US00RE37870E

(19) United States
(12) Reissued Patent

Nakano et al.

(10) Patent Number: US RE37,870 E
(45) Date of Reissued Patent: Oct. 8, 2002

(54) **CDMA/TDD RADIO COMMUNICATION SYSTEM**

(75) Inventors: **Takayuki Nakano**, Kanazawa; **Kazuyuki Miya**, Machida; **Osamu Kato**; **Masatoshi Watanabe**, both of Yokohama, all of (JP)

(73) Assignee: **Matsushita Electric Industrial Co., Ltd.**, Osaka (JP)

(21) Appl. No.: **09/154,709**

(22) Filed: **Sep. 17, 1998**

Related U.S. Patent Documents

Reissue of:

(64) Patent No.: **5,559,789**
Issued: **Sep. 24, 1996**
Appl. No.: **08/369,485**
Filed: **Jan. 6, 1995**

(30) **Foreign Application Priority Data**

Jan. 31, 1994 (JP) 6-009610
Feb. 16, 1994 (JP) 6-019366

(51) **Int. Cl.**^{7} **H04J 13/04**
(52) **U.S. Cl.** **370/342**; 455/13.4
(58) **Field of Search** 370/241, 247, 370/310, 318, 317, 320, 321, 332, 352, 441, 442, 311, 314, 329, 331, 333–338, 341–347, 350, 349; 455/38.3, 69, 13.4, 560, 561, 571, 572, 442, 439; 375/200, 130, 140, 137, 145

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,056,109 A 10/1991 Gilhousen et al. 370/342
5,103,459 A 4/1992 Gilhousen et al. 370/342
5,245,629 A * 9/1993 Hall 375/100
5,257,283 A * 10/1993 Gilhousen 370/342
5,265,119 A 11/1993 Gilhousen et al.
5,267,262 A 11/1993 Wheatley, III
5,278,992 A 1/1994 Su et al.
5,383,220 A * 1/1995 Murai 375/200
5,420,850 A 5/1995 Umeda et al.

FOREIGN PATENT DOCUMENTS

EP 0154338 A2 9/1985
EP 0565505 A2 10/1993
GB 2268365 1/1994
WO 92 22161 12/1992
WO 93 21699 10/1993

OTHER PUBLICATIONS

Mobile Radio Communications, Raymond Steele (Ed), 1992, Pentech Press Limited, London.
EPO Search Report dated Oct. 21, 1998.
Riaz Esmailzadeh, et al. "Power Control in Packet Switched Time Division Duplex Direct Sequence Spread Spectrum Communications"; IEEE Vehicular Technology Society 42nd, VTS Conference, pp. 989–992, 1992.
International Search Report dated Mar. 6, 2001.

* cited by examiner

Primary Examiner—Dang Ton
(74) *Attorney, Agent, or Firm*—Stevens, Davis, Miller & Mosher, LLP

(57) **ABSTRACT**

In addition to a structure of a conventional CDMA/TDD radio communication system, a base station includes a pilot signal generating circuit for generating a pilot signal that has a constant transmission power level and is known in mobile units and a pilot channel spreading circuit for transmitting the pilot signal to the mobile units through a transmission line. Each of the mobile units includes a pilot signal reception level measuring circuit for measuring reception power of the received pilot signal and a transmission power control circuit for controlling transmission power of a power amplification circuit based on the measured reception power of the received pilot signal.

16 Claims, 5 Drawing Sheets

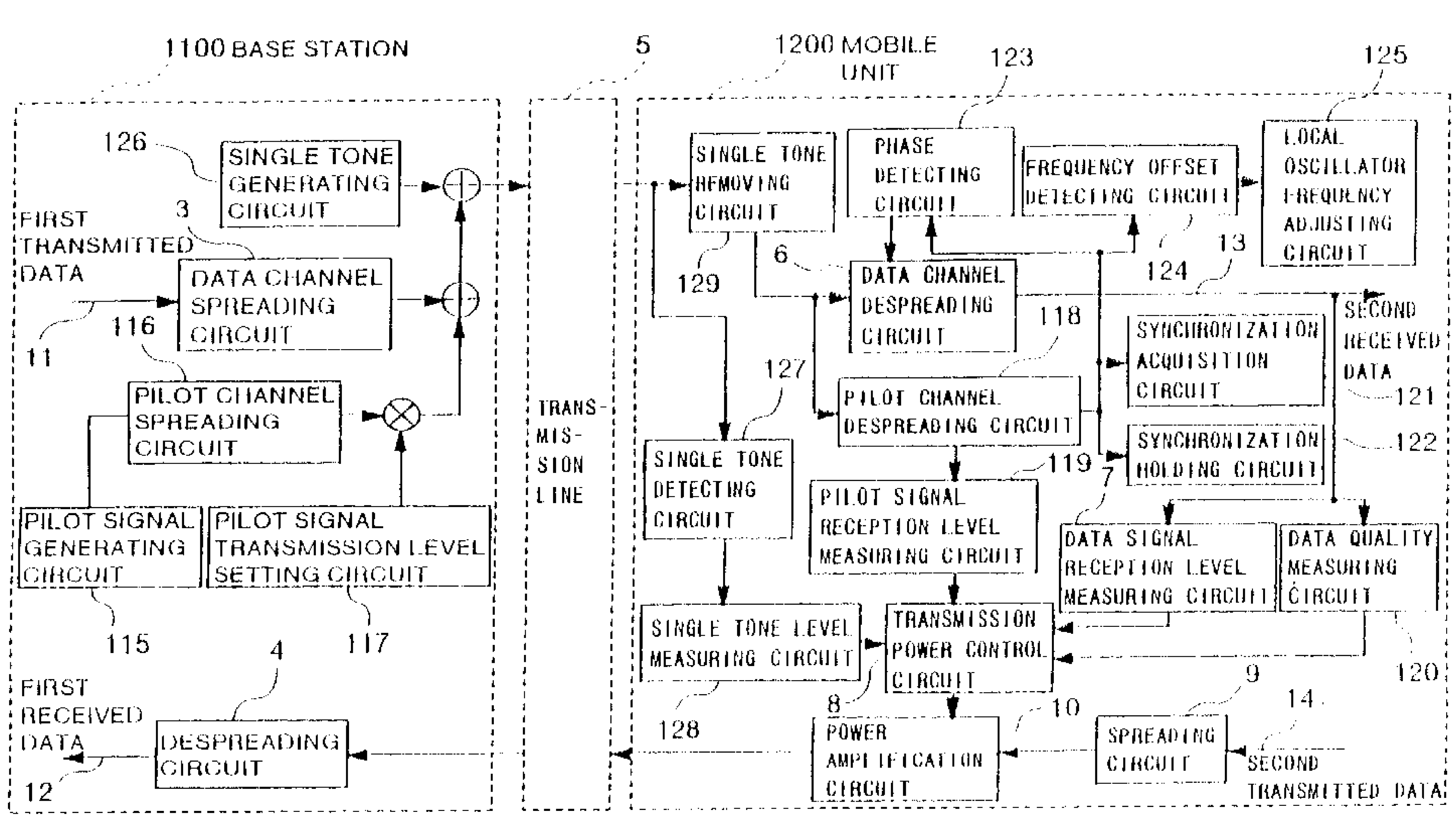


FIG.1 PRIOR ART

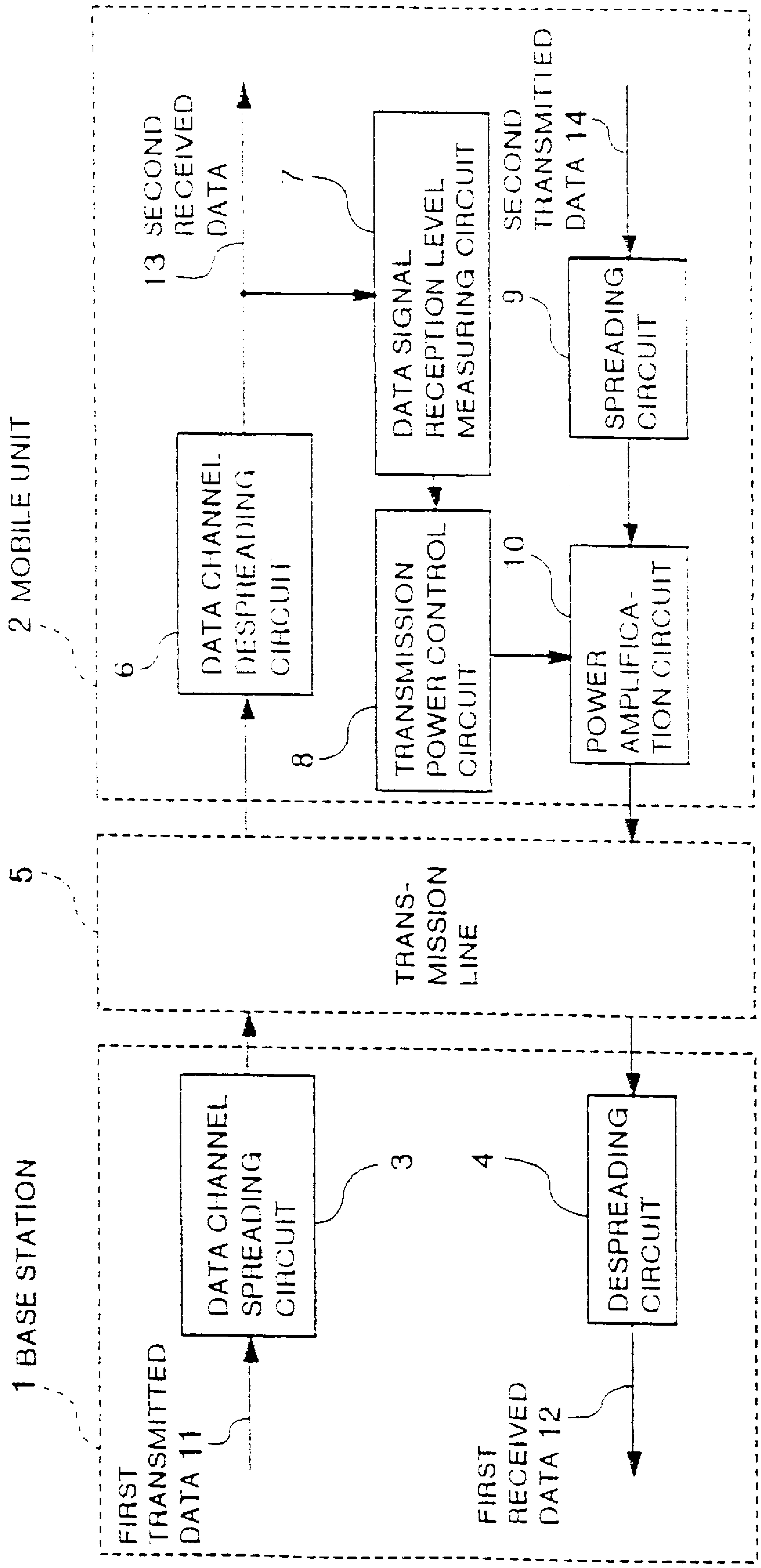


FIG.2

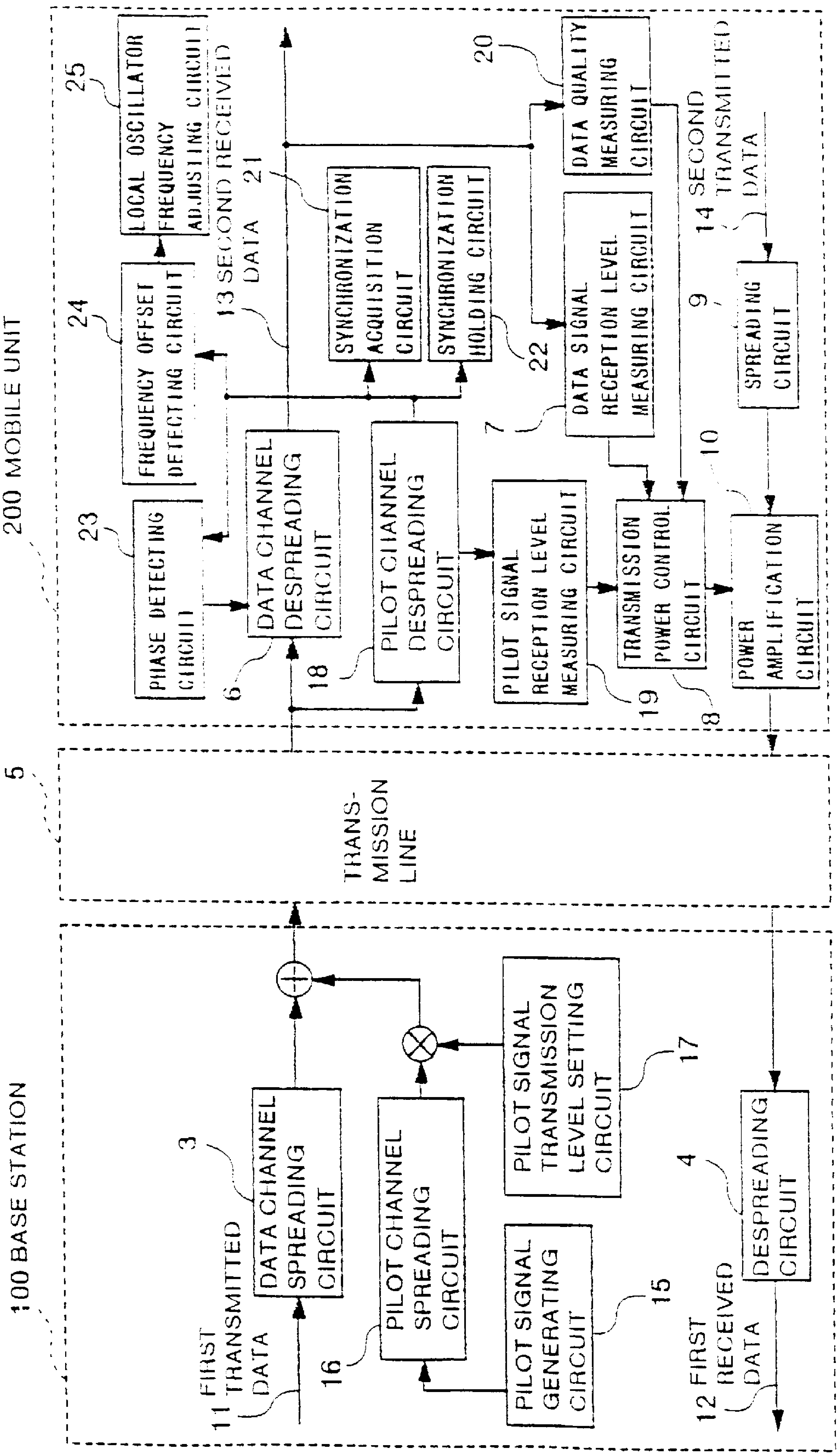

200 MOBILE UNIT
25
LOCAL OSCILLATOR FREQUENCY ADJUSTING CIRCUIT
24
FREQUENCY OFFSET DETECTING CIRCUIT
23
PHASE DETECTING CIRCUIT
6
DATA CHANNEL DESPREADING CIRCUIT
18
PILOT CHANNEL DESPREADING CIRCUIT
13 SECOND RECEIVED DATA
21
SYNCHRONIZATION ACQUISITION CIRCUIT
SYNCHRONIZATION HOLDING CIRCUIT
22
20
DATA QUALITY MEASURING CIRCUIT
7
DATA SIGNAL RECEPTION LEVEL MEASURING CIRCUIT
PILOT SIGNAL RECEPTION LEVEL MEASURING CIRCUIT
19
TRANSMISSION POWER CONTROL CIRCUIT
8
14 SECOND TRANSMITTED DATA
9
SPREADING CIRCUIT
10
POWER AMPLIFICATION CIRCUIT
5
TRANS-MISSION LINE
100 BASE STATION
3
DATA CHANNEL SPREADING CIRCUIT
11 FIRST TRANSMITTED DATA
16
PILOT CHANNEL SPREADING CIRCUIT
PILOT SIGNAL TRANSMISSION LEVEL SETTING CIRCUIT
17
PILOT SIGNAL GENERATING CIRCUIT
15
4
DESPREADING CIRCUIT
12 FIRST RECEIVED DATA

FIG.3

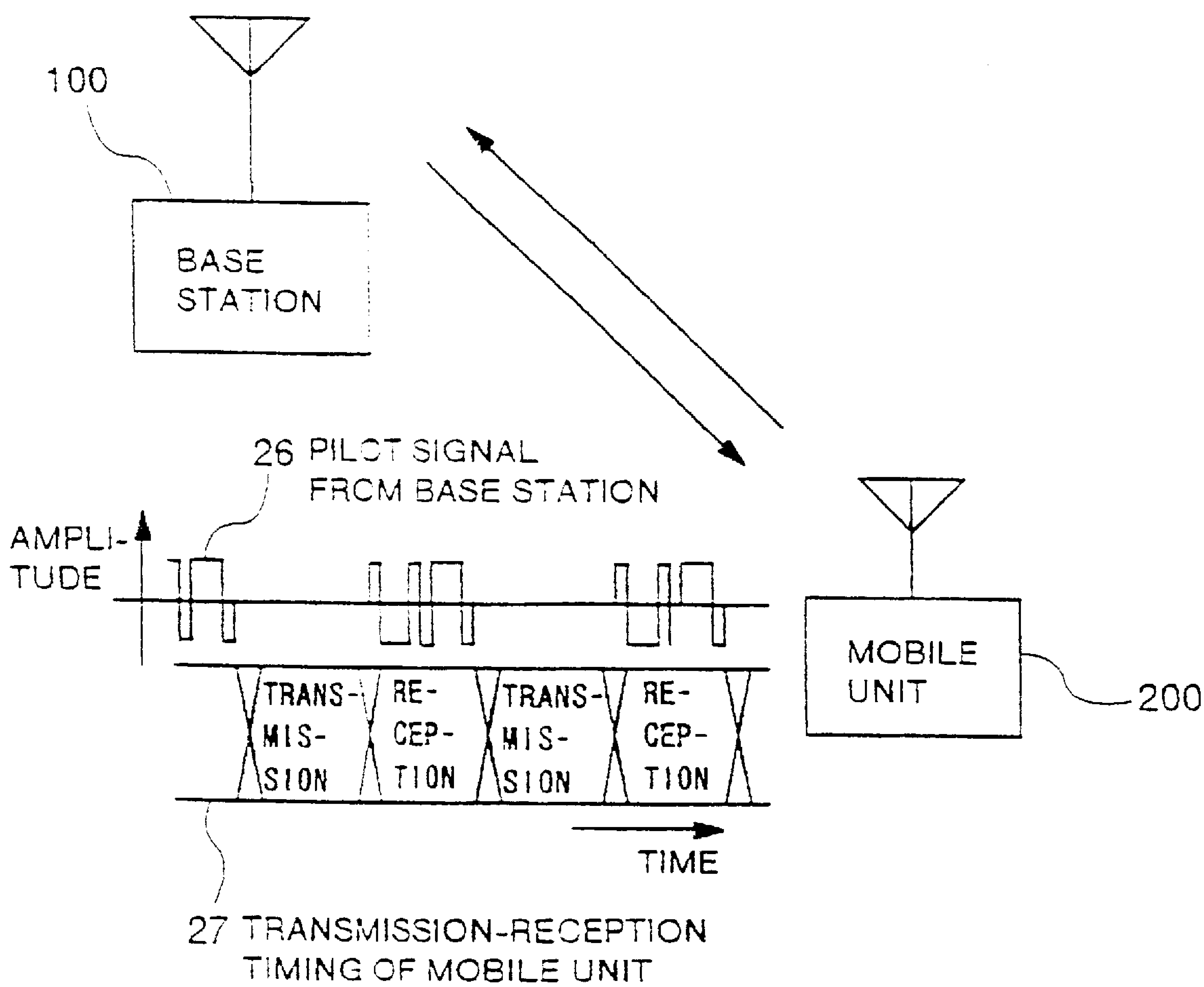

100
BASE STATION
26 PILOT SIGNAL FROM BASE STATION
AMPLI-TUDE
TRANS-MIS-SION
RE-CEP-TION
TRANS-MIS-SION
RE-CEP-TION
TIME
27 TRANSMISSION-RECEPTION TIMING OF MOBILE UNIT
MOBILE UNIT
200

FIG.4

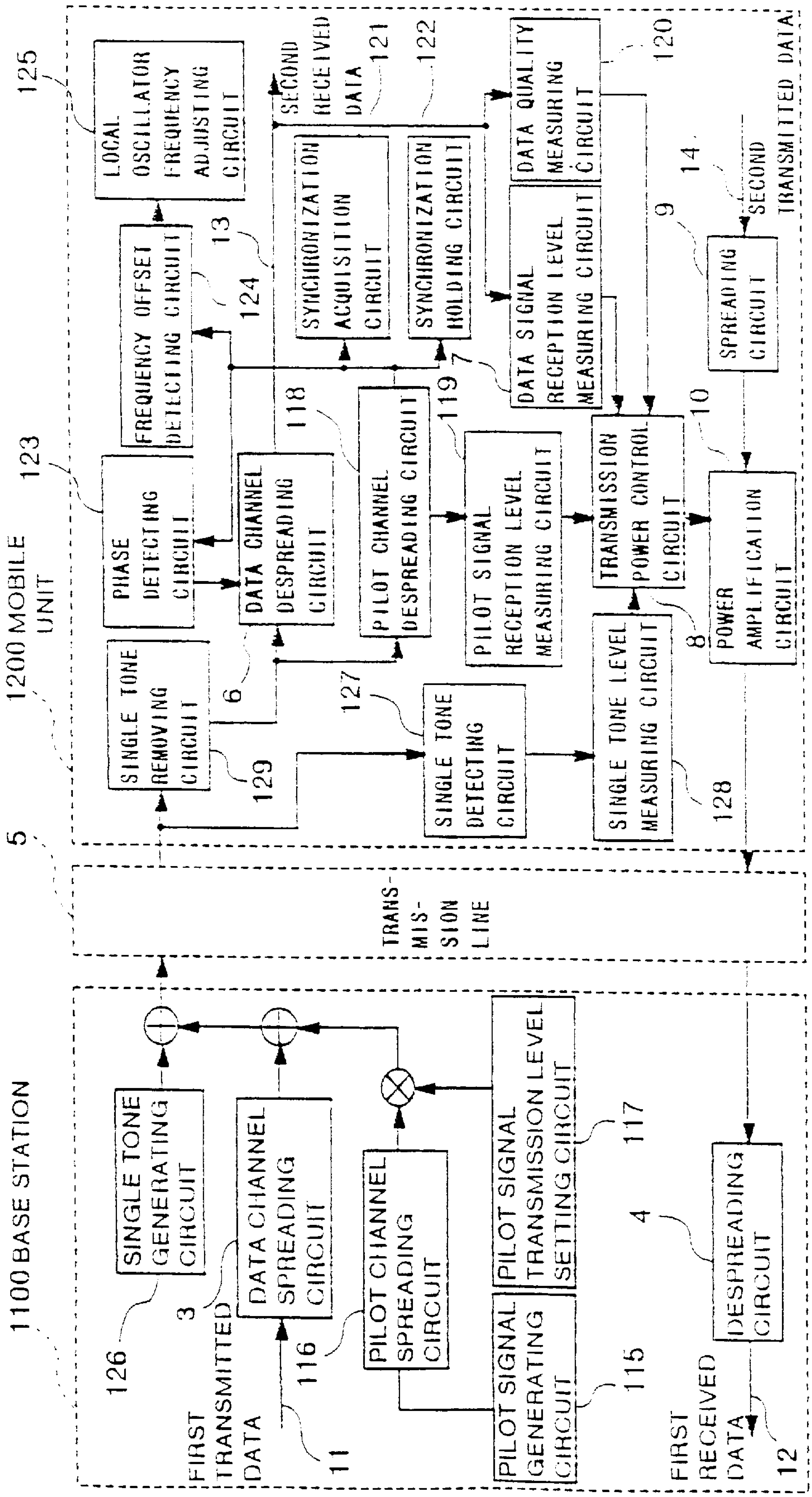
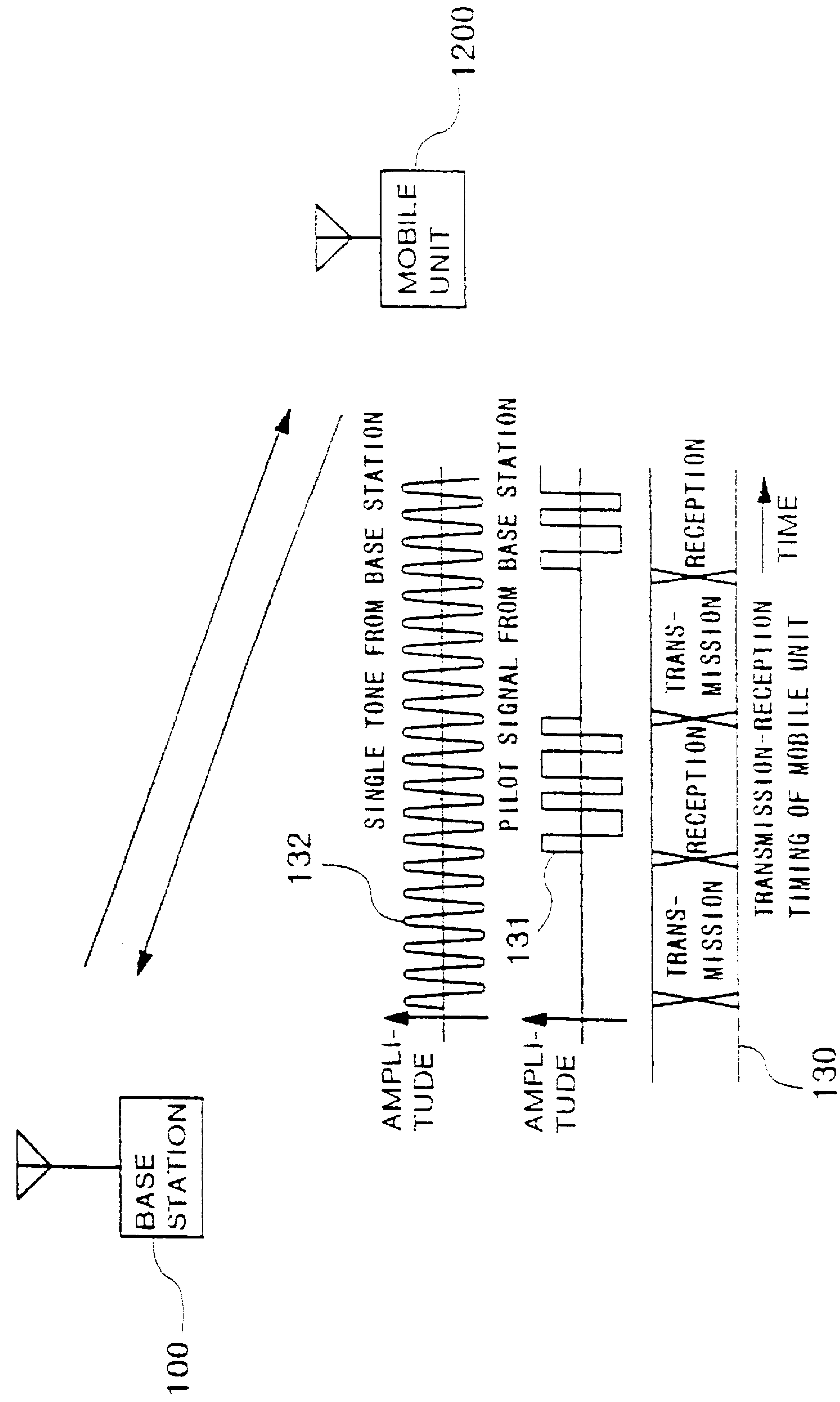

1100 BASE STATION
SINGLE TONE GENERATING CIRCUIT
DATA CHANNEL SPREADING CIRCUIT
PILOT CHANNEL SPREADING CIRCUIT
PILOT SIGNAL GENERATING CIRCUIT
PILOT SIGNAL TRANSMISSION LEVEL SETTING CIRCUIT
DESPREADING CIRCUIT
FIRST TRANSMITTED DATA
FIRST RECEIVED DATA
TRANS-MIS-SION LINE
1200 MOBILE UNIT
SINGLE TONE REMOVING CIRCUIT
SINGLE TONE DETECTING CIRCUIT
SINGLE TONE LEVEL MEASURING CIRCUIT
PHASE DETECTING CIRCUIT
DATA CHANNEL DESPREADING CIRCUIT
PILOT CHANNEL DESPREADING CIRCUIT
PILOT SIGNAL RECEPTION LEVEL MEASURING CIRCUIT
TRANSMISSION POWER CONTROL CIRCUIT
POWER AMPLIFICATION CIRCUIT
FREQUENCY OFFSET DETECTING CIRCUIT
LOCAL OSCILLATOR FREQUENCY ADJUSTING CIRCUIT
SYNCHRONIZATION ACQUISITION CIRCUIT
SYNCHRONIZATION HOLDING CIRCUIT
DATA SIGNAL RECEPTION LEVEL MEASURING CIRCUIT
DATA QUALITY MEASURING CIRCUIT
SPREADING CIRCUIT
SECOND RECEIVED DATA
SECOND TRANSMITTED DATA
3
4
5
6
7
8
9
10
11
12
13
14
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129

FIG.5


1200
MOBILE UNIT
SINGLE TONE FROM BASE STATION
132
PILOT SIGNAL FROM BASE STATION
131
AMPLI-TUDE
AMPLI-TUDE
TRANS-MISSION
RECEPTION
TRANS-MISSION
RECEPTION
TIME
TRANSMISSION-RECEPTION TIMING OF MOBILE UNIT
130
BASE STATION
1100

CDMA/TDD RADIO COMMUNICATION SYSTEM

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a CDMA/TDD radio communication system.

2. Description of the Related Art

Demand for land mobile communication devices such as car telephones and portable telephones is increasing remarkably, and a frequency effective utilization technique for securing larger subscriber capacity in a limited frequency band have become important in recent years. A code-division multiple access (CDMA) system attracts attention as one of multiple access systems for frequency effective utilization. In the CDMA system, when a signal level from a mobile unit near a base station is high in a reverse link from the mobile unit to the base station, such a near-far problem that a signal from another mobile unit become unreceivable is generated. Thus, it is required to control transmission power of the mobile unit so that the base station receives the signal from any mobile unit at the same level.

On the other hand, since propagation conditions both for transmission and reception are the same in a time division duplex (TDD) system in which transmission and reception are performed in the same frequency band, when the propagation condition on one side is known, the propagation condition on the other side can be known. With this, it is possible to measure the reception power at the mobile unit and to control the transmission power of the mobile unit based on the measured value.

Transmission power control techniques in a conventional CDMA/TDD radio communication system will be described hereinafter with reference to FIG. **1**. In FIG. **1**, reference numeral 1 represents a base station, 2 a mobile unit, 3 a data channel spreading circuit for spreading a first transmitted data **11** from the base station **1**, 4 a despreading circuit for obtaining a first received data **12**, 5 a transmission line, 6 a data channel despreading circuit for obtaining a second received data **13** in the mobile unit **2**, 7 a data signal reception level measuring circuit for measuring the level of the second received data **13**, 8 a transmission power control circuit for controlling the transmission power of the mobile unit in accordance with the reception level, 9 a spreading circuit for spreading a second transmission data **14** from the mobile unit **2**, and 10 a power amplification circuit.

Next, the operation of the conventional example described above will be explained. In the base station **1**, the first transmitted data **11** are spread by means of the data channel spreading circuit **3**. The spread signal is transmitted to the mobile unit **2** through the transmission line **5** after being added to the spread signals of other channels. The signal received by the mobile unit **2** is despread in the data channel despreading circuit **6** to obtain the second received data **13**. In the data signal reception level measuring circuit **7**, the reception level is measured with the second received data **13**. In the transmission power control circuit **8**, attenuation in the transmission line **5** is estimated based on the measured value of the reception level to determine the transmission power when the mobile unit **2** spreads the second transmitted data **14** by the spreading circuit **9** and transmits those data after amplification in the power amplification circuit **10**. The data transmitted from the mobile unit **2** through the transmission line **5** are despread by the despreading circuit **4** in the base station **1** to obtain the first received data **12**. When the power level of the first transmitted data **11** transmitted from the base station **1** is constant, it is possible to obtain the attenuation of the transmission line **5** accurately, so that it is possible to control the transmission power of the mobile unit **2** accurately.

In the conventional transmission power control techniques described above, however, it is impossible to obtain the attenuation of the transmission line **5** accurately and to control the transmission power accurately when the transmission power level of the first transmitted data **11** changes. Further, the attenuations of the transmission line **5** estimated in respective mobile units **2** are different due to the fact that the contents of the transmission data transmitted from the base station **1** to respective mobile units **2** are different from one another and separate spreading codes are used, respectively, and the transmission power of respective mobile units **2** is determined based on the estimated attenuation of the transmission line **5**. Thus, the power arriving at the base station **1** from respective mobile units **2** becomes uneven.

SUMMARY OF THE INVENTION

The present invention is to solve the above-mentioned conventional problems and has for its object to provide a CDMA/TDD radio communication system capable of controlling transmission power with high precision.

In order to achieve the above-mentioned object, according to the present invention, there is provided, in the base station, a circuit for transmitting a pilot signal that has a constant power level and is known in respective mobile units, and highly precise transmission power control is made based on this pilot signal in respective mobile units.

According to the present invention, it becomes possible to control transmission power accurately and to solve such a problem that communication becomes impossible due to a near-far problem.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic block diagram of a conventional CDMA/TDD radio communication system;

FIG. **2** is a schematic block diagram of a CDMA/TDD radio communication system according to a first embodiment of the present invention;

FIG. **3** is a typical diagram showing transmission-reception timing of a pilot signal in the first embodiment of the present invention;

FIG. **4** is a schematic block diagram of a CDMA/TDD radio communication system according to a second embodiment of the present invention; and

FIG. **5** is a typical diagram showing transmission-reception timing and a waveform of a single tone of a pilot signal in the second embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The First Embodiment

A first embodiment of the present invention will be described hereinafter with reference to FIG. **2**. In FIG. **2**, reference numeral **100** represents a base station, 200 represents a mobile unit, and elements that are indicated with reference numerals 3 to 14 are the same as corresponding elements shown in the above-mentioned conventional example in FIG. **1** described above. Reference numeral 15 represents a pilot signal generating circuit for generating a pilot signal that has a constant transmission power level and is known in the mobile unit **200**, 16 a pilot channel spreading circuit for spreading the pilot signal, 17 a pilot signal transmission level setting circuit for setting a transmission level of the pilot signal, 18 a pilot channel despreading circuit for obtaining a received pilot signal in the mobile unit **200**, 19 a pilot signal reception level measuring circuit for measuring a reception level of the received pilot signal, 20 a data quality measuring circuit for measuring the quality of a second received data **13** such as a bit error rate (BER) or a frame error rate (FER), 21 a synchronization acquisition circuit for acquiring synchronization of spreading codes by the received pilot signal, 22 a synchronization holding circuit for holding synchronization of the spreading codes by the received pilot signal, 23 a phase detecting circuit for obtaining a phase of a carrier wave by the received pilot signal, 24 a frequency offset detecting circuit for obtaining offset of a carrier frequency in a local oscillator in the mobile unit **200**, and 25 a local oscillator frequency adjusting circuit for adjusting the frequency of the local oscillator of the mobile unit **200** using the output of the frequency offset detecting circuit **24**.

The operation of the CDMA/TDD radio communication system structured as described above will be described with reference to FIGS. **2** and **3**. In FIG. **3**, reference numeral 26 represents a pilot signal transmitted from the base station **100**, and 27 shows transmission-reception timing of the mobile unit **200**. In FIG. **2**, the pilot signal generating circuit **15** generates a pilot signal that has a constant transmission power level and is known in the mobile unit **200**. This pilot signal is transmitted toward the mobile unit **200** on the transmission line **5** in a bursting manner through at least one spreading channel together with the first transmitted data **11** spread by the data channel spreading circuit **3** after being spread by the pilot channel spreading circuit **16**. The pilot signal transmitted from the base station **100** through the transmission line **5** is transmitted in the time slot that the mobile unit **200** performs reception as shown in FIG. **3**, and the mobile unit **200** obtains the second received data **13** by despreading the data signal by means of the data channel despreading circuit **6** from the signal received in this time slot, and obtains the received pilot signal by despreading the pilot signal by means of the pilot channel despreading circuit **18**. The power of the received pilot signal is measured by the pilot signal reception level measuring circuit **19**, the power of the second received data **13** is measured by the data signal reception level measuring circuit **7**, and the data quality of the second received data **13** is measured by the data quality measuring circuit **20**. Then, the transmission power in the power amplification circuit **10** when the second transmitted data **14** is spread by the spreading circuit **9** and transmitted to the base station **100** is controlled by the transmission power control circuit **8** taking not only the reception levels of the received pilot signal and the second received data **13**, but also the quality of the data channel into consideration. Alternatively, the transmission power is controlled based on the reception level of the received pilot signal and the data quality only. The data transmitted to the base station **100** from the mobile unit **200** through the transmission line **5** are despread by the despreading circuit **4** to obtain the first received data **12**.

Further, since the pilot signal is known in the mobile unit **200**, it is possible to perform the synchronization acquisition and synchronization holding of the spread signal by the synchronization acquisition circuit **21** and the synchronization holding circuit **22**, the phase detection of the carrier wave by the phase detecting circuit **23**, the detection of frequency offset in the local oscillator by the frequency offset detecting circuit **34**, and the adjustment for compensating for the shift of the carrier frequency attendant upon Doppler effect from the detected frequency offset by means of the local oscillator frequency adjusting circuit **25** by using the received pilot signal.

Furthermore, in the base station **100**, it is possible that the pilot signal transmission level setting circuit **17** lowers a relative level of the interference from the other spreading channels in the received pilot signal by making the transmission power level of the pilot signal higher than any one of the signal levels of the other spreading channels. With this, it is possible to improve the precision of the transmission power control, the synchronization acquisition, the synchronization holding, the phase detection, the frequency offset detection and the local oscillator frequency adjustment which are described previously.

Further, an optional data sequence is assumed for a pilot signal generated by the pilot signal generating circuit **15** of the base station **100**, but the pilot signal may be formed of a data sequence of all "1's" or "0's". In this case, the circuit configurations of the pilot signal generating circuit **15**, the pilot signal reception level measuring circuit **19**, the synchronization acquisition circuit **21**, the synchronization holding circuit **22**, the phase detecting circuit **23**, the frequency offset detecting circuit **24** and the local oscillator frequency adjusting circuit **25** become simple, so that it is possible to curtail the circuit scale.

As described above, according to the embodiment described above, it is possible to estimate the attenuation of the transmission line **5** accurately because the transmission power of the pilot signal transmitted from the base station **100** toward respective mobile units **200** is constant and the pilot signal is known in the respective mobile units **200**, and, even when Rayleigh fading is generated with the movement of the mobile unit **200** and the attenuation of the transmission line **5** changes suddenly, such matters can be followed by the pilot signal.

The Second Embodiment

A second embodiment of the present invention will be described hereinafter with reference to FIG. **4**. In FIG. **4**, reference numeral 1100 represents a base station, **1200** represents a mobile unit, and elements that are indicated with reference numerals 3 to 14 are the same as corresponding elements shown in the conventional example in FIG. **1** described above except the control in the transmission power control circuit **8**. Reference numeral 115 represents a pilot signal generating circuit for generating a pilot signal that has a constant transmission power level and is known in the mobile unit **1200**, 116 a pilot channel spreading circuit for spreading the pilot signal, 117 a pilot signal transmission level setting circuit for setting the transmission level of the pilot signal, 118 a pilot channel despreading circuit for obtaining the received pilot signal in the mobile unit **1200**, 119 a pilot signal reception level measuring circuit for measuring the reception level of the received pilot signal, 120 a data quality measuring circuit for measuring the quality of the second received data **13** such as a bit error rate (BER) or a frame error rate (FER), 121 a synchronization acquisition circuit for acquiring the synchronization of spreading codes by the received pilot signal, 122 a synchronization holding circuit for holding the synchronization of spreading codes by the received pilot signal, 123 a phase detecting circuit for obtaining the phase of the carrier wave by the received pilot signal, 124 a frequency offset detecting circuit for obtaining the offset of the carrier frequency in a local oscillator of the mobile unit **1200**, 125 a local oscillator frequency adjusting circuit for adjusting the frequency of the local oscillator of the mobile unit **1200** using the output of the frequency offset detecting circuit **124**, 126 a single tone generating circuit provided in the base station **1100**, 127 a single tone detecting circuit for taking a single tone (a single sine wave) out of the received signal, 128 a single tone level measuring circuit for measuring a single tone reception power level, and 129 a single tone removing circuit for removing single tone components from the received signal.

The operation of the CDMA/TDD radio communication system thus structured will be described with reference to FIGS. **4** and **5**. In FIG. **5**, reference numeral 130 represents transmission-reception timing of the mobile unit **1200**, 131 a pilot signal transmitted from the base station **1100**, and 132 a single tone transmitted from the base station **1100**. In FIG. **4**, the pilot signal generating circuit **115** generates the pilot signal that has a constant transmission power level and is known in the mobile unit **1200**. This pilot signal is transmitted toward the mobile unit **1200** on the transmission line **5** in a bursting manner through at least one spreading channel together with the first transmission data **11** spread by the data channel spreading circuit **3** after being spread by the pilot channel spreading circuit **116**. The pilot signal transmitted from the base station **1100** through the transmission line **5** is transmitted in the time slot that the mobile unit **1200** performs reception as shown in FIG. **5**, and the mobile unit **1200**, after removing the single tone first by the single tone removing circuit **129** from the signal received in this time slot, obtains the second received data **13** by spreading the data signal by the data channel despreading circuit **6** and obtains the received pilot signal by spreading the data signal by the pilot channel despreading circuit **118**. The reception power of the received pilot signal is measured by the pilot signal reception level measuring circuit **119**, and the received power of the second received data **13** is measured by the data signal reception level measuring circuit **7**. The quality of the second received data **13** is measured by the data quality measuring circuit **120**. Then, the transmission power in the power amplification circuit **10** when the second transmitted data **14** are spread by the spreading circuit **9** and transmitted to the base station **1100** is controlled by the transmission power control circuit **8** taking not only the reception levels of the received pilot signal and the second received data **13**, but also the quality of the data channel into consideration. Otherwise, control is made based on the reception level of the received pilot signal and the data quality only. The data transmitted from the mobile unit **1200** to the base station **1100** through the transmission line **5** are despread by means of the despreading circuit **4** to obtain the first received data **12**.

On the other hand, a single tone **132** such as shown in FIG. **5** is always transmitted from the single tone generating circuit **126** in the base station **1100**, and the mobile unit **1200** can follow even a sudden change in a transmission line state such as shadowing even in the time slot for performing transmission by monitoring the state of the transmission line **5** from this single tone. Namely, the single tone transmitted from the base station **1100** is detected by the single tone detecting circuit **127** of the mobile unit **1200** and the reception level thereof is measured by the single tone level measuring circuit **128**, and the transmission power control circuit **8** controls the transmission power in the transmission power amplification circuit **10** taking the reception level of the measured single tone, the reception level of the received pilot signal described above, the reception level of the data signal and/or the data quality into consideration.

Further, since the pilot signal is known in the mobile unit **1200**, it is possible to perform the synchronization acquisition and synchronization holding of the spread signal by the synchronization acquisition circuit **121** and the synchronization holding circuit **122**, the detection of the phase of the carrier wave by the phase detecting circuit **123**, the detection of frequency offset in the local oscillator by the frequency offset detecting circuit **124**, and the adjustment for compensating for the shift of the carrier frequency attendant upon the Doppler effect from the frequency offset detected by the local oscillator frequency adjusting circuit **125** using the received pilot signal.

Furthermore, in the base station **1100**, the pilot signal transmission level setting circuit **117** can lower the relative level of interference by another spreading channel in the received pilot signal by making the transmission power level of the pilot signal higher than the signal level of other spreading channels. With this, it is possible to improve precision of the transmission power control, the synchronization acquisition, the synchronization holding, the phase detection, the frequency offset detection and the local oscillator frequency adjustment described above.

Further, although an optional data sequence is assumed for the pilot signal generated by the pilot signal generating circuit **115** of the base station **1100**, the pilot signal may also be formed of the data sequence of all "1's" or "0's". In this case, the circuit configurations of the pilot signal generating circuit **115**, the pilot signal reception level measuring circuit **119**, the synchronization acquisition circuit **121**, the synchronization holding circuit **122**, the phase detecting circuit **123**, the frequency offset detecting circuit **124** and the local oscillator frequency adjusting circuit **125** become simple, so that it is possible to curtail the circuit scale.

As described above, according to the second embodiment, it is possible to estimate the attenuation of the transmission line **5** accurately because the transmission power level of the pilot signal transmitted from the base station **1100** toward respective mobile units **1200** is constant and the pilot signal is known in the mobile units **1200**, and, even when Rayleigh fading is generated and the attenuation of the transmission line **5** is changed suddenly attendant upon movement of the mobile unit **1200**, such matters can be followed by the pilot signal. Further, since the single tone having a constant transmission power level and a single frequency is always transmitted from the base station **1100** toward the respective mobile units **1200**, respective mobile units **1200** are able to monitor the state of the transmission line **5** also in the time slot for performing transmission and to follow a sudden state change of the transmission line such as shadowing.

We claim:

1. A code-division multiple access/time division duplex radio communication system comprising a base station and one or more mobile units, wherein:

said base station comprises:

pilot signal generating means for generating a pilot signal which has a constant transmission power level and which has contents that are previously known in said one or more mobile units;

pilot signal spreading means for spreading said pilot signal in accordance with spreading codes to generate a spread pilot signal; and

pilot signal transmitting means for transmitting said spread pilot signal in a bursting manner to said one or more mobile units; and each of said mobile units comprises:

pilot signal despreading means for despreading said spread pilot signal to obtain said pilot signal;

pilot signal level measuring means for measuring a reception power of said pilot signal obtained by said despreading means; and

transmission power control means for controlling a transmission power based on the measured reception power of said pilot signal obtained by said despreading means.

[2. A radio communication system according to claim **1**, wherein each of said mobile units further comprises synchronization acquisition means for acquiring synchronization of the spreading codes by the spread pilot signal transmitted from said base station.]

[3. A radio communication system according to claim **1**, wherein each of said mobile units further comprises synchronization holding means for holding synchronization of said spreading codes by the spread pilot signal transmitted from said base station.]

[4. A radio communication system according to claim **1**, wherein each of said mobile units further comprises:

phase detecting means for obtaining a phase of a carrier wave by the spread pilot signal transmitted from said base station; and

despreading means for demodulating data utilizing an output of said phase detecting means.]

[5. A radio communication system according to claim **1**, wherein each of said mobile units further comprises:

a local oscillator;

frequency offset detecting means for obtaining an offset of a carrier frequency in said local oscillator based on the spread pilot signal transmitted from said base station; and

frequency adjusting means for adjusting a frequency of the local oscillator using an output of said frequency offset detecting means.]

[6. A radio communication according to claim **1**, wherein each of said mobile units further comprises:

synchronization acquisition means for acquiring synchronization of the spreading codes by the spread pilot signal transmitted from said base station;

synchronization holding means for holding synchronization of the spreading codes by the spread pilot signal transmitted from said base station;

phase detection means for obtaining a phase of a carrier wave by the spread pilot signal transmitted from said base station;

despreading means for demodulating data utilizing an output of said phase detection means;

frequency offset detection means for obtaining an offset of a carrier frequency in a local oscillator of said mobile unit based on the spread pilot signal transmitted from said base station; and

frequency adjusting means for adjusting a frequency of the local oscillator of said mobile unit using an output of said frequency offset detection means.]

[7. A radio communication system according to any one of claim **1** to claim **6**, wherein an output of said pilot signal generating means is a data sequence of all "1's" or a data sequence of all "0's".]

[8. A radio communication system according to any of claim **1** to claim **6**, wherein said base station further comprises pilot signal transmission level setting means for setting a transmission power of the pilot signal, which is to be transmitted, larger than a transmission power of a signal of another spreading channel.]

[9. A radio communication system according to claim **8**, wherein an output of said pilot signal generating means is a data sequence of all "1's" or data sequence of all "0's".]

[10. A radio communication system according to claim **1**, wherein:

each of said mobile units further comprises data signal level measuring means for measuring a reception power of a data signal transmitted thereto; and

said transmission power control means controls the transmission power based on outputs of said pilot signal level measuring means and said data signal level measuring means.]

[11. A radio communication system according to claim **10**, wherein each of said mobile units further comprises:

synchronization acquisition means for acquiring synchronization of the spreading codes by the spread pilot signal transmitted from said base station;

synchronization holding means for holding synchronization of the spreading codes by the spread pilot signal transmitted from said base station;

phase detection means for obtaining a phase of a carrier wave by the spread pilot signal transmitted from said base station;

despreading means for demodulating data utilizing an output of said phase detection means;

a local oscillator;

frequency offset detection means for obtaining an offset of a carrier frequency in said local oscillator based on the spread pilot signal transmitted from said base station; and

frequency adjusting means for adjusting a frequency of the local oscillator using an output of said frequency offset detection means.]

[12. A radio communication system according to claim **10** or claim **11**, wherein an output of said pilot signal generating means is a data sequence of all "1's" or a data sequence of all "0's".]

[13. A radio communication system according to claim **1**, wherein:

each of said mobile units further comprises data quality measuring means for measuring a quality of received data; and

said transmission power control means controls the transmission power based on outputs of said pilot signal level measuring means and said data quality measuring means.]

[14. A radio communication system according to claim **13**, wherein each of said mobile units further comprises:

synchronization acquisition means for acquiring synchronization of said spreading codes by the spread pilot signal transmitted from said base station;

synchronization holding means for holding synchronization of said spreading codes by the spread pilot signal transmitted from said base station;

phase detection means for obtaining a phase of a carrier wave by the spread pilot signal transmitted from said base station;

despreading means for demodulating data utilizing an output of said phase detection means;

a local oscillator;

frequency offset detection means for obtaining an offset of a carrier frequency in said local oscillator based on the spread pilot signal transmitted from said base station; and frequency adjusting means for adjusting a frequency of the local oscillator using an output of said frequency offset detection means.]

[15. A radio communication system according to claim **13** or claim **14**, wherein an output of said pilot signal generating means is a data sequence of all "1's" or a data sequence of all "0's".]

[16. A radio communication system according to claim **1**, wherein:

each of said mobile units further comprises data signal level measuring means for measuring a reception power of a data signal transmitted thereto and data quality measuring means for measuring a quality of received data; and

said transmission power control means controls the transmission power based on outputs of said pilot signal level measuring means, said data signal level measuring means and said data quality measuring means.]

[17. A radio communication system according to claim **16**, wherein each of said mobile units further comprises:

synchronization acquisition means for acquiring synchronization of said spreading codes by the spread pilot signal transmitted from said base station;

synchronization holding means for holding synchronization of said spreading codes by the spread pilot signal transmitted from said base station;

phase detection means for obtaining a phase of a carrier wave by the spread pilot signal transmitted from said base station;

despreading means for demodulating data utilizing an output of said phase detection means;

a local oscillator;

frequency offset detection means for obtaining an offset of a carrier frequency in said local oscillator based on the spread pilot signal transmitted from said base station; and

frequency adjusting means for adjusting a frequency of the local oscillator using an output of said frequency offset detection means.]

[18. A radio communication system according to claim **16** or claim **17**, wherein an output of said pilot signal generating means is a data sequence of all "1's" or a data sequence of all "0's".]

[19. A radio communication system according to claim **1**, wherein:

said base station further comprises single tone transmission means for transmitting a single tone having a constant transmission power level and a single frequency to said mobile units;

each of said mobile units further comprises single tone level measuring means for measuring a reception power of said single tone; and

said transmission power control means controls the transmission power based on outputs of said pilot signal level measuring means and said single tone level measuring means.]

[20. A radio communication system according to claim **19**, wherein each of said mobile units further comprises synchronization acquisition means for acquiring synchronization of said spreading codes by the spread pilot signal transmitted from said base station.]

[21. A radio communication system according to claim **19**, wherein each of said mobile units further comprises synchronization holding means for holding synchronization of said spreading codes by the spread pilot signal transmitted from said base station.]

[22. A radio communication system according to claim **19**, wherein each of said mobile units further comprises:

phase detection means for obtaining a phase of a carrier wave by the spread pilot signal transmitted from said base station; and

despreading means for demodulating data utilizing an output of said phase detection means.]

[23. A radio communication system according to claim **19**, wherein each of said mobile units further comprises:

a local oscillator;

frequency offset detection means for obtaining an offset of a carrier frequency in said local oscillator based on the spread pilot signal transmitted from said base station; and

frequency adjusting means for adjusting a frequency of the local oscillator using an output of said frequency offset detection means.]

[24. A radio communication system according to claim **19**, wherein each of said mobile units further comprises:

synchronization acquisition means for acquiring synchronization of the spreading codes by the spread pilot signal transmitted from said base station;

synchronization holding means for holding synchronization of the spreading codes by the spread pilot transmitted from said base station;

phase detection means for obtaining a phase of a carrier wave by the spread pilot signal transmitted from said base station;

despreading means for demodulating data utilizing an output of said phase detection means;

a local oscillator;

frequency offset detection means for obtaining an offset of a carrier frequency in said local oscillator based on the spread pilot signal transmitted from said base station; and

frequency adjusting means for adjusting a frequency of the local oscillator using an output of said frequency offset detection means.]

[25. A radio communication system according to any one of claim **19** or claim **24**, wherein an output of said pilot signal generating means is a data sequence of all "1's" or a data sequence of all "0's".]

[26. A radio communication system according to any of claim **19** to claim **24**, wherein said base station further comprises pilot signal transmission level setting means for setting a transmission power of the pilot signal, which is to be transmitted, larger than a transmission power of a signal of another spreading channel.]

[27. A radio communication system according to claim **8**, wherein an output of said pilot signal generating means is a data sequence of all "1's" or data sequence of all "0's".]

[28. A radio communication system according to claim **10**, wherein:

said base station further comprises single tone transmission means for transmitting a single tone having a constant transmission power level and a single frequency to said mobile units;

each of said mobile units further comprises single tone level measuring means for measuring a reception power of said single tone; and

said transmission power control means controls the transmission power based on outputs of said pilot signal level measuring means, said data signal level measuring means and said single tone level measuring means.]

[29. A radio communication system according to claim **28**, wherein each of said mobile units further comprises:

synchronization acquisition means for acquiring synchronization of said spreading codes by the spread pilot signal transmitted from said base station;

synchronization holding means for holding synchronization of said spreading codes by the spread pilot signal transmitted from said base station;

phase detection means for obtaining a phase of a carrier wave by the pilot signal transmitted from said base station;

despreading means for demodulating data utilizing an output of said phase detection means;

a local oscillator;

frequency offset detection means for obtaining an offset of a carrier frequency in said local oscillator based on the spread pilot signal transmitted from said base station; and

frequency adjusting means for adjusting a frequency of the local oscillator using an output of said frequency offset detection means.]

[30. A radio communication system according to claim **28** or claim **29**, wherein an output of said pilot signal generating means is a data sequence of all "1's" or a data sequence of all "0's".]

[31. A radio communication system according to claim **13**, wherein:

said base station further comprises single tone transmission means for transmitting a single tone having a constant transmission power level and a single frequency to said mobile units;

each of said mobile units further comprises single tone level measuring means for measuring a reception power of said single tone; and

said transmission power control means controls the transmission power based on outputs of said pilot signal level measuring means, said data quality measuring means and said single tone level measuring means.]

[32. A radio communication system according to claim **31**, wherein each of said mobile units further comprises:

synchronization acquisition means for acquiring synchronization of the spreading codes by the spread pilot signal transmitted from said base station;

synchronization holding means for holding synchronization of said spreading codes by the spread pilot signal transmitted from said base station;

phase detection means for obtaining a phase of a carrier wave by the spread pilot signal transmitted from said base station;

despreading means for demodulating data utilizing an output of said phase detection means;

a local oscillator;

frequency offset detection means for obtaining an offset of a carrier frequency in said local oscillator based on the spread pilot signal transmitted from said base station; and

frequency adjusting means for adjusting a frequency of the local oscillator using an output of said frequency offset detection means.]

[33. A radio communication system according to claim **31** or claim **32**, wherein an output of said pilot signal generating means is a data sequence of all "1's" or a data sequence of all "0's".]

[34. A radio communication system according to claim **16**, wherein:

said base station further comprises single tone transmission means for transmitting a single tone having a constant transmission power level and a single frequency to said mobile units;

each of said mobile units further comprises single tone level measuring means for measuring a reception power of said single tone; and

said transmission power control means controls the transmission power based on outputs of said pilot signal level measuring means, said data single level measuring means, said data quality measuring means and said single tone level measuring means.]

[35. A radio communication system according to claim **34**, wherein each of said mobile units further comprises:

synchronization acquisition means for acquiring synchronization of said spreading codes by the spread pilot signal transmitted from said base station;

synchronization holding means for holding synchronization of said spreading codes by the spread pilot signal transmitted from said base station;

phase detection means for obtaining a phase of a carrier wave by the spread pilot signal transmitted from said base station;

despreading means for demodulating data utilizing an output of said phase detection means;

a local oscillator;

frequency offset detection means for obtaining an offset of a carrier frequency in said local oscillator based on the spread pilot signal transmitted from said base station; and

frequency adjusting means for adjusting a frequency of the local oscillator using an output of said frequency offset detection means.]

[36. A CDMA/TDD radio communication system according to claim **34** or claim **35**, wherein an output of said pilot signal generating means is a data sequence of all "1's" or a data sequence of all "0's".]

37. A code division multiple access/time division duplex radio communication system comprising a base station and, a mobile unit, wherein:

said base station comprises means for transmitting a data signal and a pilot signal, which has a constant transmission power level, to said mobile unit through at least one spreading channel; and

said mobile unit comprises means for controlling transmission power based on a reception power of said pilot signal and a reception power of said data signal transmitted to said mobile unit.

38. A code division multiple access/time division duplex radio communication system comprising a base station and a mobile unit, wherein:

said base station comprises means for transmitting a pilot signal, which has a constant transmission power level, to said mobile unit through at least one spreading channel; and

said mobile unit comprises means for controlling transmission power based on (i) a reception power of said pilot signal and (ii) a quality of received data, said quality being determined by measuring an error rate comprising at least one of a bit error rate and a frame error rate.

39. A code division multiple access/time division duplex radio communication system comprising a base station and a mobile unit, wherein:

said base station comprises means for transmitting a data signal and a pilot signal, which has a constant trans-

mission power level, to said mobile unit through at least one spreading channel; and

said mobile unit comprises means for controlling transmission power based on (i) a reception power of said pilot signal, (ii) a reception power of said data signal transmitted to said mobile unit and (iii) a quality of received data, said quality being determined by measuring an error rate comprising at least one of a bit error rate and a frame error rate.

40. A code division multiple access/time division duplex mobile unit comprising:

means for determining a reception power of a pilot signal which is transmitted from a base station at a constant level and a reception power of a data signal which is transmitted from said base station; and

means for controlling transmission power based on said determined reception power of said pilot signal and said determined reception power of said data signal.

41. A code division multiple access/time division duplex mobile unit comprising:

means for determining a reception power of a pilot signal which is transmitted from a base station at a constant level, a reception power of a data signal which is transmitted from said base station, and a quality of received data transmitted from said base station, said quality being determined by measuring an error rate comprising at least one of a bit error rate and a frame error rate; and

means for controlling transmission power based on said determined reception power of said pilot signal, said determined reception power of said data signal, and said determined quality of said received data.

42. A mobile unit according to claim 40 or 41 further comprising synchronization acquisition means for acquiring synchronization of a spreading signal by said pilot signal transmitted from said base station.

43. A mobile unit according to claim 40 or 41 further comprising synchronization holding means for holding synchronization of a spreading signal by said pilot signal transmitted from said base station.

44. A mobile unit according to claim 40 or 41 further comprising:

phase detecting means for obtaining a phase of a carrier wave by said pilot signal transmitted from said base station; and

despreading means for demodulating data utilizing an output of said phase detecting means.

45. A mobile unit according to claim 40 or 41 further comprising:

frequency offset detecting means for obtaining an offset of a carrier frequency in a local oscillator of said mobile unit by said pilot signal transmitted from said base station; and

frequency adjusting means for adjusting a frequency of said local oscillator of said mobile unit using an output of said frequency offset detecting means.

46. A code division multiple access/time division duplex base station comprising:

means for generating a pilot signal which has a constant transmission power level and which has contents that are previously known in a mobile unit; and

means for transmitting said pilot signal in a burst manner through at least one spreading channel.

47. A base station according to claim 46 further comprising pilot signal transmission level setting means for setting a transmission power of said pilot signal, which is to be transmitted, larger than a transmission power of a signal of another spreading channel.

48. A base station according to claim 46 or 47 wherein an output of said means for generating a pilot signal is a data sequence of all "1's" or a data sequence of all "0's".

49. A code division multiple access/time division duplex radio communication method between a base station and a mobile unit comprising the steps of:

transmitting, in said base station, a data signal and a pilot signal through at least one spreading channel, said pilot signal having a constant transmission power level; and

controlling, in said mobile unit, transmission power based on a reception power of said pilot signal and a reception power of said data signal transmitted from said base station.

50. A code division multiple access/time division duplex radio communication method between a base station and a mobile unit, comprising the steps of:

transmitting, in said base station, a pilot signal through at least one spreading channel, said pilot signal having a constant transmission power level; and

controlling, in said mobile unit, transmission power based on a reception power of said pilot signal and a quality of received data, said quality being determined by measuring an error rate comprising at least one of a bit error rate and a frame error rate.

51. A code division multiple access/time division duplex radio communication method between a base station and a mobile unit, comprising the steps of:

transmitting, in said base station, a data signal and a pilot signal through at least one spreading channel, said pilot signal having a constant transmission power level; and

controlling, in said mobile unit, transmission power based on a reception power of said pilot signal, a reception power of said data signal transmitted from said base station, and a quality of received data, said quality being determined by measuring an error rate comprising at least one of a bit error rate and a frame error rate.

* * * * *