(51) International Patent Classification ^{5} : H04B 7/005, 7/26	A1	(11) International Publication Number: **WO 94/27381** (43) International Publication Date: 24 November 1994 (24.11.94)

(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON [SE/SE]; S-126 25 Stockholm (SE).

(72) Inventors: BORG, Lars, Uno; Stickelbärsvägen 4, S-114 23 Stockholm (SE). LINDROTH, Lars, Magnus; Tingsvägen 2, S-183 40 Täby (SE).

(74) Agents: LÖVGREN, Tage et al.; Telefonaktiebolaget LM Ericsson, S-126 25 Stockholm (SE).

(54) Title: DYNAMIC CONTROL OF TRANSMITTING POWER AT A TRANSMITTER AND ATTENUATION AT A RECEIVER

(57) Abstract

A communications system includes a receiver and a transmitter for transmitting a communications signal to the receiver. The transmitter adjusts its transmission power level in response to receiver power control signals transmitted by the receiver. The receiver includes an attenuator for attenuating the received communications signal, and measurement means for measuring the signal strength of the attenuated signal. The measured signal strength is coupled to attenuator control means and to transmission power control means. The attenuator control means and the transmission control means adjust, respectively, receiver attenuation and transmitter power level so as to optimize system performance. This may include keeping the attenuated signal within the dynamic range of the receiver. This may also include eliminating disturbance signals by adjusting receiver attenuation to produce an effective dynamic range for receiving only signals having a signal strength level that is higher than the disturbance signal strength level, while at the same time increasing the transmission power level to keep it within the effective dynamic range of the receiver. The disturbance signal may be detected as an increased bit error rate of the received communication signal. The apparatus and method may also be applied to systems in which a plurality of receivers are coupled to a common antenna through a receiver multicoupler.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgystan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic	SD	Sudan
CG	Congo		of Korea	SE	Sweden
CH	Switzerland	KR	Republic of Korea	SI	Slovenia
CI	Côte d'Ivoire	KZ	Kazakhstan	SK	Slovakia
CM	Cameroon	LI	Liechtenstein	SN	Senegal
CN	China	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
CZ	Czech Republic	LV	Latvia	TJ	Tajikistan
DE	Germany	MC	Monaco	TT	Trinidad and Tobago
DK	Denmark	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	US	United States of America
FI	Finland	ML	Mali	UZ	Uzbekistan
FR	France	MN	Mongolia	VN	Viet Nam
GA	Gabon				

DYNAMIC CONTROL OF TRANSMITTING POWER AT A TRANSMITTER AND ATTENUATION AT A RECEIVER

BACKGROUND

Applicants' invention relates to communications systems
5   including transmitters and receivers, and more particularly
to a communications system that optimizes performance by
dynamically adjusting transmitter power and receiver at-
tenuation.

In a typical telecommunications system, such as in a cellular
10   telephone system, a receiver is designed to function with
signals in a given signal strength range. This signal
strength range is referred to as the dynamic range of the
receiver. The lowest acceptable signal strength that can be
received is called the receiver sensitivity. The highest
15   acceptable signal strength that can be received is called the
blocking limit.

In a cellular telephone system, the distance between a base
station (BS) and a mobile station (MS) varies as the mobile
station moves around within a cell. Consequently, in large
20   cells, the variations in received signal strength can be very
large. Sometimes, these variations are so large that they
cannot be compensated by varying the mobile station's transmit
power. In such cells, it would be useful for the receiver
dynamic range, that is, the signal level range defined by the
25   highest and lowest acceptable received signal levels, to be
changed/transposed in relation to the distance between the
base station and the mobile station.

The receiver dynamic range may be transposed by placing an
attenuator between the antenna and the receiver. As at-
30   tenuation increases, both the lowest and highest acceptable
received signal strengths increase. Similarly, the receiver

dynamic range is transposed downward as attenuation decreases. This influence of attenuation on dynamic range is illustrated in Figure 1. When attenuation is set at 0 decibels (dB), the receiver dynamic range 101 is defined by
5 the sensitivity 102 and the blocking limit 103 of the receiver (not shown).

If attenuation is increased to 3 dB, the receiver dynamic range shifts to a new dynamic range 104, defined by sensitivity 105 and blocking limit 106, both of which are
10 substantially 3 dB higher than the respective sensitivity 102 and blocking limit 103 that existed when attenuation is only 0 dB. Similarly, if attenuation is increased to 6 dB, the sensitivity 108 and blocking limit 109 are again increased, yielding a new receiver dynamic range 107.

15 In small cells, the distance between a mobile station and a base station can be very small. This can lead to disturbances in the receive band if there are large cells in the same area as the small cell. These large cells may belong to the same network as the small cell, or they may belong to another
20 network operating in the same or an adjacent frequency band. The measure of these disturbances can be a bit error rate in digital communications systems. In analog systems, other signal quality measures can be used, such as total distortion of a modulated pilot tone.

25 The situation just described is illustrated in Figure 2, in which a base station B 201 is associated with a cell 202, and a base station A 203 is associated with a cell 204. It will be observed that cell 204 is smaller than cell 202, and defines a geographical area that is located inside or near cell 202.
30 Thus, because of the difference in the cells' relative sizes with respect to one another, cell 202 may be called a "macrocell" and cell 204 may be called a "microcell". When a mobile station B 205, associated with the "macrocell" 202 comes near

base station A 203, the base station A 203 receiver may experience disturbances from mobile station B 205. This may be so even if the radio frequencies used by base station A 203 are widely separated from those used by base station B 201 and

5   mobile station B 205.

If base station A 203 is equipped with a dynamically adjustable attenuator interposed between the antenna and receiver as described above, the attenuation can be increased until the disturbance experienced by the receiver is acceptably low.

10   This is because the disturbances in the receive band are attenuated with at least the value of the attenuator. However, the desired signal from mobile station A 206, which is transmitting to base station A 203, is also attenuated with the value of the attenuator. This may cause the signal from

15   mobile station A 206 to be unacceptably low for reception by base station A 203.

SUMMARY

The above-described problem, and others, are solved in accordance with the Applicants' invention by dynamically

20   controlling both the attenuation at the base station A 203 receiver, and the transmit power of the mobile station A 206.

In one aspect, Applicants' invention provides a receiver that receives a communications signal from a transmitter, the received communications signal being attenuated at the

25   receiver. The signal strength of the signal is then measured. This measured signal strength is then applied to a means for controlling the attenuation and to a means for controlling the transmission power. The attenuation control means dynamically controls the amount by which the received signal is

30   attenuated.

The transmission power control means generates a power control
signal to be communicated to the transmitter. The transmitter
uses the received power control signal to adjust the power
level at which it transmits the communications signal to the
5 receiver. Both the attenuation control means and the trans-
mission control means control, respectively, receiver
attenuation and transmission power level so as to optimize
system performance.

In another aspect of the invention, receiver attenuation and
10 transmission power level are adjusted to keep the attenuated
signal within the dynamic range of the receiver. This feature
is useful, for example, for designing a less expensive
receiver having a reduced dynamic range which is compensated
for by appropriate adjustment of receiver attenuation and
15 transmission power level.

In still another aspect of the invention, receiver attenuation
is adjusted so that the receiver sensitivity level is relati-
vely high compared to a disturbance signal level, while at the
same time transmission power level is adjusted so that the
20 communications signal coming through the attenuator is still
within the dynamic range of the receiver.

In yet another aspect of the invention, the attenuator may
include an antenna having a dynamically adjustable gain.

In still another aspect of the invention, dynamic adjustment
25 of receiver attenuation and transmission power level are
applied to a system in which a plurality of receivers are
coupled to a common antenna through a multicoupler. In one
embodiment, a common attenuator is interposed between the
common antenna and the multicoupler. In another embodiment,
30 each receiver is also capable of further attenuating its
received communications signal.

5

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the invention will become apparent from the following description read in conjunction with the accompanying drawings in which:

5   Figure 1 is a graph showing the dynamic range of a receiver as a function of attenuation;

Figure 2 illustrates the situation of having a small mobile communications cell at least partly located within a large mobile communications cell;

10   Figure 3 is a block diagram of an apparatus in accordance with the present invention for dynamically controlling receiver attenuation and transmitter power;

Figure 4 is a block diagram of several receivers coupled to one antenna in accordance with another embodiment of the

15   invention;

Figure 5 is a block diagram of another embodiment of the invention which uses partitioned attenuation in a system having multiple receivers coupled to a common antenna by means of a multicoupler; and

20   Figure 6 is a block diagram of an alternative embodiment of the invention in which an antenna and a variable attenuator have been combined in a common element.

DETAILED DESCRIPTION

Referring now to Figure 3, a mobile telecommunications system
incorporating the present invention is illustrated. Blocks
to the right of the dotted line 301 are located in a mobile
5   station. Blocks to the left of the dotted line 301 are
located in a base station.

Signals received at the base station by means of an antenna
(not shown) are input to a dynamically adjustable attenuator
302. The signal that is output from the attenuator 302 is
10   input to a signal strength measurement circuit 303. The
output of the signal strength measurement circuit 303 is
coupled to the inputs of an attenuation control circuit 304,
and to a mobile station power control circuit 305. The
attenuation control circuit 304 is coupled to the attenuator
15   302 in order to control the amount of signal attenuation that
occurs. The mobile station power control circuit 305 uses the
output of the signal strength measurement circuit 303 in order
to generate a signal that is communicated to a mobile station
power circuit 306, where it controls the transmit power level
20   of the mobile station. In one preferred embodiment of the
invention, the signal strength measurements and power control
functions are made in accordance with the European Telecom-
munications Standards Institute's (ETSI) Global System for
Mobile Communications (GSM) standards, which are herein
25   incorporated by reference. In particular, GSM recommendation
05.08 describes signal strength measurement in Sections 8.1.2
and 8.1.3. Sections 3.2-4.7, in conjunction with GSM recom-
mendation 05.05 Section 4.1, describe RF power control. The
control functions of the attenuation control circuit 304 and
30   the mobile station power control circuit 305 are described in
more detail below.

One use of the dynamic control system depicted in Figure 3 is
to compensate for the varying signal strength received by a

7

base station B 201 (see Figure 2) that occurs when a mobile
station B 205 travels within a large cell 202. If the
transmit power of the mobile station B 205 is constant, the
signal strength received by the base station B 201 decreases
5 as the distance between the mobile station B 205 and the base
station B 201 increases. Conversely, as the mobile station B
205 comes closer to the base station B 201, the received
signal strength increases, assuming again that the transmit
power of the mobile station 205 is constant.

10 The present invention compensates for this as follows. When
the mobile station B 205 is situated near the border of the
cell 202, the mobile station power control circuit 305 detects
the diminution in received signal strength, and transmits a
signal ordering the mobile station B 205 to transmit at a high
15 power level. Due to the large path loss that occurs over this
distance, the received signal strength in the base station B
201 may still be weak, and may be close to the receiver
sensitivity level.

When the mobile station B 205 moves towards the base station
20 B 201, the received signal strength in the base station B 201
increases. This is detected by the mobile station power
control circuit 305, which responds by transmitting a signal
to the mobile station B 205 which causes it to reduce its
transmit power to a level that keeps the received signal
25 strength within the receiver dynamic range. At some point, as
the mobile station B 205 travels towards the base station B
201, the mobile station B 205 is transmitting at its lowest
possible power level. As the mobile station B 205 continues
towards the base station B 201, the received signal strength
30 will increase, and after some time may be higher than is
acceptable. In other words, despite the fact that the mobile
station B 205 is transmitting at its lowest possible power
level, its proximity to the base station B 201 causes the

received signal strength to exceed the blocking limit of the receiver.

This problem is solved in the present invention by the attenuation control circuit 304, which detects the unaccep-
5   tably high received signal strength, and orders the attenuator 302 to increase the amount of attenuation. The upper limit of the acceptable signal strength (i.e., the blocking limit) will then increase, thereby eliminating the problem with the high received signal strength.

10   Another problem that is solved by the present invention is the above-described situation that can occur when a small cell 204 is located inside, or near, a large cell 202. As explained above, the disturbance in a base station A 203 caused by a mobile station B 205 that is attempting to transmit to a base
15   station B 201 may be high, relative to the wanted signal being transmitted by the mobile station A 206.

In accordance with the present invention, the mobile station power control circuit 305 detects the high level of distur-
bance, recognizable in digital communications systems, for
20   example, as an increase in the bit error rate for the channel, and causes actions as follows. The attenuation control circuit 304 causes the attenuator 302 to increase its at- tenuation until the signal strength of the disturbance 110 (see Figure 1) is considerably reduced, possibly below the
25   receiver sensitivity level 105. However, the desired carrier signal is also attenuated by this action. To compensate for this, the mobile station power control circuit 305 transmits a signal to the power control circuit 306 of mobile station A 206, causing it to increase its transmit power level until the
30   received signal strength of the carrier signal 111 (see Figure 1) is above the receiver sensitivity level 105. Thus, the received signal strength of the desired signal is kept

constant above the sensitivity level while the disturbance is
suppressed.

It will be recognized by those skilled in the art that, in the
above scenario, the mobile station power control 305 could
5   have been the first to act by ordering the mobile station A
206 to increase its transmit power level in order to increase
the received signal strength accordingly, and thereby reduce
the bit error rate. The attenuation control circuit 304 could
then respond to this occurrence by increasing attenuation of
10   the received signal to bring the received signal strength back
down to a desired level.

In another feature of the invention, dynamic attenuation under
the control of the attenuation control circuit 304 is combined
with a mobile station power control process, carried out by
15   the mobile station power control circuit 305, in which signal
quality of the received signal is used to determine the
transmit power. By combining dynamic attenuation control with
this kind of power control, unnecessary attenuation of the
wanted signal is prevented when the disturbance is low. This
20   has the advantage of keeping the mobile transmit power to a
minimum, which is of great importance for many mobile ap-
plications. In one preferred embodiment, the mobile station
power control process, in which signal quality of the received
signal is used to determine the transmit power, is that which
25   is described in copending U.S. Patent Application Serial No.
_____ entitled METHOD AND APPARATUS FOR TRANSMISSION
POWER REGULATION IN A RADIO SYSTEM, filed in the name of
Almgren et al. on May 14, 1993 and assigned to the assignee of
this invention, the entire disclosure of which is hereby
30   incorporated by reference.

Frequently, a base station has several receivers coupled to
the same receiver antenna. In such situations, the atte-
nuation must be partitioned accordingly. Another embodiment

of the invention that solves this problem will now be described with reference to Figures 4 and 5.

In Figure 4, a number of receivers 403 are shown coupled to a single antenna 401 by means of a receiver multicoupler 402.
5   The receiver multicoupler 402 is a wideband amplifier that receives a broad band signal and has a plurality of narrow band signal outputs. Each receiver 403 may include the invention as described above with reference to Figure 3. However, the receiver multicoupler 402 may, itself, suffer
10 blocking by strong signals that are input from the antenna 401. In that case, it is apparent that any attenuation that occurs within individual receivers 403 will be unable to eliminate this blocking. To avoid this problem, the receiver multicoupler 402 may be designed to have a higher blocking
15 limit than any of the individual receivers 403.

Another solution to the problem of blocking in the receiver multicoupler 402 is shown in Figure 5. Here, attenuation is partitioned in order to achieve an optimum selection of attenuation before and after the receiver multicoupler 402.

20 One of a number N of receivers 503 is shown in Figure 5. Although the following description makes reference only to a single receiver 503, it should be understood that the description is applicable to each of the N receivers 503. Each receiver 503 has the control circuitry as described above with
25 reference to Figure 3. In addition, the output of the signal strength measurement circuit 303 from each receiver 503 is coupled to an input of a base station front end attenuation control circuit 504.

A signal representing the amount of attenuation being utilized
30 by the respective receiver 503 is also output from the receiver's base station attenuation control circuit 505 and coupled to an input of the base station front end attenuation

control circuit 504. The base station front end attenuation
control circuit 504 combines these inputs with corresponding
inputs from the other receivers 503 to determine the true
signal strength of the signal that is being output from the
5 front end attenuator 506. For example, these input signals to
the base station front end attenuation control circuit 504 may
simply be averaged. Other methods of determining the true
signal strength of the signal that is being output from the
front end attenuator 506 may also be used.

10 The base station front end attenuation control circuit 504
then adjusts, by means of an output signal that is coupled to
the front end attenuator 506, the strength of the signal that
is input to the receiver multicoupler 502. The adjustment is
such that the front end attenuation is kept as low as possible
15 while still preventing blocking in the receiver multicoupler
502. It will be recognized that in order to make this
adjustment, the base station front end attenuation control
circuit 504 must also have information regarding the dynamic
range of the receiver multicoupler 502. The information
20 pertaining to the dynamic range of the receiver multicoupler
502 should preferably be preprogrammed in the base station
front end attenuation control circuit 504.

The rest of the regulation is accomplished as described above
with reference to Figure 3. That is, each individual base
25 station-mobile station link is regulated so as to produce an
optimum balance of transmitted power and received signal
quality.

Referring now to Figure 6, an alternative embodiment of the
invention is shown. This embodiment is very much like the one
30 shown in Figure 3. The difference between the two embodiments
is that, in Figure 6, the variable attenuator has been
replaced by the antenna/attenuator 602, which is an antenna
having adjustable antenna gain, such as an electronically

adjustable phased array antenna. The remaining elements in Figure 6 operate the same as the corresponding elements described above with respect to Figure 3, and need not be described in further detail.

5   The advantage of incorporating the adjustable attenuation directly in the antenna element is that intermodulation (IM) products generated in the antenna itself are attenuated by an amount that is approximately equal to the set attenuation raised to the nth power, where n is the order of the inter-
10 modulation product. This makes it possible to implement a receiver/antenna configuration having an extreme robustness against radio environments having the kinds of disturbances discussed above, including high signal strength (causing blocking), and intermodulation products. In addition, by
15 designing a receiver which can compensate for high signal strength and intermodulation products, system margins can be widened to improve performance in the presences of other types of disturbances, such as cochannel interference and propagation channel distortion.

20 The invention has been described with reference to several specific embodiments. It will be recognized by those skilled in the art, however, that the invention may be practiced in ways not illustrated here. Thus, the scope of the invention is not limited by this description, but is, instead, defined
25 by the following claims.

13

WHAT IS CLAIMED IS:

1.   In a communications system having a receiver that
receives a communications signal transmitted by a transmit-
ter, the transmitter including transmitter power control
5 means, responsive to a received power control signal, for
controlling a power level at which the transmitter transmits
the transmitted communications signal, a receiver apparatus
comprising:
        measurement means for generating a signal strength
10 measurement signal based on the received communications
signal;
        means for attenuating the received communications signal
by an amount dynamically determined by a control signal;
        attenuation control means, coupled to the measurement
15 means and the attenuating means, for supplying a control
signal thereto; and
        first power control means, coupled to the measurement
means, for generating a power control signal to be com-
municated to the transmitter;
20   wherein the attenuation control means and the first power
·control means dynamically control, respectively, receiver
attenuation amount and transmitter power level so as to
substantially optimize communications system performance.

2.   A receiver apparatus according to claim 1, wherein
25 optimizing communications system performance includes keeping
the attenuated signal within a dynamic range of the receiver.

3.   A receiver apparatus according to claim 2, wherein the
attenuating means includes an antenna having a dynamically
adjustable antenna gain.

30 4.   A receiver apparatus according to claim 1, wherein
optimizing communications system performance includes
dynamically adjusting receiver attenuation to produce an

14

effective dynamic range for receiving only signals having a
signal strength level that is higher than a disturbance signal
strength level, while at the same time adjusting transmitter
power level so that the transmitter will produce an adjusted
5   communications signal that is within the effective dynamic
range of the receiver.

5.   A receiver apparatus according to claim 4, wherein
optimizing communications system performance is performed by
the attenuation control means and the first power control
10 means in response to a bit error rate of the received com-
munications signal being higher than a predetermined amount,
the higher bit error rate indicating the presence of a
disturbance signal.

6.   A receiver apparatus according to claim 4, wherein the
15 attenuating means includes an antenna having a dynamically
adjustable antenna gain.

7.   A receiver apparatus according to claim 1, wherein the
attenuating means includes an antenna having a dynamically
adjustable antenna gain.

20 8.   In a communications system having a plurality of recei-
vers coupled to a common antenna through a receiver mul-
ticoupler, the multicoupler having a signal input and a
plurality of signal outputs each corresponding to one of the
plurality of receivers, each of the receivers receiving a
25 communications signal transmitted by a corresponding one of
a plurality of transmitters, each transmitter including
transmitter power control means, responsive to a received
power control signal, for controlling a power level at which
the transmitter transmits the transmitted communications
30 signal, a receiver apparatus comprising:

a plurality of first measurement means, each generating
a first signal strength measurement signal based on a cor-
responding received communication signal;

front end attenuating means for attenuating the plura-
5   lity of received communications signals by an amount dynami-
cally determined by a first control signal, the front end
attenuation means having an output for supplying the at-
tenuated plurality of received communications signals to the
receiver multicoupler;

10   front end attenuation control means coupled to the
plurality of first signal strength measurement means and to
the front end attenuating means for supplying a first control
signal thereto; and

a plurality of first power control means, each coupled to
15   a corresponding one of the plurality of first signal strength
measurement means, each for generating one of the plurality of
power control signals to be communicated to a corresponding
one of the plurality of transmitters;

wherein the front end attenuation control means and the
20   plurality of first power control means dynamically control,
respectively, receiver first attenuation amount and transmit-
ter power level of the plurality of transmitters so as to
substantially optimize communications system performance.

9.   A receiver apparatus according to claim 8, wherein
25   optimizing communications system performance includes keeping
the attenuated signal within a dynamic range of each of the
plurality of receivers.

10.   A receiver apparatus according to claim 8, wherein
optimizing communications system performance includes
30   dynamically adjusting receiver front end attenuation to
produce an effective dynamic range for receiving only signals
having a signal strength level that is higher than a distur-
bance signal strength level, while at the same time adjusting
a power level of each of the plurality of transmitters so that

each transmitter will produce an adjusted communications
signal that is within the effective dynamic range of a
corresponding receiver.

11.   A receiver apparatus according to claim 10, wherein
optimizing communications system performance is performed by
the front end attenuation control means and the plurality of
first power control means in response to a bit error rate of
the received commmunications signals being higher than a
predetermined amount, the higher bit error rate indicating the
presence of a disturbance signal.

12.   A receiver apparatus according to claim 8, wherein the
front end attenuating means includes an antenna having a
dynamically adjustable antenna gain.

13.   In a communications system having a plurality of recei-
vers coupled to a common antenna through a receiver mul-
ticoupler, the multicoupler having a signal input and a
plurality of signal outputs each corresponding to one of the
plurality of receivers, each of the receivers receiving a
communications signal transmitted by a corresponding one of
a plurality of transmitters, each transmitter including
transmitter power control means, responsive to a received
power control signal, for controlling a power level at which
the transmitter transmits the transmitted communications
signal, a receiver apparatus comprising:
        front end attenuating means for attenuating the plura-
lity of received communications signals by an amount dynami-
cally determined by a first control signal, the front end
attenuation means having an output for supplying the at-
tenuated plurality of received communications signals to the
receiver multicoupler;
        a plurality of second attenuating means, each for further
attenuating a corresponding one of the attenuated plurality

of received communications signals by an amount dynamically determined by a corresponding second control signal;

a plurality of first measurement means, each for generating a first signal strength measurement signal based on the
5   corresponding received communications signal;

front end attenuation control means coupled to the plurality of first signal strength measurement means and to the front end attenuating means for supplying a first control signal thereto;

10   a plurality of first power control means, each coupled to a corresponding one of the plurality of first signal strength measurement means, each for generating one of the plurality of power control signals to be communicated to a corresponding one of the plurality of transmitters; and

15   a plurality of second attenuation control means, each coupled to a corresponding one of the plurality of first signal strength measurement means and to a corresponding one of the plurality of second attenuating means, for supplying the corresponding second control signal thereto;

20   wherein the front end attenuation control means, the plurality of first power control means, and the plurality of second attenuation control means dynamically control, respectively, receiver front end attenuation amount, trans-mitter power level of the plurality of transmitters, and
25   receiver further attenuation amount so as to substantially optimize communications system performance.

14. A receiver apparatus according to claim 13, wherein optimizing communications system performance includes keeping each of the plurality of further attenuated signals within a
30   dynamic range of a corresponding receiver.

15. A receiver apparatus according to claim 13, wherein optimizing communications system performance includes dynamically adjusting receiver front end attenuation and respective receiver further attenuation to produce, for each

of the plurality of receivers, an effective dynamic range for receiving only signals having a signal strength level that is higher than a disturbance signal strength level, while at the same time adjusting a corresponding transmitter power level

5 so that a corresponding transmitter will produce a corresponding adjusted communications signal that is within the effective dynamic range of the respective receiver.

16. A receiver apparatus according to claim 15, wherein optimizing communications system performance is performed by

10 the front end attenuation control means, the plurality of second attenuation control means, and the plurality of first power control means in response to a bit error rate of the received communications signals being higher than a predetermined amount, the higher bit error rate indicating the

15 presence of a disturbance signal.

17. A receiver apparatus according to claim 13, wherein the front end attenuating means comprises an antenna having a dynamically adjustable antenna gain.

18. In a communications system having a receiver that

20 receives a communications signal transmitted by a transmitter, the transmitter including transmitter power control means responsive to a received power control signal for controlling a power level at which the transmitter transmits the communications signal, the receiver including attenuating

25 means for attenuating the received communications signal by an amount dynamically determined by a control signal, a method for dynamically optimizing communications system performance comprising the steps of:

measuring a signal strength of the received commu-

30 nications signal;

dynamically adjusting the attenuation amount, based on the measured signal strength; and

generating a power control signal to be transmitted to the transmitter based on the measured signal strength.

19. A method according to claim 18, wherein the steps of dynamically adjusting the attenuation amount and generating
5 a power control signal are further based on keeping the attenuated signal within a dynamic range of the receiver.

20. A method according to claim 18, wherein the steps of dynamically adjusting the attenuation amount and generating a power control signal are further based on dynamically
10 adjusting receiver attenuation to produce an effective dynamic range for receiving only signals having a signal strength level that is higher than a disturbance signal strength level, while at the same time adjusting transmitter power level so that it will produce an adjusted communications
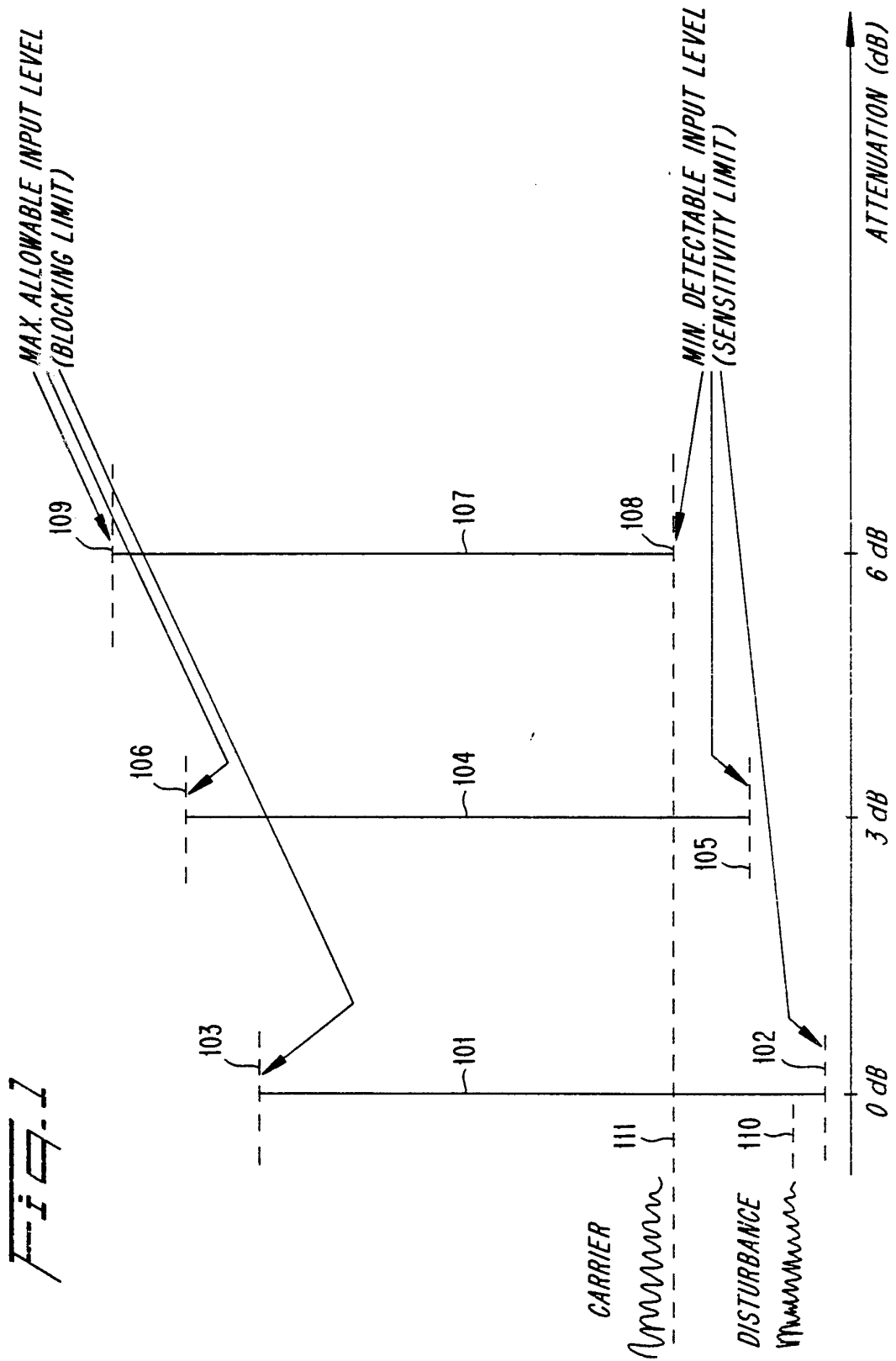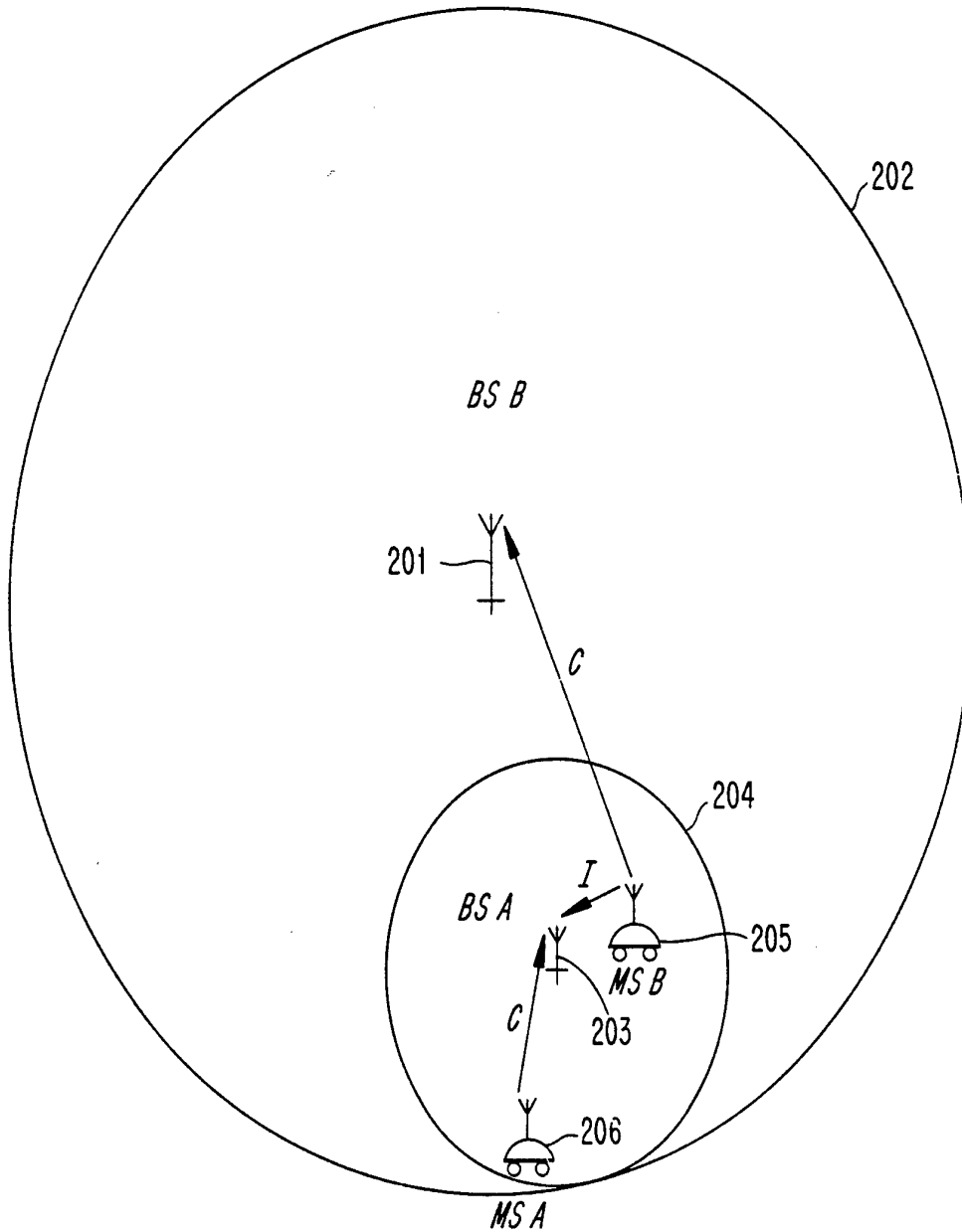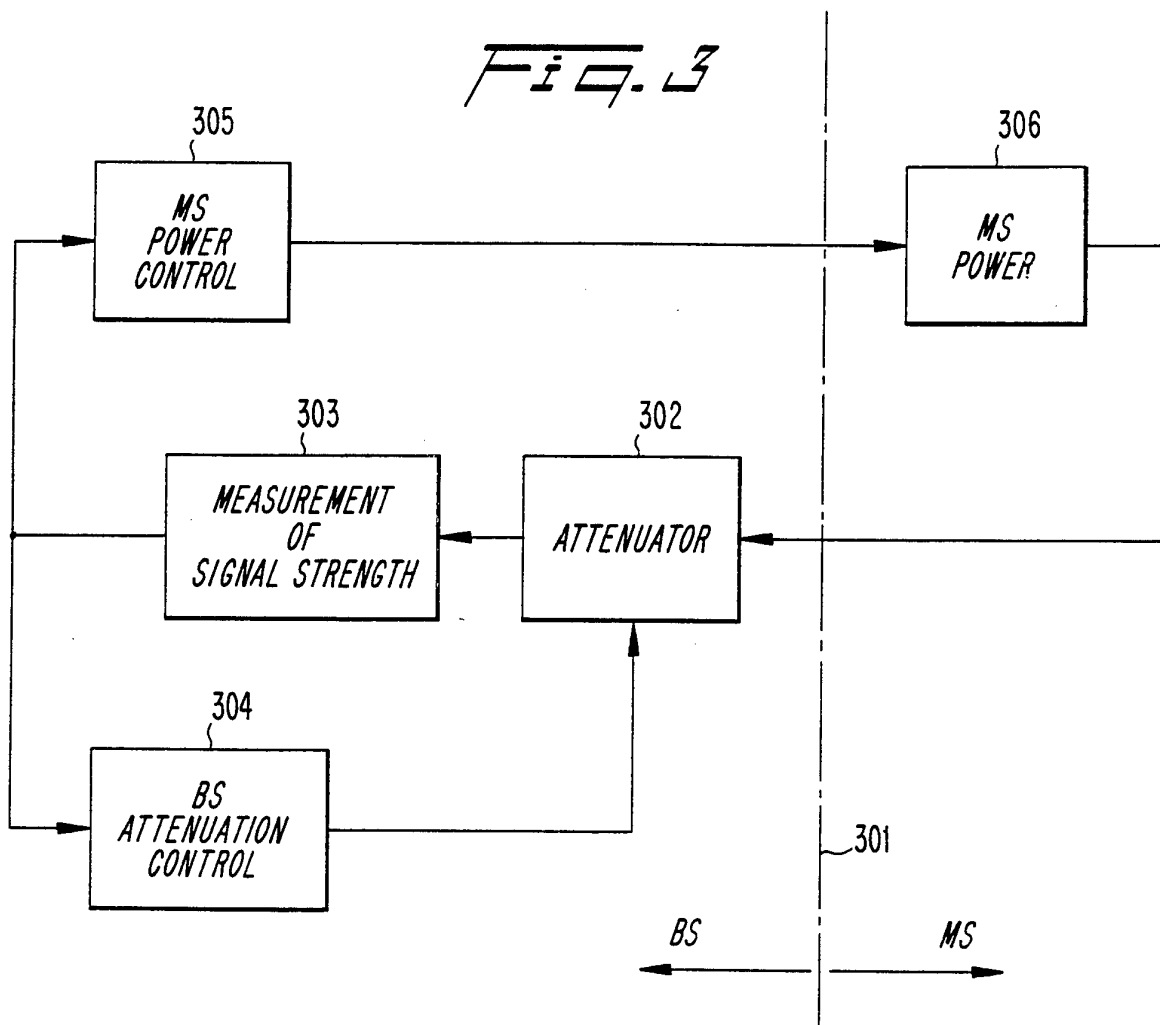15 signal that is within the effective dynamic range of the receiver.

Fig. 1

Fig. 2

Fig. 3

305 — MS POWER CONTROL

306 — MS POWER

303 — MEASUREMENT OF SIGNAL STRENGTH

302 — ATTENUATOR

304 — BS ATTENUATION CONTROL

301

BS   MS

Fig. 4

403 — RECEIVER
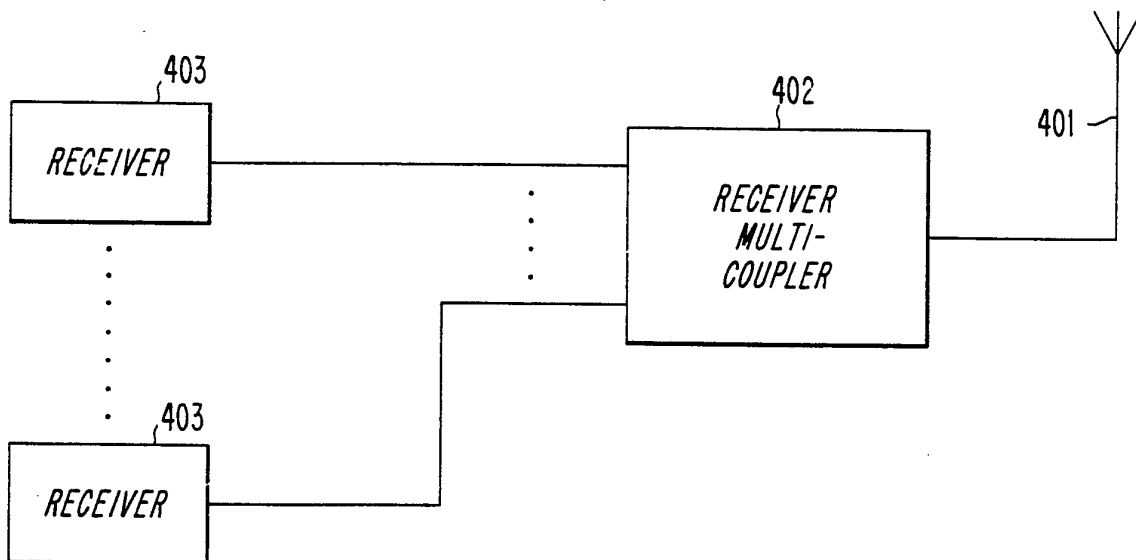
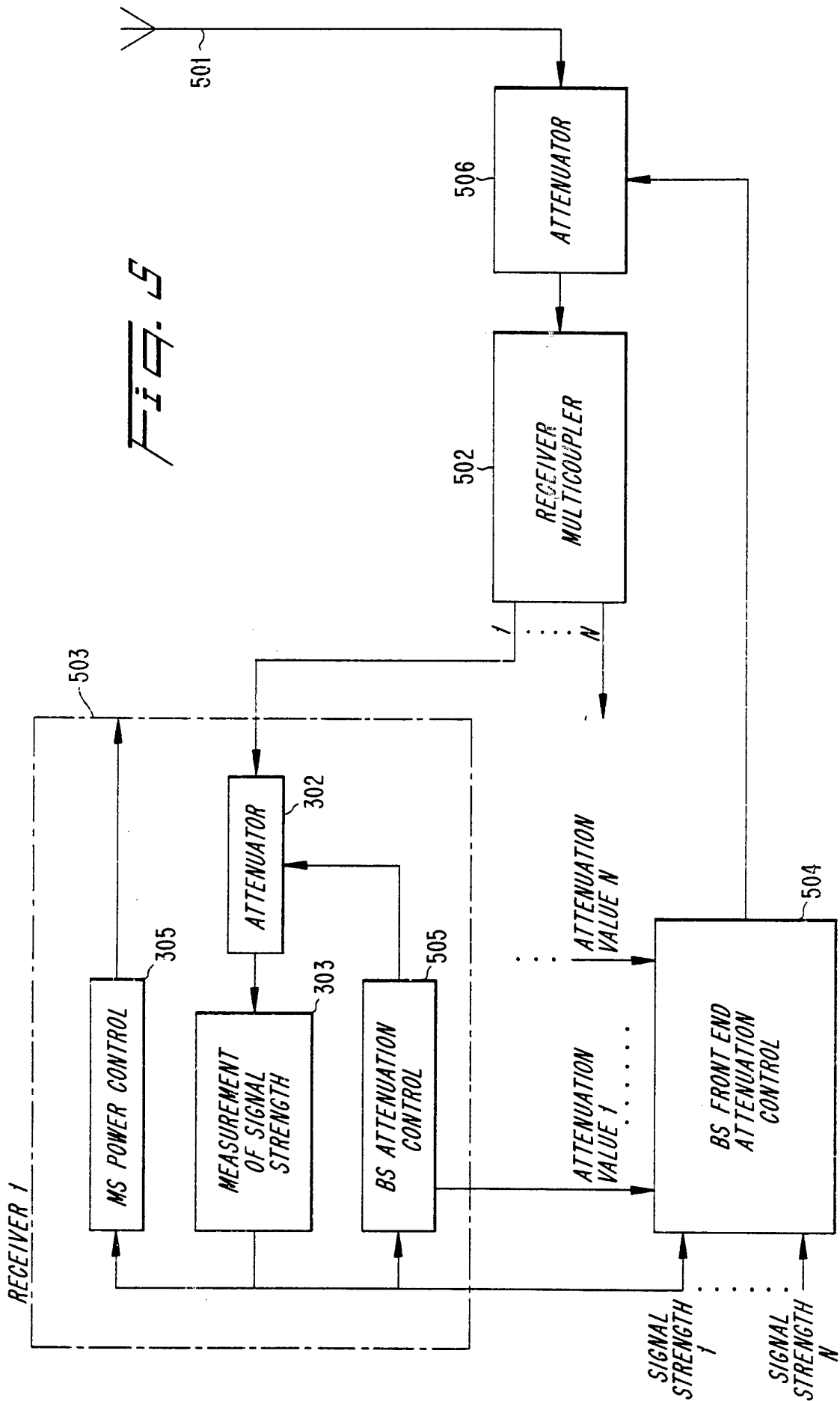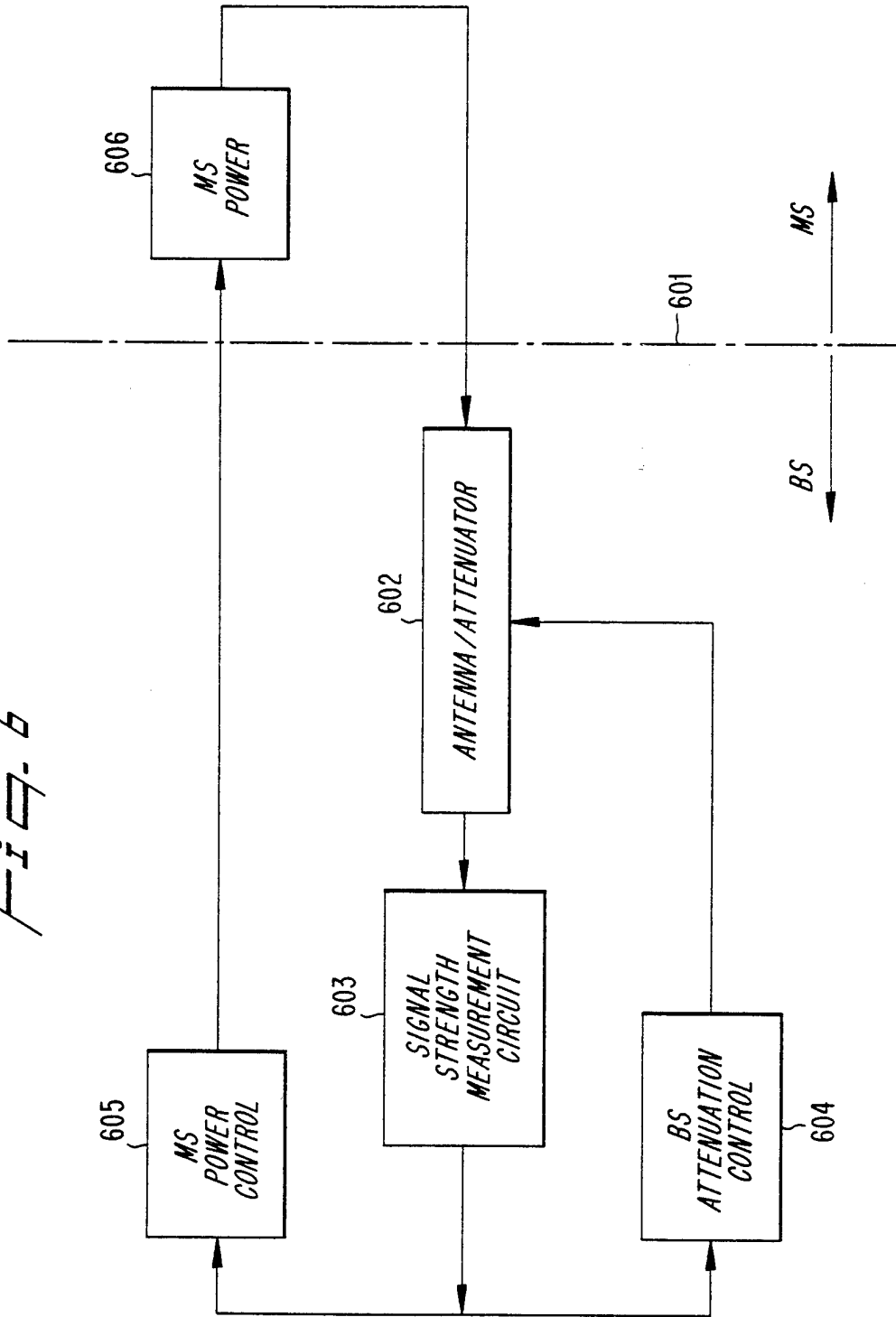402 — RECEIVER MULTI-COUPLER

401

403 — RECEIVER

Fig. 5

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 94/00435

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: H04B 7/005, H04B 7/26

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)

IPC5: H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

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

PAJ, WPI, CLAIMS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Patent Abstracts of Japan, Vol 16,No 45, E-1162, abstract of JP, A, 3-248634 (NEC CORP), 6 November 1991 (06.11.91)	1-2,4-5, 8-11,13-16, 18-20
A		3,6-7,12,17
	--	
Y	US, A, 4777653 (GEORGES BONNEROT ET AL.), 11 October 1988 (11.10.88), figure 1, abstract	1-2,4-5, 8-11,13-16, 18-20
	--	

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 August 1994	3 1 -08- 1994

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Bengt Jonsson Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A- 4777653	11/10/88	AU-A-	6665486	25/06/87
		CA-A-	1274281	18/09/90
		EP-A-	0230691	05/08/87