 is a schematic block diagram showing a repeater system installed in a building, according to a further alternative preferred embodiment of the present invention;

Fig. 7 is a schematic block diagram of a diversity master unit comprised in the system of Fig. 6, according to a preferred embodiment of the present invention; and

Fig. 8 is a schematic block diagram showing a repeater system installed in a building, according to an alternative preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Reference is now made to Fig. 1, which schematically illustrates an in-building repeater system 10, according to a preferred embodiment of the present invention. A master cellular (hereinafter referred to as CELL) antenna 14 receives a master CELL radio-frequency (RF) signal from a remote transceiver 13. Antenna 14 is most preferably positioned outside a building 16, so that signals may be transmitted between the antenna and transceiver 13 generally without hindrance. Transceiver 13 is preferably a transceiver in a base transceiver station (BTS) of a cellular telephone system operating in a frequency band in a range of approximately 820 MHz to 880 MHz, although any other suitable transceiver could also be used. The master RF signal is transferred from antenna 14 to a master CELL unit 12 by methods which are known in the art. Alternatively, master CELL unit 12 transmits RF signals to transceiver 13 and receives RF signals from the transceiver without using antenna 14, for example, by using a cable 15 connected between master unit 12 and transceiver 13. Preferably, when signals are transferred using antenna 14, master CELL unit 12 is positioned so that the path between the unit and antenna 14 is as short as possible, in order to optimize the signal-to-noise value. Further preferably, transceiver 13 and/or master unit 12 comprise one or more rake receivers when the cellular telephone system operates with CDMA signals.

Master CELL unit 12 receives the master RF signal and down-converts the signal to a forward intermediate frequency (IF-FWD) signal, so that master CELL unit 12 functions as a frequency conversion unit. The downconversion is performed using a local oscillator signal generated in unit 12, which signal has a frequency compatible with the frequency band within which unit 12 is operating. For example, if master CELL unit 12 operates at 820 MHz to 880 MHz, the local oscillator frequency could be set at 750 MHz. (The local oscillator signal in master unit 12 is also used for upconversion within the unit, as described in more detail below.) The IF-FWD signal and a reference to the local oscillator signal are transferred via one or more cables 20 to one or more slave CELL units 18, wherein the IF-FWD signal is up-converted to a "recovered" master RF CELL signal corresponding to the RF CELL signal received by master CELL unit 12. Slave CELL units 18 thus also function as frequency conversion units. When there is more than one slave CELL unit, the units are preferably connected to cables 20 in one or more "daisy-chain" topologies 23. Alternatively, the units may be connected in one or more star topologies 27, or in one or more daisy-chain-star hybrid topologies 29. The topology is preferably chosen according to installation requirements of system 10 and building 16. Slave CELL units 18 are positioned within building 16, which acts as an electromagnetic barrier substantially closing off RF signals from transceiver 13 from the interior of the building, so as to radiate the recovered master RF CELL signal within the building.

A patent application entitled "Split Repeater," filed November 1, 1999, which is assigned to the assignee of the present invention and whose disclosure is incorporated herein by reference, describes a cellular repeater which down-converts an RF signal to an IF signal, then up-converts the IF signal to recover the RF signal. Examples of frequencies that are used in the process of conversion are given in the application, which frequencies may also be used in the present invention.

Each slave CELL unit 18 is coupled to one or more slave CELL antennas 22, and the recovered RF signal is radiated by the one or more slave CELL antennas 22 and is received by a CELL transceiver 25, most preferably comprised in a mobile CELL telephone, although any other suitable transceiver could be used. Slave CELL units 18 are most preferably positioned within building 16 so that the recovered master RF CELL signal is receivable within the building by CELL transceiver 25. As described in more detail below, DC power generated to drive master CELL unit 12 is preferably also transferred as a DC bias level via cables 20 to drive slave CELL units 18. Cables 20 are preferably standard coaxial cables, although any other cables capable of transferring the signals and bias level generated within master CELL unit 12 and slave CELL units 18 may be used.

One or more antennas 22 of one or more slave units 18 also receive a slave CELL RF signal from CELL transceiver 25, The slave CELL RF signal is down-converted to a reverse intermediate frequency (IF-REV) signal by the one or more slave units 18 receiving the RF signal. The IF-REV signal is transferred via cables 20 to master unit 12, wherein the IF-REV signal is up-converted to a recovered slave CELL RF signal, which is then transferred to transceiver 13, as described hereinabove. The operations of CELL master unit 12 and of one of CELL slave units 18 are explained in detail hereinbelow.

Fig. 2 is a schematic block diagram of master CELL unit 12, according to a preferred embodiment of the present invention. An RF duplexer 41 receives the master RF signal from transceiver 13 via antenna 14, as described above. Duplexer 41 acts as a port and separates a path 43 of the master signal from a path 45 of the received slave signal, by methods which are known in the art. Alternatively, the master RF signal is received via cable 15, as is also described above. The master RF signal is transferred to a low noise variable gain RF amplifier 30. Amplifier 30 acts as a first stage of amplification in path 43, and is most preferably constructed from very-low-noise components, as are known in the art.

The amplified signal from amplifier 30 is input to a mixer 32. Mixer 46 also receives a local oscillator (LO) signal, preferably generated by a temperature controlled crystal oscillator or alternatively by a non-stabilized oscillator. The oscillator and a frequency synthesizer act as a local oscillator 42, which transfers the LO signal to mixer 46 via a splitter 44. Preferably, a controller 78 sets the frequency generated by local oscillator 42. Mixer 32 uses the local oscillator signal to generate mixed signals comprising intermediate frequency (IF) side-bands, which mixed signals are amplified in a second-stage amplifier 34. The amplified mixed signals are then filtered in a band-pass filter 36 which passes one intermediate frequency band centered on a frequency herein termed IF-FWD, and rejects other bands generated in mixer 32. Preferable choices for the local oscillator frequency, and the corresponding IF-FWD frequency, are described in the above referenced patent application.

The output of filter 36 is input to a variable-gain amplifier 38 and a power amplifier 40, which together adjust a level of the IF-FWD signal according to requirements of the topology of the slave units installed in building 16, and according to requirements of a link budget of system 10. The adjusted signal is input to a triplexer 54. Preferably, the gain of amplifier 38 is set by controller 78.

Preferably, local oscillator 42 also supplies a local oscillator (LO) signal via splitter 44 and a buffer amplifier 46 to a frequency divider 48, which divider is set to divide the frequency by an integer, which is typically in the range 2 - 16, although any other suitable value could be used. The divided local oscillator (LO) signal is filtered to remove noise introduced by the division in a narrow band-pass filter 50, and is input to an amplifier 52. Amplifier 52 amplifies the received signal and transfers its output as a reference signal operating at a reference frequency to triplexer 54. Triplexer 54 combines the amplified LO reference signal and the adjusted IF-FWD signal, and transfers the combined signal to a bias-T filter 56.

Bias T filter 56 acts as a port and as a low-pass filter which biases the combined signal from triplexer 54 with a DC level generated by a power supply 74. The DC level generated by supply 74 drives master unit 12.

Preferably, power supply 74 receives its driving power in the form of standard AC line power. Alternatively, power supply 74 receives its driving power in any other suitable standard form, such as from a battery. Filter 56 transfers the combined signal at the DC bias level to a splitter 58, which splits the signal into two paths, each path comprising at least one cable 20 and one slave unit 18. Thus each slave unit 18 receives the signal and the DC power from splitter 58.

Master unit 12 receives the IF-REV signal generated in slave units 18 via cables 20 and bias-T filter 56. The bias-T separates the signal from the DC level present in the cable, and the AC component, i.e., the IF-REV signal, is transferred to triplexer 54. Triplexer 54 directs the IF-REV signal along path 45 of unit 12, to a variable-gain amplifier 60 which amplifies the IF-REV signal to a level determined by the link budget of system 10. Mixer 62 mixes the IF-REV signal from amplifier 60 and the LO signal from splitter 44 to recover a slave RF signal received by one of the slave units 18. The recovered slave RF signal is amplified in an amplifier 64 and then filtered in a band-pass filter 66. The filtered amplified signal is then amplified in a variable-gain amplifier 68 and a power amplifier 70 before transferring via an isolator 72 to duplexer 41. The gain of amplifier 68 is preferably set by controller 78, so that the signal output from isolator 72 is at a suitable level for onward transmission from duplexer 41. Alternatively, the signal output from isolator 72 is transmitted to transceiver 13 via cable 15. Most preferably, gains of the variable-gain amplifiers of master unit 12 described hereinabove are adjusted so that the overall signal gain, from port to port, for path 43 and for path 45 is of the order of 10 - 60 dB for each path.

In a preferred embodiment of the present invention, controller 78 is able to control and/or monitor the operation of the one or more slave CELL units 18, by transferring control signals to the slave units on cables 20. Most preferably, the control signals are in the form of a frequency and/or a phase and/or an amplitude modulated signal, such as a frequency shift key (FSK) signal, as are known in the art. Preferably, master CELL unit 12 comprises a modem 76 which is coupled to controller 78, and the control signals are transferred to the slave units via the modem and filter 56.

Fig. 3 is a schematic block diagram of one of slave CELL units 18, according to a preferred embodiment of the present invention. Each slave CELL unit 18 comprises a bias-T filter 92 and a coupler 94, which together receive the IF-FWD signal, the local oscillator reference signal, i.e., the divided local oscillator signal, and the DC level from master unit 12 via cables 20. Bias-T filter 92 and coupler 94 are also able to transfer signals between other slave units connected to cables 20 and master unit 12. Most preferably, coupler 94 and filter 92 are arranged so that coupling or decoupling one of slave units 18 from cables 20 does not significantly affect operation of the other slave units 18.

Filter 92 acts as a port, splitting off the DC level to power each slave unit 18 either directly or via an optional DC-DC power supply 96, and transferring the AC signals received from master unit 12 via coupler 94 to a triplexer 100. Triplexer 100 filters and separates the AC signals into the IF-FWD signal which follows a forward path 91, and the divided local oscillator signal which follows a path 93. Path 93 comprises a frequency multiplier 120, which multiplies the frequency of the divided local oscillator signal, after amplification in a pre-amplifier 118, by the same integer value used by divider 48 of master unit 12. Thus a local oscillator signal is reconstituted in each slave unit 18, which signal has a frequency identical to that of the local oscillator signal originally synthesized by local oscillator 42 of master unit 12. The reconstituted local oscillator signal is filtered in a band-pass filter 122 to remove noise produced by the multiplication, and amplified in an amplifier 124. The amplified reconstituted LO signal is input to a splitter 126, and from the splitter the signal is input to a mixer 104 and a mixer 140. The power level of the LO signal input to the splitter is preferably set as required to drive mixers 104 and 140.

Path 91 comprises a preamplifier 102, which receives frequencies centered on IF-FWD from triplexer 100, and amplifies the IF-FWD signal before it is input to a variable delay 103. Delay 103 preferably comprises a surface acoustic wave delay which delays signals in path 91 by a time of the order of 500 ns. Most preferably, the time delay is set to be at least half a chip rate of CDMA signals received by unit 12. The time delay provided by delay

103 is preferably set on installation of each unit 18, or alternatively the time delay is set by a remote control modem 98, whose function is described in more detail below. Most preferably, the time delay provided by delay 103 for each respective unit 18 in system 10 is set to be different. Thus, CDMA pilot signals received by transceiver 25 will be delayed by different times, so avoiding possible destructive interference of transmitted pilot signals, and thus improving the overall reception of the pilot signals.

The signal from delay 103 is input to mixer 104. Mixer 104 up-converts the IF-FWD signal received, using the reconstituted local oscillator signal, to regenerate the master RF signal received by master unit 12. The regenerated RF signal is amplified in an RF amplifier 106 and filtered in band-pass filter 108, which together prepare an RF signal at a level suitable for inputting to a variable-gain amplifier 110 and an RF power amplifier 112. Power amplifier 112 generates an RF power output signal corresponding to the original master signal received by master unit 12, which power signal is transferred via an isolator 114 to increase the voltage standing wave ratio. The power signal is input to an RF duplexer 116 which acts as a port. Duplexer 116 routes the power signal to a four-way splitter 144, to which up to four slave antennas 22 are coupled and which radiate the RF power signal.

As explained above, antennas 22 also receive a slave RF signal. The slave signal is routed via RF duplexer 116 along a reverse path 95 to a low noise pre-amplifier 142, which pre-amplifier is most preferably constructed from very-low-noise components by methods known in the art. A mixer 140 uses the reconstituted local oscillator signal received from splitter 126 and the output signal of pre-amplifier 142 to down-convert the slave RF signal to the intermediate frequency signal IF-REV. The IF-REV signal is amplified by an amplifier 138 feeding a band-pass filter 136, which together operate to generate an IF-REV signal substantially free from unwanted sidebands, such as those produced in mixer 140.

The IF-REV signal output of filter 136 is preferably output to a variable delay 137. Delay 137 preferably comprises a surface acoustic wave delay which delays signals in path 95 by a time of the order of 2 ms. The time delay provided by delay 137 is preferably set on installation of each unit 18, or alternatively the time delay is set by remote control modem 98. Most preferably, the time delay provided by delay 137 for each respective unit 18 in system 10 is set to be different. As explained in more detail below, the time delay provided by each respective delay 137 is used to provide diversity in signals received by units 18. The signal from delay 137 is routed through an amplifier 134, a variable-gain amplifier 130, and a power amplifier 128 to triplexer 100.

Alternatively, delay 137 is not present in unit 18, and the IF-REV signal output of filter 136 is routed directly to amplifier 134. The output of amplifier 128 is sampled by an automatic gain control (AGC) circuit and is used to adjust the gain of variable-gain amplifier 130, so that the level of the amplified IF-REV signal is maintained at a level consistent with the link budget. Triplexer 100 routes the output of amplifier 128 via coupler 94 to cables 20, wherein it is transmitted to master unit 12.

Preferably, remote control modem 98 is able to receive and decode control signals originating from master unit 12, as described above. Most preferably, the control signals are utilized to set and/or read parameters of elements within slave unit 18, such as the gains of amplifiers 110 and 130 and the delay time of delay 103, and/or levels of signals within the slave unit. Preferably, parameters affecting the operation of each slave unit 18, such as gains of amplifiers 110 and 130, are preset when each slave unit 18 is set up, so that each slave unit 18 is able to operate independently. Most preferably, the overall signal gain, from port to port, for path 91 and for path 95 is set to be of the order of 10 - 60 dB for each path.

Returning to Fig. 1, it will be appreciated that all the slave CELL units of system 10 operate on substantially one local oscillator frequency, as provided by the local oscillator in master CELL unit 12, which also operates on the same local oscillator frequency. The local oscillator frequency is first divided by an integer, and the divided LO frequency is transferred throughout the system to the slave units. Within each slave unit the divided LO frequency is multiplied by the integer, to reconstitute the original local oscillator frequency. The process of division by an integer, then multiplication by the integer, ensures that the reconstituted frequency is substantially identical to the frequency generated by the local oscillator, and that any drift in the local oscillator frequency is substantially exactly reproduced in the slave units. Thus, regardless of the occurrence of any drift, since the same local oscillator frequency is used for down-converting and up-converting, the recovered LO frequency is substantially identical to the original LO frequency.

In some preferred embodiments of the present invention, at least some of elements 36, 41, 54, and 66 of master unit 12 (Fig. 2) are constructed so that only specific predetermined cellular channel frequencies are transmitted on path 43 and on path 45, and other cellular channel frequencies are not transmitted. Most preferably, at least some of elements 100, 108, 116, and 136 of each slave unit 18 (Fig. 3) are constructed so that the corresponding cellular channel frequencies are transmitted on path 91 and path 95. Thus master unit 12 and slave units 18 operate as a channelized communication repeater system.

Fig. 4 schematically illustrates a repeater system 150 installed in a building 170, according to an alternative preferred embodiment of the present invention. Apart from the differences described below, the operation of system 150 is generally similar to that of system 10 (Fig. 1), so that elements indicated by the same reference numerals in both systems 10 and 170 are generally identical in construction and in operation. System 150 comprises CELL master unit 12 and CELL master antenna 14, which transmit and receive RF CELL signals from transceiver 13, and which communicate with CELL slave units 18, substantially as described above for system 10.

In addition, system 150 comprises a master personal communications system (PCS) unit 154 and a master PCS antenna 176, which transmit and receive RF PCS signals from a transceiver 184, and which communicate with a plurality of PCS slave units 166. Master PCS unit 154 and master PCS antenna 176 operate generally as master CELL unit 12 and master CELL antenna 14, as described above with reference to Fig. 2, except that master PCS unit 154 and master PCS antenna 176 operate at frequencies different from those of master CELL unit 12 and master CELL antenna 14.

Alternatively, master CELL unit 12 transmits and receives signals from transceiver 13 via a cable 178 and/or master PCS unit 154 transmits and receives signals from transceiver 184 via a cable 180. PCS slave units 166 operate generally as CELL slave units 18, as described above with reference to Fig. 3, except that PCS slave units 166 operate at frequencies different from those of CELL slave units 18.

Preferably, master PCS unit 154 and PCS antenna 176 receive a master PCS signal from transceiver 184 at a frequency compatible with a personal communications system, for example, in a frequency band from approximately 1800 MHz to 1900 MHz, although transceiver 184 could operate in any other frequency band. Most preferably, a PCS local oscillator signal for master PCS unit 154 is chosen to have a frequency compatible with the frequency band within which the unit is operating, for example 1700 MHz.

The PCS LO signal is mixed with the master PCS signal to generate an IF-FWD PCS signal. As described above with reference to master CELL unit 12, the frequency of the PCS LO signal is divided by an integer, herein termed the PCS integer, to generate a divided PCS LO signal. The PCS integer may be different from the integer used in unit 12, herein termed the CELL integer. Also as described above with reference to master CELL unit 12, PCS control signals to control and/or monitor the operation of slave units 166 are generated within master PCS unit 154 The divided PCS LO signal, the IF-FWD PCS signal, and the PCS control signals are transmitted, substantially as described above with reference to master CELL unit 12, to one or more PCS slave units 166.

PCS slave units 166 operate generally as CELL slave units 18, as described above with reference to Fig. 3, except that the PCS slave units operate at frequencies compatible with signals transmitted from PCS master unit 154. Thus, PCS slave units 166 regenerate the PCS local oscillator frequency by multiplying the frequency of the divided PCS LO signal by the PCS integer. The regenerated PCS local oscillator signal is mixed with the PCS IF-FWD signal received from PCS master unit 154 to regenerate the PCS master RF signal. PCS slave units 166 are coupled to one or more PCS slave antennas 182, so that the units and associated antennas are able to transmit and receive PCS signals from a PCS slave transceiver 186. Thus, a slave PCS RF signal received by a specific PCS slave unit 166 is mixed with the regenerated PCS local oscillator signal to produce an IF-REV PCS signal.

As described above with reference to slave unit 18, PCS slave units 166 receive the PCS control signals transmitted by PCS master unit 34. Most preferably, PCS slave units 166 are powered, in substantially the same manner as CELL slave units 18, by a DC bias level generated in master CELL unit 12.

CELL master unit 12 is coupled via a coaxial cable 160 to a splitter/combiner 156, which is described in more detail below. PCS master unit 154 is also coupled via a coaxial cable 158 to splitter/combiner 156. Splitter/combiner 156 is in turn coupled via one or more coaxial cables 162 to one or more CELL slave units 18 and to one or more PCS slave units 166, most preferably in one of the topologies described hereinabove for system 10.

Fig. 5 is a schematic diagram showing signals passing through splitter/combiner 156, according to a preferred embodiment of the present invention. Splitter/combiner 156 preferably comprises one or more band-pass filters operating in the frequency bands of the signals passed by the splitter/combiner, as is known in the art. Splitter/combiner 156 effectively routes signals from CELL slave units 18 to CELL master unit 12, and vice versa, and also routes signals from PCS slave units 166 to PCS master unit 154, and vice versa. Thus, on cable 160 splitter/combiner 36 receives the divided CELL LO signal, the IF-FWD CELL signal, the CELL control signals, and the DC bias level from CELL master unit 12 and transfers the signals and the bias level to cable 162. Similarly, on cable 158 splitter/combiner 156 receives the divided PCS LO signal, the IF-FWD PCS signal and the PCS control signals from PCS master unit 154 and transfers the signals to cable 162. On cable 162 splitter/combiner 156 receives the IF-REV CELL signal and responses to the CELL control signals from slave CELL units 18, and transfers the signals to cable 160. Similarly, on cable 162, splitter/combiner

156 receives the IF-REV PCS signal and responses to the PCS control signals from slave PCS units 166, and transfers the signal to cable 158.

Returning to Fig. 4, it will be appreciated that CELL master unit 12, cable 160, splitter/combiner 156, cables 162, and CELL slave units 18 form a CELL group of communication elements 161 which operate substantially as system 10 at cellular frequencies. Similarly, PCS master unit 154, cable 158, splitter/combiner 156, cables 162, and PCS slave units 166 form a PCS group of communication elements 159 which operate substantially as system 10 at personal communication system frequencies.

Most preferably, when CELL slave units 18 and PCS slave units 166 are installed in system 150, the units are installed within building 170 so that substantially all of the interior of the building is able to receive cellular and personal communication system signals. Optionally, the units are installed in pairs, so that a CELL slave unit and a PCS slave unit are located physically close to one another. It will be appreciated that since the slave units are installed as described above for system 10, all the slave units may be powered via coaxial cables 162, substantially from power which is generated for driving CELL master unit 12. As explained above with reference to Fig. 3, most preferably the design of the slave units facilitates coupling or decoupling of one or more slave units from coaxial cables 162, substantially without affecting the operation of slave units which remain coupled to cables 162.

It will be appreciated that all the CELL slave units of group 161 operate on substantially one CELL local oscillator frequency, as provided by the local oscillator in CELL master unit 12, which also operates on the same CELL local oscillator frequency. Furthermore, all the PCS slave units of group 159 operate on substantially one PCS local oscillator frequency, as provided by the local oscillator in PCS master unit 154, which also operates on the same PCS local oscillator frequency.

Fig. 6 is a schematic block diagram showing a repeater system 200 using receive diversity, according to an alternative preferred embodiment of the present invention. Apart from the differences described below, the operation of system 200 is generally similar to that of system 10 (Fig. 1), so that elements indicated by the same reference numerals in both systems 10 and 200 are generally identical in construction and in operation. System 200 is installed in a building 202. Master unit 12 receives IF-REV signals from a plurality of slave units 18M installed in building 202 via cables 20, in response to RF signals received by the slave units from transceiver 25, substantially as described above for system 10. Each slave unit 18M is substantially identical in construction and operation to slave unit 18, and the suffix M is used herein to indicate slave units coupled to master unit 12. The IF-REV signals received from slave units 18M are converted in master unit 12 to recovered RF signals. The recovered RF signals are transmitted to transceiver 13 as receive main signals, preferably via cable 15, or alternatively over the air via antenna 14.

System 200 comprises a diversity master unit 212, which operates generally similarly to master unit 12, and whose construction and operation is described in detail below. Diversity master unit 212 is connected by a plurality of cables 220, in a daisy chain or other topology as described above with reference to system 10, to a plurality of slave units 18D. Each slave unit 18D is substantially identical in construction and operation to slave unit 18, and the suffix D is used herein to indicate slave units coupled to diversity master unit 212. It will be appreciated that since repeater system 200 comprises separate sets of slave units 18M and 18D, there will be an improvement in overall system noise figure of up to 3 dB compared to a similar system where the slave units are not separated.

Most preferably, slave units 18M and slave units 18D are separated sufficiently in position so that signals received by the separate sets of slave units are distinguishable, i.e. so that the separate signals can be used as main receive signals and diversity receive signals respectively. Most preferably, delay 137 (Fig. 3) is present in each slave unit 18D and each slave unit 18M and is set to be an integer multiple of a delay period of the order of 2 ms, so that signals received by the slave units can incorporate time diversity. Thus, signals received by slave units 18D and slave units 18M incorporate position diversity or time diversity or a combination of position and time diversity.

A cable 215 connects master unit 12 and diversity master unit 212, which cable is used to transfer the local oscillator signal from master unit 12 to diversity master unit 212. Alternatively, cable 215 transfers the divided local oscillator signal from master unit 12 to diversity master unit 212, wherein the local oscillator signal having the local oscillator frequency is regenerated, as described hereinbelow. Diversity master unit 212 receives IF-REV signals from its respective slave units 18D via cables 220, in response to RF signals received by the slave units from transceiver 25. The IF-REV signals received from slave units 18D are converted in master unit 212 to recovered RF signals, which recovered RF signals are transmitted to transceiver 13, substantially as described above for system 10, as receive diversity signals. Thus system 200 utilizes master unit 12 and its respective slave units 18M to provide receive main RF signals, and utilizes diversity master unit 212 and its respective slave units 18D to provide receive diversity RF signals, so that coverage within building 202 is enhanced compared to systems which do not use diversity.

Most preferably, system 200 comprises a two-way splitter 204 which supplies transmit RF signals from transceiver 13 to master unit 12 and diversity master unit 212. As described above with respect to system 10, master unit 12 and diversity master unit 212 convert the RF signals to IF-FWD signals, and transfer the IF-FWD signals to their respective sets of slave units 18M and slave units 18D.

In some preferred embodiments of the present invention, diversity master unit 212 operates and is constructed substantially as described above for master unit 12 (Fig. 2), apart from the differences described hereinbelow. Diversity master unit 212 does not utilize local oscillator 42, and the local oscillator may be absent from unit 212. Instead of using local oscillator 42, the local oscillator signal from main master unit 12 is transferred as a reference by cable 215 to a feed point 43 on splitter 44, which acts as a receiver to recover the local oscillator signal. The recovered local oscillator signal is utilized substantially as described above for the generated local oscillator signal of master unit 12.

Fig. 7 is a schematic block diagram of diversity master unit 212, according to an alternative preferred embodiment of the present invention. Apart from the differences described below, the operation of unit 212 is generally similar to that of unit 12 (Fig. 2), so that elements indicated by the same reference numerals in both units 12 and 212 are generally identical in construction and in operation. To provide a local oscillator signal, diversity unit 212 receives the divided LO signal as a reference from master unit 12 via cable 215. The divided LO signal is input to triplexer 54, and the signal is conveyed, as described above for master unit 12, to slave units 18D via cables 220. The divided LO signal is also input to an amplifier 224, and the output of the amplifier is input to a multiplier 225. Multiplier 225 multiplies the frequency of the amplified divided LO signal by the same integer as used in master unit 12 to produce the divided LO signal, so that the original LO frequency is recovered as an output of the multiplier. The multiplier output is filtered in a band-pass filter 226 to remove harmonics generated in the multiplier, and the filtered output is amplified in an amplifier 228 and then split in a two-way splitter 230 which thus acts as a receiver that recovers the local oscillator signal. The outputs from splitter 230 are thus signals with the original LO frequency.

One of the outputs from splitter 230 is input to mixer 32 in path 43, and the other output is input to mixer 62 in path 45. The operation of paths 43 and paths 45 is substantially as described above for master unit 12.

Fig. 8 is a schematic block diagram showing a repeater system 300 installed in a building 250, according to an alternative preferred embodiment of the present invention. Apart from the differences described below, the operation of system 300 is generally similar to that of system 10 (Fig. 1), so that elements indicated by the same reference numerals in both system 300 and system 10 are generally identical in construction and in operation. Building 210 is preferably a relatively large building such as a multi-story building wherein communication coverage of the whole interior of the building is difficult because of the volume of communications within the building. In order to provide complete coverage for the whole building, a plurality of master units 12, herein termed master unit 12A, 12B, and 12C, are connected to respective pluralities of slave units 18, herein termed slave units 18A, 18B, and 18C, so that each respective plurality of slave units (and the corresponding master unit) covers a different section of the building. Most preferably, each respective master unit communicates with one sector of a base transceiver station, by methods which are known in the art, so that each sector of the base transceiver station provides coverage for a respective section of building 210. Within each section of building 10, operation of system 300 is substantially as described above for system 10.

It will be appreciated that the preferred embodiments described above are cited by way of example, and that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove, as well as variations and modifications thereof which would occur to persons skilled in the art upon reading the foregoing description and which are not disclosed in the prior art.

We claim:

CLAIMS

1. Repeater apparatus for conveying a radio-frequency (RF) signal into an environment closed-off to the RF signal, comprising:
   a) a master transceiver unit, comprising:
      i) a master port which receives the RF signal;
      ii) a local oscillator (LO), which generates a LO signal at a LO frequency;
      iii) a frequency divider which divides the LO frequency of the LO signal by an integer to produce a divided LO signal; and
      iv) a master mixer coupled to the master port and the divider which generates an intermediate-frequency (IF) signal responsive to the RF signal and the LO signal;
   b) one or more slave transceiver units, each unit positioned within the environment closed-off to the RF signal and comprising:
      i) a frequency recovery circuit which generates a recovered LO signal at the LO frequency by multiplying the frequency of the divided LO signal by the integer;
      ii) a slave mixer coupled to the multiplier which generates a recovered RF signal responsive to the recovered LO signal and the IF signal; and
      iii) a slave port coupled to the slave mixer which receives the recovered RF signal therefrom and transmits the recovered RF signal into the closed-off environment; and
   c) one or more cables coupled between the master transceiver unit and the one or more slave transceiver units which convey the IF signal and the divided LO signal between the master transceiver unit and the one or more slave transceiver units.

2. Apparatus according to claim 1, wherein the master port is a two-way port, and wherein each slave port is a two-way port through which the respective slave transceiver unit receives an RF slave signal from the closed-off environment and mixes the RF slave signal with the

recovered LO signal to produce a slave IF signal which is conveyed by the one or more cables to the master transceiver unit, wherein a recovered slave RF signal is generated and is conveyed to the master port for transmission therefrom.

3. Apparatus according to claim 2, wherein each slave transceiver unit comprises a respective IF signal reverse path wherein the reverse path comprises a delay element which delays the IF signal in the reverse path by a predetermined time.

4. Apparatus according to claim 1, wherein the master transceiver unit comprises an antenna which receives the RF signal from a base transceiver station and transfers the received RF signal to the master port.

5. Apparatus according to claim 1, wherein the master port receives the RF signal via a cable coupled to a base transceiver station.

6. Apparatus according to claim 1, wherein each slave unit comprises one or more antennas coupled to the respective slave port which transmit the recovered RF signal into the closed-off environment.

7. Apparatus according to claim 1, wherein the master unit transceiver comprises a DC power supply which generates a DC level that is conveyed over the one or more cables to power the one or more slave transceiver units.

8. Apparatus according to claim 1, wherein the master unit transceiver comprises a controller which controls the operation of the master transceiver unit and the one or more slave transceiver units.

9. Apparatus according to claim 8, and comprising a remote control unit which transfers control signals between the controller and an operator of the apparatus.

10. Apparatus according to claim 8, wherein the controller generates modulated control signals which are conveyed by the one or more cables between the master transceiver unit and the one or more slave transceiver units.

11. Apparatus according to claim 1, wherein the apparatus operates in a cellular communications network at frequencies substantially in the range 800 MHz to 1900 MHz.

12. Apparatus according to claim 1, wherein the IF signal corresponds to one or more predetermined channels of a multiple-access communications network.

13. Apparatus according to claim 1, wherein the one or more slave transceiver units comprise a plurality of slave transceiver units coupled to the master transceiver unit in one or more daisy-chain topologies.

14. Apparatus according to claim 1, wherein the one or more slave transceiver units comprise a plurality of slave transceiver units coupled to the master transceiver unit in one or more star topologies.

15. Apparatus according to claim 1, wherein the one or more slave transceiver units comprise a plurality of slave transceiver units coupled to the master transceiver unit in one or more hybrid star-daisy-chain topologies.

16. Apparatus according to claim 1, wherein each slave transceiver unit comprises a respective IF signal forward path, wherein the forward

path comprises a delay element which delays the IF signal in the forward path by a predetermined time.

17. Apparatus according to claim 1, wherein the frequency recovery circuit comprises a frequency multiplier.

18. A method for conveying a radio-frequency (RF) signal into an environment closed-off to the RF signal, comprising:

a) receiving the RF signal at a master port;
b) providing a local oscillator (LO) signal operating at a LO frequency in a vicinity of the master port;
c) dividing the LO frequency of the LO signal by an integer to produce a divided LO signal;
d) generating an intermediate frequency (IF) signal responsive to the RF signal and the LO signal;
e) conveying the IF signal and the divided LO signal to the closed-off environment;
f) multiplying the frequency of the divided LO signal by the integer to generate a recovered LO signal having the LO frequency;
g) mixing the recovered LO signal and the IF signal to generate a recovered RF signal;
h) coupling the recovered RF signal to a slave port; and
i) transmitting the recovered RF signal into the closed-off environment from the slave port.

19. A method according to claim 18, and comprising:

a) receiving a slave RF signal from the closed-off environment at the slave port;
b) mixing the slave RF signal and the LO signal to produce a slave IF signal;
c) recovering the slave RF signal by mixing the slave IF signal with the LO signal; and
d) transmitting the slave RF signal from the master port.

20. A method according to claim 19, wherein mixing the slave RF signal and the LO signal to produce a slave IF signal comprises delaying the slave IF signal by a predetermined time.

21. A method according to claim 18, wherein receiving the RF signal comprises receiving a cellular communications transmission at a frequency in the range 800 MHz to 1900 MHz.

22. A method according to claim 18, wherein generating the IF signal comprises producing an IF signal having a frequency substantially less than the frequency of the RF signal.

23. A method according to claim 18, wherein generating the IF signal comprises producing an IF signal having a frequency substantially less than the LO frequency.

24. A method according to claim 18, wherein generating the IF signal comprises producing an IF signal to correspond to one or more predetermined channels of a multiple-access communications network.

25. A method according to claim 18, wherein conveying the IF signal to the closed-off environment comprises delaying the IF signal by a predetermined time.

26. In a communications repeater system that includes a plurality of slave units, which receive a main radio frequency (RF) signal and a diversity RF signal transmitted by one or more mobile communication units in a vicinity of the slave units and which generate, responsive to the received RF signals, a respective main intermediate frequency (IF) signal and diversity IF signal, apparatus for converting the IF signals to

respective recovered main and recovered diversity radio-frequency (RF) signals, comprising:

a) a main master unit, comprising:

i) a main IF port which receives the main IF signal;

ii) a local oscillator which generates a local oscillator (LO) signal;

iii) a reference signal generator, coupled to the local oscillator, which generates a reference signal responsive to the LO signal;

iv) a main mixer coupled to the main IF port and the local oscillator which generates the recovered main RF signal responsive to the main IF signal and the LO signal; and

v) a main RF port coupled to the main mixer which transmits the recovered main RF signal; and

b) a diversity master unit, comprising:

i) a diversity intermediate frequency (IF) port which receives the diversity IF signal;

ii) a receiver which generates a recovered LO signal from the reference signal received from the main master unit;

iii) a diversity mixer coupled to the diversity IF port and the receiver which generates a recovered diversity RF signal responsive to the diversity IF signal and the recovered LO signal; and

iv) a diversity RF port coupled to the diversity mixer which transmits the recovered diversity RF signal.

27. Apparatus according to claim 26, wherein the reference signal generator comprises a frequency divider, which divides a frequency of the LO signal by an integer to produce a divided LO signal, and wherein the receiver comprises a multiplier which multiplies the divided LO signal by the integer to generate the recovered LO signal.

28. Apparatus according to claim 26, wherein the reference signal comprises the LO signal, and wherein the receiver comprises a splitter

which receives the LO signal and splits the LO signal to generate the recovered LO signal.

29. Apparatus according to claim 26, wherein each slave unit comprises a respective IF signal forward path, wherein the forward path comprises a delay element which delays the IF signal in the forward path by a predetermined time.

30. Apparatus according to claim 26, wherein each slave unit comprises a respective IF signal reverse path, wherein the reverse path comprises a delay element which delays the IF signal in the reverse path by a predetermined time.

31. Apparatus according to claim 26, wherein the plurality of slave units comprises:
a) one or more main slave units coupled to the main IF port which receive the main RF signal and generate the main IF signal responsive to the LO signal and the main RF signal; and
b) one or more diversity slave units coupled to the diversity RF port which receive the diversity IF signal and generate the diversity IF signal responsive to the LO signal and the diversity RF signal.

32. Apparatus according to claim 31, wherein the one or more main slave units are separated sufficiently in position from the one or more diversity slave units so that the main RF signal received by the one or more main slave units and the diversity RF signal received by the one or more diversity slave units are distinguishable from each other by the one or more main slave units and the one or more diversity slave units.

33. Apparatus according to claim 26, and comprising an antenna coupled to the main RF port and the diversity RF port which radiates the main recovered RF signal and the diversity recovered RF signal.

34. Apparatus according to claim 26, and comprising a cable coupled to the main RF port and the diversity RF port which conveys the main recovered RF signal and the diversity recovered RF signal to a base transceiver station.

35. In a communications repeater system that includes a plurality of slave units, which receive a main radio frequency (RF) signal and a diversity RF signal transmitted by one or more mobile communication units in a vicinity of the slave units and which generate, responsive to the received RF signals, a respective main intermediate frequency (IF) signal, and diversity IF signal, a method for converting the main and diversity IF signals to respective recovered main and recovered diversity radio-frequency (RF) signals, comprising:
a) receiving the main IF signal generated responsive to the main RF signal in a main IF port;
b) generating a local oscillator (LO) signal;
c) mixing the main IF signal and the LO signal to generate a recovered main RF signal;
d) transmitting the recovered main RF signal from a main RF port;
e) receiving the diversity IF signal generated responsive to the diversity RF signal at a diversity IF port;
f) generating a reference responsive to the LO signal;
g) receiving the reference to generate a recovered LO signal;
h) mixing the diversity IF signal and the recovered LO signal to generate a recovered diversity RF signal; and
i) radiating the recovered diversity RF signal from a diversity RF port.

36. A method according to claim 35, wherein generating the reference comprises dividing a frequency of the LO signal by an integer to produce a divided LO signal, and wherein receiving the reference

comprises multiplying the frequency of the divided LO signal by the integer.

37. Repeater apparatus, comprising:

a) first and second master units, which communicate with respective first and second wireless communication networks operating on respective first and second frequency bands;

b) a combiner, in wired communication with the first and second master units, so as to receive therefrom and convey thereto communication signals that are transmitted over the first and second networks; and

c) a plurality of slave units, coupled to the combiner, and located at a plurality of different, respective locations within a generally closed environment, so as to communicate with mobile wireless units operating on the first and second frequency bands.

38. Repeater apparatus according to claim 37, wherein the first frequency band comprises frequencies substantially in a range 800 MHz to 900 MHz and the second frequency band comprises frequencies substantially in a range 1800 MHz to 1900 MHz.

39. Repeater apparatus according to claim 37, wherein the plurality of slave units comprises at least one slave unit operating on the first frequency band and at least one slave unit operating on the second frequency band.

40. Repeater apparatus according to claim 37, and comprising one or more antennas coupled at least to the first or the second master unit via which the respective master unit communicates with the respective wireless communication network.

41. Repeater apparatus according to claim 37, and comprising a cable coupled to at least the first or the second master unit via which the respective master unit communicates with the respective wireless communication network.

42. Repeater apparatus according to claim 37, wherein the first wireless communication network comprises a cellular network, and the second wireless communication network comprises a Personal Communication Services (PCS) network.

FIG. 1

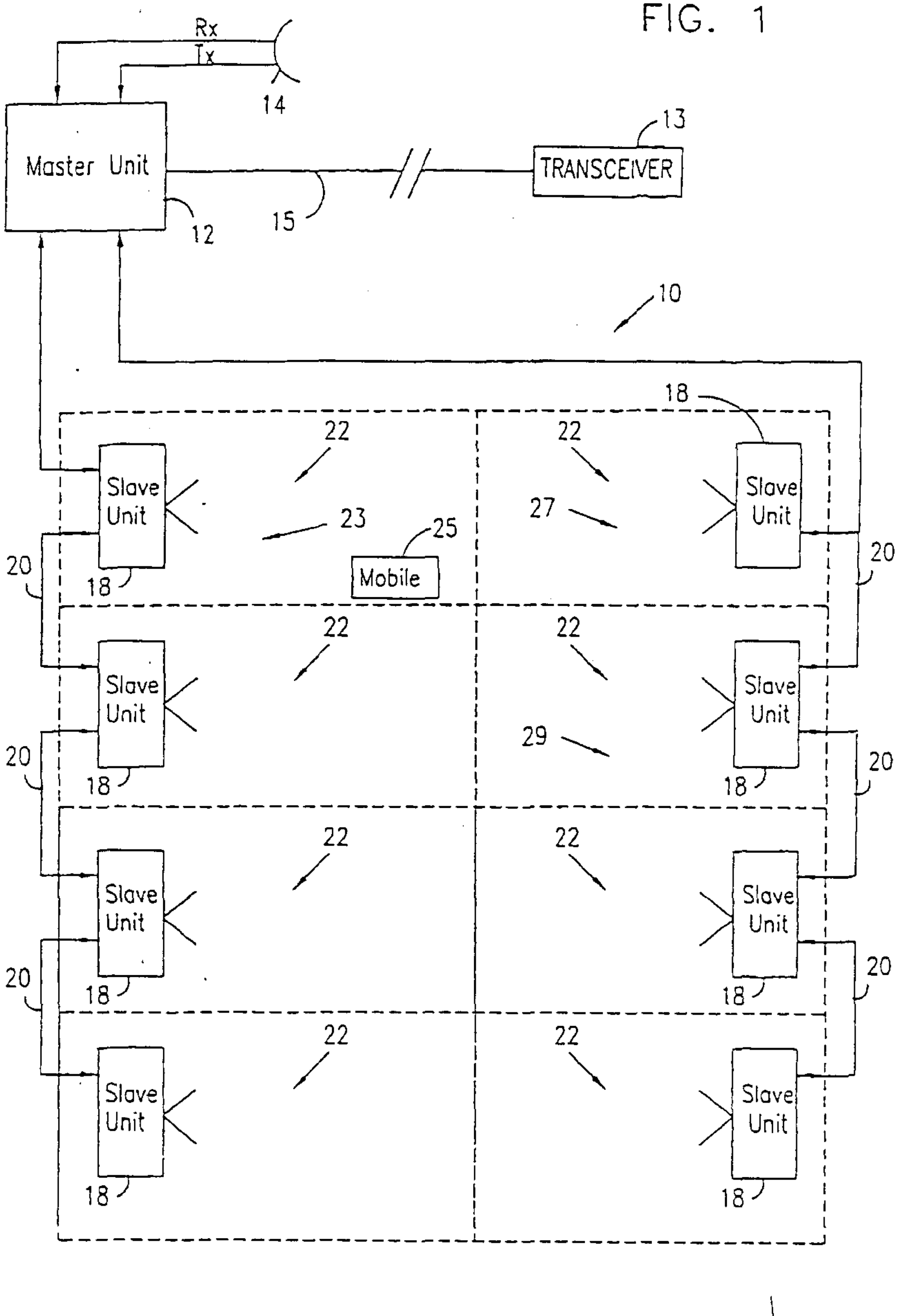

Rx
Tx
14
13
Master Unit
TRANSCEIVER
12
15
10
18
22
22
Slave Unit
Slave Unit
23
27
25
Mobile
20
20
18
22
22
Slave Unit
Slave Unit
29
20
20
18
18
22
22
Slave Unit
Slave Unit
20
20
18
18
22
22
Slave Unit
Slave Unit
18
18

FIG. 2

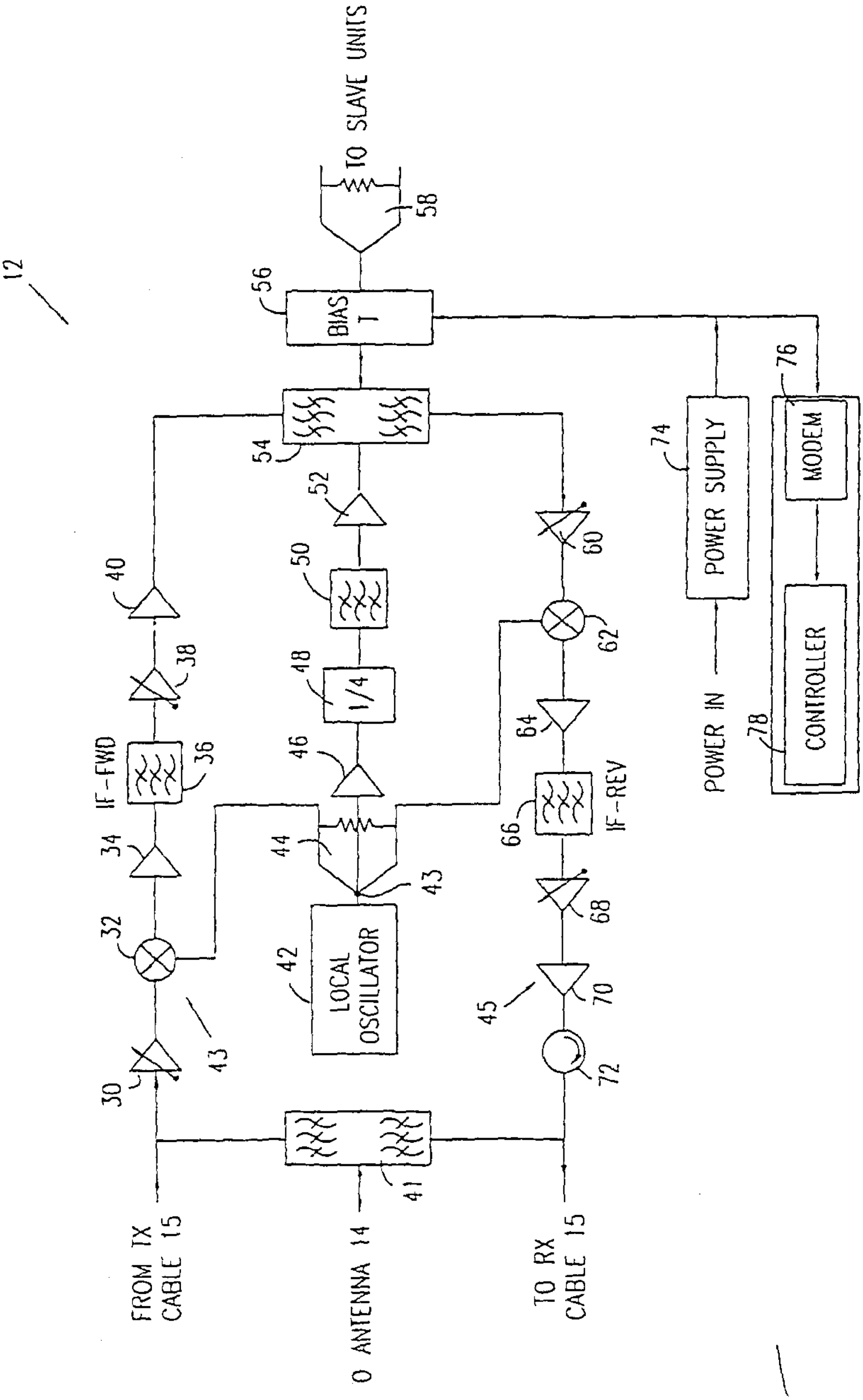

12
TO SLAVE UNITS
58
56
BIAS T
54
52
50
48
1/4
46
44
43
42
LOCAL OSCILLATOR
40
38
IF-FWD
36
34
32
30
43
41
FROM TX CABLE 15
O ANTENNA 14
TO RX CABLE 15
60
62
64
66
IF-REV
68
70
45
72
74
POWER SUPPLY
POWER IN
76
MODEM
CONTROLLER
78

FIG. 3

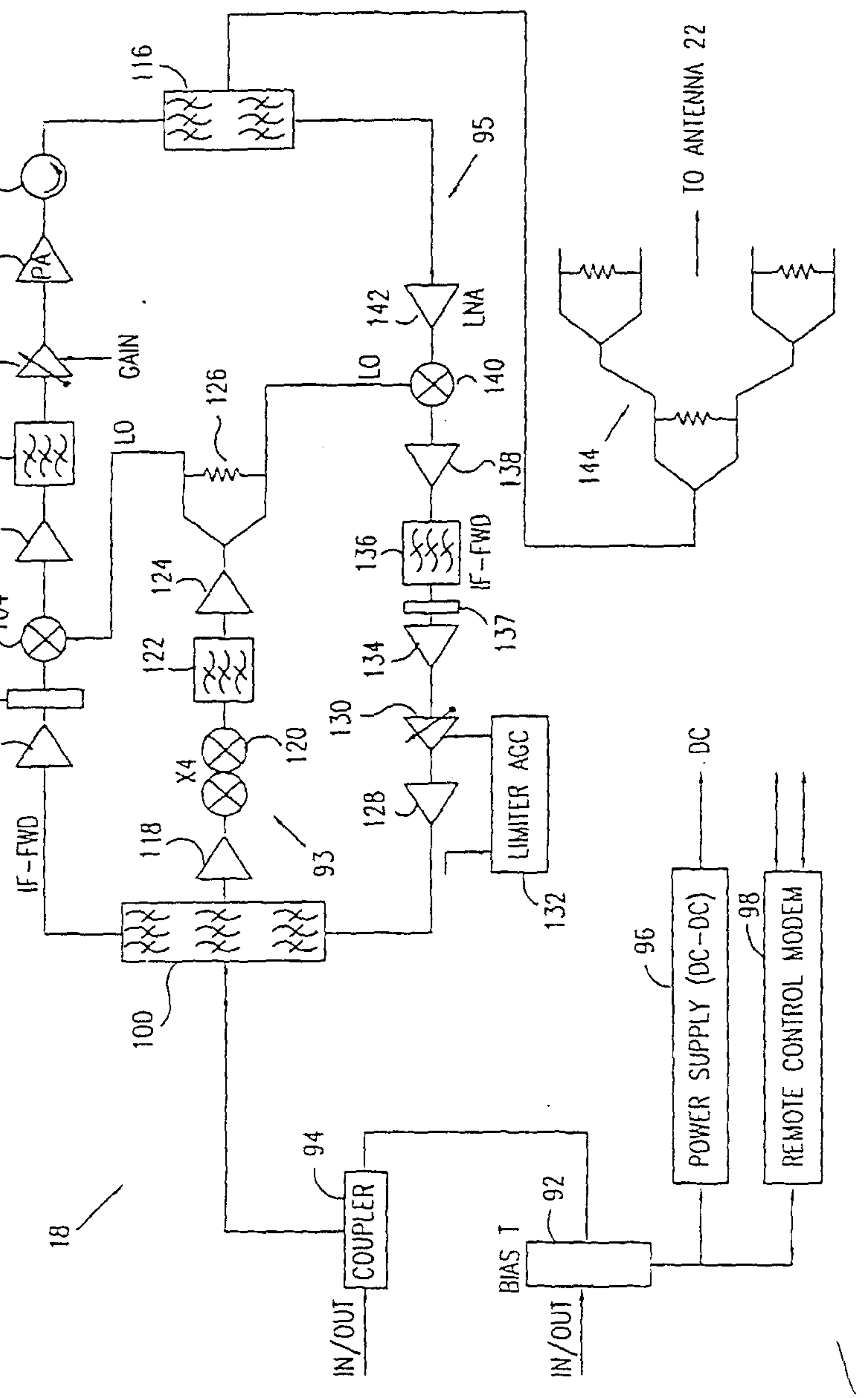

TO ANTENNA 22
116
114
112
PA
110
GAIN
108
106
104
103
102
91
IF-FWD
LO
126
124
122
120
X4
118
93
95
LNA
142
LO
140
138
136
IF-FWD
137
134
130
128
LIMITER AGC
132
144
100
94
COUPLER
IN/OUT
92
BIAS T
IN/OUT
18
96
POWER SUPPLY (DC-DC)
DC
98
REMOTE CONTROL MODEM

FIG. 4

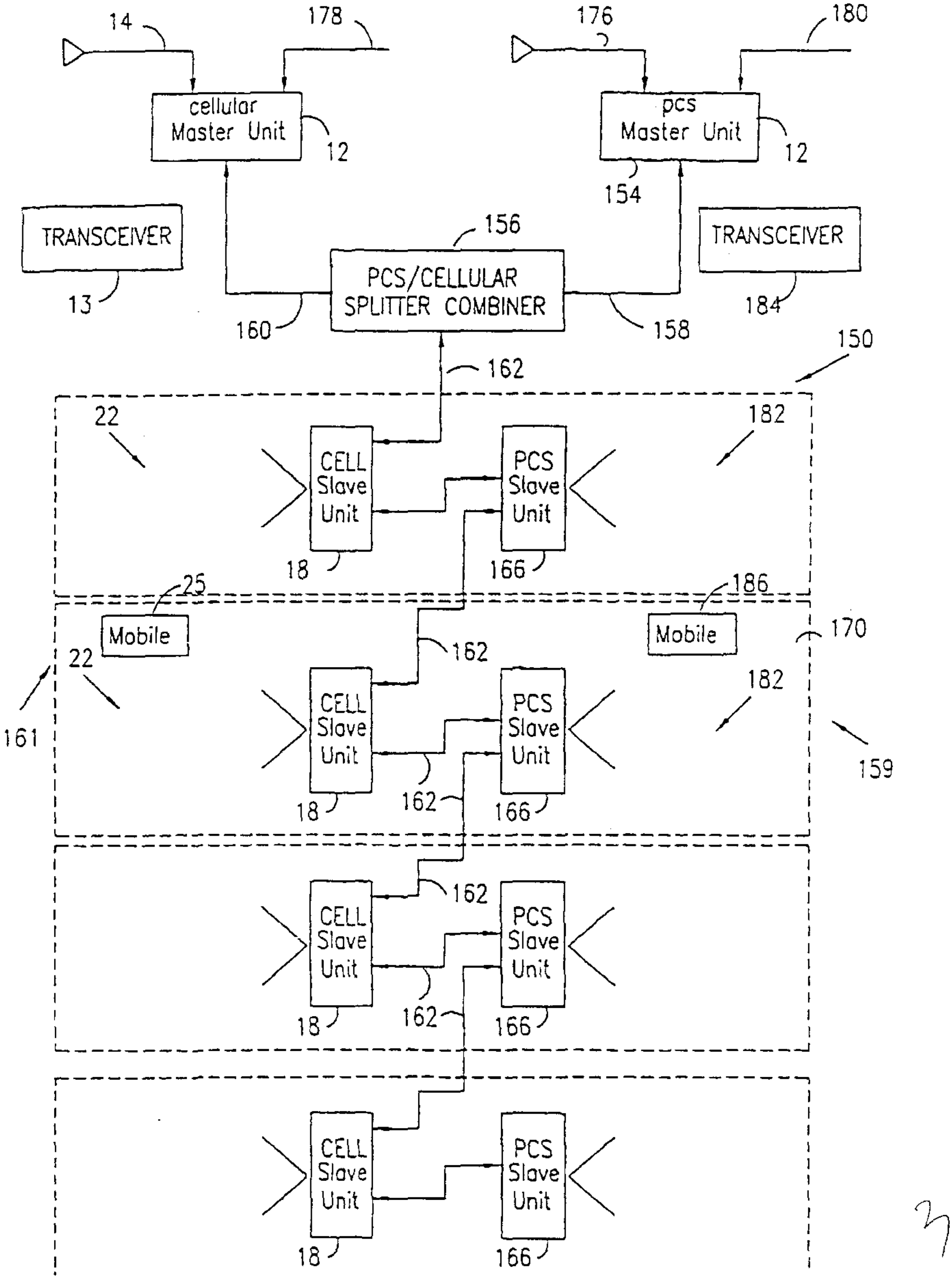

14
178
176
180
cellular Master Unit
12
pcs Master Unit
12
154
TRANSCEIVER
13
156
PCS/CELLULAR SPLITTER COMBINER
160
158
TRANSCEIVER
184
150
162
22
182
CELL Slave Unit
PCS Slave Unit
18
166
25
Mobile
186
Mobile
170
161
159

FIG. 5

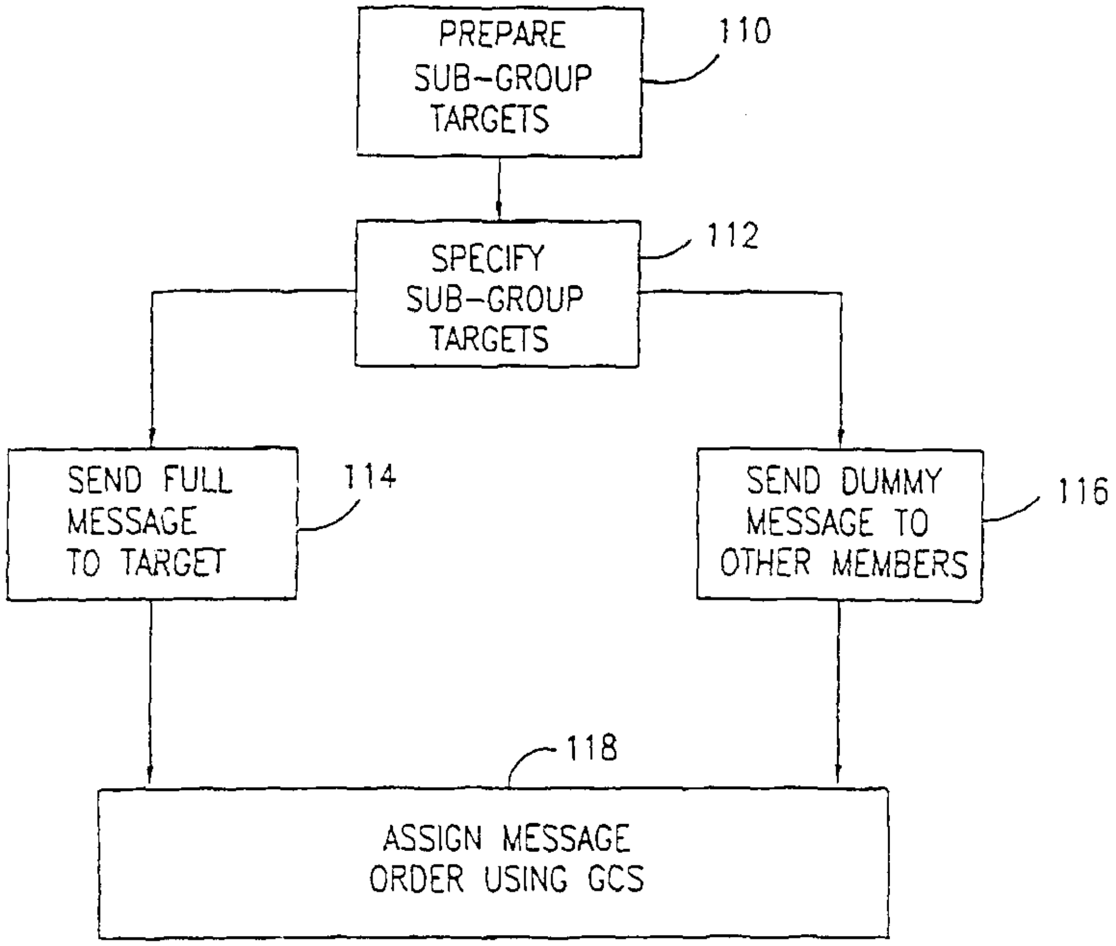
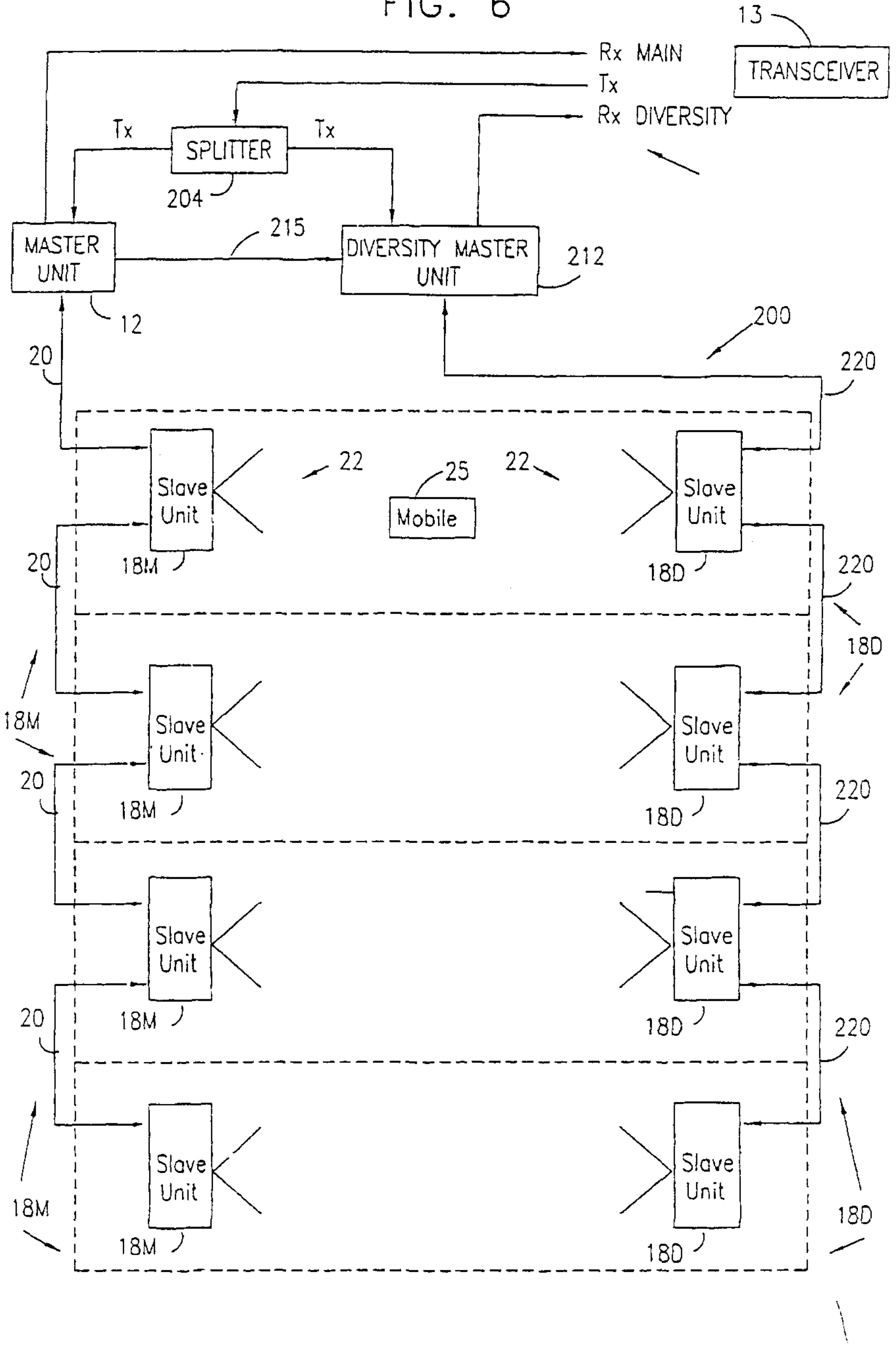

PREPARE SUB-GROUP TARGETS
110
SPECIFY SUB-GROUP TARGETS
112
SEND FULL MESSAGE TO TARGET
114
SEND DUMMY MESSAGE TO OTHER MEMBERS
116
118
ASSIGN MESSAGE ORDER USING GCS

FIG. 6



13
TRANSCEIVER
Rx MAIN
Tx
Rx DIVERSITY
Tx
SPLITTER
Tx
204
MASTER UNIT
215
DIVERSITY MASTER UNIT
212
12
200
20
220
22
25
Mobile
22
Slave Unit
18M
18D
18M
20
220
18D
18M
18D

WO 01/33878 PCT/US00/29801

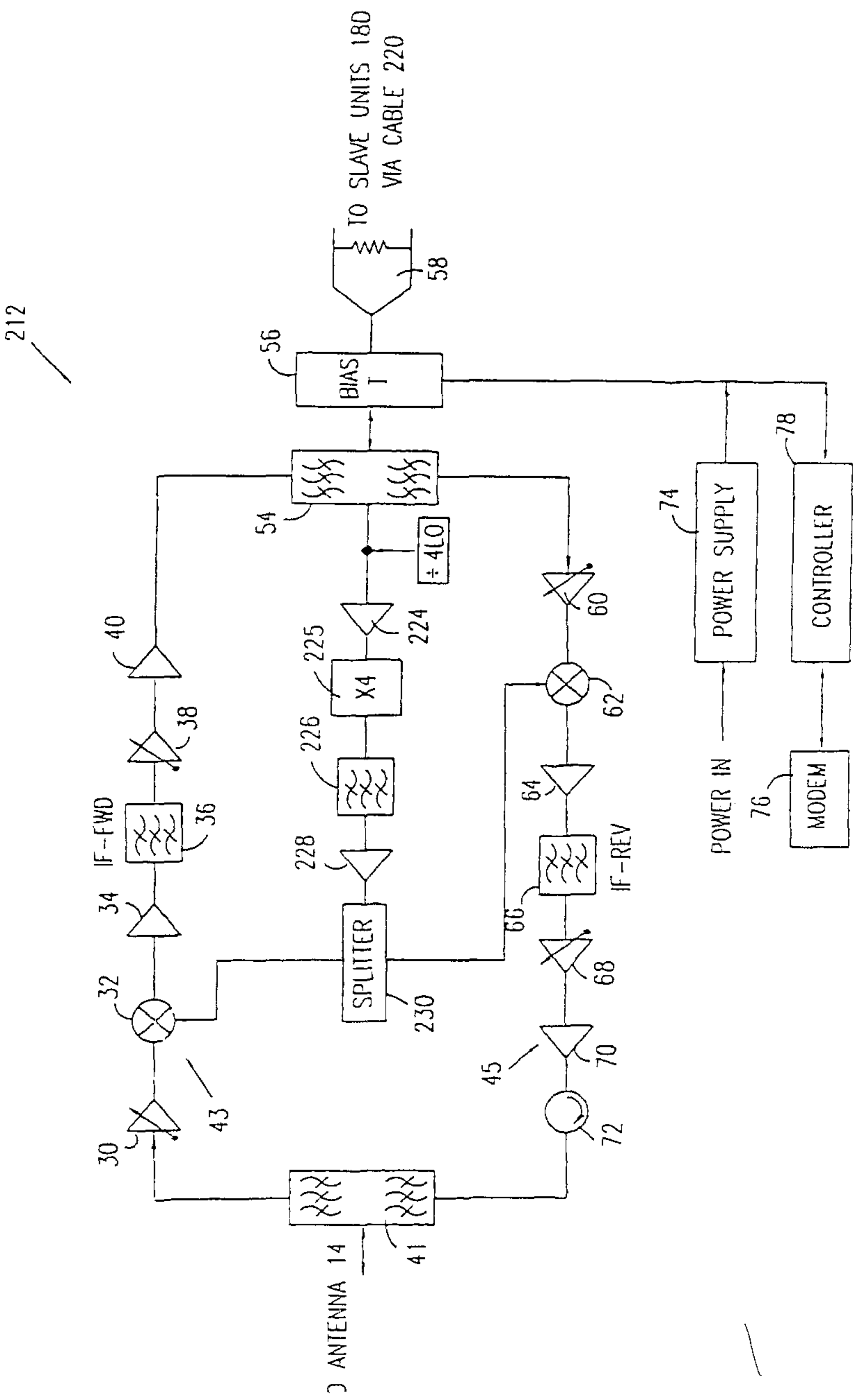
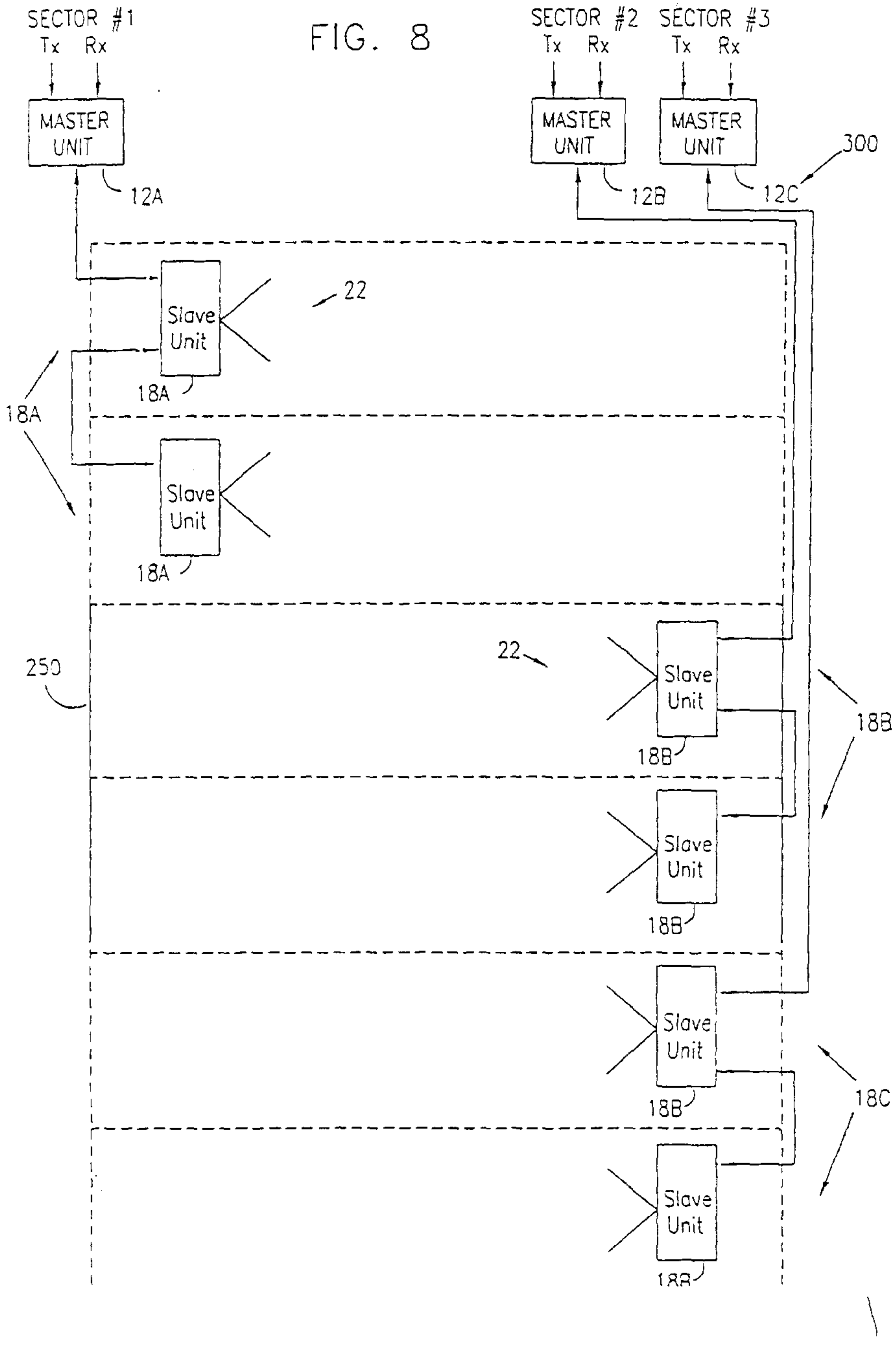


FIG. 7

FIG. 8


SECTOR #1
Tx Rx
MASTER UNIT
12A
SECTOR #2
Tx Rx
MASTER UNIT
12B
SECTOR #3
Tx Rx
MASTER UNIT
12C
300
Slave Unit
18A
22
18A
Slave Unit
18A
250
22
Slave Unit
18B
18B
Slave Unit
18B
Slave Unit
18B
18C
Slave Unit
18B

[19] 中华人民共和国国家知识产权局

[51] Int. Cl⁷
H04Q 7/30

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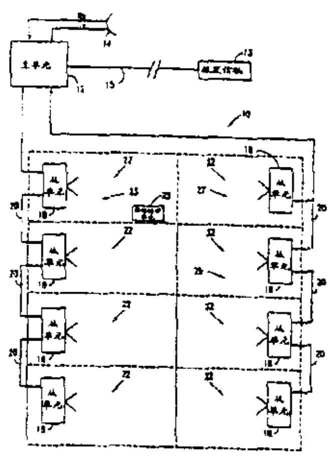
权利要求书 7 页 说明书 24 页 附图 8 页

[54] 发明名称 室内射频覆盖

[57] 摘要

描述一种用于把射频信号传输至与射频信号隔离的环境中的中继设备，它包括一个含有用于接收射频信号的主端口(master port)的主收发信(master transceiver)单元；一个本地振荡器(LO)，用于产生LO频率的LO信号；一个分频器，用于以某一个整数对LO信号的LO频率分频以某一个整数以生成分频LO信号。主收发信单元还包括一个连接至主端口和分频器的混频器，用于产生响应于射频信号以及LO信号的中频信号。本设备还包括一个或多个从收发信单元，每个单元都位于与射频信号隔离的环境中，包括有一个倍频器，用于通过把分频LO信号的频率倍频以相同整数，来产生LO频率的恢复的LO信号；一个连接至倍频器的从混频器，用于产生响应于恢复的LO信号以及中频信号的恢复的射频信号；一个连接至从混频器的的从端口(slave port)，用于由从混频器接收恢复后的射频信号，并将其发射到隔离的环境中去。本设备进一步包括一条或多条连接主收发信单元和一个或多个从收发信单元的电缆，用于在主收发信单元和一个或多个从收发信单元之间传输中频信号和分频LO信号。



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1. 一种用于把射频信号传输至与射频信号隔离的环境中的中继设备，其特征在于，包括：

a) 一个主收发信单元，它包括：

i. 一个主端口，用于接收射频信号；

ii. 一个本地振荡（LO）器，用于产生LO频率的LO信号；

iii. 一个分频器，用于以一个整数对LO信号的LO频率分频，以产生分频LO信号；

iv. 一个和主端口及分频器耦合的主混频器，用于产生响应于射频信号和LO信号的中频信号；

b) 一个或多个从收发信单元，每一个从收发信单元都处于与射频信号隔离的环境中，它包括：

i. 一个频率恢复电路，用于以整数将分频 LO 信号倍频后产生恢复LO频率的LO信号；

ii. 一个和倍频器耦合的从混频器，用于产生响应于恢复 LO 信号和中频信号的射频信号；

iii. 一个和从混频器耦合的从端口，用于接收恢复的射频信号，并将其发射至隔离环境中；

c) 一条或多条连接主收发信单元和一个或多个从收发信单元的电缆，用于在主收发信单元和一个或多个从收发信单元间传输中频信号和分频LO信号。

2. 如权利要求 1 所述的设备，其特征在于，主端口是一个双向端口，每个从端口也是一个双向端口，不同的从收发信单元通过从端口接收隔离环境中的射频从信号，把射频从信号和恢复的LO信号混频，产生从中频信号，通过一条或多条电缆传输至主收发信单元，在那儿生成恢复后的从射频信号，再被送至主端口并从那儿发射出去。

3. 如权利要求 2 所述的设备，其特征在于，每个从收发信单元包括一个

自己的中频信号反向通路，反向通路中包括一个延时组件，用于把反向通路中的中频信号加上预定的时延。

4. 如权利要求1所述的设备，其特征在于，主收发信单元包括一副天线，用于接收来自基站收发信台的射频信号，并把接收到的射频信号传输至主端口。

5. 如权利要求1所述的设备，其特征在于，主端口通过耦合至基站收发信台的电缆接收射频信号。

6. 如权利要求1所述的设备，其特征在于，每个从收发信单元都包括一副或多副耦合至各自的从端口的天线，用于把恢复后的射频信号发射至隔离环境中去。

7. 如权利要求1所述的设备，其特征在于，主收发信单元包括一个直流电源，用于产生通过一条或多条电缆传输，驱动一个或多个从收发信单元的直流电平。

8. 如权利要求1所述的设备，其特征在于，主收发信单元包括一个控制器，用于控制主收发信单元和一个或多个从收发信单元的运行。

9. 如权利要求8所述的设备，其特征在于，还包括一个远程控制单元，用于在控制器和设备操作者之间传输控制信号。

10. 如权利要求8所述的设备，其特征在于，控制器产生调制的控制信号，并通过一条或多条电缆在传输主收发信单元和一个或多个从收发信单元之间传输。

11. 如权利要求1所述的设备，其特征在于，设备工作于蜂窝通信网络中，严格地使用800兆赫至1900兆赫范围内的频率。

12. 如权利要求1所述的设备，其特征在于，中频信号对应于多址通信网络中的一个或多个预设信道。

13. 如权利要求1所述的设备，其特征在于，一个或多个从收发信单元中应包括一个和主收发信单元耦合的，拓扑结构为一个或多个菊花链结构的多个从收发信单元。

14. 如权利要求1所述的设备，其特征在于，一个或多个从收发信单元中应包括一个和主收发信单元耦合的，拓扑结构为单个或多个星型结构的多个从收发信单元。

15. 如权利要求1所述的设备，其特征在于，一个或多个从收发信单元中应包括一个和主收发信单元耦合的，拓扑结构为单个或多个星型-菊花链混合结构的多个从收发信单元。

16. 如权利要求1所述的设备，其特征在于，每个从收发信单元应包括一个自己的中频信号前向通路，而前向通路包括一个延时单元，用于将中频信号在前向通路中进行一个预定的延时。

17. 如权利要求1所述的设备，其特征在于，频率恢复电路包括一个倍频器。

18. 一种用于将射频（RF）信号传输至射频屏蔽环境的方法，其特征在于，包括：

a) 在主端口接收射频信号；

b) 在主端口附近提供一个工作于本地振荡（LO）频率的LO信号；

c) 将LO信号的LO频率以某个整数进行分频，产生分频LO信号；

d) 响应于射频信号及LO信号产生中频（IF）信号；

e) 将中频信号和分频LO信号传输至隔离环境中；

f) 以整数将分频LO信号倍频，以生成LO频率的恢复的LO信号；

g) 将恢复的LO信号和中频信号进行混频，以生成恢复的射频信号；

h) 将恢复的射频信号耦合至从端口；

i) 由从端口将恢复的射频信号发射至隔离环境中。

19. 如权利要求18所述的方法，其特征在于，还包括：

a) 由从端口接收隔离环境中的从射频信号；

b) 将从射频信号和LO信号进行混频，以生成从中频信号；

c) 将从中频信号和LO信号进行混频，以恢复从射频信号；

d) 由主端口将从射频信号发射出去。

20. 如权利要求19所述的方法，其特征在于，把从射频信号和LO信号混频以

产生从中频信号的过程包括将从中频信号进行预定的延时。

21. 如权利要求 18 所述的方法，其特征在于，射频信号的接收包括接收 800 兆赫至 1900 兆赫范围内的蜂窝通信信号发射。

22. 如权利要求 18 所述的方法，其特征在于，中频信号的生成包括产生一个频率严格低于射频信号频率的中频信号。

23. 如权利要求 18 所述的方法，其特征在于，中频信号的生成包括产生一个频率严格低于 LO 频率的中频信号。

24. 如权利要求 18 所述的方法，其特征在于，中频信号的生成包括产生一个对应于多址通信网络中的一个或多个预设信道的中频信号。

25. 如权利要求 18 所述的方法，其特征在于，将中频信号传输至隔离环境中包括将中频信号进行预定的延时。

26. 一个通信中继系统中，用于将中频信号转换至各自的恢复的主射频信号和恢复的分集射频信号的转换设备，该通信中继系统包括多个从收发信单元，多个从收发信单元用于接收从收发信单元附近的，由一个或多个移动通信单元发射的主射频信号和分集射频信号，并响应于接收到的射频信号产生各个主中频信号和分集中频信号；其特征在于，所述转换设备包括：

a) 一个主要主收发信单元，包括：

i. 一个主中频端口，用于接收主中频信号；

ii. 一个本地振荡（LO）器。用于产生 LO 信号；

iii. 一个耦合至本地振荡器的参考信号发生器，用于产生和 LO 信号对应的参考信号；

iv. 一个与主中频端口和本地振荡器耦合的主混频器，用于产生和主中频信号及 LO 信号对应的恢复的主射频信号；

v. 一个和主混频器耦合的主射频端口，用于发射恢复的主射频信号；

b) 一个分集主收发信单元，包括：

i. 一个分集中频端口，用于接收分集中频信号；

ii. 一个接收器，用于从由主要主收发信单元接收到的参考信号中产生恢复的 LO 信号；

iii. 一个与分集中频端口和接收器耦合的分集混频器，用于产生和分集中频信号及恢复的 LO 信号对应的恢复的分集射频信号；

iv. 一个和分集混频器耦合的分集射频端口，用于发射恢复的分集射频信号；

27. 如权利要求 26 所述的设备，其特征在于，参考信号发生器包括一个用于以一整数对 LO 信号的频率进行分频以产生分频 LO 信号的分频器，而接收器包括一个以相同整数对分频 LO 信号进行倍频以产生恢复的 LO 信号的倍频器。

28. 如权利要求 26 所述的设备，其特征在于，参考信号包括 LO 信号，而接收器包括一个分离器，用于接收 LO 信号并将 LO 信号分离以产生恢复的 LO 信号。

29. 如权利要求 26 所述的设备，其特征在于，每一个从收发信单元包括自己的中频信号前向通路，而前向通路包括一个延时单元，用于将中频信号在前向通路中进行一个预定的延时。

30. 如权利要求 26 所述的设备，其特征在于，每一个从收发信单元包括自己的中频信号反向通路，而反向通路包括一个延时单元，用于将中频信号在反向通路中进行一个预定的延时。

31. 如权利要求 26 所述的设备，其特征在于，多个从收发信单元包括：

a) 一个或多个和主中频端口耦合的主要从收发信单元，主中频端口用于接收主射频信号，并产生和 LO 信号及主射频信号对应的主中频信号；

b) 一个或多个和分集射频端口耦合的分集从收发信单元，分集射频端口用于接收分集中频信号，并产生对应于 LO 信号及分集射频信号的分集中频信号。

32. 如权利要求31所述的设备，其特征在于，一个或多个主要从收发信单元应在空间位置上充分地和一个或多个分集从收发信单元分离，这样，一个或多个主要从收发信单元接收到的主射频信号和由一个或多个分集从收发信单元接收到的分集射频信号才能被主要从收发信单元和分集从收发信单元加以区别。

33. 如权利要求26所述的设备，其特征在于，包括一个与主射频端口和分集射频端口耦合的天线，用于将主恢复射频信号和分集恢复射频信号发射出去。

34. 如权利要求26所述的设备，其特征在于，系统包括一条和主射频端口及分集射频端口耦合的电缆，用于传输主恢复射频信号和分集恢复射频信号至基站收发信台。

35. 一个通信中继系统中，用于将主中频信号和分集中频信号转换至各自的恢复的主射频（RF）信号和恢复的分集射频信号的转换方法，该通信中继系统包括多个从收发信单元，多个从收发信单元用于接收从收发信单元附近的，由一个或多个移动通信单元发射的主射频信号和分集射频信号，并响应于接收到的射频信号产生各个主中频信号和分集中频信号；其特征在于，所述转换方法包括：

a) 在主中频端口接收相应于主射频信号而产生的主中频信号；

b) 生成一个本地振荡（LO）器信号；

c) 将主中频信号和LO信号混频产生恢复的主射频信号；

d) 从主射频端口发射恢复的主射频信号；

e) 在分集中频端口接收相应于分集射频信号而产生的分集中频信号；

f) 由LO信号生成一个参考信号；

g) 接收参考信号，以生成恢复的LO信号；

h) 将分集中频信号和恢复的LO信号混频产生恢复的分集射频信号；及

i) 从分集射频端口将恢复的分集射频信号发射出去。

36. 如权利要求 35 所述的方法，其特征在于，生成参考信号包括以一整数对 LO 信号的频率进行分频以产生分频 LO 信号，而接收参考信号包括以同一整数对分频 LO 信号进行倍频。

37. 中继设备，其特征在于，包括：

a) 第一和第二主收发信单元，用于和各自的第一和第二无线通信网络进行通信，第一和第二无线通信网络运行在各自的第一和第二频带；

b) 一个组合器，和第一及第二主收发信单元进行有线通信，从而可以接收和发送第一和第二网络中传输的通信信号；

c) 耦合至组合器的多个从收发信单元，从收发信单元位于隔离环境中的不同位置，因而可以和工作于第一及第二频带的移动无线单元进行通信。

38. 如权利要求 37 所述的中继设备，其特征在于，第一频带在 800 兆赫至 900 兆赫范围内，第二频带在 1800 兆赫至 1900 兆赫范围内。

39. 如权利要求 37 所述的中继设备，其特征在于，多个从收发信单元中包括至少一个工作于第一频带的从收发信单元，和至少一个工作于第二频带的从收发信单元。

40. 如权利要求 37 所述的中继设备，其特征在于，中继设备包括一个或多个至少耦合至第一或第二主收发信单元的天线，不同的主收发信单元能通过其和各自的无线通信网络进行通信。

41. 如权利要求 37 所述的中继设备，其特征在于，中继设备包括一条至少耦合至第一或第二主收发信单元的电缆，不同的主收发信单元能通过其和各自的无线通信网络进行通信。

42. 如权利要求 37 所述的中继设备，其特征在于，第一个无线通信网络包括一个蜂窝网络，第二个无线通信网络包括一个个人通信业务（PCS）网络。

室内射频覆盖

发明背景

1. 发明领域

本发明总体上涉及蜂窝通信系统领域，具体涉及用于射频信号难于到达的区域的蜂窝通信系统。

2. 相关技术的描述

在蜂窝通信系统中典型地存在着某些信号难于或者是不完全覆盖预定区域，例如，金属框架的建筑和地下。造成这种覆盖困难的一个主要原因是由于法拉第栅型屏蔽，致使射频信号难以穿透此类有效封闭的导体结构。另一个原因是瑞利衰减，这种衰减是由发送端和接受端之间的多路径传输造成的。通常这种多路径是由信号在发送端和接收端之间的物体间发生反射和/或折射引起的。信号传输的多路径在接受端产生了干扰效应，这些干扰效应通过接收端的信号测量强度差异体现出来，而信号测量强度则是信号传输的不同路径的函数。在本领域中，已知一些用于改善发生法拉第栅型屏蔽和瑞利衰减区域的覆盖的方法。

授予 Charas 等人的第 5404570 号美国专利描述了用于一个在能够接收信号的基站收发信台（BTS）和诸如隧道之类密闭环境之间的中继系统，在这类密闭环境中，基站收发信台发射的信号是被隔离的。我们在此引入该专利的说明作为参考资料。该系统将从基站收发信台接收的高频射频（RF）信号下转换至中频（IF）信号，然后由密闭环境中的电缆和天线辐射至接收端。接受端再将该中频信号上转换至原始的射频信号。在上述专利说明的系统中还包括一个在隧道中移动的车辆，车辆上的乘客将可以收到信号，否则他们将被切断与无线基站收发信台的联系。

授予 Kallandar 等人的第 5603080 号美国专利描述了用于多个基站收发信台和密闭环境之间的中继系统集，在这类密闭环境中，基站收发信台发射的信

号是被隔离的。我们在此引入该专利的说明作为参考资料。每个系统将从各自的基站收发信台接收的高频射频信号下转换至中频信号，然后由密闭环境中的电缆传输至各自的一个或多个的接收端。每个接受端再将该中频信号上转换至原始的射频信号。在上述专利说明的系统中还包括一个在隧道的交迭区域之间移动的车辆，每个区域是由一个基站收发信台通过自己的中继系统覆盖的。这样车辆上的乘客将可以在隧道中从至少一个基站收发信台收到信号，否则他们将被切断与某个或更多的无线基站收发信台的联系。

授予 Georges 等人的第 5765099 号美国专利描述了应用诸如双绞线缆等窄带介质在两个或多个区域之间传输射频信号的一个系统和方法。我们在此引入该专利的说明作为参考资料。在第一个区域中，射频信号和第一个本地振荡器发生混频，产生一个下转换的中频信号。这个中频信号通过窄带介质传输至第二个区域，并在那里利用第二个本地振荡器上转换至原来的射频信号。所有的本地振荡器由每个区域的锁相环（PLL）锁定，以产生相同频率的信号。这种锁定是通过比较本地振荡器频率和由某区域所产生的一个低频稳定参考信号来在每个环中实现的。参考信号在区域间通过窄带介质传输。

克服瑞利衰减的方法之一是应用多方向接收天线集（a plurality of spatially-diverse receiving antennas），这是基于在所有天线上都发生某个信号的破坏性干扰的机会是很小的这么一个统计事实。天线集（在通常情况下，两组天线就足够了）的应用为被分析的接收信号提供了分集性，而通常我们都选择最强的信号。对于两组天线的情况而言，接收信号被称为主信号和分集信号（diversity signals）。

授予 Dean 等人的第 5513176 号美国专利描述了应用于接收困难区域的一种分布式天线阵。我们在此引入该专利的说明作为参考资料。正是由于利用了由天线在空间上的不同分布所产生的信号分集性，这种天线阵的接收效果得到了增强。每组天线都对接收到的信号进行不同的时延，因此分集信号在时间上都是被分隔开的。分时延信号被转换至中频信号，然后组合，组合后的信号通过电缆传输至区域外。

发明概述

本发明的目的在于为在蜂窝通信困难区域进行更好的信号覆盖提供解决方法和设备。

在本发明的较佳实施例中，用于蜂窝通信系统中的中继设备由一个主收发信单元（master transceiver unit）构成，主收发信单元较佳地通过无线方式利用主射频信号和基站收发信台进行通讯，也可选择通过电缆方式。主收发信单元通过一条或更多电缆和一个或多个从收发信单元连接，这些从收发信单元处于一个和主收发信单元所处环境完全电磁隔离的环境中。从收发信单元包括各自的从天线，通过从天线利用从射频信号，从收发信单元可以和移动蜂窝收发信机进行通信。从收发信单元较佳地位于主射频信号无法穿透的区域，例如建筑物内部。主收发信单元和从收发信单元间的信号通过电缆的中频传输。在主收发信单元和从收发信单元，中频信号由相应的射频信号下转换产生，而射频信号则由中频信号上转换恢复。上转换和下转换是使用在主收发信单元和从收发信单元上的同一个本地振荡器（LO）频率进行的。为了在所有单元上产生相同的 LO 频率，主收发信单元的一个本地振荡器产生 LO 频率，这个 LO 频率在主收发信单元上除以一个整数。除后的 LO 频率通过电缆传至从收发信单元，然后在从收发信单元上乘以相同的整数以恢复 LO 频率。

作为参考的整数分频 LO 频率在整个系统内传输，使得原 LO 频率可以通过倍频以相同整数来恢复。而且，整数分频 LO 频率可以通过常用的，不昂贵的电缆低损耗地传播。这样，一个本地振荡器就可以提供给整个系统相同的 LO 频率，也就避免了由于系统内 LO 频率不同所可能产生的问题。

在本发明的一些较佳实施例中，射频信包括号码分多址（CDMA）信号，CDMA 信号包括与蜂窝信道有关的一个或多个导频信号，移动收发信机通过蜂窝信道进行通信。从收发信单元由各自的传输延时组件构成，传输延时组件给从主收发信单元发射至各自的从收发信单元的信号加上不同的延时。这些不同的延时有效的增加了从收发信单元接收到的信号的分集性，因而，由主收发信单元发

射的导频音信号的接收被增强了。在本发明的一些较佳实施例中，从收发信单元包括各自的接收延迟单元，用于给主收发信单元从各自的从收发信单元接收到的信号加上不同的延时，因而，由从收发信单元发射的信号的接收增强了。

在本发明的一些较佳实施例中，用来产生LO频率的本地振荡器不必要是高稳定度的振荡器，因为LO频率的变化会被传输至整个网络。

在本发明的一些较佳实施例中，多个主收发信单元只和各自的由一个或多个从收发信单元组成的多个从收发信单元进行通讯，每个主从收发信单元组严格依照前述机制运行。较佳地，多个主收发信单元（以及他们各自的从收发信单元）使用同一个LO频率以产生主从通信使用的中频信号。另外，每个主收发信单元及其从收发信单元也可以使用不同的LO频率。通过在主收发信单元间划分从收发信单元，降低了系统的总噪声系数。最佳地，至少一部分从收发信单元应该提供用作分集接收信号（diverse receive signals）的信号，这样，从收发信单元的总体接收能力将可以得到提高。

在本发明的一些较佳实施例中，整个系统作为一个在主收发信单元和从收发信单元间传输多路信号的多路中继系统进行运行。最佳地，一个或多个主收发信单元或一个或多个从收发信单元中要有一个或多个滤波器，用于过滤干扰信号，例如指定的在主从收发信单元间传输的专门信道外的信号。

因此，根据本发明的较佳实施例，我们提供了用于将射频（RF）信号传输至射频屏蔽环境的中继设备，它包括：

一个主收发信单元，它包括：

一个主端口（master port），用于接收射频信号；

一个本地振荡器（LO），用于产生LO频率的LO信号；

一个分频器，用于将LO信号的LO频率分频以一个整数，以产生分频LO信号；及

一个和主端口及分频器连接的主混频器，用于产生响应于射频信号和LO信号的中频（IF）信号。

一个或多个从收发信单元，每一个从收发信单元都处于射频屏蔽的环境中，它包括：

一个频率恢复电路，较佳地是一个倍频器，用于将分频 LO 信号倍频以整数后产生 LO 频率的恢复的 LO 信号。

一个和倍频器连接的从混频器，用于产生响应于恢复的 LO 信号和中频信号的恢复的射频信号。

一个和从混频器连接的从端口，用于接收恢复的射频信号，并将其发射至隔离环境中。及

一条或多条连接主收发信单元和一个或多个从收发信单元的电缆，用于在主收发信单元和一个或多个从收发信单元间传输中频信号和分频 LO 信号。

较佳地，主端口和每个从端口都是双向端口。通过从端口，各自的从收发信单元从隔离环境中接收到从射频信号，并将其与恢复的 LO 信号混频后产生从中频信号，中频信号通过一条或多条电缆传输至主收发信单元，在那儿产生恢复的从射频信号后，送至主端口，从那儿发射。

较佳地，每一个从收发信单元应包括一个自己的中频信号反向通路（reverse path），而反向通路由一个时延单元构成，用于将中频信号在反向通路中进行一个预定的延时。

较佳地，主收发信单元应包括一个用于接收从基站收发信台来的射频信号，和将接收到的射频信号发射至主端口的天线。

较佳地，主端口从连接到基站收发信台的电缆接收射频信号。

进一步较佳地，每个从收发信单元包括一个或多个连接到各自从端口的天线，用于将恢复后的射频信号发射至隔离环境。

较佳地，主收发信单元包括一个直流电源，用于产生在一条或多条电缆上传输的，驱动一个或多个从收发信单元所需的直流电平。

较佳地，主收发信单元转发器应包括一个控制器，用于控制主收发信单元和一个或多个从收发信单元的运行。

进一步较佳地，中继设备应包括一个远程控制单元，用于在控制器和设备操作者之间传递控制信号。

进一步较佳地，控制器能生成调制的控制信号，并能通过一条或更多电缆在主收发信单元和一个或多个从收发信单元间传输。

较佳地，该设备应严格地运行于工作在 800 兆赫至 1900 兆赫范围的蜂窝通信网络上。

较佳地，中频信号对应于多址通信网络中的一个或多个预设信道。

较佳地，一个或多个从收发信单元中应包括一个和主收发信单元连接的，拓扑结构为一个或多个菊花链结构的多个从收发信单元。

进一步较佳地，一个或多个从收发信单元中应包括一个和主收发信单元连接的，拓扑结构为一个或多个星型结构的多个从收发信单元。

较佳地，一个或多个从收发信单元中应包括一个和主收发信单元连接的，拓扑结构为一个或多个星型-菊花链混合结构的多个从收发信单元。

较佳地，每个从收发信单元应包括一个自己的中频信号前向通路（forward path），而前向通路包括一个延时单元，用于将中频信号在前向通路中进行一个预定的延时。

因此，根据本发明的较佳实施例，我们进一步提供了一种用于将射频信号传输至射频屏蔽环境的方法，它包括：

在主端口接收射频信号；

在主端口附近提供一个工作于本地振荡器（LO）频率的 LO 信号；

将 LO 信号的 LO 频率以某个整数进行分频，产生分频 LO 信号；

生成与射频信号及 LO 信号相应的中频信号；

将中频信号和分频 LO 信号传输至隔离环境中；

将分频 LO 信号倍频以相同的整数，以生成 LO 频率的恢复 LO 信号；

将恢复的 LO 信号和中频信号进行混频，以生成恢复的射频信号；

将恢复的射频信号连接至从端口；及

由从端口将恢复的射频信号发射至隔离环境中。

较佳地，该方法包括：

由从端口接收隔离环境中的从射频信号；

将从射频信号和 LO 信号进行混频，以生成从中频信号；

将从中频信号和 LO 信号进行混频，以恢复从射频信号；

由主端口将从射频信号发射出去。

较佳地，射频信号的接收包括对 800 兆赫至 1900 兆赫范围内的蜂窝通信信号发射的接收。

较佳地，中频信号的生成包括产生一个频率严格低于射频信号频率的中频信号。

进一步较佳地，中频信号的生成包括产生一个对应于多址通信网络中的一个或多个预设信道的中频信号。

较佳地，将中频信号传输至隔离环境中包括将中频信号进行预定的延时。

较佳地，将从射频信号和 LO 信号进行混频产生从中频信号包括将从中频信号进行预定的延时。

因此，根据本发明的较佳实施例，我们进一步提供了在一个通信中继系统中，用于将中频信号转换至相应的恢复的主射频信号和恢复的分集射频信号的转换设备。该中继系统包括多个从收发信单元。多个从收发信单元用于接收从收发信单元附近的，由一个或多个移动通信单元发射的主射频信号（main RF signal）和分集射频信号（diversity RF signal），并响应于接收到的射频信号生成各个主中频信号（main IF signal）和分集中频信号（diversity IF signal）。所述的转换设备包括：

一个主要主收发信单元（main master unit），包括：

一个主中频端口，用于接收主中频信号；

一个本地振荡器。用于产生 LO 信号；

一个连接至本地振荡器的参考信号发生器，用于产生和 LO 信号对应的参考信号；

一个和主中频端口，本地振荡器连接的主混频器，用于产生和主中频信号及LO信号对应的恢复的主射频信号；及

一个和主混频器连接的主射频端口，用于发射恢复的主射频信号。

一个分集主收发信单元（diversity master unit），包括：

一个分集中频（IF）端口，用于接收分集中频信号；

一个接收器，用于从由主要主收发信单元接收到的参考信号中产生恢复的LO信号；

一个和分集中频端口，接收器连接的分集混频器，用于产生和分集中频信号及恢复的LO信号对应的恢复的分集射频信号；及

一个和分集混频器连接的分集射频端口，用于发射恢复的分集射频信号。

较佳地，参考信号发生器包括一个用于对LO信号的频率以一个整数进行分频来产生分频LO信号的分频器，而接收器包括一个对分频LO信号以同一个整数进行倍频来产生恢复的LO信号的倍频器。

较佳地，参考信号包括LO信号，而接收器包括一个分离器，用于接收LO信号并将LO信号分离以产生恢复的LO信号。

较佳地，每一个从收发信单元包括自己的中频信号前向通路，而前向通路包括一个延时单元，用于将中频信号在前向通路中进行一个预定的延时。

进一步较佳地，每一个从收发信单元包括自己的中频信号反向通路，而反向通路包括一个延时单元，用于将中频信号在反向通路中进行一个预定的延时。

较佳地，多个从收发信单元包括：

一个或多个和主中频端口连接的主要从收发信单元，主中频端口用于接收主射频信号，并产生响应于LO信号及主射频信号的主中频信号。

一个或多个和分集射频端口连接的分集从收发信单元，分集射频端口用于接收分集中频信号，并产生响应于LO信号及分集射频信号的分集中频信号。

较佳地，一个或多个主要从收发信单元应在空间位置上充分地和一个或多个分集从收发信单元分离，这样，一个或多个主要从收发信单元接收到的主射频信号和由一个或多个分集从收发信单元接收到的分集射频信号才能被主要从收发信单元和分集从收发信单元加以区别。

较佳地，系统包括一个和主射频端口及分集射频端口连接的天线，用于将主恢复射频信号和分集恢复射频信号发射出去。

进一步较佳地，系统包括一个和主射频端口及分集射频端口连接的的电缆，用于传输主恢复射频信号和分集恢复射频信号至基站收发信台。

因此，根据本发明的较佳实施例，我们进一步提供了在一个通信中继系统中，用于将主要中频信号和分集中频信号转换至相应的恢复的主射频信号和恢复的分集射频信号的转换方法。该中继系统包括多个从收发信单元。多个从收发信单元用于接收从收发信单元附近的，由一个或多个移动通信单元发射的主射频信号（main RF signal）和分集射频信号（diversity RF signal），并响应于接收到的射频信号产生各个主中频信号（main IF signal）和分集中频信号（diversity IF signal）。它包括：

在主中频端口接收响应于主射频信号的主中频信号；

生成一个本地振荡器（LO）信号；

将主中频信号和LO信号混频产生恢复的主射频信号；

从主射频端口发射恢复的主射频信号；

在分集中频端口接收响应于分集射频信号的分集中频信号；

响应LO信号生成参考信号；

接收参考信号，以生成恢复的LO信号；

将分集中频信号和恢复的LO信号混频以产生恢复的分集射频信号；及

从分集射频端口将恢复的分集射频信号发射出去。

较佳地，生成参考信号包括对LO信号的频率以一整数进行分频以产生分频LO信号，而接收参考信号包括对分频LO信号以同一整数进行倍频。

因此，根据本发明的较佳实施例，我们进一步提供了中继设备，它包括：

第一和第二主收发信单元（first and second master unit），用于和各自的第一和第二无线通信网络进行通信，第一和第二无线通信网络运行于各自的第一和第二频带；

一个组合器（a combiner），和第一及第二主收发信单元进行有线通信，从而可以接收和发送第一和第二网络中的通信信号；及

一个连接至组合器的多个从收发信单元，从收发信单元一般位于密闭环境中的不同位置，因而可以和工作于第一及第二频带的移动无线单元进行通信。

较佳地，第一频带严格地在800兆赫至900兆赫范围内，第二频带严格地在1800兆赫至1900兆赫范围内。

较佳地，多个从收发信单元中应包括至少一个工作于第一频带的从收发信单元，和至少一个工作于第二频带的从收发信单元。

较佳地，中继设备应包括一个或多个至少连接至第一或第二主收发信单元的天线，不同的主收发信单元能通过其和各自的无线通信网络进行通信。

进一步较佳地，中继设备应包括一条至少连接至第一或第二主收发信单元的电缆，不同的主收发信单元能通过其和各自的无线通信网络进行通信。

较佳地，第一个无线通信网络包括一个蜂窝网络，第二个无线通信网络包括一个个人通信业务（PCS）网络。

通过附图和后面的较佳实施例的详细说明，会更充分的理解本发明。

附图简述

图 1 是根据本发明的较佳实施例构成的一个室内中继系统的方框示意图；

图 2 是根据本发明的较佳实施例的包括在图 1 系统中的蜂窝主收发信单元的方框示意图；

图 3 是根据本发明的较佳实施例构成的图 1 中的蜂窝从收发信单元的方框示意图；

图 4 是根据本发明的一个可选较佳实施例构成的安装在建筑物中的一个中继系统的方框示意图；

图 5 是根据本发明的较佳实施例的显示信号如何通过图 4 系统中的分离/组合器（splitter/combiner）的方框示意图；

图 6 是根据本发明的另一可选较佳实施例构成的显示安装在建筑物中的一个中继系统的方框示意图；

图 7 是根据本发明的较佳实施例的图 6 系统中的分集主收发信单元的方框示意图；

图 8 是根据本发明的一可选较佳实施例构成的安装在建筑物中的一个中继系统的方框示意图。

3. 发明详述

现在参见图 1，根据本发明的较佳实施例，图 1 概略显示了一个室内中继系统 10。主蜂窝（后面称为 CELL）天线（a master cellular antenna）14 从远处的收发器 13 接收主 CELL 射频（RF）信号。天线 14 较佳地置于建筑 16 外部，这样天线和收发器 13 之间通常可以无阻碍地进行信号传输。收发器 13 较佳地是运行于近乎 820 兆赫至 880 兆赫范围内的频带的蜂窝电话系统中基站收发信台（BTS）的收发器，尽管其它适合的收发器也是可以使用的。主射频信号(master RF signal)使用已有的技术从天线 14 传输至主 CELL 单元(master

CELL unit）12。可选地，主 CELL 单元 12 将射频信号传至收发器 13，并且不使用天线 14 从收发器接收射频信号，而是，例如，使用连接主收发信单元 12 和收发器 13 的电缆 15。较佳地，当使用天线 14 传输信号时，主 CELL 单元 12 应该放置得使单元和天线 14 之间的通路尽可能地近，这样可使信噪比值最优化。进一步较佳地，当蜂窝电话系统使用 CDMA 信号时，收发器 13 和/或主收发信单元 12 包括一个或多个分离多径接收器（rake receivers）。

主 CELL 单元 12 接收到主射频信号，然后将其下变频至一个前向中频（IF-FWD）信号，因此，主 CELL 单元 12 是一个频率变换单元。这样的下变频是通过使用一个单元 12 产生的本地振荡器信号来实现的。这个信号的频率是和单元 12 使用的频带相兼容的。例如，如果主 CELL 单元 12 工作于 820 兆赫至 880 兆赫，那么本地振荡器频率可以设置为 750 兆赫。（主收发信单元 12 中的本地振荡器也用于单元中的上变频，后面还有详细的描述）IF-FWD 信号和本地振荡器信号的一个参考信号通过一条或多条电缆 20 传输至一个或多个从 CELL 单元 18，在那里 IF-FWD 信号被上变频至响应于主 CELL 单元 12 所接收到射频 CELL 信号的恢复后的主射频 CELL 信号。这样从 CELL 单元 18 也是一个频率变换单元。当从 CELL 单元超过一个时，所有的单元较佳地以一个或多个菊花链拓扑结构 23 连接到电缆 20。可选地，所有单元也可连接成一个或多个星型拓扑结构 27，或一个或多个菊花链-星型混合拓扑结构 29。拓扑结构较佳地根据系统 10 和建筑 16 的安装要求来进行选择。从 CELL 单元 18 位于建筑 16 内部，而在建筑 16 的内部，收发器 13 发射的射频信号被完全的屏蔽，因此，从 CELL 单元在建筑 16 内部辐射恢复后的主射频 CELL 信号。

一项 1999 年 11 月 1 日送交的，名为“分离式中继器”的专利申请书中描述了一种用于将射频信号下变频至中频信号，然后将中频信号上变频至射频信号的蜂窝中继器。上述专利已转让给本专利的受让人并在此引入作为参考资料。在上面的申请中已给出了变换过程中所使用的示范频率，本发明中也将使用这些频率。

每一个从 CELL 单元 18 都连接至一个或多个从 CELL 天线 22，恢复射频信

号就由一个或多个从CELL天线22辐射出去，并由CELL收发信机25接收，CELL收发信机25最佳地是移动CELL电话，但是其它合适的收发信机也可以使用。从CELL单元18较佳地位于建筑16内部，这样CELL收发信机25就可以在建筑内接收到恢复主射频CELL信号。用于驱动主CELL单元12的直流电平推荐通过电缆20传输，并以偏置电平的形式同时也驱动从CELL单元18，这一点后面还会详述。电缆20较佳地是标准同轴电缆，但能用于传输主CELL收发信单元12和从CELL收发信单元18产生的信号和偏置电平的电缆也可使用。

一个或多个从收发信单元18的一个或多个天线22也可以从CELL收发信机25接收从CELL射频信号。接收射频信号的一个或多个从收发信单元18，将从CELL射频信号下变频至反向中频（IF-REV）信号。IF-REV信号通过电缆20传输至主收发信单元12，在那儿上变频至恢复的从CELL射频信号，再如上所述地传输至收发器13。CELL主收发信单元12和每个CELL从收发信单元18的运行机制将在下面详细介绍。

图2是根据本发明的较佳实施例的主CELL收发信单元12的方框示意图。如上所述，射频天线共用器41通过天线14接收来自收发器13的主射频信号。天线共用器41是一个采用已有的技术，将主信号的通路43和接收从信号的通路45分隔开的端口。可选地，主射频信号可以通过电缆15接收，这前面也已作了描述。主射频信号被送至低噪声变增益射频放大器30。放大器30是通路43上的第一级放大器，正如我们已知的，较佳地由低噪声元件构成。

经放大器30放大后的信号被送至混频器32。混频器46还接收本地振荡器（LO）信号，本地振荡信号较佳地是由温控晶体振荡器产生，也可以使用其它稳定性不高的振荡器。振荡器和频率合成器构成了本地振荡器42，本地振荡器通过分离器44将LO信号送至混频器46。较佳地，本振42的频率应由控制器78设置。混频器32利用本振信号产生混频信号，混频信号包括了中频（IF）边频带，而混频信号将在第二级放大器34被放大。放大后的混频信号再经过带通滤波器36滤波，而带通滤波器36只允许这里

被称为 IF-FWD 的频率的一个中间频带通过，其它在混频器 32 中产生的频带将被抑制。本振频率，和相应的 IF-FWD 频率的的较佳选择在前述的参考专利申请中已有介绍。

滤波器 36 的输出被送至变增益放大器 38 和功率放大器 40，这两者根据安装在建筑 16 内从收发信单元的拓扑结构要求，以及系统 10 的链路预算要求一起调节 IF-FWD 信号的电平。调节后的信号输入至三工器 54。较佳地，放大器 38 的增益应由控制器 78 设置。

较佳地，本振 42 也应该通过分离器 44 和缓冲放大器 46 提供本振信号给分频器 48，分频器 48 将本振频率以某一整数分频，通常的整数范围是 2 至 16，但也可使用其它合适的整数值。分频本振信号要经过滤波以滤除窄带带通滤波器 50 中由于分频引入的噪声，再输入至放大器 52。放大器 52 将接收到的信号放大，并将其送至输出端作为工作于参考频率的参考信号输出至三工器 54。三工器 54 将放大后的本振参考信号和调节后的 IF-FWD 信号组合，然后将组合后的信号传送至 T-偏置滤波器 56（bias-T filter）。

T-偏置滤波器 56 是一个用直流电源 74 产生的直流电平对三工器 54 输出的组合后的信号和进行偏置的端口和低通滤波器。电源 74 产生的直流电平用以驱动主收发信单元 12。较佳地，电源 74 应由标准的交流市电驱动。可选地，电源 74 可由其他各种合适的标准形式的能源驱动，如通过电池。滤波器 56 将偏置于直流电平的组合信号送至分离器 58，分离器 58 将信号分成两路，每一路包括至少一条电缆和一个从收发信单元 18。这样，每一个从收发信单元 18 都会从分离器 58 收到信号以及直流电源。

主收发信单元 12 通过电缆 20 和 T-偏置滤波器 56 接收到从收发信单元 18 产生的 IF-REV 信号。T-偏置将信号与电缆上的直流电平分离，这些交流部分，如 IF-REV 信号，被送至三工器 54。三工器 54 将 IF-REV 信号沿单元 12 中的通路 45 导至变增益放大器 60，变增益放大器 60 将 IF-REV 信号放大至系统 10 的链路预算所决定的大小。混频器 62 将从放大器 60 来的 IF-REV 信号和分离器 44 来的 LO 信号进行混频，以恢复由某个从收发信单元 18 接收到的从射频

信号。恢复后的从射频信号在放大器 64 处放大，然后在带通滤波器 66 中被滤波。过滤后的放大信号再被变增益放大器 68 和功放 70 放大，然后由隔离器 72 送至双工器 41。放大器 68 的增益较佳地是由控制器 78 进行设置，这样，由隔离器 72 输出的信号才能有一个大小合适的电平以便被双工器 41 向上传输。可选地，隔离器 72 输出的信号也可通过电缆 15 传至收发器 13。最佳地，上述主单元 12 的变增益放大器的增益应该是可调的，以保证通路 43 和通路 45 上的端口之间的中的信号增益大约在 10dB 至 60dB 范围内。

在本发明的较佳实施例中，控制器 78 通过在电缆 20 传送控制信号至从收发信单元，能够控制和/或监控一个或多个从 CELL 收发信单元 18 的运行。最佳地，控制信号应该是一个频率和/或相位和/或幅度调制的信号，例如已知的频移键控（FSK）信号。较佳地，主 CELL 收发信单元 12 应包括一个连接至控制器 78 的调制解调器 76，控制信号可以通过调制解调器和滤波器 56 传送至从收发信单元。

图 3 是根据本发明的较佳实施例的一个从 CELL 单元 18 的方框示意图。每个从 CELL 单元 18 都包括有一个 T-偏置滤波器 92 和一个耦合器 94，用来通过电缆 20 接收从主收发信单元 12 来的 IF-FWD，本地振荡器参考信号，分频本地振荡器信号，及直流电平。T-偏置滤波器 92 和耦合器 94 也能够在主收发信单元 12 和连接至电缆 20 的其它从收发信单元间传递信号。最佳地，耦合器 94 和滤波器 92 应该被合理安排，以使得某个从收发信单元 18 和电缆 20 间的耦合或去耦不会严重影响到其它从收发信单元 18 的工作。

滤波器 92 作为一个端口，将直流电平进行分离，来直接或是通过备用直流-直流电源 96 驱动每个从单元 18，并将从主单元 12 接收到的交流信号通过耦合器 94 传输至三工器 100。三工器 100 过滤该交流信号并从中独立出 IF-FWD 信号，IF-FWD 信号沿前向通路 91 传输，而分频本地振荡器信号沿通路 93 传输。通路 93 包括一个倍频器 120，用来对经过前级放大器 118 放大的分频本地振荡器信号进行倍频，倍频数与主单元 12 中的分频器 48 的分频数一致。这样，本地振荡器信号就在从单元中被重建，该信号的频率和主单元 12 中的振

荡器 42 所产生的本地振荡器频率是一致的。重建后的本地振荡器信号先经过带通滤波器 122 的滤波，去除倍频过程中的引入的噪声，然后再由放大器 124 进行放大。放大后的重建本地振荡器信号输入至分离器 126，再从分离器输入至混频器 104 和混频器 140。输入至分离器的本地振荡器信号的功率较佳地能够足以驱动混频器 104 和 140。

通路 91 包括一个前级放大器 102，它从三工器 100 接收中心频率为 IF-FWD 的信号，并将 IF-FWD 信号进行放大，然后将其输入至可变延时器 103，延时器 103 较佳地是一个表面声波延时器，它将通路 91 中的信号进行大约 500ns 的延时。最佳地，时延至少被设置成单元口接收到的 CDMA 信号的码片速率的一半。延时器 103 的时延较佳地是在每个单元 18 安装时设定的，或者可选地，时延也可通过远程控制调制解调器 98 进行设置，远程控制调制解调器 98 的功能下面还会详细描述。最佳地，系统 10 中每个单元 18 的延时器 103 提供的时延都是不同的。这样，收发器 25 接收到的 CDMA 导频信号会有不同的时延，可以避免对传播的导频信号的可能的破坏性干扰，因而可以总地改善导频信号的接收。

延时器 103 的输出信号被输入至混频器 104。混频器利用重建的本地振荡器信号将接收到的 IF-FWD 信号进行上变频，以重新生成主收发信单元 12 接收到的主射频信号。重新生成的射频信号被射频放大器 106 放大和带通滤波器 108 过滤，以使射频信号获得输入到变增益放大器 110 和射频功放 112 所需的功率。射频功放 112 生成一个和主收发信单元 12 接收到的原始主信号相应的射频功率输出信号，该功率信号再经过隔离器 114 传输以提高电压驻波比。功率信号被输入至作为端口的射频双工器 116。双工器 116 再将该功率信号导至一个四向分离器 144，该四向分离器和四副从天线 22 连接，而再由这些天线该功率信号辐射出去。

正如前面所解释的，天线 22 也接收从射频信号。从射频信号由射频双工器 116 沿反向通路 95 引导至低噪声的前级放大器 142，该前级放大器较佳地由已知的超低噪声元件组成。混频器 140 利用分离器 126 接收到的重建的本地

振荡信号，和前级放大器 142 的输出信号来将从射频信号下变频至中频信号 IF-REV。IF-REV 信号经过馈给带通滤波器 136 的放大器 138，两者共同工作，以生成一个和混频器 140 产生的信号一样，完全没有多余边带的 IF-REV 信号。

较佳地，滤波器 136 的 IF-REV 信号输出送至一个变时延延时器 137。延时器 137 较佳地包括一个表面声波延时器，表面声波延时器将通路 95 中的信号进行 2ms 的延时。延时器 137 的时延较佳地是在每个单元 18 安装时设定的，或者可选地，时延也可通过远程控制调制解调器 98 进行设置。最佳地，系统 10 中每个单元 18 的延时器 137 的时延都应是不同的。每个延时器 137 所提供的时延将会被用于给单元 18 接收到的信号提供分集性，这一点下面还会详述。延时器 137 输出的信号被引导通过放大器 134，变增益放大器 130，和功率放大器 128，发送至三工器 100。

可选地，单元 18 中不包括延时器 137，滤波器 136 输出的 IF-REV 信号被直接送至放大器 134。放大器 128 的输出由一个自动增益控制（AGC）电路采样，用于调节变增益放大器 130 的增益，使得放大后的 IF-REV 信号的电平保持在和链路预算要求相一致的水平上。三工器 100 通过耦合器 94 将放大器 128 的输出发送至电缆 20，并通过电缆传输至主收发信单元 12。

较佳地，远程控制调制解调器 98 应能够如前述地接收并解码出主单元 12 的控制信号。最佳地，控制信号是用来设置和/或读取从单元 18 中的元件参数，诸如放大器 110 和 130 的增益，延时器 103 的时延，和/或从收发信单元中的信号电平。较佳地，如放大器 110 和 130 的增益之类的影响从单元 18 工作的参数在安装从收发信单元时能被预设好，使得每个从单元 18 能够独立地工作。最佳地，通路 91 和通路 95 上端口到端口的总信号增益应在 10dB 至 60dB 范围内。

现在再回到图 1，可以认识到的是，系统 10 中的所有从 CELL 收发信单元较佳地能工作于完全相同的一个本地振荡器频率，即由 CELL 主收发信单元 12 的本地振荡器所提供的频率，当然，主 CELL 收发信单元也工作于同一个本地振荡器频率。本地振荡器频率首先被一个整数分频，分频 LO 频率被传至整个

系统的从收发信单元。在每个从收发信单元中，分频 LO 频率再被同一个整数倍频，以重建原始的本地振荡器频率。先除以某个整数，再倍频以相同整数的这个过程保证了重建后的本地振荡器频率和本地振荡器产生的频率严格一致，并且本地振荡器的任何频率偏移都会被严格地在从收发信单元中重建。这样，不管发生任何的偏移，因为使用同一个本地振荡器的频率进行下变频和上变频，恢复后的 LO 频率和原始的 LO 频率是严格一致的。

在本发明的一些较佳实施例中，至少应构建主收发信单元 12 的 36，41，54 和 66 等组件（图 2），使得在通路 43 和通路 45 上只有预定的预设的蜂窝信道频率，而其它的蜂窝信道频率则不会被传输。最佳地，至少应构建每个从收发信单元 18 的 100，108，116 和 136 等组件（图 3），使得相应的蜂窝信道频率能在通路 91 和 95 上传输。这样，主单元 12 和从单元 18 就成为一个多路的通信中继系统。

图 4 是根据本发明的一个可选较佳实施例构成的显示安装在建筑物 170 中的一个中继系统 150 的方框示意图。除了下面将要描述的区别外，系统 150 的运行和系统 10（图 1）是大体相似的，因而在系统 10 和系统 170 中用同样的数字表明的组件在结构和运行方面大致上是相同的。系统 150 包括 CELL 主收发信单元 12 和小区主天线 14，用于从收发器 13 发射和接收射频 CELL 信号，并同从 CELL 收发信单元 18 进行通信，正如上面的对系统 10 的描述一样。

另外，系统 150 包括一个个人通信系统（PCS）主收发信单元 154 和一个 PCS 主天线 176，用于从接收器 184 发射和接收射频 PCS 信号，并和一个 PCS 多个从收发信单元 166 进行通信。如前参考图 2 所述的，PCS 主收发信单元 154 和 PCS 主天线 176 大致上与主 CELL 单元 12 和主 CELL 天线 14 相类似的进行运行，除了 PCS 主收发信单元 154 和 PCS 主天线 176 工作于和主 CELL 单元 12 和主 CELL 天线 14 不同的频率。可选地，主 CELL 单元 12 通过电缆 178 从收发器 13 发送和接收信号并且/或者 PCS 主收发信单元 154 通过电缆 180 从收发器 184 发送和接收信号。如前参考图 3 所述，

PCS 从收发信单元 166 大致上和从 CELL 单元类似地运行，除了 PCS 从收发信单元 166 工作于和从 CELL 单元 18 不同的频率。

较佳地，PCS 主收发信单元 154 和 PCS 天线 176 在与个人通信系统兼容的某个频率上接收来自收发器 184 的 PCS 主信号，例如，在从大约 1800 兆赫至 1900 兆赫的频带，但是收发器 184 也有可能工作于其它的频带。最佳地，PCS 主收发信单元 154 的 PCS 本振信号应选择和该单元的工作频率兼容，如 1700 兆赫。

PCS LO 信号和 PCS 主信号混频后产生 IF-FWD PCS 信号。参照前面有关主 CELL 单元 12 的描述，PCS LO 信号被某个整数进行分频，这里称其为 PCS 整数，产生分频 PCS LO 信号。该 PCS 整数可以和单元 12 中所使用的整数不一样，这里称其为 CELL 整数。同样参照前面有关主 CELL 单元 12 的描述，用以控制和/或监控从收发信单元 166 的运行的 PCS 控制信号在 PCS 主收发信单元 154 内产生。严格参照前面有关主 CELL 单元 12 的描述，分频 PCS LO 信号、IF-FWD PCS 信号、以及 PCS 控制信号被传输至一个或多个 PCS 从收发信单元 166。

如前参照图 3 所述，PCS 从收发信单元 166 的运行和 CELL 从收发信单元 18 大致上类似，除了 PCS 从收发信单元是工作于和 PCS 主收发信单元 154 发射的信号相兼容的频率上。这样，PCS 从收发信单元 166 可以通过将分频PCS LO信号的频率倍频以PCS整数来再生PCS本地振荡器频率。再生的 PCS 本地振荡器信号和从 PCS 主收发信单元 154 接收到的 PCS IF-FWD 信号进行混频，以再生 PCS 主射频信号。PCS 从收发信单元 166 和一个或多个 PCS 从天线 182 连接，使得该单元及相连的天线能够发射和接收来自 PCS 从收发器 186 的 PCS 信号。这样，被某个预定的 PCS 从收发信单元 166 接收到的从 PCS 射频信号和再生的 PCS 本振信号混频后以产生 IF-REV PCS 信号。

如前关于从单元 18 的描述，PCS 从收发信单元 166 接收由 PCS 主收发信单元 34 发射的 PCS 控制信号。最佳地，和从 CELL 单元 18 的方法一样，

PCS 从收发信单元 166 应该由主 CELL 单元 12 产生的直流偏置电平供电。

主 CELL 单元 12 通过同轴电缆 160 和分离/组合器 156 连接，这一点下面将会详细描述。PCS 主收发信单元 154 通过同轴电缆 158 也和分离/组合器 156 连接。分离/组合器 156 通过一条或多条同轴电缆 162 依次和一个或多个 CELL 从收发信单元 18 以及一个或多个 PCS 从收发信单元 166 连接，较佳地是通过前面描述的系统 10 的几种拓扑结构之一。

图 5 是根据本发明的较佳实施例构成的显示信号如何通过分离/组合器 156 的方框示意图。较佳地，分离/组合器 156 包括一个或多个已知的工作于通过分离/组合器的信号所在频带的带通滤波器。分离/组合器 156 将信号有效地从 CELL 从收发信单元 18 发送至 CELL 主收发信单元 12，反之亦然，同时也将信号有效地从 PCS 从收发信单元 166 发送至 PCS 主收发信单元 154，反之亦然。这样，分离/组合器 156 在电缆 160 上接收到从 CELL 主收发信单元 12 来的分频小区 LO 信号、小区 IF-FWD 信号、小区控制信号、以及直流偏置电平，并将信号和偏置电平送至电缆 162。类似地，分离/组合器 156 在电缆 158 上接收到从 PCS 主收发信单元 154 来的分频 PCS LO 信号、PCS IF-FWD 信号、以及 PCS 控制信号，并将信号送至电缆 162。分离/组合器 156 在电缆 162 上接收到从 CELL 从收发信单元 18 来的小区 IF-REV 信号，以及对小区控制信号的响应，并将信号送至电缆 160。类似地，分离/组合器 156 在电缆 162 上接收到从 PCS 从收发信单元 166 来的 PCS IF-REV 信号，以及对 PCS 控制信号的响应，并将信号送至电缆 158。

回到图 4，可以认识到，CELL 主收发信单元 12、电缆 160、分离/组合器 156、电缆 162 以及 CELL 从收发信单元 18 组成了一个通信元件小区组（CELL group of communication elements）161，它和系统 10 一样严格工作于蜂窝频率。类似地，PCS 主收发信单元 154、电缆 158、分离/组合器 156、电缆 162 以及 PCS 从收发信单元 166 组成了一个通信元件 PCS 组（PCS group of communication elements）159，它和系统 10 一样严格工作于个人通信系统频率。

最佳地，当 CELL 从收发信单元 18 和 PCS 从收发信单元 166 被安装到系统 150 时，这些单元应安装至建筑 170 内部，以使整个建筑内部都可以接收到蜂窝以及个人通信系统信号。可选地，这些单元可以成对安装，以使 CELL 从收发信单元和 PCS 从收发信单元在物理位置上比较接近。可以认识到的是，因为在系统 10 中如前述安装了从收发信单元，所有的从收发信单元较佳地都通过同轴电缆 162 供电，即通过用于驱动 CELL 主收发信单元 12 的电源。如前参照图 3 所述，最佳地，从收发信单元的设计应使得便于从同轴电缆 162 上和一个或多个从收发信单元进行耦合或去耦，并且完全不影响其它连接在电缆 162 上的从收发信单元的工作。

可以认识到的是，在组 161 中的所有 CELL 从收发信单元较佳地都工作于同一小区本地振荡器频率，即由 CELL 主收发信单元中的本地振荡器提供的本地振荡频率，CELL 主收发信单元 12 也工作于该小区本地振荡器频率。进一步地，所有 PCS 从收发信单元较佳地都严格工作于同一 PCS 本地振荡器频率，即由 PCS 主收发信单元 154 中的本地振荡器提供的本地振荡频率，PCS 主收发信单元也工作于该小区本地振荡器频率。

图 6 是根据本发明的可选较佳实施例构成的显示利用接收分集性的一个中继系统 200 的方框示意图。除了下面将要描述的区别外，系统 200 的运行和系统 10（图 1）是大致相似的，因而在系统 10 和系统 200 中用同样的数字表明的组件在结构和运行上大致是相同的。系统 200 安装在建筑 202 内。严格按照前面在系统 10 中所述，主收发信单元 12 通过电缆 20 接收来自安装在建筑 202 内的多个从单元 18M 的，与从收发信单元由收发信机 25 处接收到的射频信号对应的 IF-REV 信号。每个从收发信单元 18M 在接收和运行上与从收发信单元 18 是完全一样的，这里我们使用后缀 M 来表示和主收发信单元 12 连接的从收发信单元。由从收发信单元 18M 处收到的 IF-REV 信号在主收发信单元 12 处转换至恢复的射频信号。恢复的射频信号作为主接收信号被送至收发器 13，较佳地应通过电缆 15，或可选地通过天线 14 采用无线方式。

系统 200 包括一个分集主收发信单元（diversity master unit），它在运行上大体类似于主收发信单元 12，它的结构和运行下面还将详细描述。分集主收发信单元 212 通过一个电缆集 220，以菊花链或其它在系统 10 的描述中的拓扑结构，和多个从收发信单元 18D 连接。每个从收发信单元 18D 在接收和运行上与从收发信单元 18 是完全一样的，这里我们使用后缀 D 来表示和分集主收发信单元 212 连接的从收发信单元。因为中继系统 200 包括相互区别的从收发信单元 18M 和 18D，所以和类似的从收发信单元不加区别的系统相比，中继系统 200 在总的系统噪声系数上提高了 3dB。

最佳地，从收发信单元 18M 和从收发信单元 18D 在位置上也应充分加以区别，以使得从不同多个从收发信单元接收到的信号能够相互区别，即，使不同的信号能分别作为主接收信号（main receive signal）和分集接收信号（diversity reveive signal）被使用。最佳地，在每个从收发信单元 18D 和从收发信单元 18M 中都有延时器 137（图 3），并且被设置为一个大约 2ms 的整数倍的时延，以使得从收发信单元接收到的信号具有时间多样性。这样，从收发信单元 18D 和从收发信单元 18M 接收到的信号具备了位置多样性或时间多样性或两者的组合。

电缆 215 连接主收发信单元 12 和分集主收发信单元 212，用于把本地振荡器信号从主收发信单元 12 传至分集主收发信单元 212。可选地，电缆 215 把分频本地振荡器信号从主收发信单元 12 传至分集主收发信单元 212，再如下所述地在分集主收发信单元 212 把具有本地振荡器频率的本地振荡器信号再生。分集主收发信单元 212 通过电缆 220 从各自的从收发信单元 18D 接收 IF-REV 信号，这些 IF-REV 信号是和从收发信单元从收发器 25 接收到的射频信号相对应。这些由从收发信单元 18D 来的 IF-REV 信号在主收发信单元 212 转换至恢复的射频信号，再如前述的系统 10 一样，恢复后的射频信号被传输至收发器 13，作为接收分集信号。于是，系统 200 使用主收发信单元 12 及其从收发信单元 18M 来提供主接收射频信号（receive main RF signal），使用分集主收发信单元 212 及其从收发信单元 18D 来提

供分集接收射频信号（receive diversity RF signal），因此，和那些不使用分集信号的系统相比，建筑 202 内部的信号覆盖被增强了。

最佳地，系统 200 包括一个双向分离器 204，用于把从收发器 13 来的发射射频信号提供给主收发信单元 12 和分集单元 212。如上有关系统 10 的描述，主收发信单元 12 和分集主收发信单元 212 把射频信号转换成 IF-FWD 信号，并将 IF-FWD 信号传输至各自的多个从收发信单元 18M 和 18D。

在某些本发明的最佳实施例中，分集主收发信单元 212 在构造和运行上都和前述的主收发信单元 12（图 2）完全一样，除了下面描述的一些区别之外。分集主收发信单元 212 不需要本地振荡器 42，所以单元 212 中可能没有本地振荡器。为了取代本地振荡器 42，由主要主收发信单元 12 产生的本地振荡器信号被作为参考，通过电缆 215 传输至分离器 44 上的馈点 43，分离器 44 是一个用于恢复本地振荡器信号的接收器。恢复后的本地振荡器信号再如前述一样地用于产生主收发信单元 12 的本地振荡器信号。

图 7 是根据本发明的一个可选较佳实施例构成的分集主收发信单元 212 的方框示意图。除了下面描述的一些区别之外，单元 212 的运行和单元 12 的大致相似（图 2），因而在单元 12 和单元 212 中用同样的数字表明的组件在结构和运行方面大致上是相同的。为了提供一个本地振荡器信号，分集单元 212 通过电缆 215 接收来自主收发信单元 12 的分频 LO 信号作为参考。分频 LO 信号被输入到三工器 54，再和前面有关单元 12 的描述一样，通过电缆 220 传输至从收发信单元 18D。分频 LO 信号也被输入至放大器 224，放大器的输出再被输入到倍频器 225。倍频器 225 将放大后的分频 LO 信号的频率倍频以一个整数，该整数和在主收发信单元 12 中用来产生分频 LO 信号的整数相同，因此，作为倍频器的输出，原始的 LO 频率被恢复了。倍频器的输出在带通滤波器 226 中进行滤波以去除倍频器中产生的谐波，滤波后的输出在放大器 228 中被放大，然后在双向分离器 230 中被分离，这样分离器 230 成了一个恢复本地振荡信号的接收器。因此，分离器 230

的输出是具有原始 LO 频率的信号。

分离器 230 的一个输出被输入到通路 43 中的混频器 32，而另一个输出则被输入至通路 45 中的混频器 62。通路 43 和通路 45 的运行和前述的主收发信单元 12 中的完全一样。

图 8 是根据本发明的一个可选较佳实施例构成的显示安装于建筑 250 的中继系统 300 的方框示意图。除了下面描述的一些区别之外，系统 300 的运行和系统 10（图 1）大致相似，因而在系统 10 和系统 300 中用同样的数字表明的组件在结构和运行方面大致上是相同的。建筑 210 较佳地是一个相对较大的建筑物，如一幢多层建筑，鉴于建筑物内的通信量，在该建筑整个内部进行通信覆盖是困难的。为了提供整个大楼的完整的覆盖，多个主收发信单元 12，这里称作主收发信单元 12A，12B，12C，和各自的多个从收发信单元 18 相连，这里称作从收发信单元 18A，18B，18C，因此每个多个从收发信单元（及其相应的主收发信单元）覆盖大楼的不同区域。最佳地，通过已有技术，每个不同的主收发信单元只和基站收发信台的一个扇形进行通信，这样，基站收发信台的每个扇形都可以覆盖建筑 210 的不同区域。在建筑 10 的每个区域内，系统 300 的运行和前述的系统 10 的完全一样。

上述的较佳实施例较佳地作为范例来进行引证，本发明不仅仅局限于前面所专门展示和描述的。本发明的范围包括了上述不同特征的组合和再组合，以及熟悉本技术领域的人通过阅读前面的描述所进行的，以前没有揭示的改变和修改。

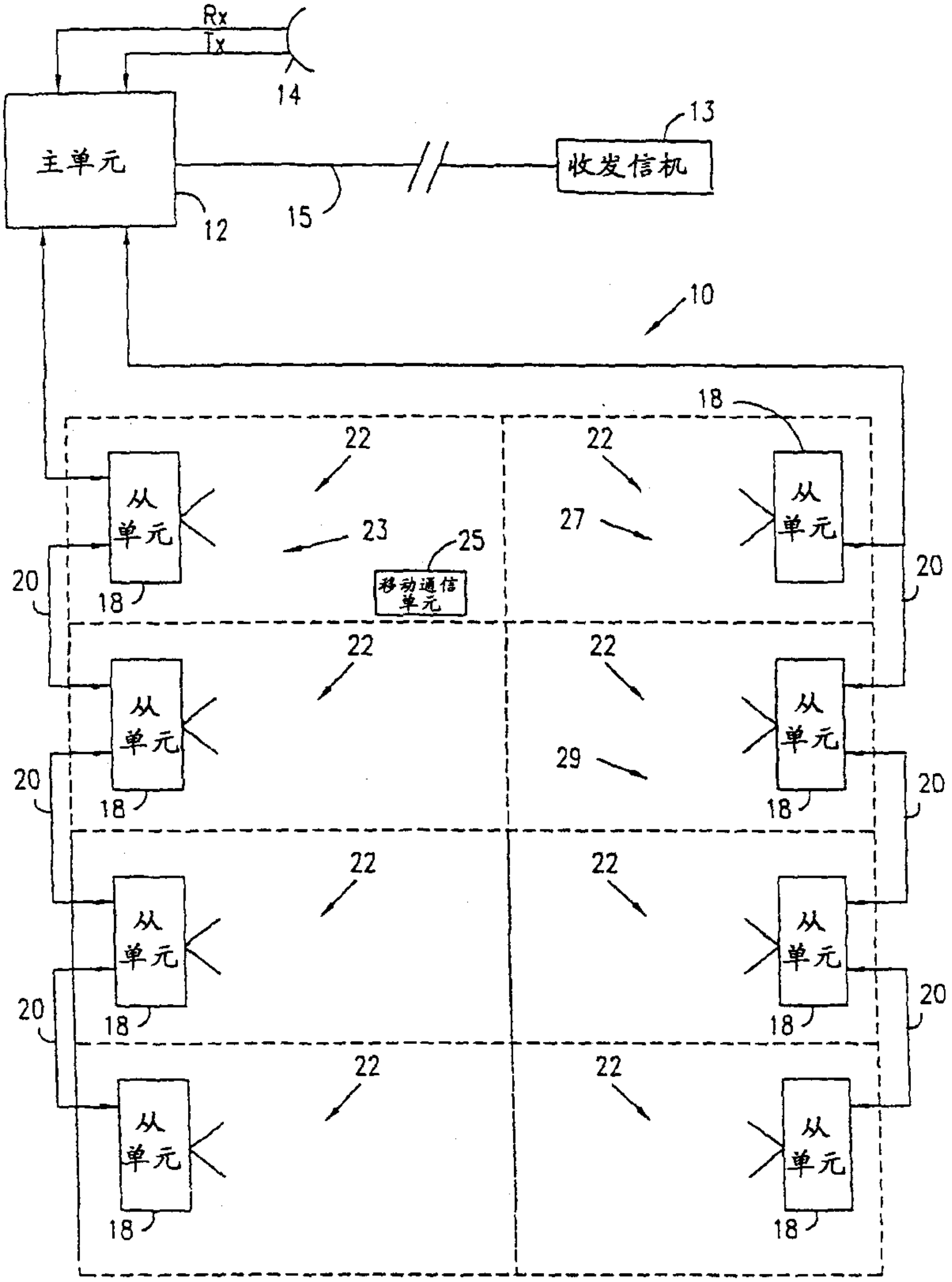


图 1

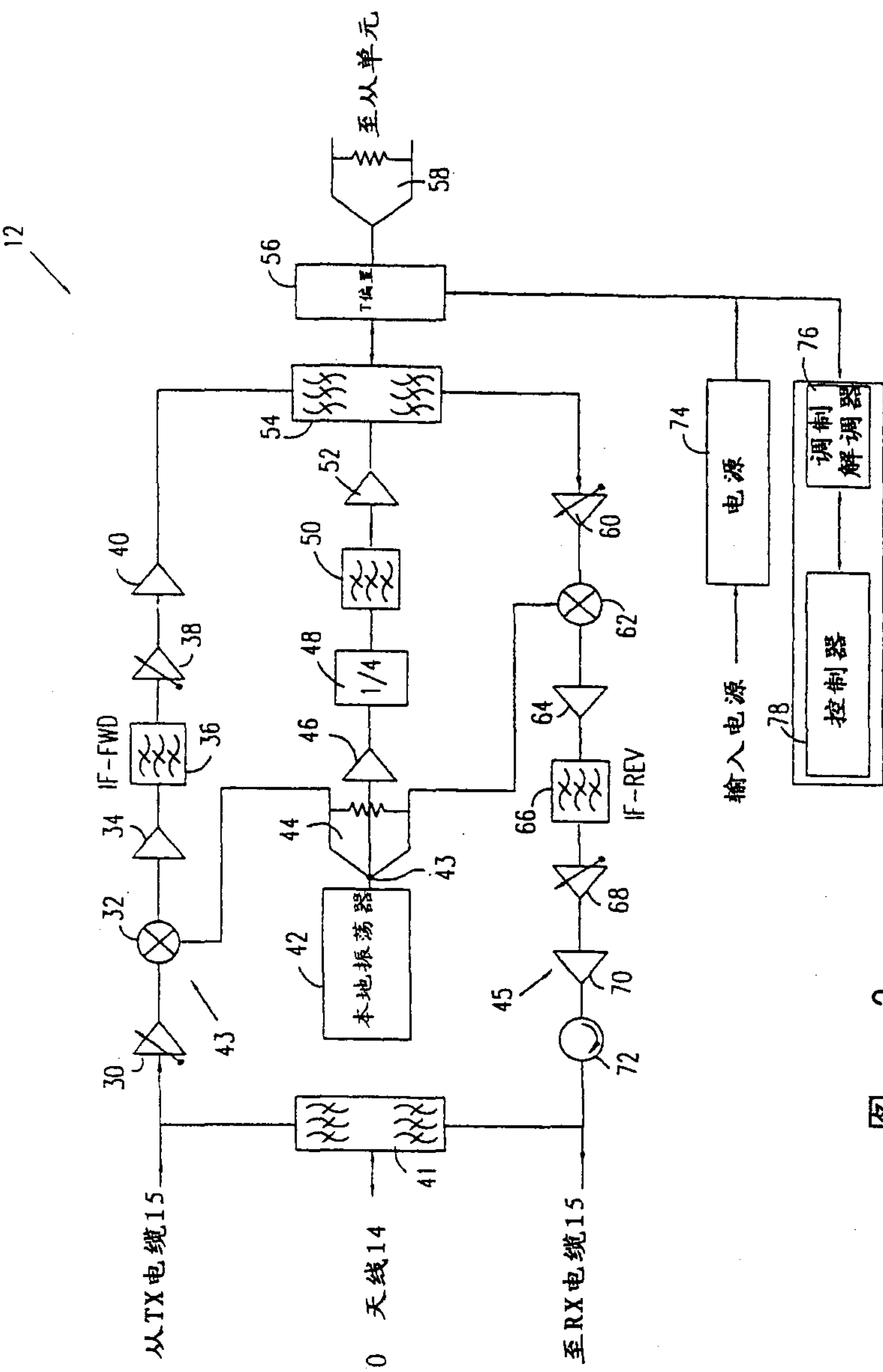

12
至从单元
58
56
T偏置
54
52
50
48
1/4
46
44
43
42
本地振荡器
40
38
IF-FWD
36
34
32
30
41
从TX电缆15
0 天线14
至RX电缆15
60
62
64
IF-REV
66
68
70
45
72
74
电源
输入电源
76
调制解调器
78
控制器

图 2

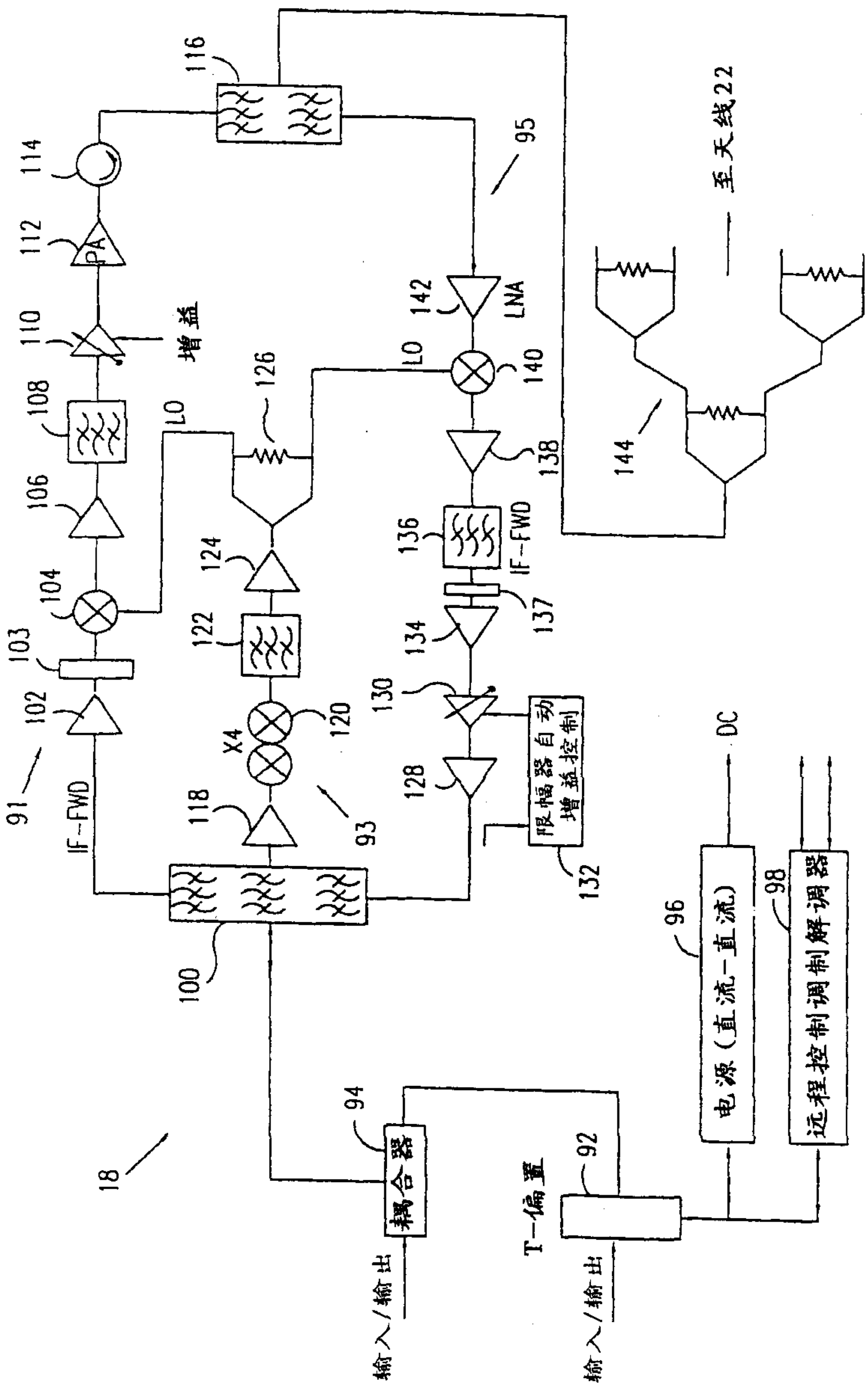

116
114
112
PA
110
增益
108
106
104
103
102
91
IF-FWD
LO
126
LO
140
142
LNA
95
至天线22
144
138
136
IF-FWD
137
134
130
124
122
120
X4
118
93
128
限幅器自动增益控制
132
100
DC
96
电源（直流-直流）
98
远程控制调制解调器
94
耦合器
92
T-偏置
18
输入/输出
输入/输出

图 3

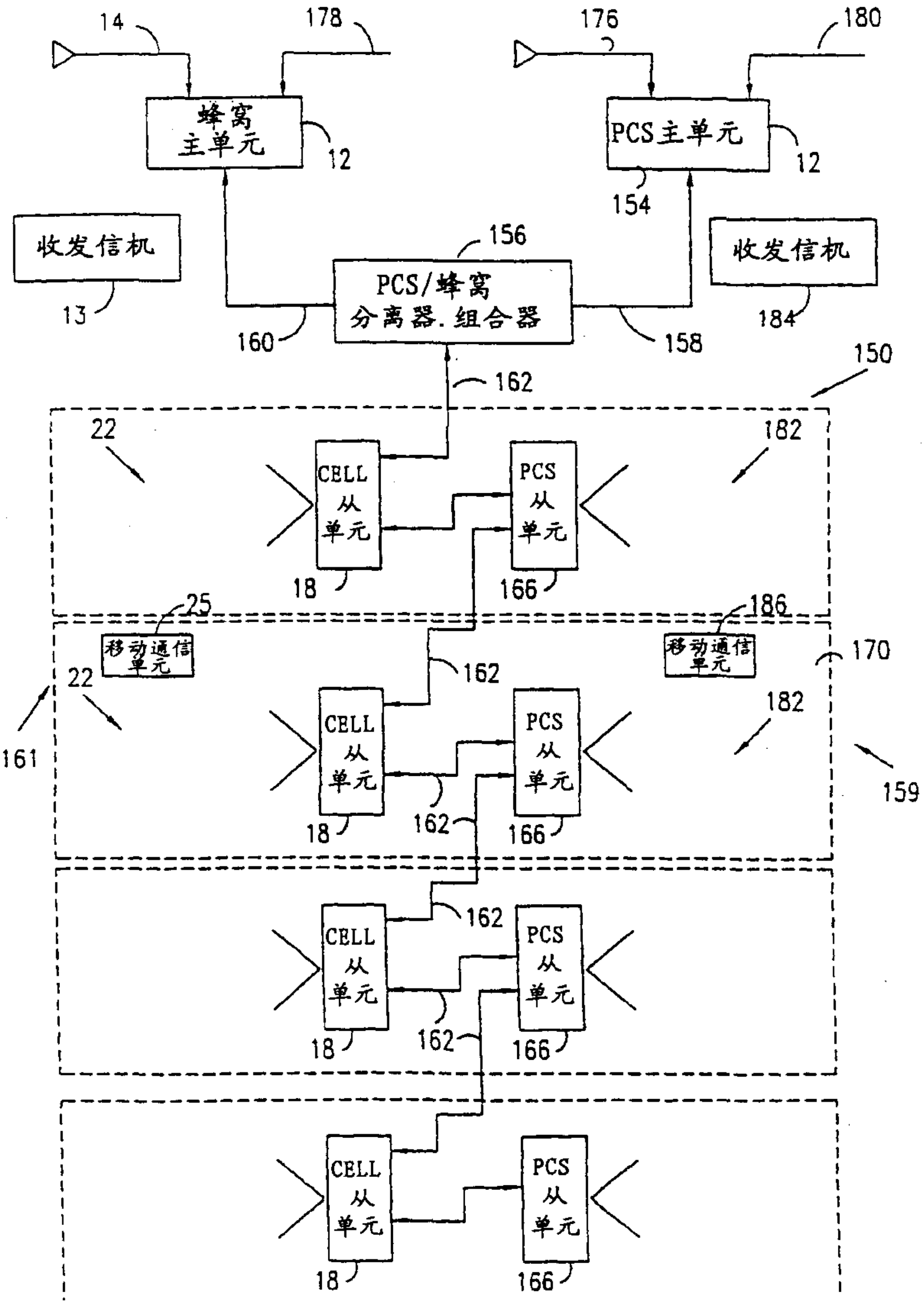
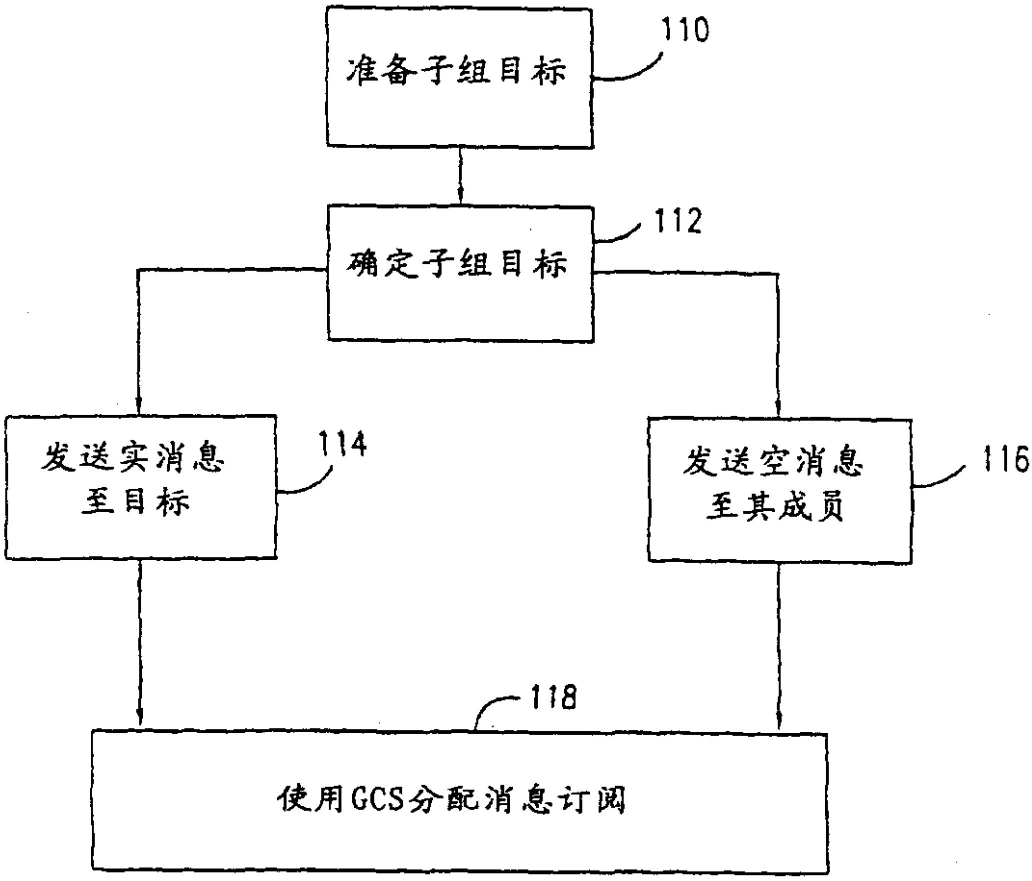
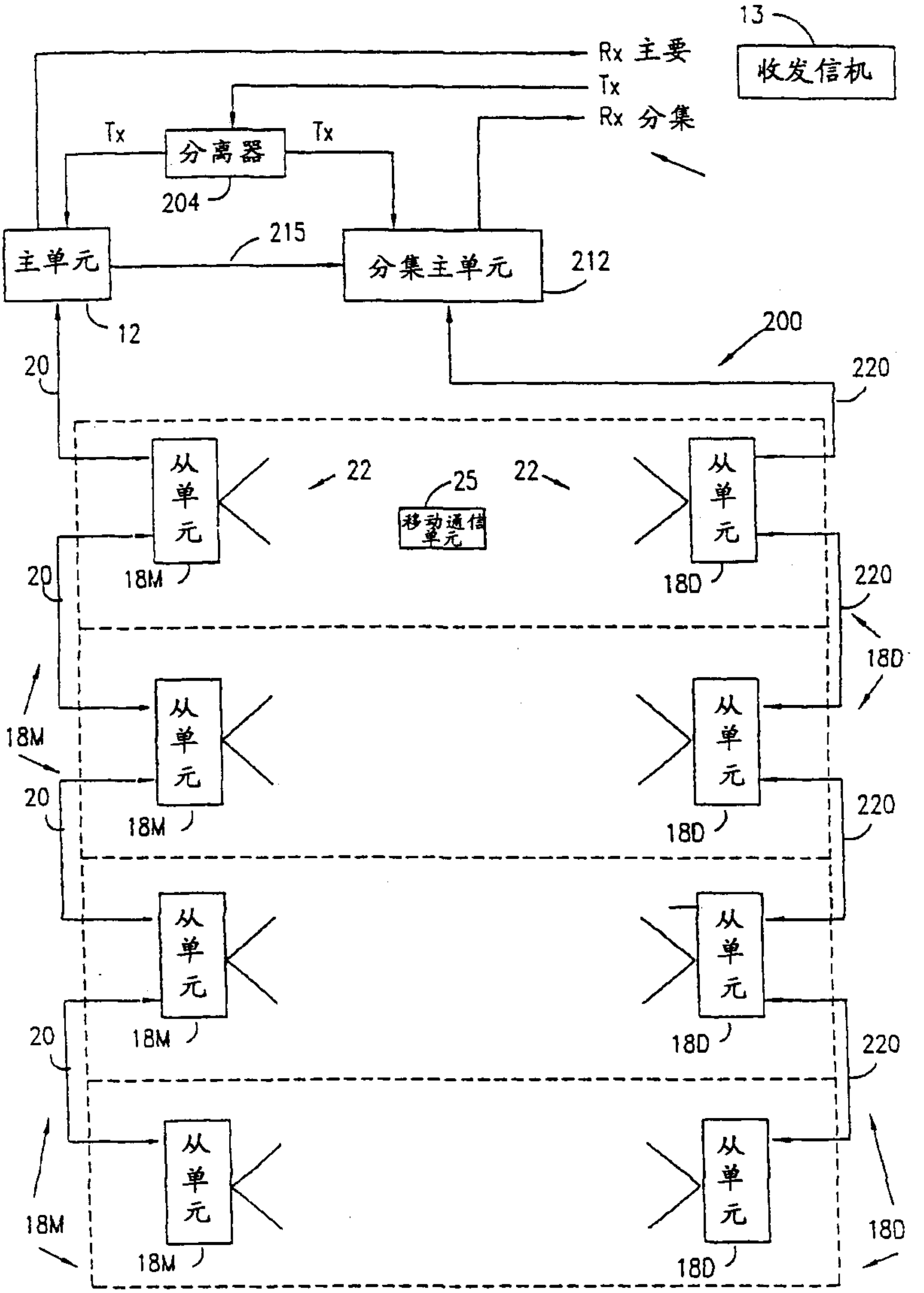

14
178
176
180
蜂窝主单元
12
PCS主单元
12
154
收发信机
13
156
PCS/蜂窝分离器.组合器
160
158
收发信机
184
150
162
22
182
CELL从单元
PCS从单元
18
166
25
186
移动通信单元
移动通信单元
170
22
182
162
161
159
162
166
162
162

图 4



准备子组目标
110
确定子组目标
112
发送实消息
至目标
114
发送空消息
至其成员
116
118
使用GCS分配消息订阅

图 5



13
收发信机
Rx 主要
Tx
Rx 分集
Tx
分离器
Tx
204
215
主单元
分集主单元
212
12
200
20
220
从单元
22
25
22
移动通信单元
从单元
18M
18D
20
220
18D
18M
从单元
从单元
20
220
18M
18D
从单元
从单元
20
220
18M
18D
从单元
从单元
18M
18D
18M
18D

图 6

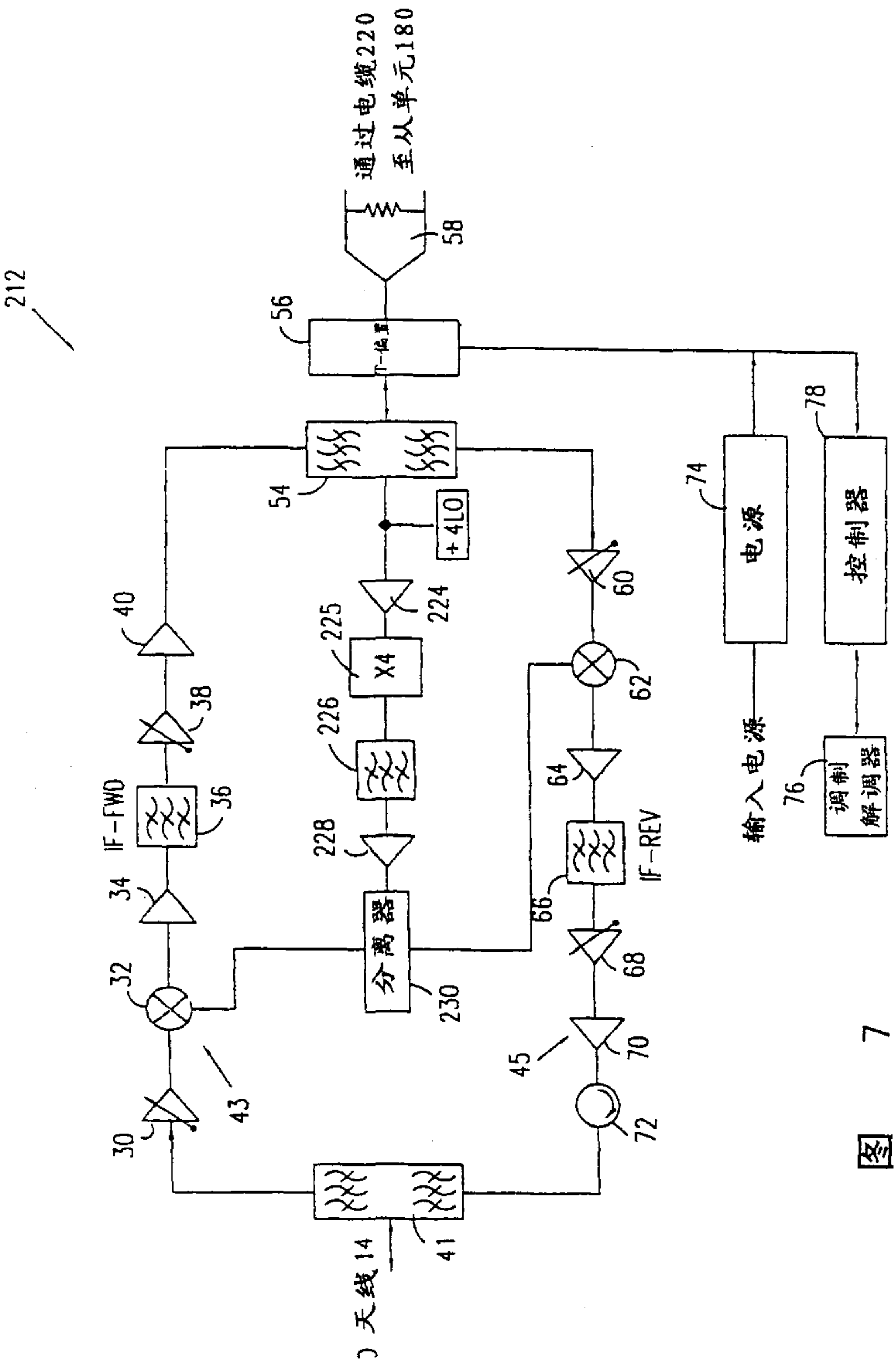

212
通过电缆220
至从单元180
58
56
T-偏置
54
+4LO
40
38
IF-FWD
36
34
32
30
43
41
天线14
224
225
X4
226
228
分离器
230
60
62
64
IF-REV
66
68
70
45
72
74
电源
78
控制器
输入电源
76
调制
解调器

图 7

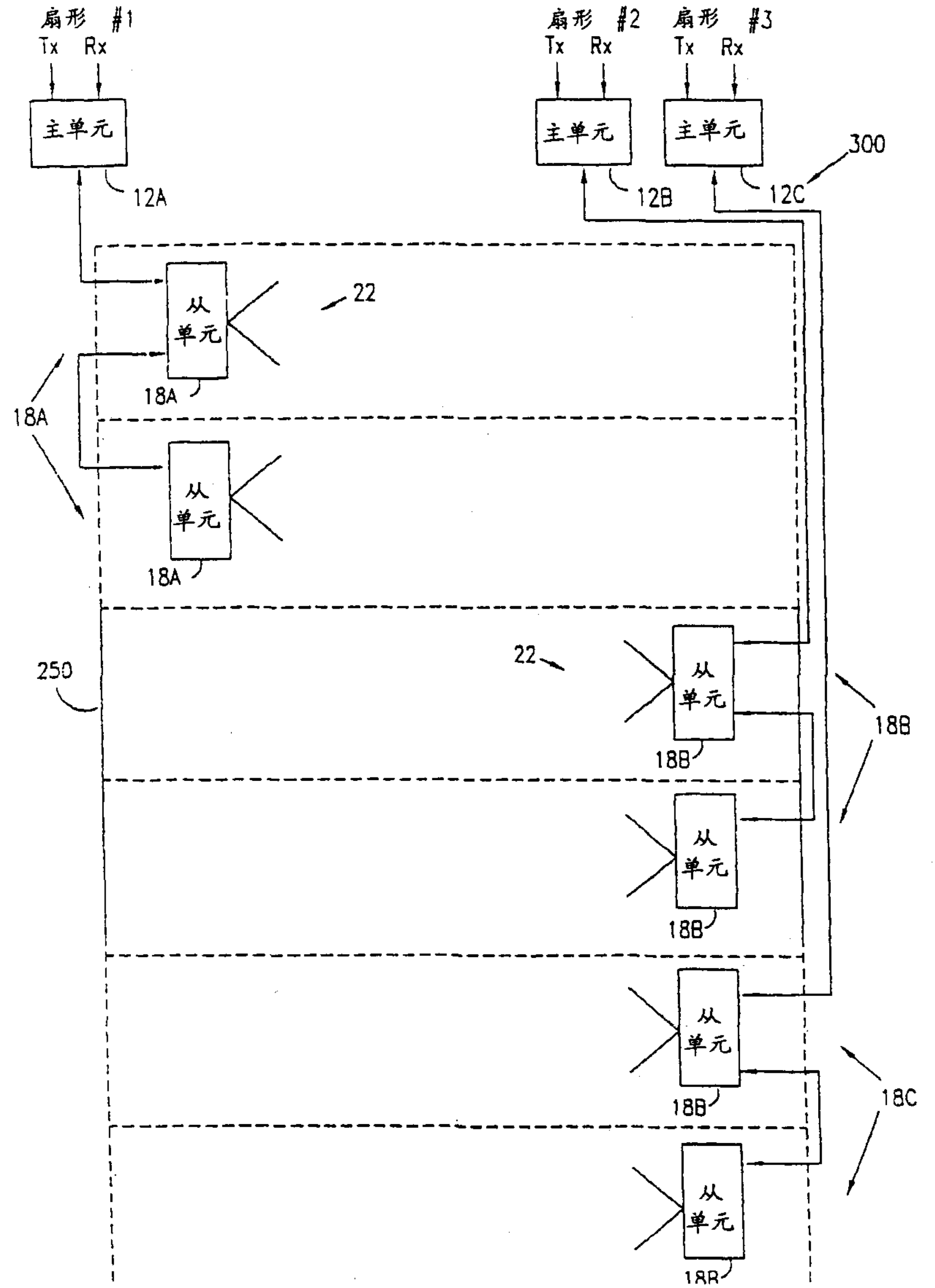

扇形 #1
Tx Rx
主单元
12A
扇形 #2
Tx Rx
扇形 #3
Tx Rx
主单元
主单元
300
12B
12C
从
单元
22
18A
18A
从
单元
18A
250
22
从
单元
18B
18B
从
单元
18B
从
单元
18B
18C
从
单元
18B

图 8