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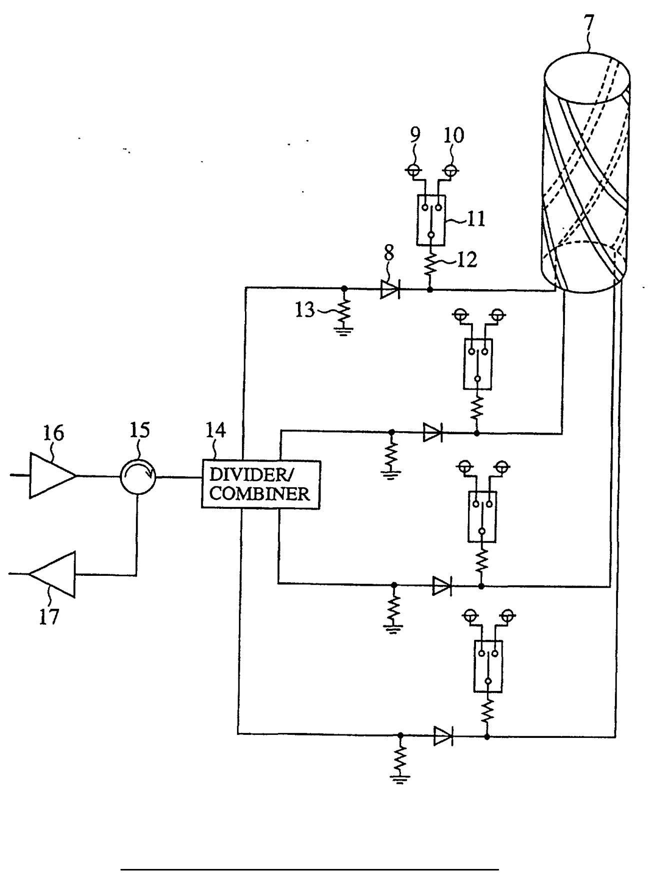
(54) TRANSMITTING AND RECEIVING ANTENNA

(57) The present invention pertains to a transmitting-receiving shared antenna that is used in portable terminals for satellite communication and terrestrial communication. A varactor diode is provided in the feeder to each antenna element of a helical antenna. A transmitting-receiving shared antenna device is obtained in which the bias voltage to be applied to each varactor diode is switched between transmission and reception to thereby change the electrical length of the antenna, permitting resonance at transmitting and receiving frequencies.

FIG.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a transmitting-receiving shared antenna device that is used in a portable terminal for satellite communication and terrestrial communication.

BACKGROUND ART

[0002] Fig. 4 depicts a conventional transmitting-receiving antenna device for portable terminal use. In Fig. 4, reference numeral 1 denotes a four-wire transmitting helical antenna which provides circular polarization, and 2 a four-wire receiving helical antenna which also provides circular polarization. Reference numeral 3 denotes a divider for feeding to the transmitting helical antenna 1, and 4 a transmitter formed by a high output amplifier or the like which outputs a transmission signal. Reference numeral 5 denotes a combiner for combining signals received by the receiving helical antenna 2, and 6 a receiver formed by a low noise amplifier or the like.

[0003] A description will be given of the transmitting-receiving operation by the conventional transmitting-receiving antenna device. The transmission signal of the transmitting system is subjected to operations for the removal of unwanted waves and high output amplification in the transmitter 4, thereafter being input to the divider 3. This transmission signal is divided by a delay operation of the divider 3 to four signals of phase differences 0°, 90°, 180° and 270°, which are input to the four-wire transmitting helical antenna 1. Now, let it be assumed that the line lengths of four feeders from four output ends of the divider 3 to the transmitting helical antenna 1 are the same and that respective antenna elements of the transmitting helical antenna 1 have the same line length. Letting the wavelength of the transmission wave be represented by λ_1, the lengths of the respective antenna elements are each set to any one of $\lambda_1/4$, $3\lambda_1/4$, ..., by which the antenna elements are allowed to resonate at a transmitting frequency and hence transmit circularly polarized wave signals of the above-mentioned phases. And the combiner 5 in the receiving system combines circularly polarized wave signals received by the four wires of the receiving helical antenna 2 with the phase differences 0°, 90°, 180° and 270°. Letting the wavelength of the received wave be represented by λ_2, the lengths of the respective antenna elements of the receiving helical antenna 2 are each set to any one of $\lambda_2/4$, $3\lambda_2/4$, ..., by which the antenna. elements are allowed to resonate at a receiving frequency and hence receive circularly polarized wave signals of the above-mentioned phase differences.

[0004] When the transmitting and receiving frequencies are different from but close each other, it is possible to construct a transmitting and receiving shared helical antenna which has a gain in a band common to both of the transmission and reception. However, when the transmitting and receiving frequencies are apart from each other or when it is desirable to optimize the gain in transmission and reception, it is necessary to use two different helical antennas for transmission and reception and set the lengths of antenna elements of each helical antenna to physical sizes that match the transmitting or receiving frequency.

[0005] Nowadays various terrestrial cellular telecommunication systems and satellite-portable telephone systems using artificial satellites have been developed, and a dual mode or multi mode portable terminal has also been developed which is capable of communicating with plural communication services. The frequencies of radio waves for transmission and reception by portable terminals are determined for each communication system; for example, in the case of a portable terminal for transmission to and reception from two communication systems, it is necessary to use antennas corresponding to four frequencies for transmission and reception.

[0006] As described above, in the case of the conventional antenna device for portable terminal use, when the transmitting and receiving frequencies are not close to each other or when the antenna gain is optimized, it is necessary to provide helical antennas for transmission and reception, respectively--this gives rise to the problem of the portable terminal becoming bulky. Furthermore, the portable terminal for transmission to and reception from plural communication systems also requires plural helical antennas for communication, raising the same problem that the portable terminal becomes inevitably bulky.

[0007] The present invention is intended to solve the above-mentioned problems and provide a transmitting-receiving shared antenna device for portable terminals which is formed by a helical antenna for use in common to plural radio waves of different frequencies.

DSICLOSURE OF THE INVENTION

[0008] A transmitting-receiving shared antenna device according to an aspect of the present invention comprises: a helical antenna for use in common to transmission and reception; varactor diodes each provided in one of feeders to antenna elements of the helical antenna; and bias voltage switching means for switching a reverse bias voltage to be applied to the varactor diode between transmission and reception to switch between frequency bands of signals for transmission and reception by the helical antenna. Accordingly, it is possible to switch between resonance frequencies of the helical antenna for transmission and reception, providing enhanced frequency characteristics of the antenna during transmission and reception.

[0009] The varactor diode has its cathode side connected to the antenna element side of the helical antenna, and the bias voltage switching means may be one that applies the reverse bias voltage via a resistor connected to the cathode side of the varactor diode. With this construction, the resistor interposed between the feeder and the voltage input terminal increases the impedance of the voltage input terminal side, permitting reduction of losses of transmission and received signals that propagate through the feeder.

[0010] Furthermore, the varactor diode has its cathode side connected to the antenna element side of the helical antenna, and the bias voltage switching means may be one that applies the reverse bias voltage via a coil connected to the cathode side of the varactor diode. With this construction, the coil interposed between the feeder and the voltage input terminal allows matching between the voltage input terminal side and the helical antenna, permitting reduction of losses of transmission and received signals that propagate through the feeder.

[0011] A transmitting-receiving shared antenna device according to another aspect of the present invention comprises: a four-wire helical antenna for use in common to transmission and reception of circularly polarized wave signals; a divider/combiner for generating four signals divided from a transmission signal, for phasing the four divided signal apart by a first delay line, and for combining received signals from the helical antenna via a second delay line; varactor diodes each provided between the helical antenna and the divider/combiner; and bias voltage switching means for switching a reverse bias voltage to be applied to the varactor diode between transmission and reception to switch between frequency bands of signals for transmission and reception by the helical antenna. Accordingly, for the helical antenna that is used in common to transmission and reception of circularly polarized wave signals, too, it is possible to switch the resonance frequencies between transmission and reception, providing enhanced frequency characteristics of the antenna during transmission and reception.

[0012] A transmitting-receiving shared antenna device according to another aspect of the present invention comprises: a four-wire helical antenna for use in common to transmission and reception of circularly polarized wave signals; a divider/combiner for generating four signals divided from a transmission signal, for phasing the four divided signal apart by a delay line, and for combining received signals from the helical antenna via the delay line; four varactor diodes each provided between one of antenna elements of the helical antenna and the divider/combiner; and bias voltage switching means for switching a reverse bias voltage to be applied to the varactor diode between transmission and reception to switch between frequency bands of signals for transmission and reception by the helical antenna. Accordingly, for the helical antenna that is used in common to transmission and reception of circularly polarized wave signals, too, it is possible to switch the resonance frequencies between transmission and reception, providing enhanced frequency characteristics of the antenna during transmission and reception.

[0013] A transmitting-receiving shared antenna device according to still another aspect of the present invention comprises: a helical antenna for use in common to transmission and reception; varactor diodes each provided between one of feeders to antenna elements of the helical antenna and a grounding point; and bias voltage switching means for switching a reverse bias voltage to be applied to the varactor diode between transmission and reception to switch between frequency bands of signals for transmission and reception by the helical antenna. Accordingly, it is possible to switch between resonance frequencies of the antenna for transmission and reception by matching between the varactor diodes and the helical antenna, providing enhanced frequency characteristics of the antenna during transmission and reception.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a block diagram illustrating the configuration of the transmitting-receiving shared antenna device according to the present invention (Embodiment 1).

Fig. 2 is a block diagram illustrating the configuration of the. transmitting-receiving shared antenna device according to the present invention (Embodiment 2).

Fig. 3 is a block diagram illustrating the configuration of the transmitting-receiving shared antenna device according to the present invention (Embodiment 3).

Fig. 4 is a block diagram showing the configuration of a conventional antenna device.

BEST MODE FOR CARRYING OUT THE INVENTION

EMBODIMENT 1

[0015] Fig. 1 is a block diagram depicting the configuration of the transmitting-receiving shared antenna device according to Embodiment 1 of the present invention. Reference numeral 7 denotes a helical antenna shared between transmission and reception, and 8 a varactor diode set on each feeder to the helical antenna 7. The varactor diode 8 is set for each antenna element of the helical antenna 7 and is series-connected with its cathode on the side of the antenna element. Reference numeral 9 denotes a first voltage input terminal, 10 a second voltage input terminal, and 11 a switch for switching between the voltage input terminals 9 and 10. Reference numeral 12 denotes a resistor connected to the cathode side of the varactor diode 8, the resistor being connected at the other end to the switch 11. Reference numeral 14 denotes a divider/combiner for feeding to the helical antenna 7, 15 a circulator, 16 a transmitter formed by a high output amplifier or the like, and 17 a receiver formed by a low noise amplifier or the like.

[0016] A transmission signal is subjected to the removal of unwanted waves and high output amplification, and input to the divider/combiner 14 via the circulator 15. The circulator 15 prevents the transmission signal from. sneaking in the receiver 17. The transmission signal is divided by the divider/combiner 14 to a required of feeding signals according to the number of antenna elements of the helical antenna 7, and they are fed via feeders to the helical antenna 7. Fig. 1 shows the case where the transmission signal is divided to four signals. On the other hand, received signal from the helical antenna 7 are combined by the divider/combiner 14, then the combined signal is provided via the circulator 15 to the receiver 17, wherein it is subjected to low noise amplification or the like, and the amplified signal is input to a signal processing part or the like not shown. The circulator 15 prevents the received signal from sneaking in the transmitter 16.

[0017] The transmission signals divided by the divider/combiner 14 are fed via the varactor diodes 8 to the respective antenna elements of the helical antenna 7. Across the anode and cathode of each varactor diode 8 is applied a reverse bias voltage from the voltage input terminal 9 or 10 via the switch 11. The condenser capacitance of the varactor diode 8 varies with the value of this reverse bias voltage. The resonance frequency of the helical antenna 7 is dependent on the condenser capacitance of the varactor diode 8 and the electrical length of each antenna element of the helical antenna 7, and accordingly, the resonance frequency varies as the condenser capacitance varies. By setting different voltages to be applied from the voltage input terminals 9 and 10 and switching between them by the switch 11, it is possible to construct an antenna that resonates to different frequencies for transmission and reception. The switch 11 is so actuated, for example, as to apply therethrough a reverse bias voltage from the voltage input terminal 9 to the varactor diode 8 during a transmission gate period and a reverse bias voltage from the voltage input terminal 10 to the varactor diode 8 during a receiving gate period. At the time of reception, too, the resonance frequency for reception by the antenna is dependent on the reverse bias voltage applied across the anode and cathode of the varactor diode 8 from the voltage input terminal 10 as in the case of transmission. The signals received by the helical antenna 7 are combined by the divider/combiner 14, thereafter being input via the circulator 15 to the receiver 17.

[0018] In this example, the resistor 12 is used to supply the reverse bias voltage to the varactor diode 8 and provide impedance sufficiently higher than that of the transmission line to reduce signal losses. The resistor 13 is used to ground the anode side of the varactor diode 8 to provide a potential difference between its anode and cathode and provide impedance sufficiently higher than that of the transmission line to reduce signal losses.

[0019] While in Fig. 1 the resistors 12 and 13 are used in the voltage supply circuit for applying the reverse bias voltage to the varactor diode 8, they may be replaced with coils. With the use of coils, it is possible to provide matching between the voltage supply circuit for the bias application and the anode grounding circuit and each antenna element of the helical antenna, permitting enhancement of the antenna radiation efficiency. The voltage supply circuit mentioned herein is a circuit composed of the voltage input terminals 9 and 10, the switch 11 and the resistor 12, and the anode grounding circuit is a circuit formed by the resistor 13.

[0020] Incidentally, Fig. 1 shows the case in which the helical antenna 7 is four-wire one, and even if this helical antenna 7 is a two-wire one, this embodiment can similarly be constructed by the above-described circuitry. The use of the two-wire helical antenna decreases the number of antenna elements, and hence decreases the number of varactor diodes 8 connected to the antenna elements, permitting miniaturization of the antenna device.

EMBODIMENT 2

[0021] Fig. 2 is a block diagram illustrating the configuration of a transmitting-receiving shared antenna device according to Embodiment 2 of the present invention. In Fig. 2, reference numeral 18 a divider/combiner containing built-in delay circuits, which is shown to have a delay circuit for producing signals of phases 0°, 90°, 180° and 270°. The other circuits identified by the same reference numerals as those in Fig. 1 are the same or corresponding circuits or parts in Embodiment 1 of Fig. 1.

[0022] This embodiment is characterized in that, as described above, the transmission signal to be fed to the helical antenna 7 is divided by the divider/combiner 18 to four signals of the phase differences 0°, 90°, 180° and 270° to generate circularly polarized waves. And this embodiment is further characterized in that the received signals are combined by the divider/combiner 18 provided with the delay circuits that provides the above-mentioned phase differences. In the case of using different frequencies for transmission and reception, when the divider/combiner 18 has circuits which provide such phase differences, for example, when the delay circuits are provided according to the frequencies for transmission, the signals to be combined do not become in-phase because their frequencies differ from those for transmission--this causes a phase error in the received signal.

[0023] In the helical antenna device of the type transmitting and receiving circularly polarized wave signal, the phase error in the transmission and reception due to the delay circuits could be reduced by separately providing in the divider/combiner 18 delay lines for the passage therethrough of the transmission signal and delay lines for the passage therethrough of the received signal. Such a configuration inevitably makes bulky the delay circuit in the divider/combiner 18, but solves the problem of phase error.

[0024] Further, in the case of sharing the delay lines for the passage of the transmission and received signals with a view to preventing the delay circuit in the divider/combiner 18 from becoming bulky, the phase error between the transmission and received signals can be reduced by applying a different reverse bias voltage to the varactor diode 8 for each antenna element. The delay circuit in the divider/combiner 18 is shared between the transmission and reception, and is formed by delay lines which provide phase differences 0°, 90°, 180° and 270° for either one of the transmission and received signals, for example, for the transmission signal. Accordingly, when the received signals combined using these delay lines are not in phase because the frequencies of the transmission and received signals differ. To correct the phase shift, the reverse bias voltages to be applied to the four varactor diodes corresponding to the antenna elements of the helical antenna 7 are set to different values and the condenser capacitances of the four varactor diodes 8 are chosen different. In the above example, since the delay circuit is provided so that the four phase differences are 0°, 90°, 180° and 270° during transmission, the reverse bias voltage during transmission, for example, the values at the voltage input terminals 9 are set to the same value for the four varactor diodes 8. During reception the values at the four voltage input terminals 10 to be applied to the four varactor diodes are set to different values.

[0025] When the condenser capacitances of the varactor diodes are set to different values for the respective antenna elements of the helical antenna 8, the resonance frequency somewhat shifts. This embodiment makes the shift of the resonance frequency smaller than in the case of transmitting and receiving signals of different frequencies without changing the condenser capacitances of the varactor diodes 8.

EMBODIMENT 3

[0026] Fig. 3 is a block diagram illustrating the configuration of a transmitting-receiving shared antenna according to Embodiment 3 of the present invention. In Fig. 3, reference numeral 19 denotes capacitive elements each connected in series to the feeder to the helical antenna 7. Reference numeral 20 denotes varactor diodes each connected to the feeder and the grounding point. The other circuits identified by the same reference numerals as those in Fig. 1 are the circuits or parts identical with or corresponding to those in Embodiment 1 of Fig. 1.

[0027] Across the cathode and anode of the varactor diode 20 is applied the reverse bias voltage from either of the voltage input terminals 9 and 10 via the switch 11. The condenser capacitance of the varactor diode 20 varies with the reverse bias voltage, and by matching between the condenser capacitance and each antenna element of the helical antenna 7, the resonance frequency of the antenna changes, making it possible to change the transmitting frequency or receiving frequency.

Claims

1. A transmitting-receiving shared antenna device, comprising:

> a helical antenna for use in common to transmission and reception;
> varactor diodes each provided in one of feeders to antenna elements of the helical antenna; and
> bias voltage switching means for switching a reverse bias voltage to be applied to the varactor diode between transmission and reception to switch between frequency bands of signals for transmission and reception by said helical antenna.

2. The transmitting-receiving shared antenna device according to claim 1, wherein said each varactor diode has its cathode side connected to the antenna element side of said helical antenna, and said bias voltage switching means applies the reverse bias voltage via a resistor connected to the cathode side of said varactor diode.

3. The transmitting-receiving shared antenna device according to claim 1, wherein said each varactor diode has its cathode side connected to the antenna element side of said helical antenna, and said bias voltage switching means applies the reverse bias voltage via a coil connected to the cathode side of said each varactor diode.

4. A transmitting-receiving shared antenna device, comprising:

> a four-wire helical antenna for use in common to transmission and reception of circularly polarized wave signals;
> a divider/combiner for generating four signals divided from a transmission signal, for phasing said four divided signals apart by a first delay line, and for combining received signals from said helical antenna via a second delay line;
> varactor diodes each provided between said helical antenna and said divider/combiner; and
> bias voltage switching means for switching a reverse bias voltage to be applied to the varactor diode between transmission and reception to switch between frequency bands of signals for transmission and reception by said helical antenna.

5. A transmitting-receiving shared antenna device, comprising:

a four-wire helical antenna for use in common to transmission and reception of circularly polarized wave signals;
a divider/combiner for generating four signals divided from a transmission signal, for phasing said four divided signals apart by a delay line, and for combining received signals from said helical antenna via said delay line;
four varactor diodes each provided between one of antenna elements of said helical antenna and said divider/combiner; and
bias voltage switching means for switching a reverse bias voltage to be applied to said each varactor diode between transmission and reception to switch between frequency bands of signals for transmission and reception by said helical antenna.

6. A transmitting-receiving shared antenna device, comprising:

a helical antenna for use in common to transmission and reception;
varactor diodes each provided between one of feeders to antenna elements of the helical antenna and a grounding point; and
bias voltage switching means for switching a reverse bias voltage to be applied to the varactor diode between transmission and reception to switch between frequency bands of signals for transmission and reception by said helical antenna.

FIG.1

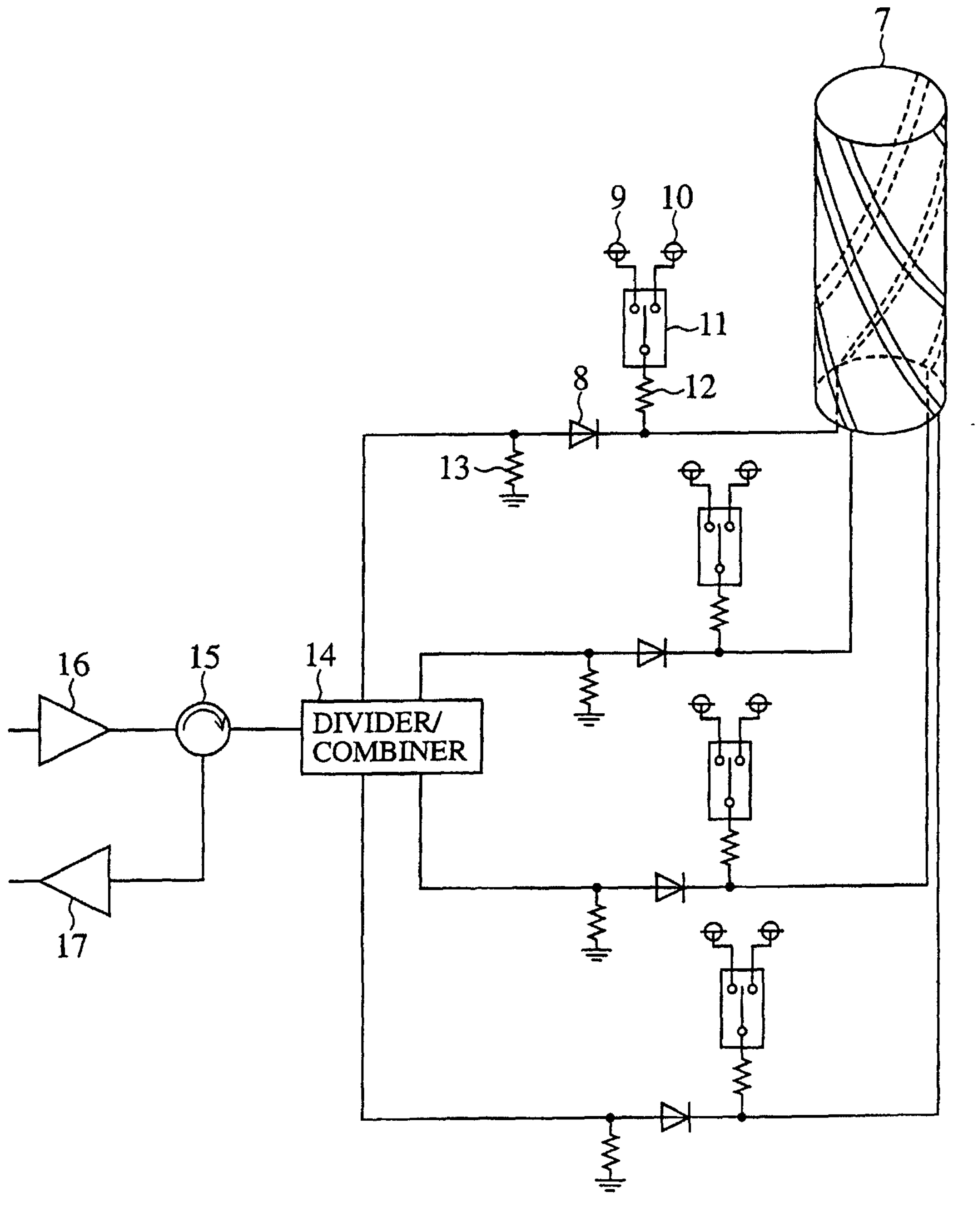


FIG.2

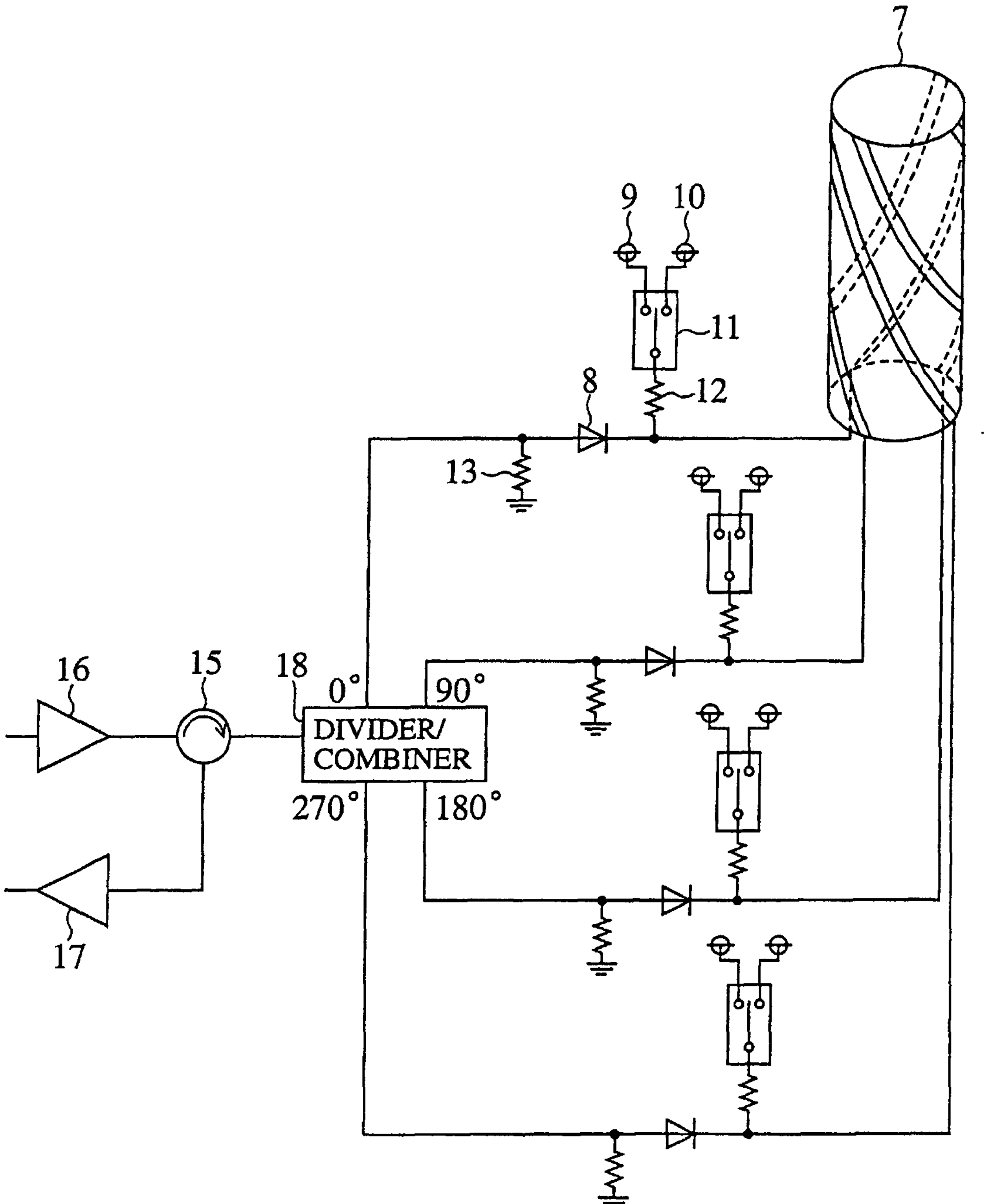


FIG.3

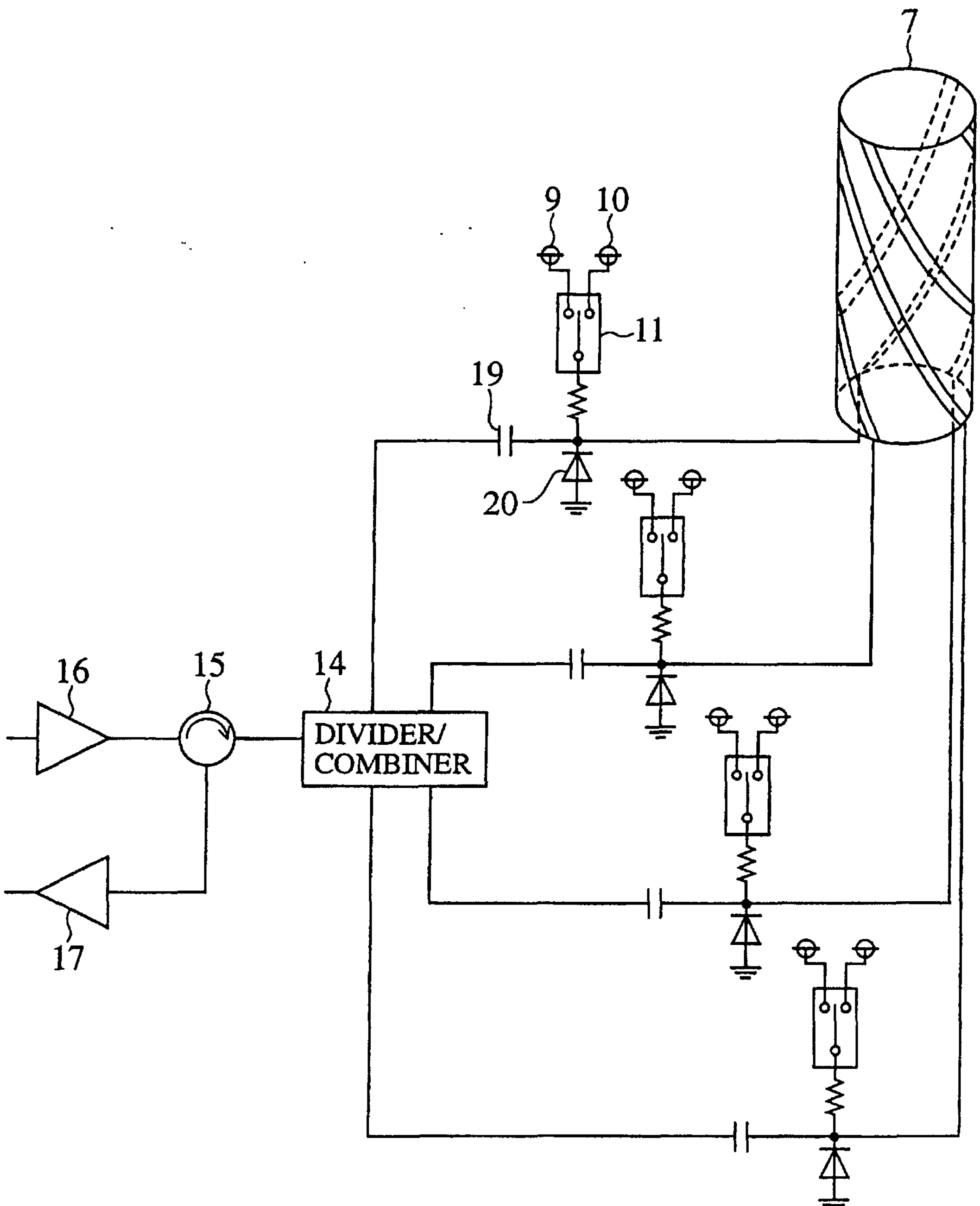
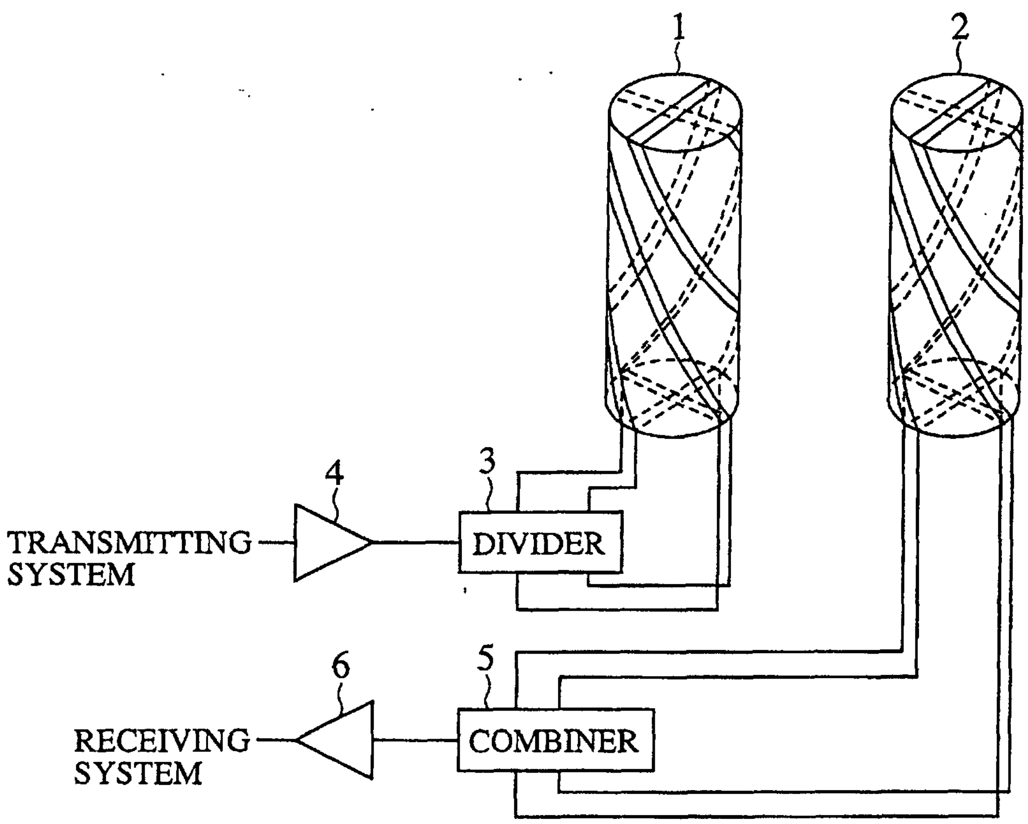


FIG.4


1
2
4
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TRANSMITTING SYSTEM
DIVIDER
6
5
RECEIVING SYSTEM
COMBINER

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/01324

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^7 H01Q11/08, H01Q5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^7 H01Q11/08, H01Q5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2000
Kokai Jitsuyo Shinan Koho 1971-2000 Jitsuyo Shinan Koho 1996-2000

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	EP, 0877442, A2 (NEC CORPORATION), 11 November, 1998 (11.11.98) & AU, 6479198, A & JP, 10-308624, A & CN, 1202745, A	
Y	Full text; all drawings	1,6
A		2-5
	CD-ROM of Japanese Utility Model Application No.84628/1991 (Laid-open No. 39016/1993) (Family: none)	
Y	Par. Nos. 3-6	1,6
A	Fig. 6	2-5
	JP, 6-268564, A (Hitachi, Ltd.), 22 September, 1994 (22.09.94) (Family: none)	
Y	Par. Nos. 7 to 10, (esp. Par. No. 10); Fig. 5	1,6
	Microfilm of Japanese Utility Model Application No. 84670/1982 (Laid-open No. 189638/1983) (Family: none)	
Y	page 4, line 14 to page 5, line 2; Fig. 6	1

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

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Date of the actual completion of the international search	Date of mailing of the international search report
27 April, 2000 (27.04.00)	16 May, 2000 (16.05.00)

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