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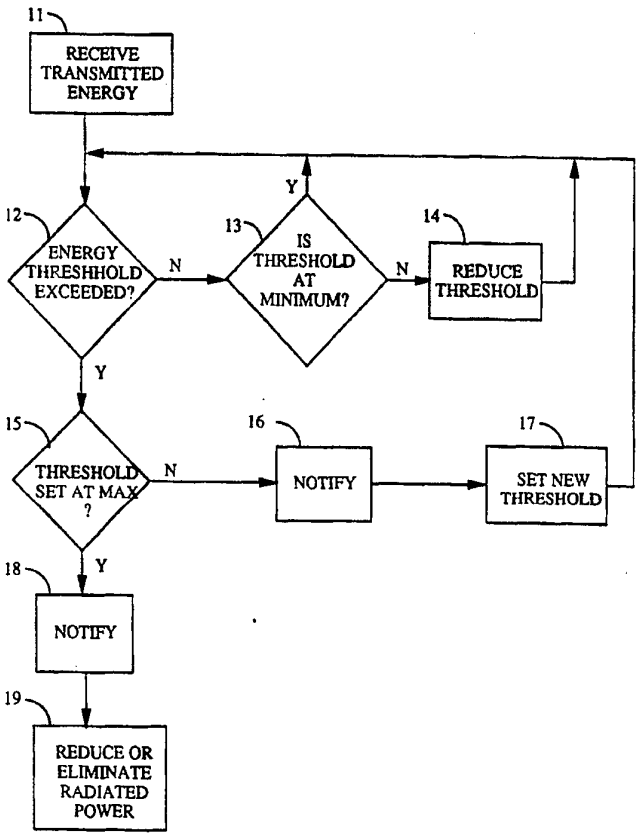
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(54) Title: METHOD AND APPARATUS FOR CONTROLLING THE EXPOSURE TO RF TRANSMISSIONS

(57) Abstract

A method and apparatus for monitoring and controlling the exposure of a user (3) of a handheld portable communication device (2) to RF emissions from the device antenna (1). The total energy transmitted in a predetermined window of time is continuously monitored by the device (2). Should the accumulated transmitted energy exceed a predetermined threshold, measures are taken by the device (2) to control user exposure to the RF emissions from the device antenna (1).



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METHOD AND APPARATUS FOR CONTROLLING THE EXPOSURE TO RF TRANSMISSIONS

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to communication systems where the antenna radiation is in close proximity to the user. More particularly, the present invention relates to a novel and improved method and apparatus for monitoring RF exposure levels associated with the use of handheld transmitters and providing response measures when the exposure to the RF transmissions exceeds a predetermined threshold value.

II. Description of the Related Art

It is frequently desirable to have self contained handheld personal communications units for their convenience and mobility. These features have given rise to an enormous demand for the hand held units. In response to the demand, industry has desired to place in effect a series of precautionary measures to monitor and control the user's RF exposure.

SUMMARY OF THE INVENTION

The present invention is a novel and improved method and apparatus for controlling user RF exposure levels. In accordance with the present invention the total amount of energy transmitted is measured until a predetermined exposure level within a fixed time period is reached at which time an automated sequence of preventative measures commences.

The transmission circuitry of a handheld telephone is comprised essentially of an antenna and a power amplifier coupled to the antenna. In general the power amplifier is responsive to a power level request signal that determines the transmission power from the antenna.

In present invention the transmission energy is monitored throughout the telephone operation, either by monitoring the power level request signal or by monitoring the output of the power amplifier. The amount of transmitted energy in a fixed period of time is accumulated by an integrator, which may take the form of a leaky integrator or a sliding window accumulator depending on if the moitored signal is in an analog or digital format. This accumulated value of transmitted energy is compared

to a predetermined threshold. When the accumulated value exceeds the predetermined threshold a signal is sent to a hazard control processor and precautionary steps are actuated.

In a more elegant implementation of the present invention the accumulated transmission energy is compared against an intermediate level or a series of intermediate levels after the accumulated energy exceeds each of said intermediate thresholds new precautionary steps are taken until the transmission power is reduced or until a final threshold is surpassed at which time the transmit power is reduced or eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

Figure 1 is an illustration of the RF exposure associated with the use of portable communications devices;

Figure 2 is a flowchart of the steps of the RF exposure monitor and control system; and

Figure 3 is an exemplary embodiment of the RF exposure monitor and control apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, Figure 1 illustrates the RF exposure associated with the use of portable personal communication devices, such as cellular telephones or similar devices. The proximity of the antenna 1 of the portable phone 2 to the users body 3 is of interest. The electromagnetic energy 4 emanating from antenna 1 of phone 2 are the source of interest. The control and monitoring of RF exposure is the objective of the present invention.

In portable communication devices, transmitter power is increased and decreased to maintain a quality communication link. In a fading environment or in the situation in which the transmission path is obstructed, the portable communication device increases transmission power to maintain link quality. The level of transmission energy and the

changes thereto should be monitored. Therefore proper control processes and circuitry are needed to limit the RF exposure level.

Figure 2 illustrates a flowchart of the steps involved in controlling the exposure levels of RF transmissions of the present invention. The accumulated energy is obtained, block 11, and compared against a current energy threshold, block 12. If in block 12 the accumulated energy value is determined to be less than the current threshold, the system checks if the threshold value is set to its minimum value, block 13. If in block 13 the threshold value is determined not to be at its minimum value, the threshold value is decreased by a predetermined decrement, block 14.

If in block 12 the current energy threshold is determined to be exceeded, a check is made to determine if the threshold is an intermediate threshold or the maximum threshold, block 15. If in block 15 the threshold is determined to be an intermediate threshold the following precautionary steps are actuated. The user is notified, block 16, and the energy threshold value is increased to a greater value, block 17.

The above described procedure continues until such time that the threshold value is determined to no longer be an intermediate value, but rather a maximum value in block 15 that will not be increased. At this time the user is notified, block 18, and the radiated power is reduced or eliminated block 19.

Figure 3 illustrates an exemplary embodiment of the present invention in a communications device. Power level requests which control transmission power are processed through an RF Exposure Control Processor 20 before being passed on to the power amplifier 21 as a Power Level Request' signal. The power amplifier 21, is responsive to the Power Level Request' signal for amplifying the input information signal to provide a transmission signal at a predetermined transmission power level to antenna 22. The information signal may be in either analog or digital format. The input information signal might be in analog or digital form and modulated for transmission using TDMA, CDMA, FM or any other modulation scheme well known in the art.

In satellite based portable telephone systems, the typical transmission frequencies are in the range of approximately 1610 - 1626.5 MHz. These telephones are designed to operate in the power range between 100mW and 1W. It should be noted the present invention is equally applicable to any transmission frequency or power range of either satellite or terrestrial based communication system.

In a preferred embodiment an integrator 13 taps off of the Power Level Request Signal from RF Exposure Control Processor 20. In an alternative embodiment the integrator could tap off the output of the power amplifier for its measurement of transmitted energy (as illustrated by the dashed line in Figure 3). The integrator can be in the form of a leaky integrator if the power request signal is analog in nature or a sliding window accumulator if the power request signal is digital in nature. The transmitted energy is ideally calculated using the formulas:

$$E_t = \int_{t}^{t+\Delta t} \text{Power}(t)\, dt \qquad (1)$$

where E_t is the transmitted energy and Power(t) is the transmission power as a function of time, or

$$E_t = \sum_{i=n}^{n+m} \text{Power}(i) \bullet \Delta t \qquad (2)$$

where E_t is the transmitted energy and Power(i) is the transmission power as a function of sample number.

The computation of equation 1 can be accomplished using an analog integrator, as is well known in the art, and the computation of equation 2 can be accomplished using digital accumulating circuitry which is also well known in the art. There are simplified implementations that approximate the functions of in Equations 1 and 2. For example, a simple RC network can approximate the analog integral of Equation 1. The integration or summation period used in the exemplary embodiment may be 6 minutes, or any other selected time period. The period of integration is a programmable quantity and can be varied to conform to local laws or differing needs.

In addition, the integration need not be a linear process. Instead, the rate of accumulation or integration may be weighted based on the characteristics of the RF transmission at any given time. At the present, it is commonly believed that the significance of the radiation exposure is simply proportional to the total amount of accumulated exposure. However, it is envisioned in the present invention that should an alternative model wherein the characteristics of the RF transmissions are of interest to the user, the integration can be weighted in accordance with these characteristics. Characteristics that could be taken into effect and be

weighted accordingly may include the frequency of the electromagnetic radiation, the intensity of the radiation, or any other measureable characteristic of the radiation.

The transmitted energy (E_t) is compared against the current threshold value (T) provided by RF Exposure Control Processor 20, by means of a comparator 24. In the exemplary embodiment, the current threshold value is stored within a ROM or RAM memory storage device associated with the RF Exposure Control Processor 20. The threshold values are also programmable and can be varied to conform to local laws or differing needs. A suggested maximum exposure threshold might be 180 Joules of transmitted energy in a 6 minute period. So in the exemplary embodiment an initial threshold might be set at 90 Joules of transmitted energy in a 6 minute period. If the initial threshold, as supplied by RF Exposure Control Processor 20, is exceeded then comparator 24 sends the Threshold Exceeded signal back to RF Exposure Control Processor 20.

At this point the RF Exposure Control Processor 20 sends out a Control Notification signal that makes the user aware of the condition. For example in response to the Control Notification Signal, the communications device may provide either or both an audio or visual warning. The visual alert for example may take the form of a script warning on a digital display on the communications device or an illumination of an indicator lamp. The user in response to the warning can take measures to reduce the needed transmission energy by reducing the in path interference. The RF Exposure Control Processor 20 then increases the threshold value and allows the user to continue operation.

The process of increasing the threshold values continues until at some point the threshold value has reached its maximum value, at which time the RF Exposure Control Processor 20 modifies the Power Level Request signal to reduce or eliminate the transmission radiation. If, on the other hand, the accumulated value is less than the current threshold value for a predetermined period of time the threshold is reduced. The process of reducing the threshold value continues until the threshold value is reduced to its minimum value.

An optional feature which may be added to the present invention is a system override subsystem. As illustrated in Figure 3, a override signal can be provided to the RF Exposure Control Processor 20 by the user in cases where it is necessary to maintain the high transmission power. The override subsytem of RF Exposure Control Processor 20 would in response to the override signal inactivate the hazard control processor and allow the

power request signal to pass through RF Exposure Control Processor 20 unaltered. A subsystem of this type could, for example, be invoked under emergency circumstances that dictate that a transmission must get out. The design of such override systems are well known in the art.

Although in the diagrams and in the text the system has been illustrated as an autonomous system controlled by its own processor, the present invention can reside partially or entirely in the existing processing elements of the portable communications device.

The previous description of the preferred embodiments is provided to enable any person skilled in the art to make or use the present invention. The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

CLAIMS

1. In a communications device having a transmitter and an antenna, a system for controlling the exposure level of RF transmissions comprising:

means for determining the amount of energy transmitted by said antenna in a predetermined length of time to provide an accumulated energy value;

comparison means for comparing said accumulated energy value against a threshold value to provide a comparison result signal; and

response means responsive to said comparison result signal for, if said comparison result signal is indicative of said accumulated energy value exceeding said threshold value, providing a precautionary response indicative of a condition of high transmission radiation exposure.

2. The apparatus of Claim 1 wherein said means for determining comprises a sliding window accumulator.

3. The apparatus of Claim 1 wherein said means for determining comprises a leaky integrator.

4. The apparatus of Claim 1 wherein said precautionary response comprises notifying the user of the condition.

5. The apparatus of Claim 2 wherein said precautionary response comprises notifying the user of the condition.

6. The apparatus of Claim 3 wherein said precautionary response comprises notifying the user of the condition.

7. The apparatus of Claim 1 wherein said precautionary response comprises limiting the transmission power of said transmitter.

8. The apparatus of Claim 2 wherein said precautionary response comprises limiting the transmission power of said transmitter.

9. The apparatus of Claim 3 wherein said precautionary response comprises limiting the transmission power of said transmitter.

10. The apparatus of Claim 4 wherein said precautionary response further comprises limiting the transmission power of said transmitter.

11. The apparatus of Claim 5 wherein said precautionary response further comprises limiting the transmission power of said transmitter.

12. The apparatus of Claim 6 wherein said precautionary response further comprises limiting the transmission power of said transmitter.

13. The apparatus of Claim 1 wherein said response means is further for, when said comparison result signal is indicative of said accumulated energy value exceeding said threshold value, comparing said threshold value with a predetermined maximum threshold value, and if said threshold value is less than said maximum threshold value increasing said threshold value.

14. The apparatus of Claim 13 wherein said response means is further for, when said comparison result signal is indicative of said accumulated energy value less than said threshold value, reducing said threshold value.

15. The apparatus of Claim 13 wherein said response means is further for, when said comparison result signal is indicative of said accumulated energy value less than said threshold value, comparing said threshold value with a predetermined minimum threshold value, and reducing said threshold value only when said threshold value is greater than minimum threshold value.

16. The apparatus of Claim 14 wherein said response means is further for reducing said threshold value only when said threshold value is greater than a minimum threshold value.

17. In a handheld telephone having a transmitter and an antenna, a method for controlling the exposure levels of RF transmissions comprising:

determining the amount of energy transmitted by said antenna in a predetermined length of time to provide an accumulated energy value;

comparing said accumulated energy value against a predetermined threshold value;

providing a comparison result signal; and

providing a precautionary response responsive to said comparison result signal, if said comparison result signal is indicative of said accumulated energy value exceeding said threshold value.

18. The method of Claim 17 wherein said step of determining the amount of energy transmitted by said antenna comprises summing transmission power for a predetermined number of transmitted symbols.

19. The method of Claim 17 wherein said step of determining the amount of energy transmitted by said antenna comprises integrating transmission power over a predetermined time interval.

20. The method of Claim 17 wherein said step of providing a precautionary response comprises notifying the user of the condition.

21. The method of Claim 18 wherein said step of providing a precautionary response comprises notifying the user of the condition.

22. The method of Claim 19 wherein said step of providing a precautionary response comprises notifying the user of the condition.

23. The method of Claim 17 wherein said step of providing a precautionary response comprises limiting the transmission power of said transmitter.

24. The method of Claim 18 wherein said step of providing a precautionary response comprises limiting the transmission power of said transmitter.

25. The method of Claim 19 wherein said step of providing a precautionary response comprises limiting the transmission power of said transmitter.

26. The method of Claim 20 wherein said step of providing a precautionary response further comprises limiting the transmission power of said transmitter.

27. The method of Claim 21 wherein said step of providing a precautionary response further comprises limiting the transmission power of said transmitter.

28. The method of Claim 22 wherein said precautionary response further comprises limiting the transmission power of said transmitter.

29. The method of Claim 17 further comprising increasing said threshold responsive to said comparison result signal, if said comparison result is indicative of said accumulated energy value exceeding said threshold value.

30. The method of Claim 29 further comprising decreasing said threshold responsive to said comparison result signal, if said comparison result is indicative of said accumulated energy value less than said threshold value.

31. The method of Claim 29 further comprising comparing said threshold value with a predetermined minimum threshold value, and reducing said threshold value only when said threshold value is greater than said minimum threshold value.

32. The method of Claim 30 wherein said step of decreasing said threshold only when said threshold value is greater than a minimum threshold value.

33. In a handheld communication device having a transmitter and an antenna, a circuit for controlling the exposure levels of RF transmissions comprising:

an RF exposure control processor with two inputs, with a first input for receiving a power request signal, and having two outputs with a first output for providing an exposure threshold value and a second output for providing a modified power request signal;

an amplifier having two inputs with a first input for receiving an information signal and a second input for receiving said modified power request signal and having an output for providing an amplified information signal;

a leaky integrator having an input coupled to said modified power request signal and having an output; and

a comparator having two inputs and an output, with a first input coupled to the output of said leaky integrator, and a second input coupled to said first output of said hazard control processor and wherein said output is coupled to a second input of said hazard control processor.

34. The circuit of Claim 33 wherein said hazard control processor further comprises a third output for providing a Control notification signal.

35. In a handheld telephone having an antenna, a circuit for controlling the exposure levels of RF transmissions comprising:

an RF exposure control processor with two inputs, with a first input for receiving a power request signal, and having two outputs with a first output for providing an exposure threshold value and a second output for providing a modified power request signal;

an amplifier having two inputs with a first input for receiving an information signal and a second input for receiving said modified power request signal and having an output for providing an amplified information signal;

a sliding window accumulator having an input coupled to said modified power request signal and having an output; and

a comparator having two inputs and an output, with a first input coupled to the output of said leaky integrator, and a second input coupled to said first output of said hazard control processor and wherein said output is coupled to a second input of said hazard control processor.

36. The circuit of Claim 35 wherein said hazard control processor further comprises a third output for providing a Control notification signal.

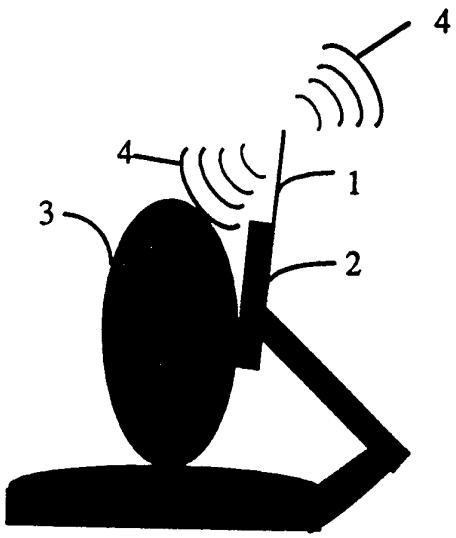

4
4
1
3
2

FIG. 1

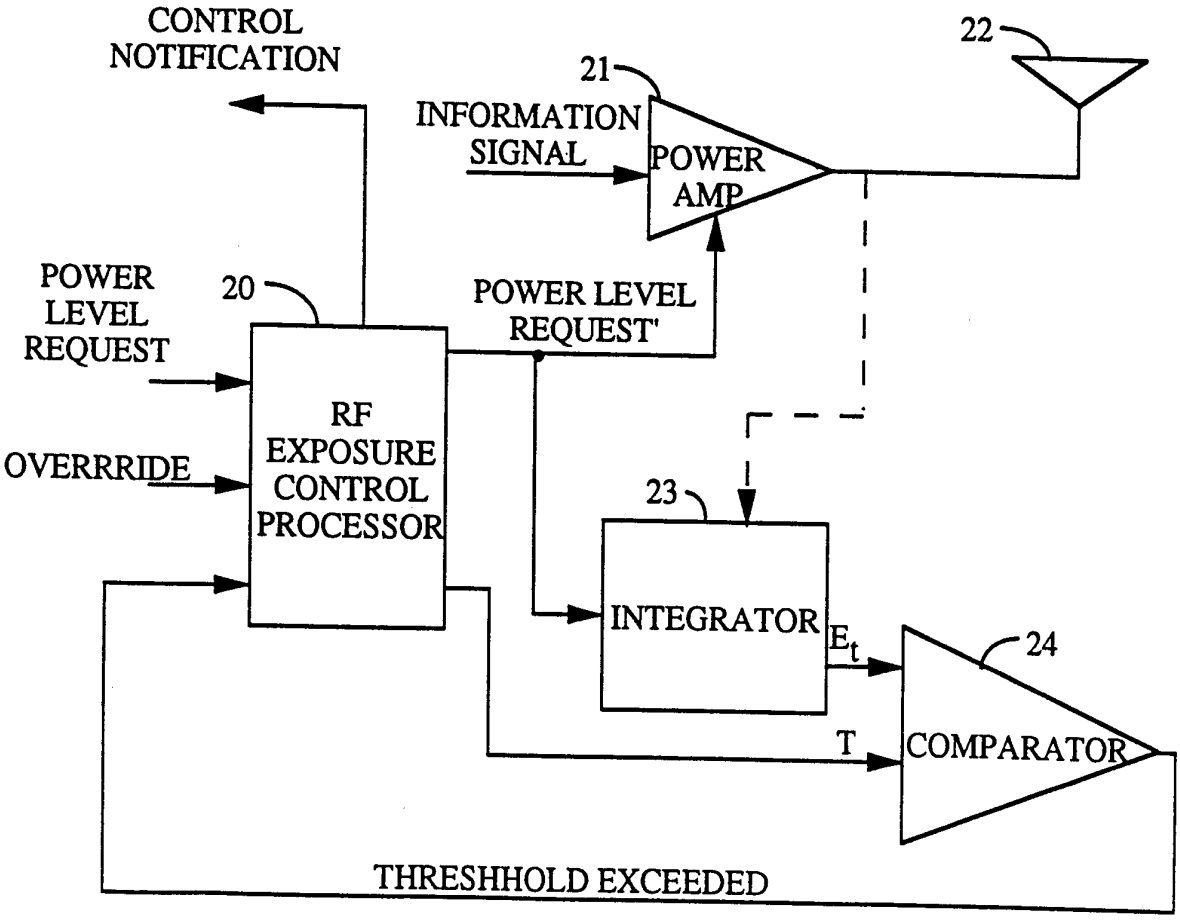

CONTROL NOTIFICATION
22
21
INFORMATION SIGNAL
POWER AMP
POWER LEVEL REQUEST
20
POWER LEVEL REQUEST'
RF EXPOSURE CONTROL PROCESSOR
OVERRRIDE
23
INTEGRATOR
E_t
24
T
COMPARATOR
THRESHHOLD EXCEEDED

FIG. 3

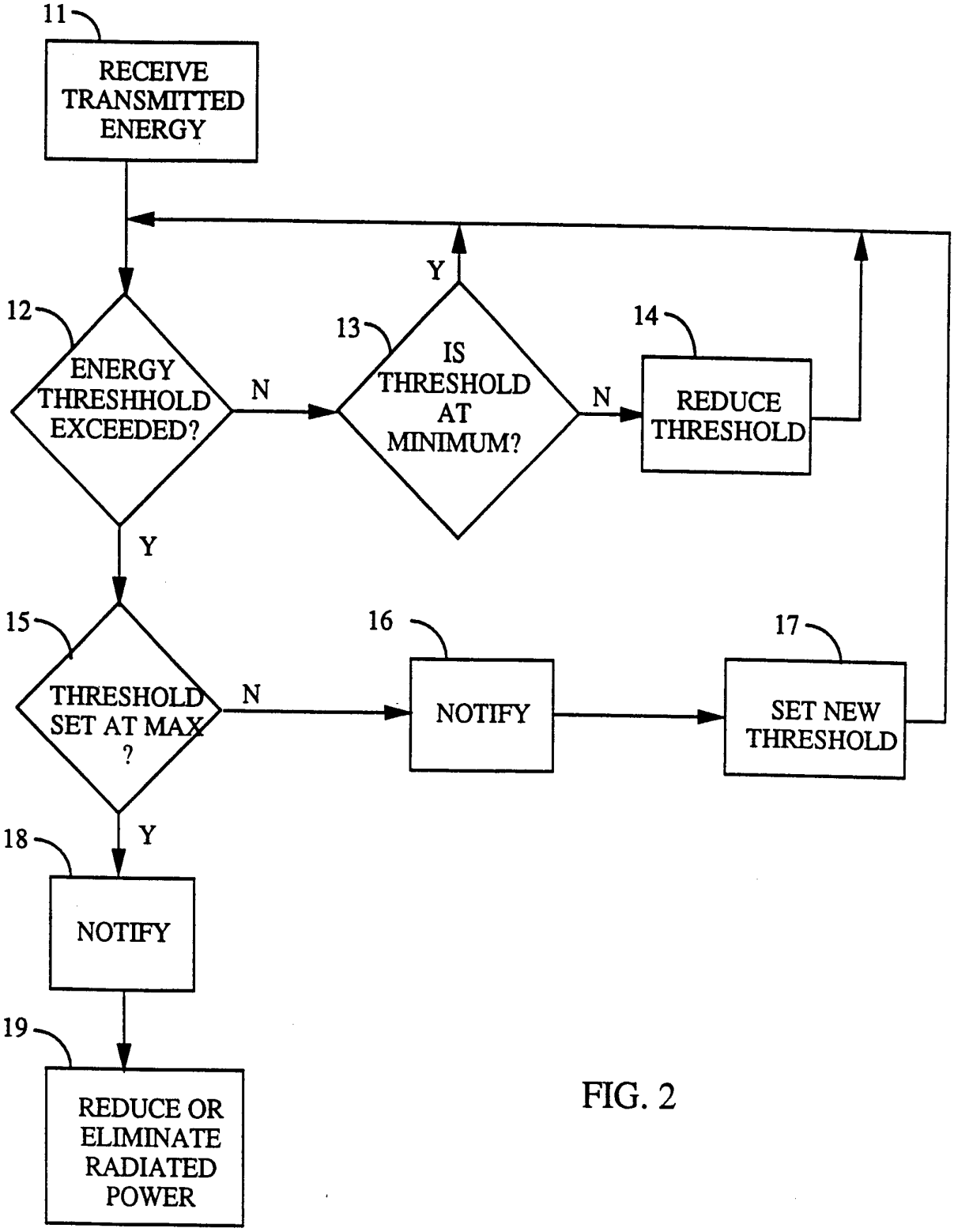

11
RECEIVE TRANSMITTED ENERGY
12
ENERGY THRESHHOLD EXCEEDED?
N
13
IS THRESHOLD AT MINIMUM?
Y
N
14
REDUCE THRESHOLD
Y
15
THRESHOLD SET AT MAX ?
N
16
NOTIFY
17
SET NEW THRESHOLD
Y
18
NOTIFY
19
REDUCE OR ELIMINATE RADIATED POWER

FIG. 2

INTERNATIONAL SEARCH REPORT

Internatio .pplication No
PCT/US 94/08435

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01R29/08 H04B1/38 H01Q1/24

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)
IPC 6 G01R H04B H01Q G01T

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,4 634 969 (EDLIN ET AL) 6 January 1987 see the whole document ---	1-6, 17-22, 33,35,36
Y	IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, vol.41, no.6, June 1993, NEW YORK US pages 739 - 746, XP000387365 TOFTGARD ET AL 'effects on portable antennas of the presence of a person' introduction ---	1-6, 17-22, 33,35,36
A	NEW SCIENTIST, vol.134, no.1824, 6 June 1992, LONDON GB page 19 PATEL 'the yuppie gamma-ray detector' see the whole document --- -/--	1

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Date of the actual completion of the international search	Date of mailing of the international search report
14 November 1994	14. 12. 94

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,5 168 265 (ASLAN) 1 December 1992 see abstract -----	2

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Internatio. Application No
PCT/US 94/08435

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4634969	06-01-87	NONE	
US-A-5168265	01-12-92	NONE	