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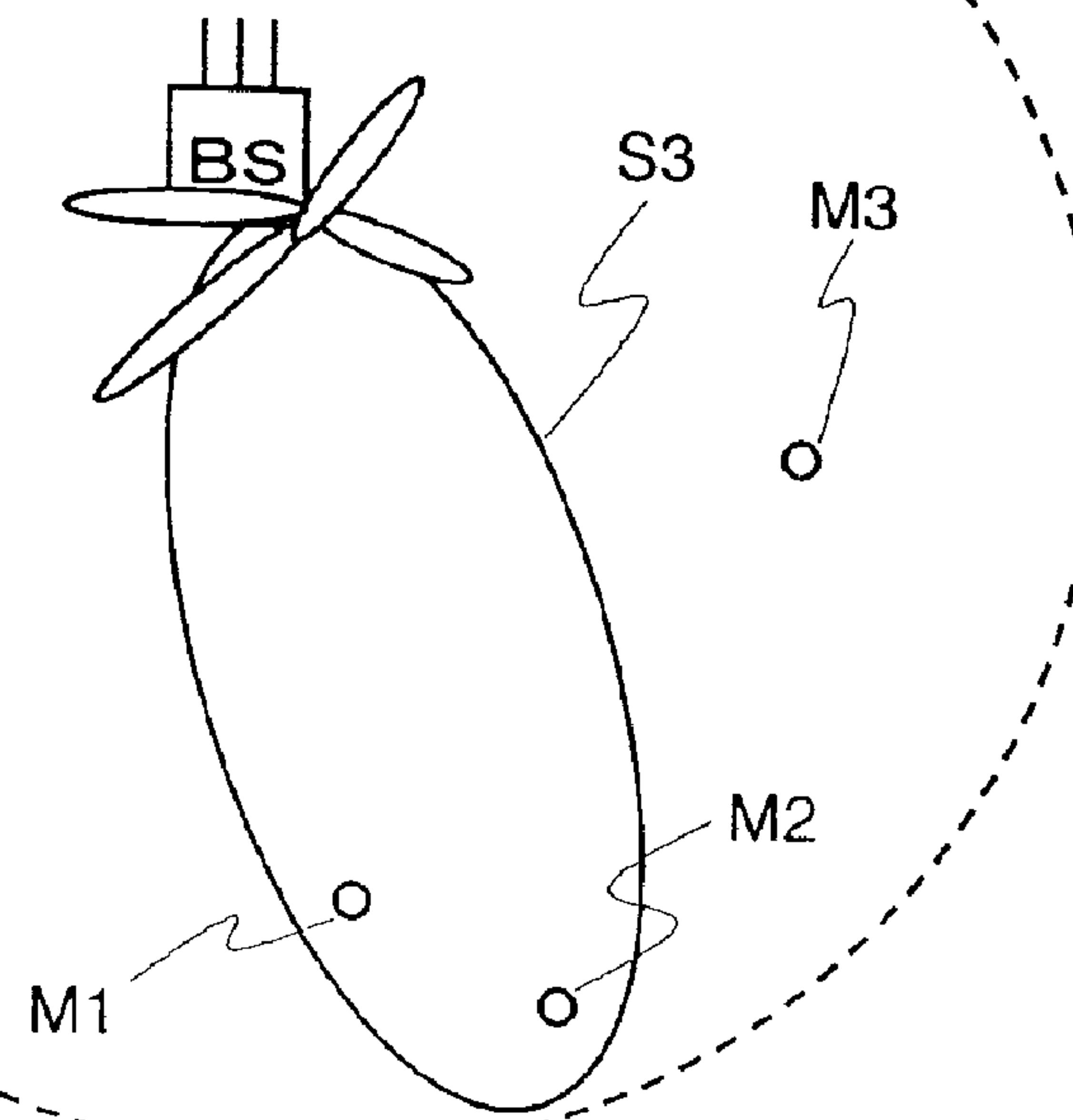
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(72) Inventeur/Inventor:  
ESMAILZADEH, RIAZ, JP

(73) Propriétaire/Owner:  
TELEFONAKTIEBOLAGET L M ERICSSON (PUBL), SE

(74) Agent: MARKS & CLERK

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(54) Title: WIRELESS TELECOMMUNICATION SYSTEM, BASE STATION THEREOF AND BEAMFORMING  
TELECOMMUNICATIONS METHOD



(57) Abrégé/Abstract:

A wireless telecommunications system capable of transmitting desired information to a plurality of mobile stations efficiently is adapted to transmit the information to the plurality of mobile stations by forming a signal beam that covers these mobile stations



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

simultaneously. Since information can thus be sent to a plurality of mobile stations at the same time, it is possible to send information in a highly efficient. In addition, because transmission power can be reduced, interference acting upon other mobile stations can be suppressed.



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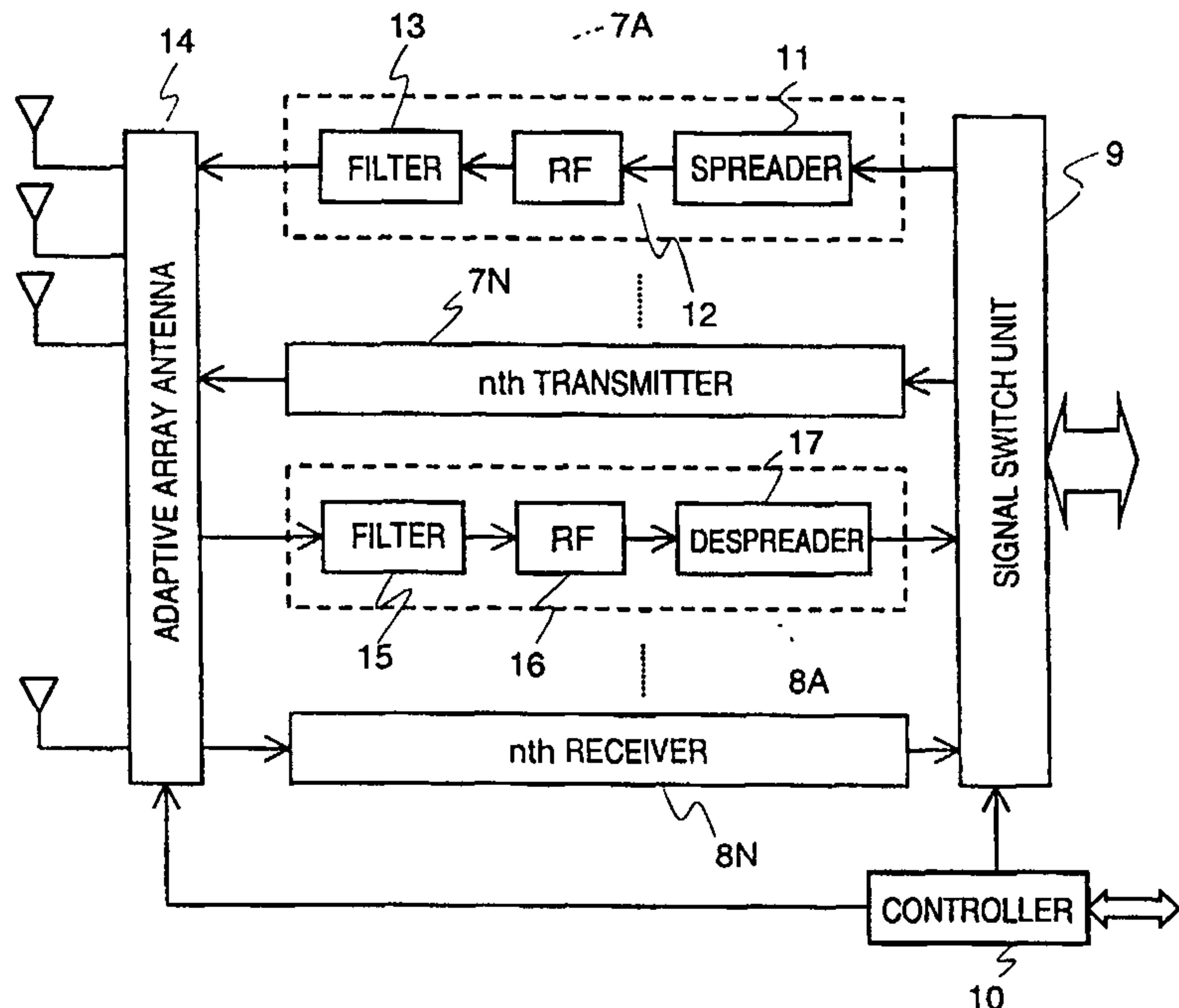
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(71) Applicant (for all designated States except US): TELEFONAK-TIEBOLAGET LM ERICSSON (publ) [SE/SE]; SE-126 25 Stockholm (SE).	
(72) Inventor; and	
(75) Inventor/Applicant (for US only): ESMAILZADEH, Riaz [AU/JP]; 1-25-111 Ooka 1-chome, Minami-ku, Yokohama-shi, Kanagawa 232-0061 (JP).	Published With international search report.
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(54) Title: WIRELESS TELECOMMUNICATION SYSTEM, BASE STATION THEREOF AND BEAMFORMING TELECOMMUNICATIONS METHOD



(57) Abstract

A wireless telecommunications system capable of transmitting desired information to a plurality of mobile stations efficiently is adapted to transmit the information to the plurality of mobile stations by forming a signal beam that covers these mobile stations simultaneously. Since information can thus be sent to a plurality of mobile stations at the same time, it is possible to send information in a highly efficient. In addition, because transmission power can be reduced, interference acting upon other mobile stations can be suppressed.

## DESCRIPTION

## WIRELESS TELECOMMUNICATION SYSTEM, BASE STATION THEREOF AND BEAMFORMING TELECOMMUNICATIONS METHOD

5

## TECHNICAL FIELD

This invention relates to a wireless telecommunications system in which it is possible to transmit desired information to a plurality of mobile stations in an efficient manner.

## BACKGROUND ART

Great strides in wireless telecommunications techniques have been made in recent years and this has been accompanied by the implementation and practical use of various wireless communications systems. A mobile radiotelephone system or so-called cellular phone system best typifies such wireless telecommunications systems.

Various wireless telecommunications schemes have been proposed for such mobile radiotelephone systems. For example, FDMA (Frequency Division Multiple Access) is currently being employed in analog mobile radiotelephone systems. According to the FDMA scheme, a single communication channel is allocated to a single radio frequency and communication channels used by respective ones of a plurality of users are set to

different radio frequencies on a per-user basis.

TDMA (Time-Division Multiple Access) is currently being employed in digital mobile radiotelephone systems, which have rapidly come into widespread use in recent 5 years. With TDMA, a single radio frequency is divided up into a plurality of time slots and signals are transmitted at the timings of time slots that have been allocated to the local station, whereby three or six communication channels, for example, are formed on one 10 radio frequency. In accordance with this scheme, a plurality of communication channels can be formed on a single radio frequency, as a result of which the capacity of the system can be enlarged over that of the analog scheme.

15 CDMA (Code-Division Multiple Access) has recently been proposed as a communications scheme for the next-generation of mobile radiotelephone systems. With CDMA, the same radio frequency band is shared simultaneously by a plurality of users. At the time of transmission, 20 transmitted data is multiplied by spreading codes that differ for each user, thereby forming a plurality of channels on the same frequency. Since this scheme makes it possible for the same frequency band to be used by all cells of a cellular system, the system capacity can 25 be increased further over that of the TDMA scheme. For this reason, CDMA is currently the focus of interest in

regard to its application to the next-generation of mobile communications.

Since a mobile radiotelephone systems using CDMA is such that common use is made of the same frequency, a 5 situation arises in which a signal transmitted by a certain user acts upon another user as interference. This is an important problem encountered when constructing the communications system. Accordingly, a variety of expedients for reducing interference waves in 10 CDMA communications system have been devised. One is the usage of an adaptive array antenna. An adaptive array antenna increases system capacity by reducing interference waves inflicted upon other users.

An adaptive array antenna is composed of a 15 plurality of antenna elements. When the amplitudes and phases of signals to be transmitted are adjusted and the signals are then supplied to respective ones of the antenna elements, the signals sent from the antenna elements are combined and, as a result, a signal beam of 20 a radio signal is formed in a prescribed direction, as illustrated in Fig. 7. Since a signal S1 is thus capable of being transmitted almost solely in the direction of a mobile station M1, it is possible to prevent the transmitted signal S1 from acting upon a 25 mobile station M2 as interference.

The number of array elements in an adaptive array

antenna is decided depending upon the extent to which a signal beam is to be concentrated on a specific user, the extent to which signals are to be isolated and the degree to which mutual interference between users is to 5 be reduced. An adaptive array antenna of this kind is disclosed in detail in IEEE ASSP Magazine, pp. 4 - 24, April 1988; Barry D. van Veen and Keven Buckley: "Beamforming: A versatile approach to spatial filtering".

10 There is demand for various functions other than a voice function, and particularly intense demand for a multicast function, in next-generation mobile radiotelephone systems. A multicast function is a function for transmitting the same information from a 15 base station to a plurality of mobile stations simultaneously. A specific example of a service that relies upon the multicast function is the simultaneous transmission of information (referred to as "multicast data" below) such as traffic information, weather 20 information and stock-market information to a plurality of contract users.

If an attempt is made to implement such a multicast function using a CDMA mobile radiotelephone system, a conceivable approach is to form signal beams S1 and S2 25 individually in the directions of contract mobile stations M1 and M2 using an adaptive array antenna in a

manner similar to that of ordinary individual communication, and transmit the multicast data individually by these signal beams S1, S2, as shown in Fig. 8.

5        With this method, however, the multicast data is transmitted upon forming the signal beams S1, S2 individually for the mobile stations M1, M2 of the contracting parties. This is inefficient in terms of multicasting. Further, the multicast data is

10      transmitted separately to the mobile stations M1, M2. This also is inefficient in terms of transmission power. Thus, inefficiencies remain in regard to the transmission of multicast data and there seems to be room for improvement.

15      Forssén et al. (U.S. Patent No. 5,615,409) discloses a base station for transmitting and receiving data by using 2 classes of channels each of which has different antenna lobe from each other. These lobes are formed by adaptive antenna array. However, Forssén et

20      al. does not disclose nor suggest the forming of an antenna lobe which covers specific mobile stations permitted to receive the multicast data and transmitting multicast data to the specific mobile stations.

          Forssén et al. (U.S. Patent No. 5,649,287) discloses technique for forming a wide antenna lobe without any deep nulls by a plurality of antenna arrays

each of which having a narrow antenna lobe. Forssén et al. do not disclose nor suggest both the multicast data and transmitting multicast data by a single antenna lobe that covers specific mobile station(s) permitted to 5 receive the multicast data.

Dybdal et al. (U.S. Patent No.5,781,845) discloses an adaptive transmitting antenna capable of reducing multipath components included in the transmitted signal. Dybdal et al. does not disclose nor suggest both the 10 multicast data and transmitting multicast data by a single antenna lobe that covers specific mobile station(s) permitted to receive the multicast data.

RALEIGH at al. (WO 97/00543) discloses beamforming technique that enhances remote user received signal 15 quality by using adaptive antenna without the need for feedback from the mobile user. RALEIGH et al. do not disclose that transmitting multicast data to the specific mobile station(s) by a single antenna lobe that covers the specific mobile station(s) permitted to 20 receive the multicast data.

#### Disclosure of Invention

Accordingly, an object of the present invention is to provide a wireless telecommunications system and 25 method in which desired information can be transmitted efficiently to a plurality of mobile stations.

According to the present invention, the foregoing object is attained by providing a wireless telecommunications system in which a radio link is established between a base station and a mobile station 5 by predetermined wireless communication technique, wherein when the same information is sent to plurality

of mobile stations, the base station sends the  
information by forming a signal beam that covers the  
5 plurality of mobile stations simultaneously. By thus  
sending information by forming a signal beam that covers  
a plurality of mobile stations simultaneously, the  
information can be sent to a plurality of mobile  
10 stations more efficiently than in a case where  
information is sent by forming signal beams  
individually. In addition, transmission power can be  
reduced to mitigate the influence of interference waves  
15 on other mobile stations.

According to an aspect of the present invention  
there is provided a wireless telecommunications system,  
having at least one base station and mobile station, in  
which radio links are established between said base  
20 station, which is provided with an antenna whose  
directivity is capable of being controlled, and said  
mobile station, wherein when communication is performed  
with one of said mobile stations, a signal beam pointing  
substantially toward only said one mobile station is  
25 formed by said antenna to communicate with said one  
mobile station;

    said base station forming a multicast signal beam,  
    which is directed only toward a plurality of specific  
    mobile stations which are permitted to receive specific  
30 information, by said antenna when said specific  
    information is to be sent to the plurality of said  
    specific mobile stations, and sending this information  
    by said multicast signal beam.

6a

According to another aspect of the present invention there is provided a base station for establishing radio links with mobile stations, wherein when communication is performed with one of said mobile stations, a signal beam pointing toward only said one mobile station is formed by an antenna, the directivity whereof is capable of being controlled, to communicate with said one mobile station;

wherein when a specific information is to be sent to a plurality of specific mobile stations which are permitted to receive said specific information, a multicast signal beam directed only toward the plurality of said specific mobile stations is formed by said antenna and said specific information is sent by said multicast signal beam.

According to a further aspect of the present invention there is provided a telecommunications method of establishing radio links between a base station, which is provided with an adaptive array antenna, and mobile stations, wherein when communication is performed with one of said mobile stations, a signal beam pointing toward only said one mobile station is formed by said adaptive array antenna to communicate with said mobile station;

said base station forming a multicast signal beam, which covers only a plurality of specific mobile stations which are permitted to receive specific information simultaneously, by said adaptive array antenna when said specific information is to be sent to the plurality of said specific mobile stations, and sending this information by said multicast signal beam.

6b

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

10 BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a block diagram showing the configuration of a CDMA mobile radiotelephone system to which the present invention has been applied;

15 Fig. 2 is a block diagram showing the construction of a base station according to the present invention;

Fig. 3 is a beam waveform diagram useful in describing a signal beam that covers a plurality of

mobile stations;

Fig. 4 is a beam waveform diagram useful in describing an instance where a mobile station wishing to receive multicast data appears at a later time;

5 Fig. 5 is a block diagram showing the construction of an adaptive array antenna;

Figs. 6A to 6C is a schematic diagram showing the principle in accordance with which a signal beam is formed in a prescribed direction by the adaptive array 10 antenna;

Fig. 7 is a beam waveform diagram useful in describing an adaptive array antenna; and

Fig. 8 is a beam waveform diagram useful in describing an instance where multicast data is 15 transmitted individually using the adaptive array antenna.

#### BEST MODE FOR CARRYING OUT THE INVENTION

Fig. 1 illustrates a CDMA mobile radiotelephone 20 system 1 to which the present invention has been applied. The mobile radiotelephone system 1 includes a mobile services switching center (MSC) 2, a radio network controller (RNC) 3 and a plurality of base stations 4A to 4C. The mobile services switching center 25 2, which is connected to the radio network controller 3 via a prescribed transmission line, performs call

control and registration management, etc., of mobile stations 5A to 5C via the radio network controller 3, and exercises overall control of the system. Further, the mobile services switching center 2 is connected to a 5 public switched telephone network (PSTN) 6 via a prescribed transmission line to relay calls between telephones connected to the PSTN 6 and desired ones of the mobile stations 5A to 5C.

The radio network controller 3, which is a device 10 for controlling a radio network, connects and disconnects the base stations 4A to 4C and mobile stations 5A to 5C, hands over the mobile stations, controls transmission power, etc.

The base stations 4A to 4C are transceivers which, 15 on the basis of control performed by the radio network controller 3, actually establish CDMA radio links with the mobile stations 5A to 5C. This enables the base stations 4A to 4C to communicate with other mobile stations in the system, or with other telephones 20 connected to the PSTN 6, via the base stations 4A to 4C.

Though the three base stations 4A to 4C and three mobile stations 5A to 5C are discussed here for the sake of simplicity, the numbers of these stations are not limited to those of this embodiment. Further, the 25 mobile stations 5A to 5C may be portable telephones whose basic function is the voice function or

transportable general-purpose computers, for example, each having a radio interface for interfacing the mobile stations 4A to 4C.

The mobile radiotelephone system 1 has a multicast function in addition to the voice function mentioned above. More specifically, the mobile services switching center 2 is so adapted as to periodically acquire information such as traffic information, weather information and stock-market information from prescribed information sources via the PSTN 6, send this information as multicast data to the base stations 4A to 4C via the radio network controller 3, and send the information to the desired mobile stations 5A to 5C via the base stations 4A to 4C. In such case the multicast data is not sent to all mobile stations but only to mobile stations that have entered into an information-service agreement with a provider of the mobile radiotelephone system 1.

Information as to whether an agreement has been made is stored, in association with the identification number of the mobile station, in the mobile services switching center 2 of the mobile radiotelephone system 1. This makes it possible to send multicast data only to contract users based upon the stored data.

The multicast function will now be described in greater detail.

The mobile services switching center 2 sends multicast data, which has been acquired periodically via the PSTN 6, to the base stations 4A to 4C via the radio network controller 3.

5       A user wishing to receive multicast data inputs a data receive command to the mobile station 5A (or 5B or 5C) by performing a prescribed operation. Upon receiving the command, the mobile station 5A (or 5B or 5C) transmits a request command for requesting the 10 multicast data. For example, the request command includes mobile station ID information and the type of content desired to be received. The request command is received by the base station 4A (or 4B or 4C), whence the command is sent to the mobile services switching 15 center 2 via the radio network controller 3.

Upon receiving the request command, the mobile services switching center 2 determines, based upon the mobile station ID information, whether the mobile station 5A (or 5B or 5C) that sent the request command 20 is that of a contract user. If the mobile station is a contract user, the mobile services switching center 2 instructs the base station 4A (or 4B or 4C) that received the request command to transmit the multicast data to the mobile station 5A (or 5B or 5C). The base 25 stations 4A - 4C each have an adaptive array antenna. The base station 4A (or 4B or 4C) that was instructed to

transmit the multicast data uses its adaptive array antenna to form a signal beam that will point only toward the mobile station 5A (or 5B or 5C) desiring the multicast data and transmits the multicast data solely 5 to this mobile station 5A (or 5B or 5C).

It should be noted that a single cell may contain one or a plurality of mobile stations desiring multicast data. In a case where a plurality of mobile stations desiring multicast data reside in one cell, a signal 10 beam that will encompass these plurality of mobile stations simultaneously is formed by the adaptive array antenna to transmit the multicast data to these mobile station at a stroke. Further, the base station 4A (or 4B or 4C) is adapted to transmit the multicast data 15 repeatedly a prescribed number of times in order that the multicast data can be received with certainty at the mobile station 5A (or 5B or 5C).

When a request to receive multicast data is thus generated in the mobile radiotelephone system 1 of the 20 present invention, the multicast data is transmitted to the mobile station. Though a method of transmitting multicast data continuously is conceivable as an approach that contrasts with that of this invention, this would mean transmitting multicast data even when 25 mobile stations desiring such reception are not present within a cell. As a consequence, the signal would act

as interference and might have a deleterious effect upon mobile stations participating in ordinary individual communication or mobile stations other than those of contracting parties. In order to avoid this, therefore, 5 the present invention is adapted to transmit multicast data only when there is a request to receive this data.

The construction of the base stations 4A to 4C which transmit a signal beam of multicast data in a prescribed direction will now be described. Since the 10 base stations 4A to 4C basically are identical in construction, only the base station 4A will be described.

Fig. 2 shows the construction of the base station 4A. It should be noted, however, that a baseband signal 15 processing circuit and an interface circuit for interfacing the radio network controller 3 are not described here.

As shown in Fig. 2, the base station 4A has a plurality of transmitters 7A to 7N and a plurality of 20 receivers 8A to 8N and is adapted so as to be capable of communicating with a plurality of mobile stations simultaneously using these transmitters 7A to 7N and receivers 8A to 8N. Individual transmission data such as voice data sent from the radio network controller 3 25 is input to a signal switch unit 9 via an interface circuit (not shown).

The signal switch unit 9 comprises a demultiplexer circuit, for example, for assigning input individual transmission data to corresponding ones of the transmitters 7A to 7N. On the assumption that the 1st through nth transmitters 7A to 7N correspond to 1st through nth communication channels, respectively, the signal switch unit 9 sends individual transmission data to the corresponding transmitters 7A to 7N in the following manner: individual transmission data transmitted on the first communication channel is sent to the first transmitter 7A, individual transmission data transmitted on the second communication channel is sent to the second transmitter 7B, and so on.

Control data sent from the radio network controller 3 enters a controller 10 via an interface circuit, which is not shown. The controller 10 receives the control data from the radio network controller 3, controls the operation of the signal switch unit 9 based upon the control data and controls the operation of an adaptive array antenna 14, which is described later.

The 1st through nth transmitters 7A - 7N are identically constructed. The first transmitter 7A has a spreading circuit 11 to which the entered individual transmission data is input first. The spreading circuit 11 multiplies the individual transmission data by a predetermined spreading code that has been allocated to

the first communication channel, thereby subjecting the individual transmission data to spread-spectrum modulation.

In CDMA communication, communication channels are  
5 distinguished from one another by allocating a different spreading code for each channel. On the receiving side, received data is multiplied by a spreading code the same as that on the transmitting side and despread processing is then executed to restore the data.

10 The transmission signal output by the spreading circuit 11 enters a radio-frequency unit (RF) 12. Here the signal undergoes frequency conversion processing so as to be converted to a transmission signal of a prescribed frequency band. The transmission signal  
15 output by the radio-frequency unit 12 enters a filter 13, which eliminates unwanted signal components from the signal and then inputs the resulting signal to the adaptive array antenna 14.

Similarly, the 2nd through nth transmitters 7B - 7N  
20 also multiply input individual transmission data by respective spreading codes assigned thereto, apply spread-spectrum modulation, then subject the transmission signals to frequency conversion processing and filtering processing and output the resulting  
25 signals to the adaptive array antenna 14.

On the basis of control by the controller 10, the

adaptive array antenna 14, which has a plurality of antenna elements, controls the amplitude and phase of each of the transmission signals applied to respective ones of the plurality of antenna elements to thereby 5 form signal beams in prescribed directions and transmit each signal. More specifically, the adaptive array antenna 14 controls the amplitude and phase of the transmission signal output by the first transmitter 7A, thereby forming and transmitting a signal beam in the 10 direction of the mobile station that is to receive this transmission signal. Similarly, the adaptive array antenna 14 controls the amplitudes and phases of the transmission signals output by the 2nd to nth transmitters 7B to 7N, thereby forming and transmitting 15 signal beams in the direction of the respective mobile stations that are to receive these transmission signals.

As a result of the operation described above, the mobile radiotelephone system 1 forms signal beams S1 and S2 pointing toward the mobile stations M1 and M2, as 20 shown in Fig. 8, at the time of individual transmission, and transmits the individual transmission data to the respective mobile stations M1 and M2. Accordingly, the mobile radiotelephone system 1 makes it possible to reduce interference within the system when an individual 25 data transmission is made to each mobile station.

Meanwhile, signals received from the mobile

stations by the adaptive array antenna 14 enter the corresponding 1st through nth receivers 8A - 8N. The 1st through nth receivers 8A - 8N are identically constructed. Each has a filter 15 which eliminates 5 unwanted components from the received signal, a radio-frequency (RF) unit 16 which subsequently extracts the signal component of the baseband, and a despreading circuit 17 for extracting the received data by executing despread processing using a despreading code identical 10 with that on the transmitting side. Each item of received data thus extracted is sent to the radio network controller 3 via the signal switch unit 9 and is then sent to the terminal of the communicating party.

Operation in the case of a multicast data 15 transmission, which differs from the individual data transmission set forth above, will now be described.

Specifically, multicast data sent from the radio network controller 3 enters the signal switch unit 9 via an interface circuit, which is not shown, in a manner 20 similar to the foregoing. On the basis of control exercised by the controller 10, the signal switch unit 9 supplies the multicast data solely to, e.g., the transmitter 7A. In a manner similar to that when an individual transmission is made, the transmitter 7A 25 applies spread-spectrum modulation to the multicast data, then executes frequency conversion processing to

generate a transmission signal and outputs this signal to the adaptive array antenna 14.

In a case where only one mobile station that is to receive the multicast data resides in a cell, the 5 adaptive array antenna 14, based upon control by the controller 10, adjusts the amplitude and phase of the multicast data transmission signal and supplies the resulting signal to each antenna element, thereby forming a signal beam directed toward this mobile 10 station and transmitting the multicast data transmission signal using this signal beam.

In a case where a plurality of mobile stations that wish to receive the multicast data reside in a cell, the adaptive array antenna 14, based upon control by the 15 controller 10, adjusts the amplitude and phase of the multicast data transmission signal and supplies the resulting signal to each antenna element, thereby forming a signal beam S3 that simultaneously covers the plurality of mobile stations M1, M2 desiring to receive 20 the multicast data, as depicted in Fig. 3, and transmitting the multicast data. Thus, when multicast data is transmitted to the plurality of mobile stations M1, M2, the mobile radiotelephone system 1 transmits the signal to the plurality of mobile stations M1, M2 at one 25 time. This makes it possible to reduce the power of transmission within the cell and, as a result, to reduce

interference that acts upon the other mobile station M3 present in the cell.

In an instance where the mobile station M1 receiving the multicast data is already inside the cell 5 and the other mobile station M2 then issues a multicast data request anew, as illustrated in Fig. 4, a signal beam S4 that covers the mobile station M2 that subsequently requested the multicast data is formed by the adaptive array antenna 14, whereby the aforesaid 10 multicast data is sent simultaneously to all mobile stations M1, M2 desiring the multicast data.

The adaptive array antenna 14 will be described in detail with reference to Fig. 5.

As shown in Fig. 5, the adaptive array antenna 14 15 has a plurality of signal processing units 20A to 20N conforming to the number of communication channels. These signal processing units 20A to 20N process the signals of the respective communication channels.

First, at the time of individual communication, 20 signals received by a plurality of antenna elements 21A to 21M enter the signal processing units 20A to 20N via antenna couplers 22A to 22M, respectively. Each of the signal processing units 20A to 20N includes multipliers 23A to 23M to which respective ones of the received 25 signals are input, a coefficient calculation unit 24 which supplies coefficients  $(\gamma'_1, \theta'_1)$  to  $(\gamma'_M, \theta'_M)$  by

which the received signals are multiplied, and a vector adder 25 for adding the products obtained from the multipliers.

Among the coefficients  $(\gamma'_1, \theta'_1)$  to  $(\gamma'_M, \theta'_M)$  output 5 by the coefficient calculation unit 24, the coefficients  $\gamma'_1$  to  $\gamma'_M$  are for adjusting the amplitudes of the respective received signals, and the coefficients  $\theta'_1$  to  $\theta'_M$  are for adjusting the phases of the respective received signals.

10 The coefficient calculation unit 24 accepts the combined received signal output by the vector adder 25 and performs control so as to maximize the combined received signal by adjusting the coefficients  $(\gamma'_1, \theta'_1)$  to  $(\gamma'_M, \theta'_M)$  while monitoring the combined received 15 signal. Maximization of the combined received signal indicates that the directivity pattern of the antenna is directed toward the mobile station that is the object of reception. Combined received signals thus maximized by such control in the 1st through nth signal processing 20 units 20A to 20N are output to the corresponding 1st through nth receivers 8A - 8N, respectively.

Meanwhile, transmission signals that have been output by the 1st through nth transmitters 7A to 7N are output to the corresponding 1st through nth signal 25 processing units 20A to 20N. Each of the signal processing units 20A to 20N includes multipliers 26A to

26M to which respective ones of the transmission signals are input. The coefficient calculation unit 24 supplies coefficients  $(\gamma_1, \theta_1)$  to  $(\gamma_M, \theta_M)$  by which the transmission signals are multiplied, after which the products 5 obtained from the multipliers are supplied to adders 27A to 27M, respectively, the outputs of which are supplied to the antennas 21A to 21M via the antenna couplers 22A to 22M, respectively.

The coefficients  $\gamma_1$  to  $\gamma_M$  similarly are for 10 adjusting the amplitudes of the respective transmission signals, and the coefficients  $\theta_1$  to  $\theta_M$  are for adjusting the phases of the respective transmission signals. Though the coefficients  $(\gamma'_1, \theta'_1)$  to  $(\gamma'_M, \theta'_M)$  calculated at the time of reception may be used as is as the 15 coefficients  $(\gamma_1, \theta_1)$  to  $(\gamma_M, \theta_M)$ , it is preferred that the coefficients  $(\gamma_1, \theta_1)$  to  $(\gamma_M, \theta_M)$  be obtained by correcting the coefficients  $(\gamma'_1, \theta'_1)$  to  $(\gamma'_M, \theta'_M)$  calculated at the time of reception. The reason for this is that if the transmitting frequency and receiving frequency differ, 20 there is the possibility that the characteristics will differ slightly. In any case, since the transmitting pattern and the receiving pattern of the antenna generally are considered to be the same, the directivity pattern of the antenna will be directed toward the 25 mobile station that is the object of transmission if the coefficients  $(\gamma_1, \theta_1)$  to  $(\gamma_M, \theta_M)$  based upon the

coefficients  $(\gamma'_1, \theta'_1)$  to  $(\gamma'_M, \theta'_M)$  are used.

When a multicast data transmission is made, on the other hand, the signal processing units 20A to 20N receive multicast data request commands from each of the 5 mobile stations and first calculate, for every mobile station, coefficients  $(\gamma'_1, \theta'_1)$  to  $(\gamma'_M, \theta'_M)$  for reception purposes based upon the received signals. Once the coefficients  $(\gamma'_1, \theta'_1)$  to  $(\gamma'_M, \theta'_M)$  of every mobile station have been reported to the controller 10, the 10 coefficients are communicated via the controller 10 to the signal processing unit that will take charge of transmission of the multicast data. Assume here that the signal processing unit 20A corresponds to this signal processing unit.

15 On the basis of the coefficients  $(\gamma'_1, \theta'_1)$  to  $(\gamma'_M, \theta'_M)$  of every mobile station, the coefficient calculation unit 24 of the signal processing unit 20A calculates coefficients  $(\gamma_1, \theta_1)$  to  $(\gamma_M, \theta_M)$ , which are for transmission purposes, in such a manner that a plurality 20 of mobile stations desiring multicast data will be encompassed simultaneously by a single signal beam. The coefficients  $(\gamma_1, \theta_1)$  to  $(\gamma_M, \theta_M)$  are supplied to the multipliers 26A to 26M, which proceed to multiply the multicast data transmission signals by these 25 coefficients.

The transmission signals thus adjusted in phase and

amplitude owing to multiplication by the coefficients (γ<sub>1</sub>, θ<sub>1</sub>) to (γ<sub>M</sub>, θ<sub>M</sub>) are supplied to the antenna elements 21A to 21M via the adders 27A to 27M and antenna couplers 22A to 22M, respectively, whereupon the 5 transmission signals are combined to form a signal beam that encompasses the plurality of mobile stations M<sub>1</sub>, M<sub>2</sub> simultaneously, as shown in Figs. 6A to 6C. As a result, multicast data can be transmitted simultaneously to the plurality of mobile stations M<sub>1</sub>, M<sub>2</sub> desiring the 10 multicast data.

Thus, at the time of individual transmission, the adaptive array antenna 14 calculates coefficients (γ<sub>1</sub>, θ<sub>1</sub>) to (γ<sub>M</sub>, θ<sub>M</sub>) that will point the signal beam solely toward the mobile station of the communicating party and sends 15 a signal solely to this mobile station of the communicating party. At the time of multicast data transmission, on the other hand, the adaptive array antenna 14 calculates coefficients (γ<sub>1</sub>, θ<sub>1</sub>) to (γ<sub>M</sub>, θ<sub>M</sub>) that will cause a plurality of mobile stations requesting 20 multicast data to be covered by one signal beam and sends the multicast data to these plurality of mobile stations simultaneously.

The arrangement described above is such that if 25 multicast data is transmitted, the mobile radiotelephone system 1 calculates the coefficients (γ<sub>1</sub>, θ<sub>1</sub>) to (γ<sub>M</sub>, θ<sub>M</sub>) based upon received signals prevailing when multicast

data request commands are received, multiplies the transmission signals by these coefficients  $(\gamma_1, \theta_1)$  to  $(\gamma_M, \theta_M)$  and transmits the respective signals obtained as a result to the plurality of antennas 21A to 21M. When 5 the transmission signals thus adjusted in amplitude and phase are output to the plurality of antennas 21A to 21M, the transmission signals are combined and a signal beam pointing in a prescribed direction is formed.

When multicast data is transmitted in the mobile 10 radiotelephone system 1, the system calculates the coefficients  $(\gamma_1, \theta_1)$  to  $(\gamma_M, \theta_M)$  that will cause the plurality of mobile stations requesting multicast data to be covered by one signal beam. Consequently, the signal beam of the multicast data output by the adaptive 15 array antenna 14 covers a plurality of base stations desiring the multicast data, as illustrated in Fig. 3, and the multicast data can be transmitted simultaneously to the plurality of mobile stations efficiently as a result. Furthermore, since the multicast data is 20 capable of being transmitted to the plurality of mobile stations at one time, transmission power is reduced compared with the transmission power needed when transmitting multicast data individually. The result is a reduction in interfering waves within the cell. 25 Moreover, since interference within the cell can be reduced, it is possible to increase system capacity.

In accordance with the arrangement set forth above, transmission of multicast data is carried out by forming a signal beam that will simultaneously encompass a plurality of mobile stations desiring the multicast data 5 and sending the multicast data over this beam. As a result, multicast data can be transmitted to a plurality of mobile stations at the same time, the multicast data can be transmitted efficiently and interference within the cell can be reduced.

10 The above-described embodiment relates to a case where multicast data is acquired via the PSTN 6. However, the present invention is not limited to this arrangement. By way of example, the mobile services switching center 2 may be provided with input means and 15 the multicast data may be entered via this input means.

Further, the above-described embodiment relates to a case where the coefficients  $(\gamma_1, \theta_1)$  to  $(\gamma_M, \theta_M)$  are calculated based upon a received signal that prevailed when a multicast data request command was received.

20 However, the present invention is not limited to such an arrangement, for it is permissible to calculate the coefficients  $(\gamma_1, \theta_1)$  to  $(\gamma_M, \theta_M)$  based upon another received signal sent from a mobile station, such as a received signal prevailing at the time of individual 25 communication. Still another feasible arrangement is to provide a mobile station with a receiving device used in

a GPS system, communicate mobile-station position information, which has been computed by this receiving device, to the base station, calculate coefficients based upon this position information representing the 5 mobile station, and form a signal beam that will cover a plurality of mobile stations.

Further, the above-described embodiment relates to a case where the present invention is applied to a communication system with a CDMA communications scheme.

10 However, the present invention is not limited to such application but can be adapted so as to be applicable to any wireless communications systems such as a TDMA and FDMA system.

Further, the above-described embodiment relates to 15 a case where the present invention is applied to the mobile radiotelephone system 1. However, the present invention is not limited to such application but can be adapted so as to be applicable to a wireless LAN system or other wireless system. What is essential is that in 20 a case where identical information is transmitted to a plurality of mobile stations in a wireless communications system, in which radio links are established between a base station and a plurality of mobile stations by predetermined wireless communication 25 technique, and of which base station communicates by forming a signal beam substantially in the direction to

certain one mobile station to which a base station communicates with, effects similar to those realized in such case will be obtained if a signal beam that covers the plurality of mobile stations simultaneously is 5 formed and the information is transmitted by means of this signal beam.

Further, though an adaptive array antenna is used in the foregoing embodiment, any other means and methods may be used as long as directivity can be controlled.

10 The present invention is advantageous in that information can be sent to plurality of mobile stations simultaneously by so arranging it that the information is transmitted to the plurality of base stations by forming such a signal beam that will cover the plurality 15 of base stations simultaneously. This makes it possible to send information in a highly efficient. In addition, because transmission power can be reduced, interference acting upon other mobile stations can be suppressed.

As many apparently widely different embodiments of 20 the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A wireless telecommunications system, having at least one base station and mobile station, in which radio links are established between said base station, which is provided with an antenna whose directivity is capable of being controlled, and said mobile station, wherein when communication is performed with one of said mobile stations, a signal beam pointing substantially toward only said one mobile station is formed by said antenna to communicate with said one mobile station;  
said base station forming a multicast signal beam, which is directed only toward a plurality of specific mobile stations which are permitted to receive specific information, by said antenna when said specific information is to be sent to the plurality of said specific mobile stations, and sending this information by said multicast signal beam.
2. The system according to claim 1, wherein said base station transmits said specific information in response to a request from one of said specific mobile stations.
3. The system according to claim 1, wherein said antenna is formed from a plurality of antenna elements, and said base station adjusts, by multiplying coefficients, amplitude and phase of a transmission signal generated based upon said specific information to be transmitted and transmits the resulting signals from respective ones of the plurality of said antenna elements, thereby forming the multicast signal beam.

4. The system according to claim 3, wherein said base station calculates said coefficients based upon reception signals received from said specific mobile stations.
5. The system according to any one of claims 1 to 4, wherein said antenna is an adaptive array antenna.
6. A base station for establishing radio links with mobile stations, wherein when communication is performed with one of said mobile stations, a signal beam pointing toward only said one mobile station is formed by an antenna, the directivity whereof is capable of being controlled, to communicate with said one mobile station; wherein when a specific information is to be sent to a plurality of specific mobile stations which are permitted to receive said specific information, a multicast signal beam directed only toward the plurality of said specific mobile stations is formed by said antenna and said specific information is sent by said multicast signal beam.
7. The base station according to claim 6, wherein said specific information is transmitted in response to a request from one of said specific mobile stations.
8. The base station according to claim 6, wherein said antenna is formed from a plurality of antenna elements, and amplitude and phase of a transmission signal generated based upon said specific information to be transmitted are adjusted by multiplying coefficients and the resulting signals are transmitted from respective ones of the plurality of said antenna elements, thereby forming said multicast signal beam.

9. The base station according to claim 8, wherein said base station calculates said coefficients based upon reception signals received from said specific mobile stations.

10. A telecommunications method of establishing radio links between a base station, which is provided with an adaptive array antenna, and mobile stations, wherein when communication is performed with one of said mobile stations, a signal beam pointing toward only said one mobile station is formed by said adaptive array antenna to communicate with said mobile station;

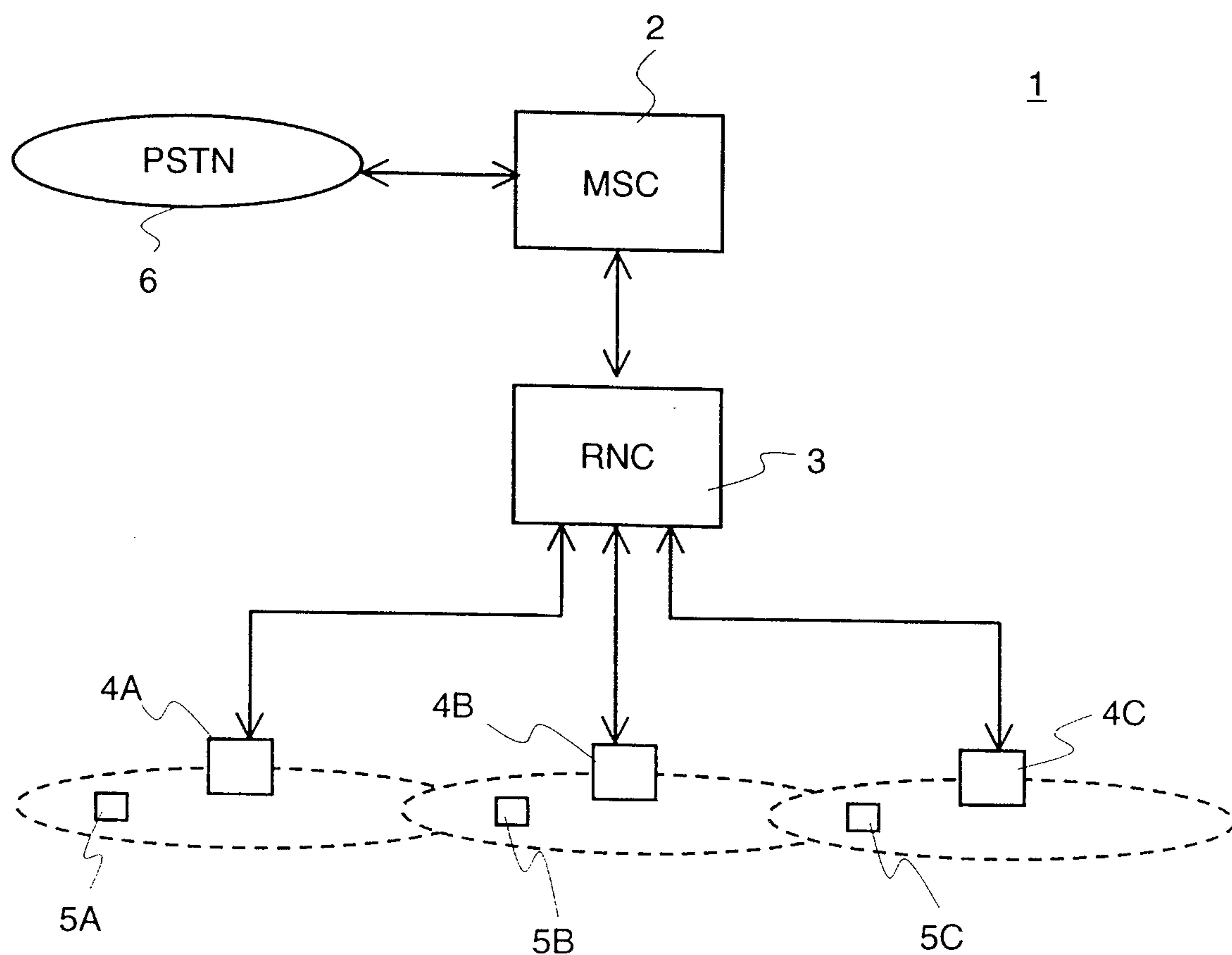
    said base station forming a multicast signal beam, which covers only a plurality of specific mobile stations which are permitted to receive specific information simultaneously, by said adaptive array antenna when said specific information is to be sent to the plurality of said specific mobile stations, and sending this information by said multicast signal beam.

11. The method according to claim 10, wherein said base station transmits said specific information in response to a request from one of said specific mobile stations.

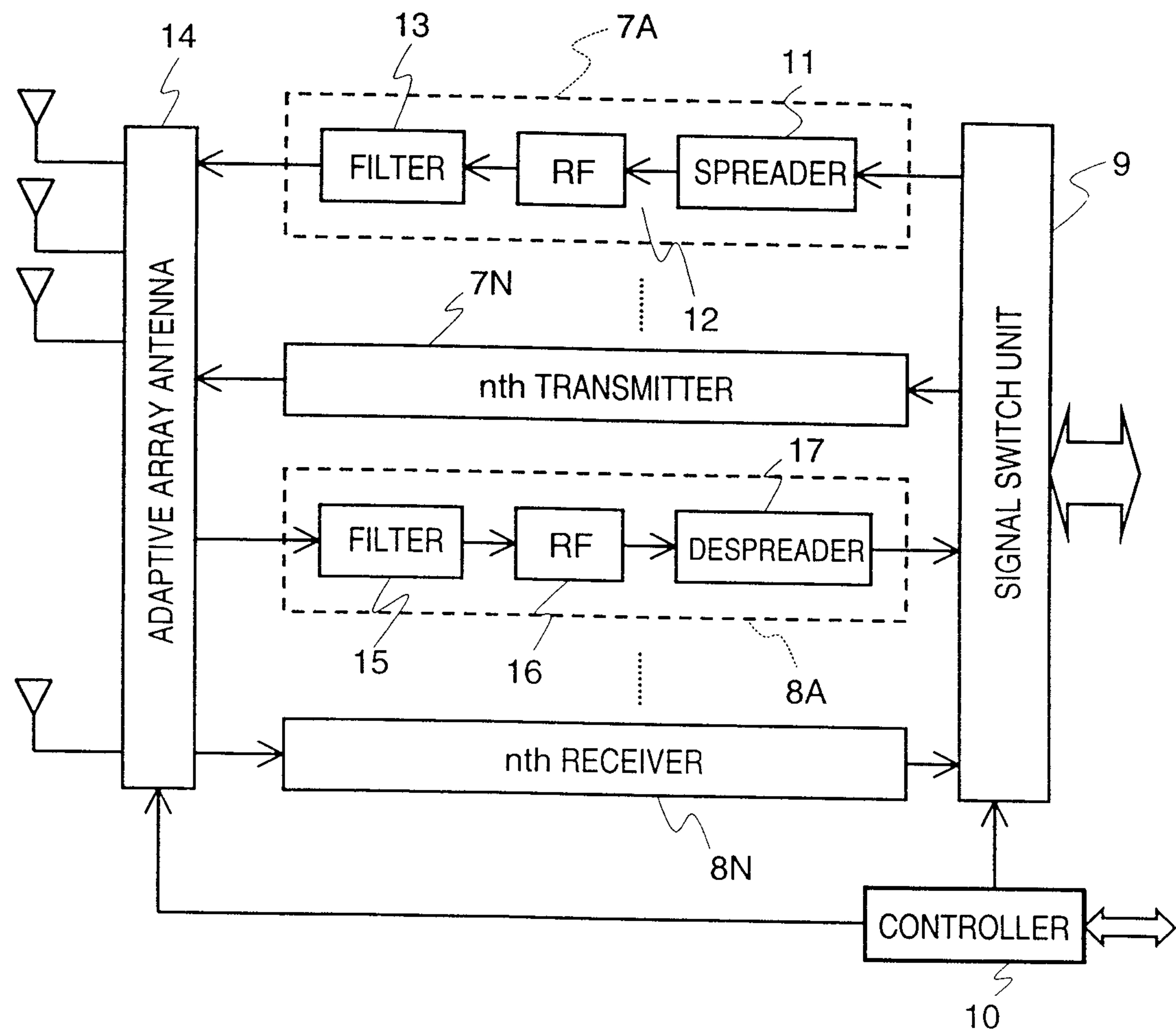
12. The method according to claim 10, wherein said base station adjusts, by multiplying coefficients, amplitude and phase of a transmission signal generated based upon said specific information to be transmitted and transmits the resulting signals from respective ones of a plurality of antenna elements of said adaptive array antenna, thereby forming said multicast signal beam.

13. The method according to claim 12, wherein said base station calculates said coefficients based upon reception signals received from said specific mobile stations.

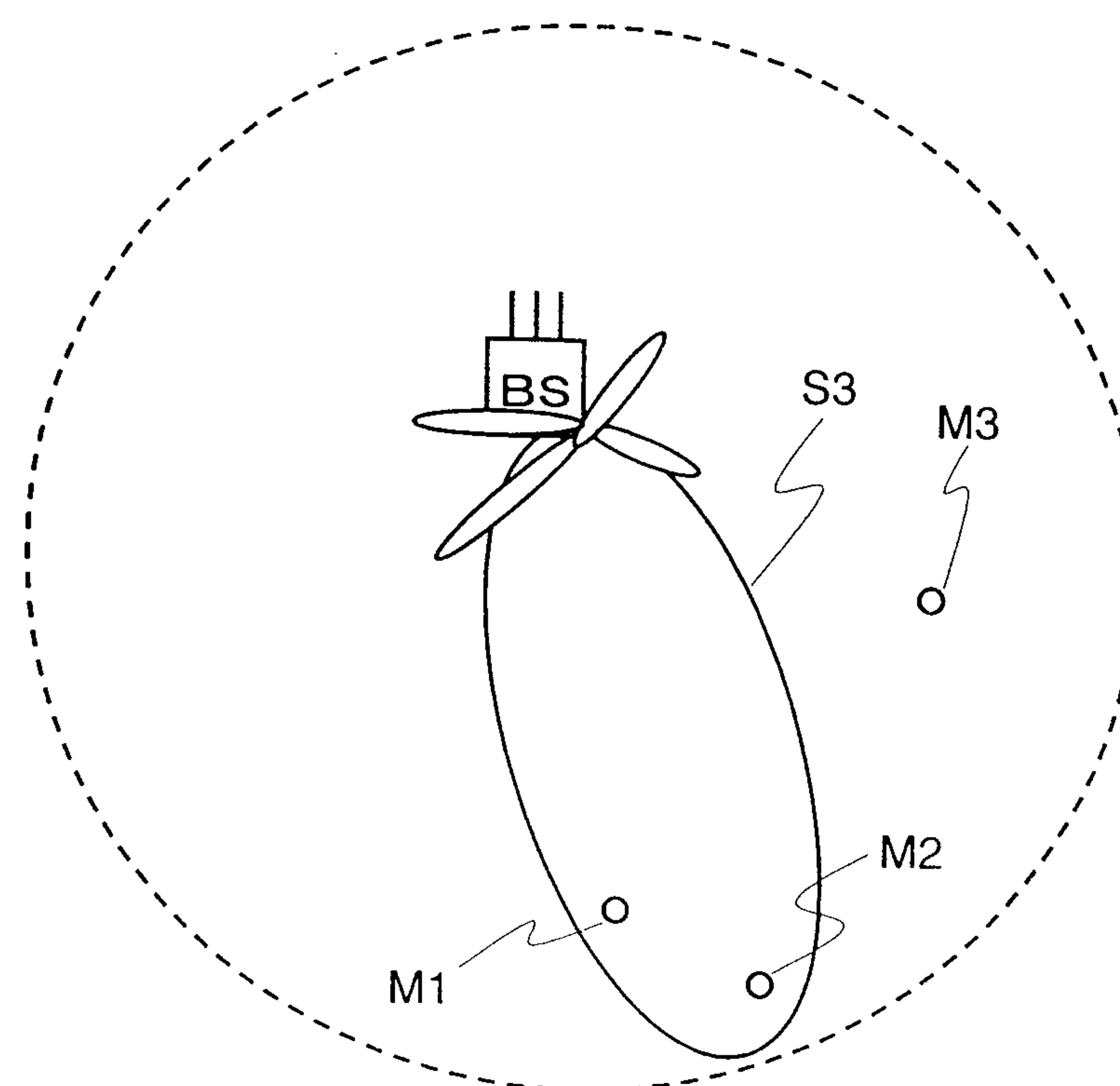
## FIG. 1



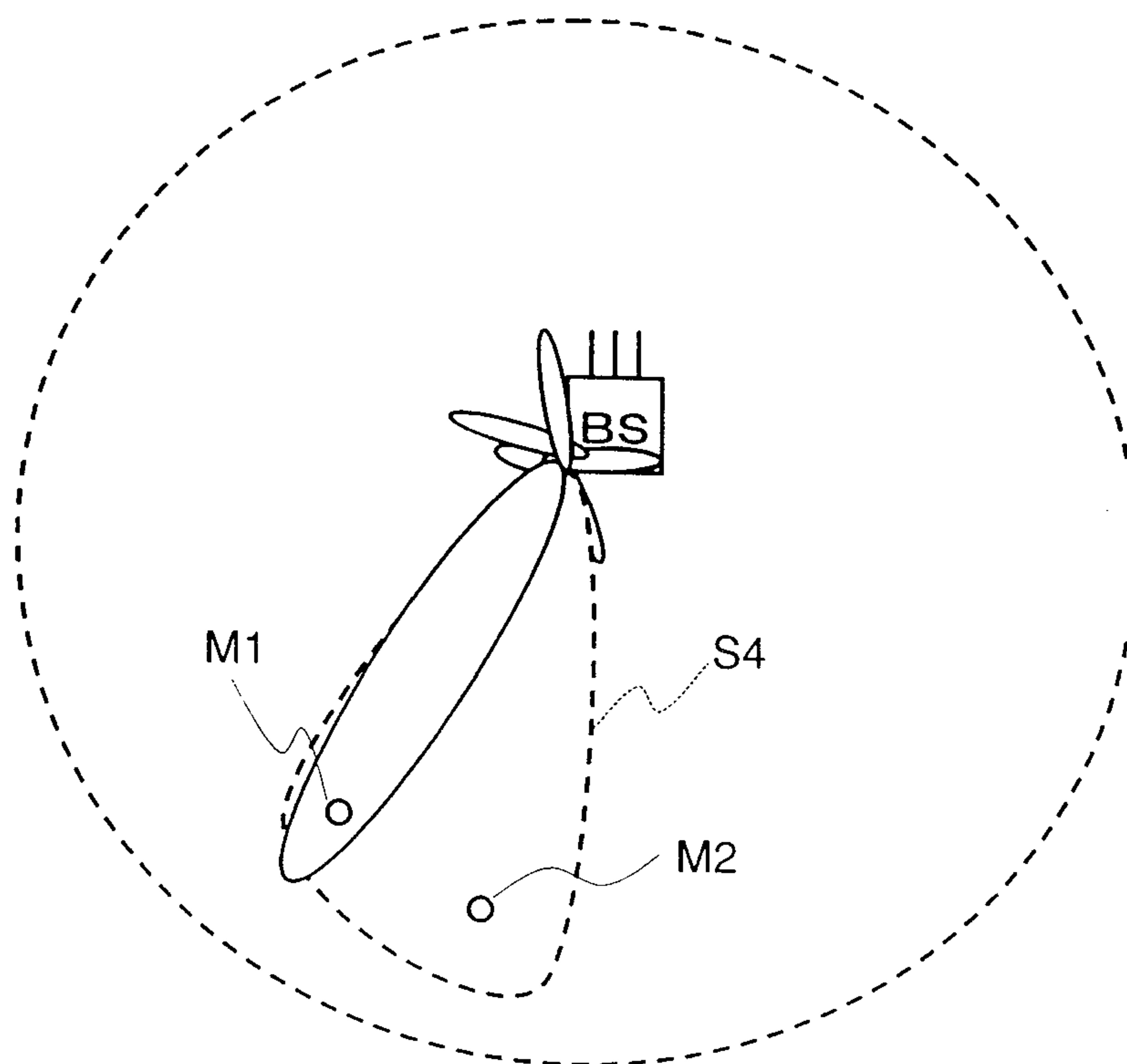
## FIG. 2

4A(4B~4C)

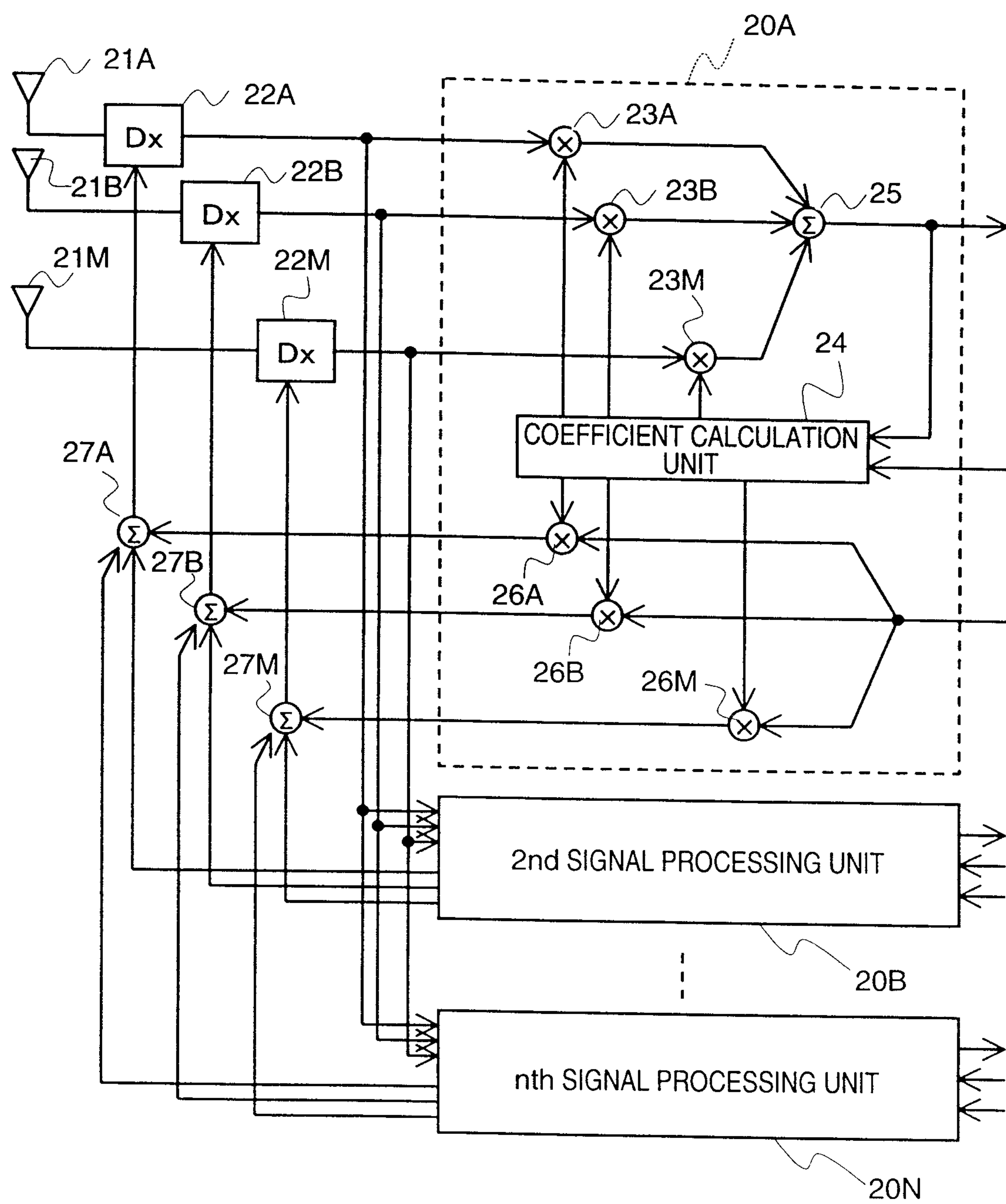
## FIG. 3

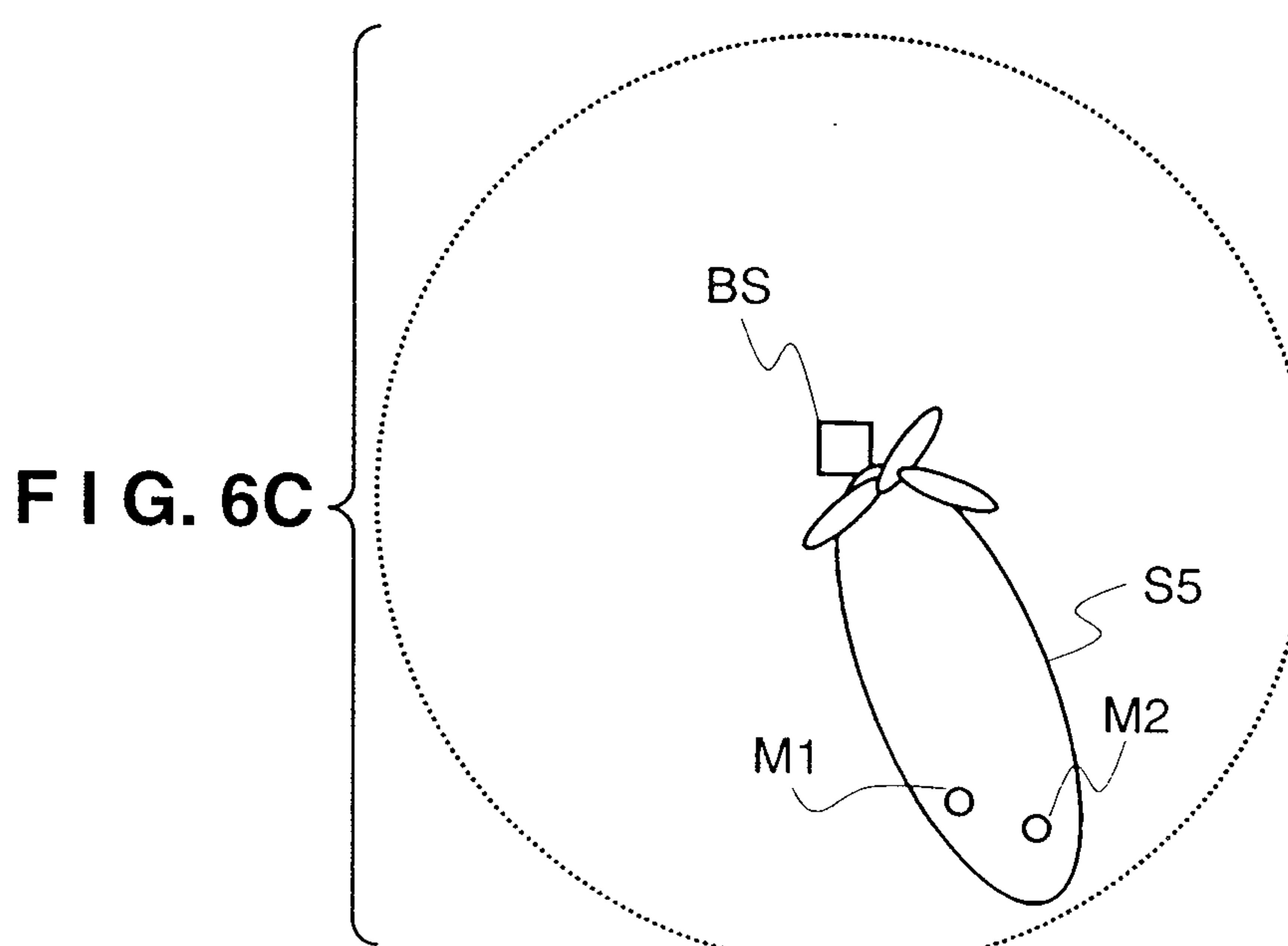
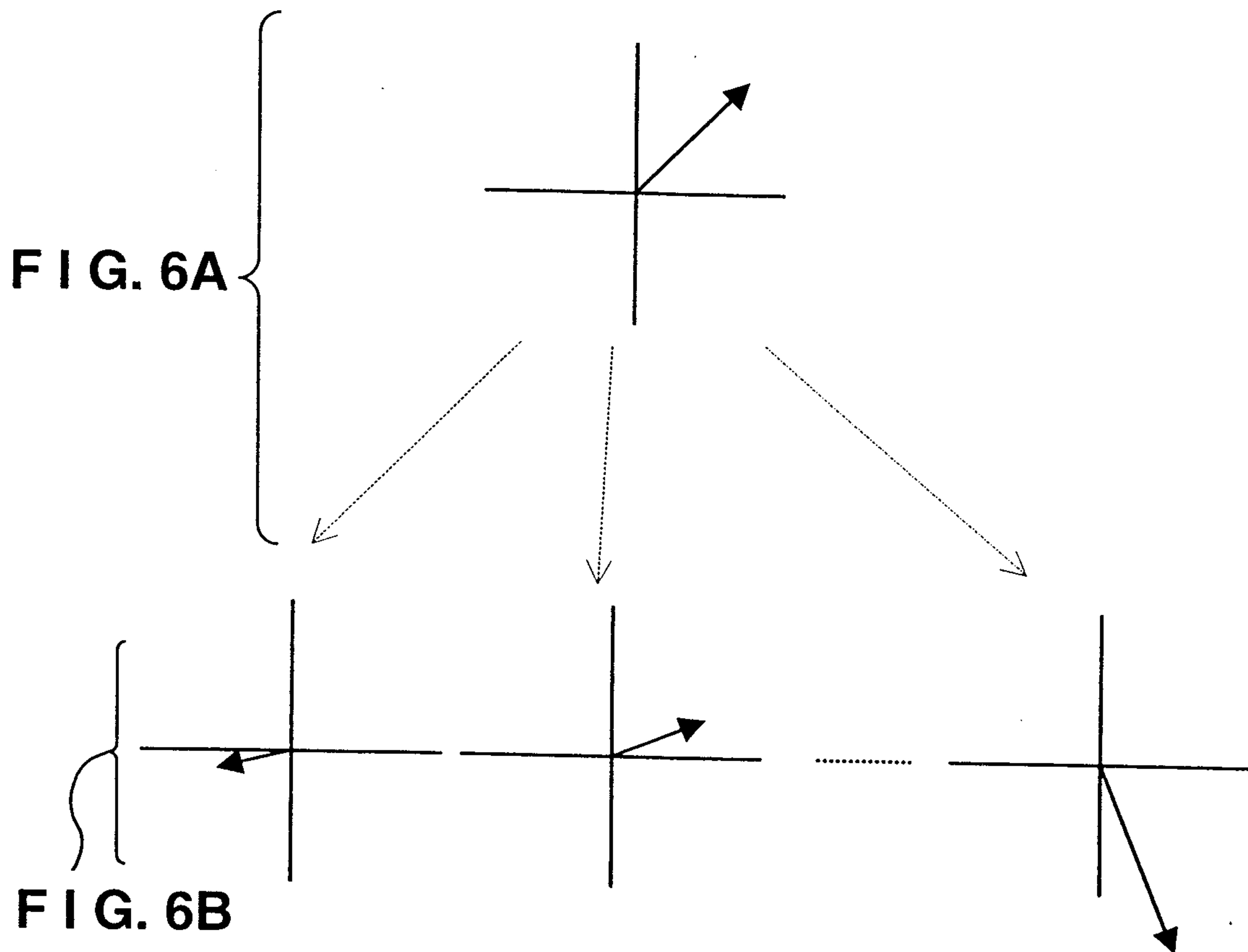


## FIG. 4



## FIG. 5





## FIG. 7

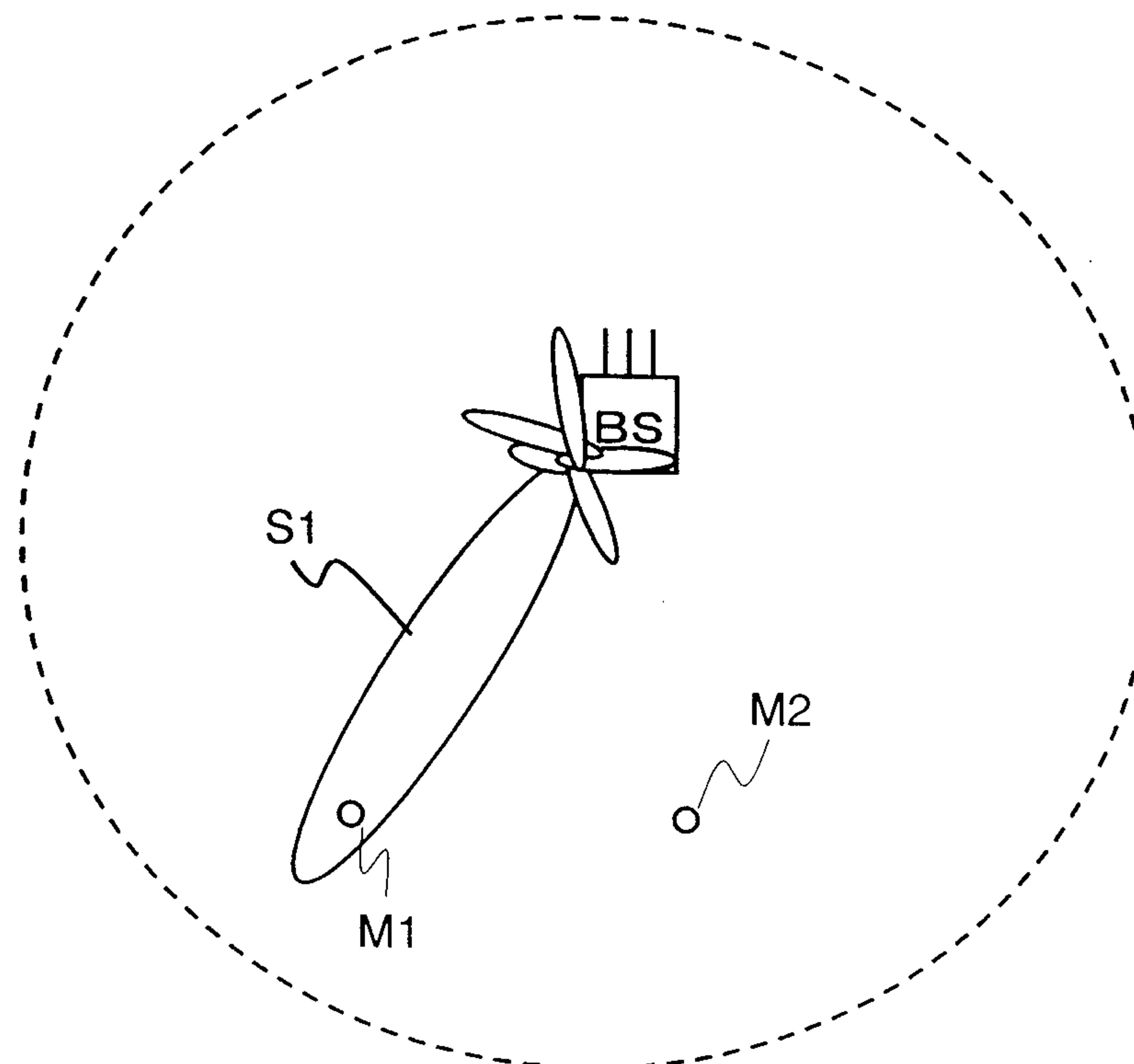


FIG. 8

