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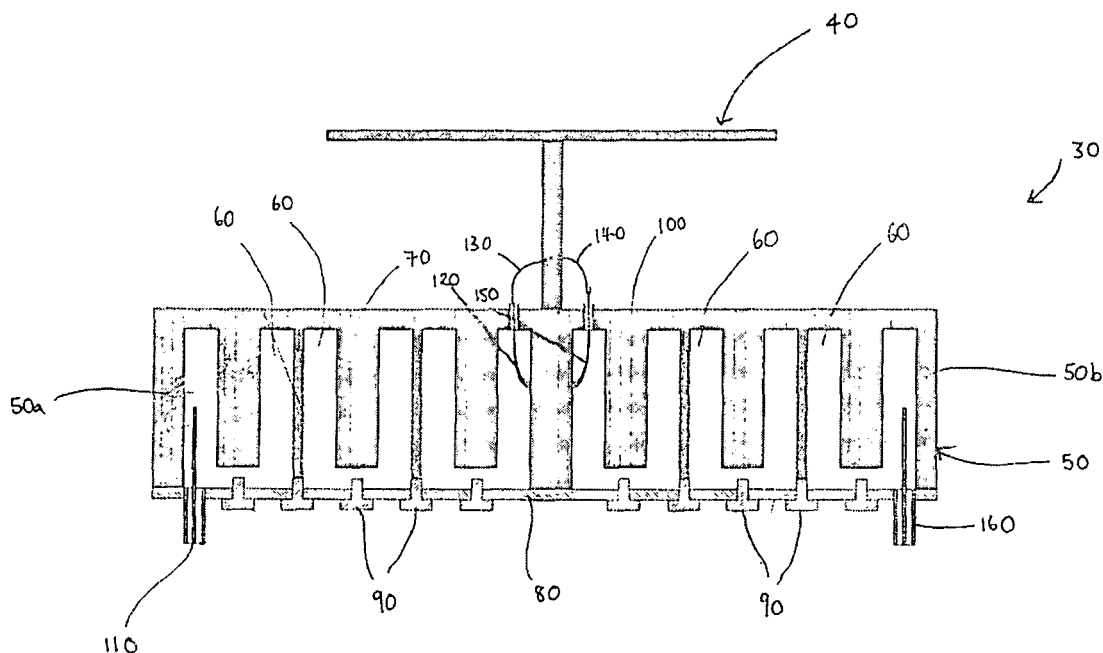
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(54) **An active antenna element**

(57) An active antenna element comprises a filter (50), an antenna element (40) and a common plate (100).

At least a part of said common plate is shared by said filter and antenna element and provides both a reflector of said antenna element and a part of said filter.

FIGURE 3



Description

FIELD OF THE INVENTION

[0001] The present invention relates to an active antenna element.

BACKGROUND

[0002] Wireless telecommunications systems are known. In a cellular system, radio coverage is provided in areas known as cells. A base station is located in each cell to provide the radio coverage. Traditional base stations provide coverage in relatively large geographical areas and the cells are often referred to as macro cells.

[0003] A typical base station comprises: a control centre at ground level, a radio mast and an array of antenna located on the mast. The array of antenna operates to provide radio coverage to end users within the cell, and transmits signals to, and receives signals from, end users within the cell. In such a typical base station, the base station control centre contains, amongst other things: a data management unit, a digital to analogue converter, a filter and a power amplifier. Housing the data management unit, digital to analogue converter, power amplifier and filter in the control centre at ground level allows those components of the system to be substantially protected from prevailing environmental conditions, such as precipitation or temperature fluctuation.

[0004] Analogue radio frequency (RF) signals generated in the control centre at ground level are communicated to each antenna element making up the antenna array via coaxial cable extending from the control centre at the base of the radio mast to the antenna array provided near the top of the radio mast. In a 'passive' array the RF signals supplied to each antenna element is substantially identical; provision may be made in the antenna array for a fixed phase shift across the array to be introduced to the signal to be transmitted by the array. Such a phase shift across the array allows redirection of wavefronts produced by the array, also known as 'beam forming'. An array which performs such a fixed phase shift, irrespective of signal is known as a 'passive' system.

[0005] A passive antenna array, introduces a fixed phase difference across an antenna array to all radio frequency signals conveyed by that passive antenna array to an end user. In contrast, an 'active' antenna array is able to introduce a phase shift across the antenna array appropriate to the location of an end user receiving a signal. An active antenna array is able to simultaneously shift different signals for different end users by introducing different phase shifts. In particular, an active antenna array is able to make use of linear superposition of radio waves to transmit, for example, a high power signal to an end user a large distance from the array and a lower power signal to an end user closer to the array simultaneously by introducing differing phase shifts.

[0006] An active antenna array can be understood to

function as a set of several parallel low-power transceiver chains which operate in a parallel manner. The parallel transceiver chains enable dynamic beam forming of transmissions to end users.

[0007] It is desired to provide an active antenna element for use in an improved active antenna array.

SUMMARY

[0008] Accordingly, a first aspect provides an active antenna element comprising: a filter, an antenna element, and a common plate, at least a part of said common plate being shared by said filter and antenna element to provide a reflector of said antenna element and a part of said filter.

[0009] A base station including an active antenna array is typically arranged such that it includes a control centre, a radio mast, and an active antenna array provided near the top of the radio mast.

[0010] In such an arrangement, rather than providing a complete data management system in the control centre at the base of the radio mast, some processing logic is provided closer to the active antenna array. Such an arrangement can be advantageous since a digital signal is no longer converted to an RF signal at the base of the radio tower, and carried to an antenna array at the top of the mast via a length coaxial cable or the like. Transmission of an RF signal along a significant length of coaxial cable typically results in significant attenuation of the signal and the introduction of signal aberrations.

[0011] In an active antenna array, information regarding the signal to be sent to an end user is carried a large distance up the radio mast in a digital form, only being transferred to a radio frequency signal once it has been passed through further processing logic and to the active antenna array comprising a series of low-power transceiver chains. It can thus be seen that an active antenna array arrangement may act to mitigate losses and aberrations in a signal to be transmitted.

[0012] The first aspect recognises that it is possible to further reduce losses in an active antenna array by providing components of an active antenna element in such a way that radio frequency losses between the various components forming the array are minimised. As mentioned above, it is common for radio frequency signals to be transferred between components in an antenna array by coaxial cable. The losses over coaxial cable are significant and therefore use of coaxial cable in order to channel signals between components may lead to significant losses. Minimising the length of coaxial cable and the distance over which a signal must be passed enables the signal to be generated at a lower power and also allows for more efficient operation of an active antenna array. Arranging a filter and an antenna element such that they share a common plate, results in a physical proximity of those components of the active antenna element. Locating the filter in the direct vicinity of the antenna element assists in minimising possible connection

losses. Use of the common plate to provide a functional element of one or both of the antenna element and filter can also ensure that the antenna element is compact. Close integration of the filter and antenna element by use of a common plate enhances the performance of the filter and antenna element assembly in terms of filter functionality and minimisation of transmission losses between the antenna and the filter.

[0013] The filter may comprise a single filter intended to filter either transmission or received signals, or may, for example, be a full duplexer for a dual-polarized antenna element.

[0014] In one embodiment, the filter, antenna element and common plate form a unitary assembly. Creation of the filter, antenna element and common plate such that they are assembled together to form one unit ensures that the loss of signal between the filter and the antenna element is minimised, and further allows for the creation of a compact unit which operates as a 'filtenna' rather than a separate filter and antenna element.

[0015] In one embodiment, one or more of the filter, antenna element and common plate may be formed from a plastics material, and assembled together with the other elements prior to undergoing a metallisation process.

[0016] In one embodiment, the filter and antenna element are integrally formed with the common plate. It is possible to integrally form a filter and antenna element with said common plate such that the filter, antenna element, and common plate are one piece. In such an arrangement, the signal losses between the filter and antenna element and visa versa are low, and the physical dimensions of the unit may be minimised.

[0017] In one embodiment, the common plate provides at least a part of a backplate of the filter. In one embodiment, the common plate provides substantially the entire backplate of the filter. Ensuring that the common plate provides a part of a functional element of the filter, in this case a backplate, may further aid integration of the physical proximity of the filter and antenna and thereby reduces potential signal losses.

[0018] In one embodiment, the filter comprises a coaxial cavity filter having a coaxial cavity and the shared part defines a part of the coaxial cavity. Use of a coaxial cavity filter may be particularly advantageous since such filters are relatively easy to manufacture and maintain. Furthermore the typical required dimensions of a coaxial cavity filter may be such that the common plate may form substantially the entire reflector of the antenna element. Such an arrangement is particularly efficient in terms of material and construction.

[0019] In one embodiment, the coaxial cavity filter further comprises a tuning plate. A tuning plate acts to tune coaxial cavities forming the filter and selectively filters the desired frequencies from an input signal. The tuning plate may be provided separately from the common plate of the first aspect.

[0020] In one embodiment, the active antenna element further comprises a radio transceiver.

[0021] In one embodiment, the active antenna element further comprises a radio transmitter and a power amplifier.

[0022] In one embodiment, the active antenna element further comprises a low noise amplifier and a radio receiver.

[0023] Inclusion of a transmitter, receiver, or transceiver in an active antenna element recognises that provision of a series of components is a close physical proximity may allow for further minimisation of potential RF losses by minimising necessary cabling and connections provided between the components.

[0024] In one embodiment, the radio transceiver is provided within an environmentally sealed housing. Provision of an environmentally sealed housing mitigates the chance that the operation of any electronic equipment provided within the housing will be damaged by prevailing environmental conditions, such as precipitation or temperature.

[0025] In one embodiment, the active antenna element further comprises a signal coupling between the filter and the antenna element. In one embodiment the signal coupling comprises a connector. The connector may comprise a strip, coaxial coupling, or coupling probe. In such an arrangement the length of said connector will typically be minimised to minimise any potential losses.

[0026] A second aspect provides a method of providing an active antenna element comprising the steps of: providing a filter, providing an antenna element, and providing a common plate, arranged such that at least a part of the common plate is shared by the filter and antenna element to provide a reflector of the antenna element and a part of the filter.

[0027] In one embodiment, the method further comprises the step of forming a unitary assembly from the filter, antenna element, and common plate.

[0028] In one embodiment, the method further comprises the step of integrally forming the filter and the antenna element with the common plate.

[0029] In one embodiment, the method further comprises the step of ensuring the common plate provides at least part of a backplate of the filter.

[0030] In one embodiment, the method further comprises the steps of providing a coaxial cavity filter, that filter having a coaxial cavity, and ensuring that the shared part defines a part of the coaxial cavity.

[0031] In one embodiment, the method further comprises a step of providing a coaxial cavity filter which further comprises a tuning plate.

[0032] In one embodiment, the method further comprises the step of providing an active antenna element which further comprises a radio transceiver.

[0033] In one embodiment, the method further comprises the step of providing an environmentally sealed housing within which the radio transceiver is provided.

[0034] In one embodiment, the method further comprises the step of providing a signal coupling between the filter and said antenna element. In one embodiment,

the method further comprises the step of providing a connector between the filter and the antenna element. The connector may comprise a strip, coaxial coupling, or coupling probe.

[0035] Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. Features of the dependent claims may be combined with the features of the independent claims as appropriate, and in combinations other than those explicitly set out in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] Embodiments of the present invention will now be described further, with reference to the accompanying drawings, in which:

Figure 1 illustrates schematically the main components of a wireless network base station;
 Figure 2 illustrates schematically the main components of an active antenna array for use in a base station such as that shown in Figure 1;
 Figure 3 illustrates a first embodiment of an active antenna element;
 Figure 4 illustrates a second embodiment of an active antenna element; and
 Figure 5 illustrates an active antenna array formed from a series of active antenna elements similar to that shown in Figure 4.

DESCRIPTION OF THE EMBODIMENTS

[0037] Figure 1 illustrates schematically the main components of a wireless communications network base station 1. The base station 1 comprises a radio mast 2, and a data management unit 3 which communicates with a 'core network' of the wireless communications network. The base station further comprises a processing unit 4 and an active antenna array 5 operable to transmit radio frequency signals to, and receive radio frequency signals from, an end user 6 in response to information received from the core network.

[0038] Figure 2 illustrates schematically the main components of an active antenna array for use in a base station such as that shown in Figure 1. The active antenna array 5 comprises a set of substantially identical active antenna elements 7. In Figure 2, four active antenna elements 7 are shown. Each active antenna element may comprise transmission and reception apparatus and thus functions as a low-power transceiver chain. For the sake of clarity, Figure 2 only includes a schematic representation of transmission apparatus in such a low-power transceiver chain. In the active antenna element 7 shown, each active antenna element 7 comprises: a radio transmitter 8, a power amplifier 9, a filter 10 and an antenna element 11.

[0039] A simplified explanation of the operation of the base station in transmission mode follows: Data man-

agement unit 3 receives digital information relating to a signal to be transmitted to a user 6 from a core network. The information received by the data management unit 3 is transferred via a digital connection 15 to processing unit 4. Processing unit 4 acts to dynamically generate signals to be transmitted by each of the active antenna elements 7 forming the active antenna array 5. It is processing unit 4 that calculates, for each signal to be received by transmitted to a user 6, an appropriate phase shift to introduce across the active antenna array 5. A calculated digital signal is generated by processing unit 4 for each element 7 and transmitted via a digital connection 20 to each of the active antenna elements 7. The signal received by each active antenna element 7 is converted by radio transmitter 8 into a radio frequency signal. That radio frequency signal is fed to a power amplifier 9 and then filtered by a frequency filter 10 before being passed to the antenna element 11 for transmission to the end users.

[0040] Figure 3 illustrates a first embodiment of an active antenna element 30. Active antenna element 30 comprises an antenna element 40, and a filter 50. In the embodiment shown, the filter 50 comprises a diplexer. The filter thus essentially comprises two filters: 50a which acts to filter RF signals to be transmitted, and 50b which acts to filter received RF signals. Each filter 50a, 50b has a substantially identical structure and is of the coaxial-cavity type. Each coaxial cavity filter comprises a series of resonant cavities 60. The cavities are formed from the main body 70, which in this embodiment, is machined from a solid block of aluminum. In other embodiments the body 70 may be injection moulded from a plastics material and then metalised. The resonant coaxial cavity filters 50a, 50b further comprise a tuning plate 80 which, in the embodiment shown, is a conductive aluminum plate. The tuning plate 80 includes tuning screws 90. Tuning screws 90 allow the resonant cavities 60 of the filters 50a, 50b to be properly tuned and thereby optimize operation of the filter 50. The main body 70 of the filter 50 also provides a substantially flat plate or 'backplate' 100. The antenna element 40 is placed (for example, a patch or dipole arrangement) on the backplate 100. The backplate 100 is conductive and thus acts as a reflector of antenna element 40.

[0041] An RF transmission signal to be filtered is passed into filter 50a via coupling probe 110. The filtered signal exits the filter 50a via coupling pin 120 and is connected to the antenna element 40 via a jumper connection 130 of only a few millimeters in length. The output of the filter 120, 130 to the antenna element is located such that the shortest and most integrable connection to the antenna element can be made.

[0042] In a substantially analogous manner the signals received by the antenna element 40 are coupled to the filter 50b via a jumper connector 140 which couples with coupling pin 150 and couples the unfiltered signal to filter 50b. A filtered signal is able to leave the filter 50b via a coupling 160. The received signal filter port 140, 150 may

be located anywhere on the backplate 100, such that it best fits the physical design constraints of the active antenna unit 30. In the embodiment shown it is placed substantially symmetrically with regard to the transmission signal filter port.

[0043] In known active antenna arrays the backplate 100 of a resonant cavity filter is not functionally utilized by any other component forming part of the active antenna element, and is connected to the antenna element via a length of coaxial cable. Such a connection results in significant signal losses. In the arrangement shown in Figure 3, it can be seen that the backplate 100 of the cavity filter acts as a reflector for the antenna element. This arrangement allows the length of the jumper connections 130, 140 between the filter and the antenna element to be minimized. The result is a highly integrated filter plus antenna which acts as a single functional unit, namely a 'filtenna'. Furthermore, the embodiment shown maintains access to tuning screws 90 on the tuning plate 80 of a coaxial cavity filter and so that filter may still be tuned and maintained to optimize performance.

[0044] Figure 4 illustrates a second embodiment of an active antenna element. The active antenna element 200 of Figure 4 comprises an antenna element 40 and filter 50 substantially identical to that shown in Figure 3 and therefore identical reference numerals have been used throughout. The active antenna element 200 as shown in Figure 4 further comprises a radio transceiver 210 located within an environmentally sealed housing 220. The radio transceiver 210 is connected (not shown) to a processing unit 4 as shown in Figure 1 and 2. The primary functional elements of the transceiver are shown schematically that transceiver comprises: a radio signal transmitter 230, a power amplifier 240, a low noise amplifier 250 and a radio receiver 260. In use, the processing unit 4 passes a signal to be sent to end users 6 to the transmitter 230 which acts to generate a radio frequency signal which is passed through power amplifier 240 before being coupled to filter 50a via coupling 110. The filtered signal for transmission is coupled to the antenna element via jumper connection 130 and is then transmitted to end users by the antenna element 40.

[0045] The antenna element 40 also receives radio frequency transmissions from end users 6. Those received signals are passed from the antenna element 40 via jumper connection 140 to filter 50b which filters the received radio frequency signal. The filtered signal is coupled to a low noise amplifier via coupling 160. The amplified signal is passed to radio receiver 260 which acts to convert the radio frequency signal to a signal which may be received by processing unit 4, and passed back to the core network.

[0046] Figure 5 illustrates an active antenna array formed from a series of 8 active antenna elements similar to those shown in Figure 4. Those active antenna elements act as a set of parallel, low power transceiver chains, and operate to dynamically shape waves sending signals to end users 6.

[0047] It should be appreciated by those skilled in the art that any block diagrams herein represent conceptual views of illustrative circuitry embodying the principles of the invention. Similarly, it will be appreciated that any flow charts, flow diagrams, state transition diagrams, pseudo code, and the like represent various processes which may be substantially represented in computer readable medium and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

[0048] The description and drawings merely illustrate the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the invention and are included within its spirit and scope. Furthermore, all examples recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor(s) to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass equivalents thereof.

Claims

1. An active antenna element comprising:
 - a filter,
 - an antenna element,
 - and a common plate,
 - at least a part of said common plate being shared by said filter and antenna element to provide a reflector of said antenna element and a part of said filter.
2. An active antenna element according to claim 1, wherein said filter, antenna element and common plate form a unitary assembly.
3. An active antenna element according to claim 1, wherein said filter and antenna element are integrally formed with said common plate.
4. An active antenna element according to any preceding claim, wherein said common plate provides at least a part of a backplate of said filter.
5. An active antenna element according to any preceding claim, wherein said filter comprises a coaxial cavity filter having a coaxial cavity and said shared part defines a part of said coaxial cavity.
6. An active antenna element according to claim 5,

wherein said coaxial cavity filter further comprises a tuning plate.

7. An active antenna element according to any preceding claim, further comprising a radio transceiver. 5
8. An active antenna element according to claim 7, wherein said radio transceiver is provided within an environmentally sealed housing. 10
9. An active antenna element according to any preceding claim, further comprising a signal coupling between said filter and said antenna element.
10. An active antenna element according to claim 9, wherein said signal coupling comprises a connector. 15
11. An active antenna element according to claim 10, wherein said connector comprises a strip, coaxial coupling, or coupling probe. 20
12. A method of providing an active antenna element comprising the steps of: 25
 - providing a filter,
 - providing an antenna element,
 - and providing a common plate, arranged such that at least a part of said common plate is shared by said filter and antenna element to provide a reflector of said antenna element and a part of said filter. 30

Amended claims in accordance with Rule 137(2) EPC. 35

1. An active antenna array element (30) comprising:
 - a filter (50), comprising a coaxial cavity filter having a coaxial cavity (60) and a tuning plate(80); 40
 - an antenna element (40),
 - and a common plate (100),
 - at least a part of said common plate being shared by said filter (60) and antenna element (40) to provide a reflector of said antenna element (40) 45
 - and a part of said filter and wherein said shared part (100) defines a part of said coaxial cavity, and wherein 50
 - the tuning plate (80) is provided separately from the common plate.
2. An active antenna array element according to claim 1, wherein said filter, antenna element and common plate form a unitary assembly. 55
3. An active antenna array element according to claim 1, wherein said filter (50) and antenna element (40) are integrally formed with said common plate.

4. An active antenna array element according to any preceding claim, wherein said common plate provides at least a part of a backplate (100) of said filter.

5. An active antenna array element according to claim 4, wherein said tuning plate (80) is provided opposite said backplate (100).

6. An active antenna array element (30) according to any preceding claim, further comprising a radio transceiver (210).

7. An active antenna array element according to claim 6, wherein said radio transceiver (210) is provided within an environmentally sealed housing (220).

8. An active antenna array element according to any preceding claim, further comprising a signal coupling (130, 140) between said filter and said antenna element.

9. An active antenna array element according to claim 10, wherein said signal coupling (130, 140) comprises a connector.

10. An active antenna array element according to claim 9, wherein said connector comprises a strip, coaxial coupling, or coupling probe.

11. A method of providing an active antenna array element (30) comprising the steps of:

- providing a filter (50) comprising a coaxial cavity filter having a coaxial cavity (60) and a tuning plate(80),
- providing an antenna element (40),
- and providing a common plate, arranged such that at least a part of said common plate is shared by said filter (50) and antenna element (40) to provide a reflector of said antenna element and a part of said filter and wherein said shared part (100) defines a part of said coaxial cavity and arranged such that the tuning plate (80) is provided separately from the common plate.

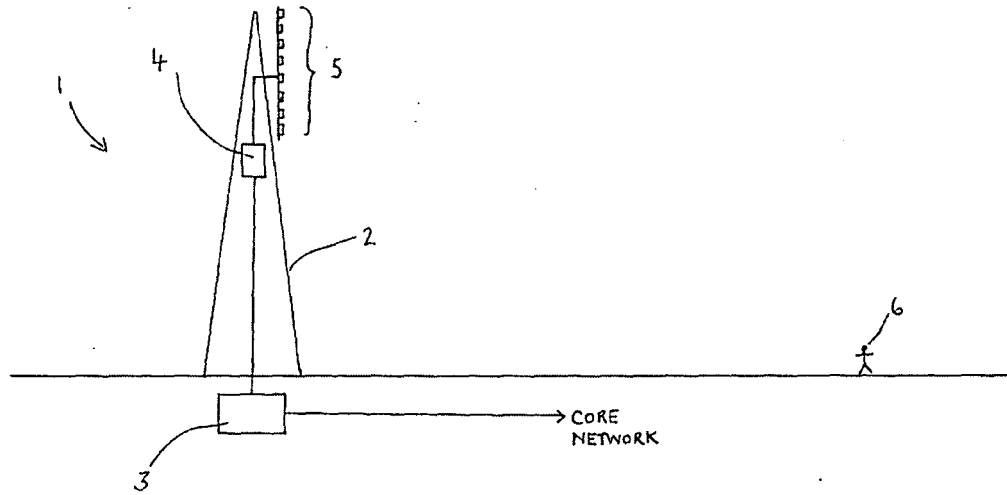


FIGURE 1

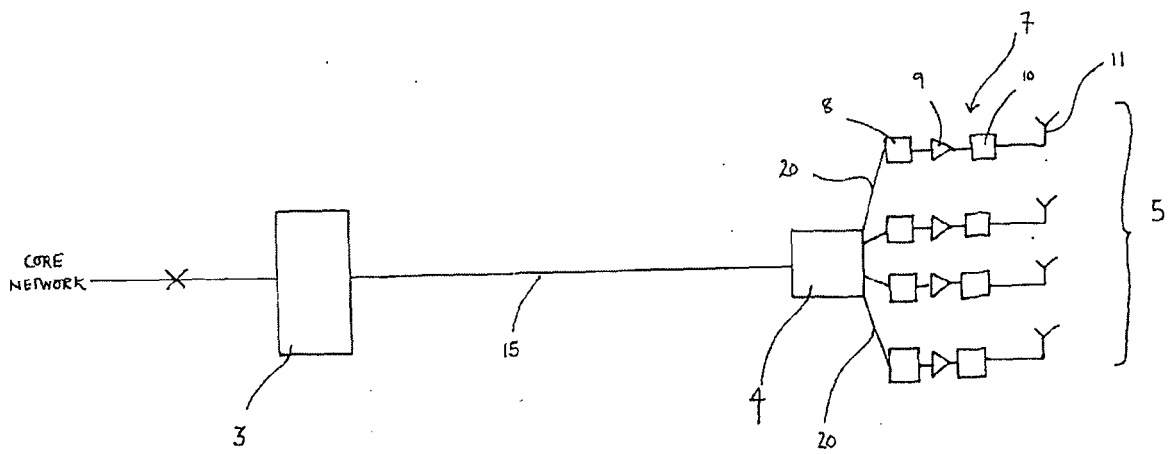


FIGURE 2

FIGURE 3

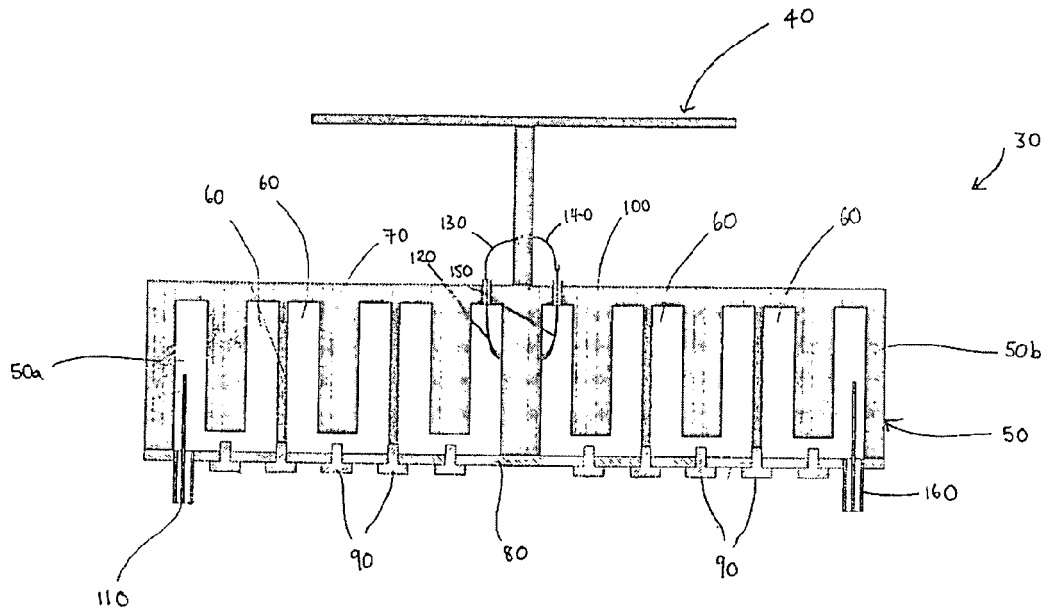


FIGURE 4

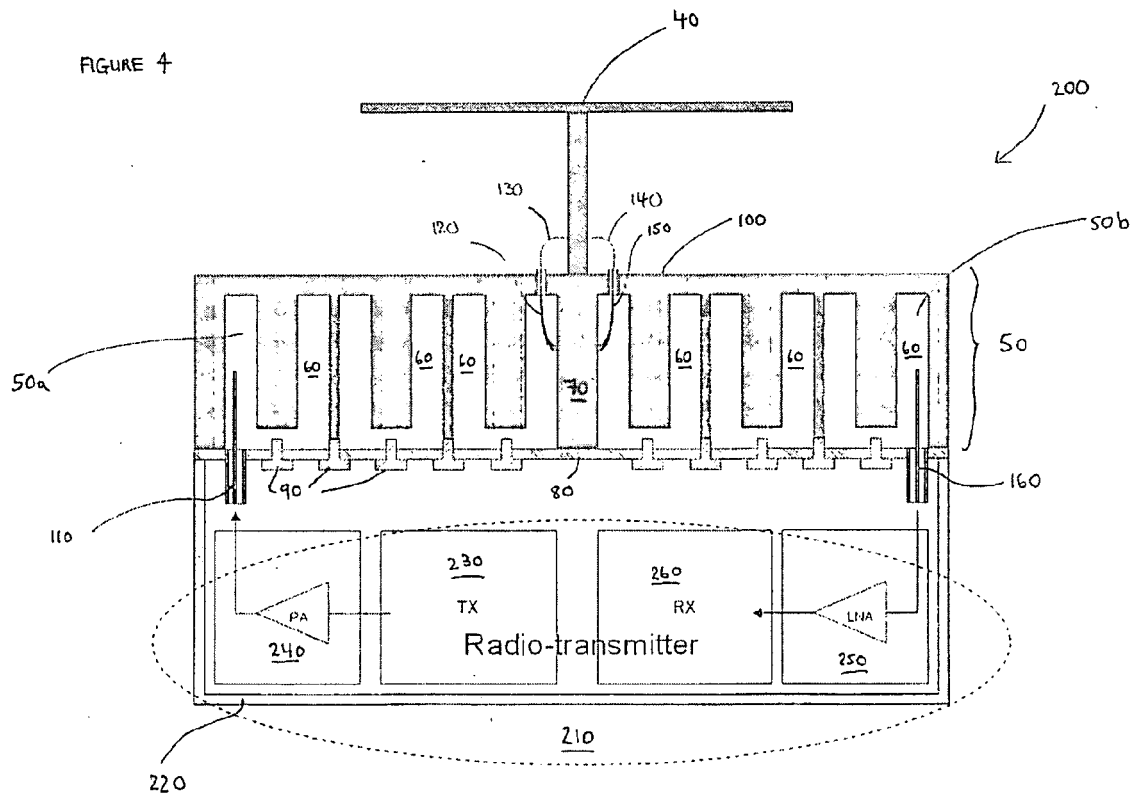
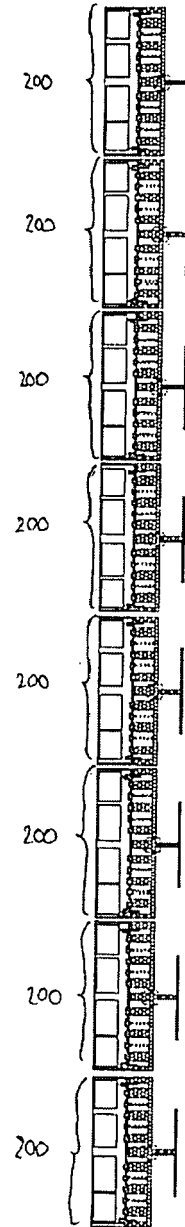


FIGURE 5





EUROPEAN SEARCH REPORT

Application Number
EP 09 36 0028

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EPO FORM 1503 03.82 (P04C01)

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