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(54) **Space borne antenna system**

(57) The invention provides a space borne antenna system, that comprises a platform (10), at least one feed arrangement and at least one radiating element (40; 40a, 40b; 40b-1, 40b-2). The platform (10) comprises at least one boom (20; 20-1, 20-2). The feed arrangement is arranged on or close to the platform (10) wherein the feed arrangement comprises at least one reflecting element.

The at least one radiating element (40; 40a, 40b; 40b-1, 40b-2) is mounted at the tip of the at least one boom which is remote to the platform (10), wherein the at least one radiating element (40; 40a, 40b; 40b-1, 40b-2) is adapted to receive electromagnetic waves from the feed arrangement and to redirect it in a different direction and/or vice versa.

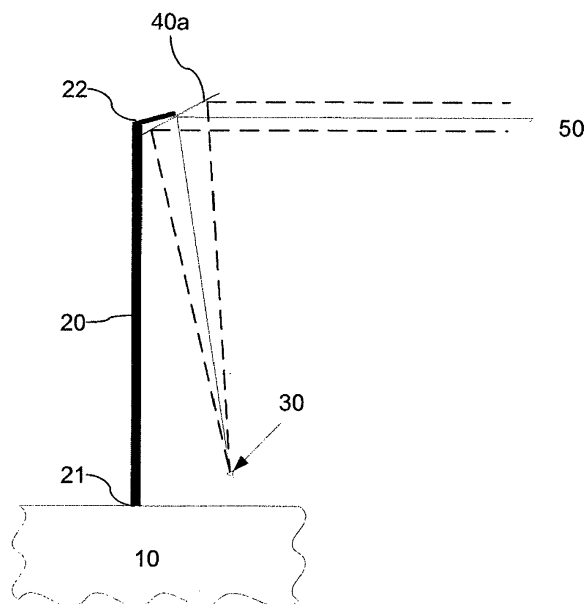


Fig. 1

Description

[0001] The invention relates to a space borne antenna system. In particular, the invention relates to a multiple antenna system for space borne applications like radar, synthetic aperture radar (SAR), interferometric SAR or moving target indication (MTI).

[0002] Known antenna systems, for example an interferometric SAR instrument, often comprise two or more radiating apertures (i.e. antenna arrangements) which are mounted on a single platform, e.g. a spacecraft or a satellite, with a certain spatial sensor separation. A large separation, i.e. baseline, between the radiating apertures is reached by mounting at least one of the antennas on the tip of a boom like structure. The boom like structure (e.g. arm or mast) may be fixed or deployable. According to the partly high weight of the antenna mounted at the tip of the boom, the boom has to be adapted to have a sufficient, predetermined stiffness. However, this may result in a heavy and mechanically complex boom. Furthermore, the distance between platform and antenna may influence the performance of the antenna system.

[0003] It is therefore an object of the present invention to provide a space borne antenna system which is structural and/or functional improved.

[0004] This object is solved by an antenna system according to the features of claim 1. Preferred embodiments are set out in the dependent claims.

[0005] The invention provides a space borne antenna system that comprises a platform, at least one feed arrangement and at least one radiating element. The platform comprises at least one boom. The platform may be, for example, a satellite or a spacecraft. The feed arrangement is arranged on or close to the platform, wherein the feed arrangement comprises at least one reflecting element. The at least one radiating element is mounted at the tip of the at least one boom which is remote to the platform, wherein the at least one radiating element is adapted to receive electromagnetic waves from the feed arrangement and to redirect it in a different direction and/or vice versa.

[0006] The invention is based on the consideration that separation of the feed arrangement and the radiation element enables a more performing antenna system. The reason for the better performance is the fact that no cables between the platform and the tip of the boom have to be installed. In known antenna systems, for the exchange of control commandos or RF signals between the platform and an antenna being arranged on the tip of the boom, the signals have to be routed along the boom by cables or waveguides which is complex. RF signal quality suffers from losses due to cable or waveguide length. Furthermore, in contrast to the known antenna systems, no calibration effort and thermal control of the antennas remote from the platform is necessary.

[0007] In the antenna system according to the invention, the at least one radiating element may be adapted

to receive electromagnetic waves from the feed arrangement and to redirect them in a different direction. Hence this antenna arrangement represents a transmit (Tx) antenna. Alternatively, the at least one radiating element may be adapted to receive electromagnetic waves and to redirect them in a different direction to the feed arrangement. In this case the antenna arrangement is adapted to be a receive (Rx) antenna. Furthermore, the at least one radiating element may be adapted to receive electromagnetic waves from the feed arrangement and to redirect them in a different direction and to receive electromagnetic waves from the different direction and to redirect them to the feed arrangement. Hence, this antenna arrangement represents a receive and transmit (Rx/Tx) antenna.

[0008] According to a further embodiment, the radiating element can comprise a flat reflector, such as a reflecting plane, or a reflector or a reflect-array. In these embodiments, the radiating elements are passive elements having a predetermined shape and reflecting properties according to a desired signal beam deflection.

[0009] According to a further embodiment, the feed arrangement comprises at least one secondary antenna comprising at least one reflector antenna or reflect-array antenna or antenna elements.

[0010] According to a further embodiment, the feed arrangement comprises at least one secondary antenna system, comprising a feed system and one or more reflectors or one and more reflect-arrays. The feed system may comprise one or more antenna elements.

[0011] In other words, according to this invention the feed arrangement is realized as focusing secondary antenna for the radiating element. It may comprise of at least one or more reflector antennas or reflect-array antennas. Likewise, the feed arrangement may comprise at least one reflector antenna system, comprising or consisting of at least one or more feed elements and a one or more reflectors. The feed arrangement may alternatively comprise at least one reflect-array antenna system, comprising or consisting of one or more feed elements and one or more reflect-arrays. Hence, electromagnetic waves may be deflected by or within the feed arrangement. In such an antenna system, multiple antenna elements in the feed system may be used for beam squint in any direction. Likewise, one or more secondary antennas may be used for beam squint in any direction.

[0012] An example for the secondary antenna with more than one reflector comprises a cassegrain like secondary (hyperbolic) reflector which is illuminated with at least one focusing (parabolic) ternary reflector which is illuminated by a feed system with one or more antenna elements.

[0013] The at least one boom may be a fixed or a deployable or extractable structure (e.g. a mast or telescopic arm) with arbitrary shape and configuration. The shape and the configuration of the boom may be arbitrary, since it is not essential for the current invention as long as there is a baseline, i.e. distance, between the feed arrange-

ment and a corresponding radiating element.

[0014] According to a further embodiment, a further antenna or antenna system (in other words: an antenna arrangement) may be arranged on or close to the platform, wherein the antenna or antenna system is adapted for reception and/or transmission of electromagnetic waves. As a result, the antenna system according to the invention may comprise more than one antenna arrangements. For example, the antenna arranged on or close to the platform may be used as a receive antenna, while the at least one antenna arrangement which has a respective radiating element mounted at the tip of the at least one boom is/are transmit antenna(s). In case of two (or more) such transmit antennas, the antenna system

[0015] An advantage of the antenna system according to the invention is that the radiating elements can be realized passive, i.e. no RF signals need to be routed along the boom(s) being connected to the platform. The weight of the passive radiating element at the end of the boom is low. This approach avoids laying RF waveguides along the deployable boom, and minimizes calibration efforts and electrical losses in these waveguides.

[0016] A further advantage of the proposed antenna system is that the feed system and its assigned electronics are mounted in close vicinity of the platform or directly into the platform where they are under tight thermal control.

[0017] The principle advantage is that the proposed feed system allows architectures with very long boom (boom length $\gg$ diameter of reflecting element at tip of boom) as the secondary antenna illuminates the radiating element.

[0018] All described configurations might be used for transmit (Tx) antennas and/or receive (Rx) antennas.

[0019] The invention will be explained in more detail with reference to the accompanying figures.

Fig. 1 shows a first example of a known antenna system in which a radiating element is carried out as a flat reflector, such as a reflecting plane, or a reflect-array.

Fig. 2 shows a second example of a known antenna system in which the radiating element is carried out as a curved reflector.

Fig. 3 shows a first example of an antenna system according to the invention, in which a feed arrangement is carried out as a secondary antenna acting as focusing element.

Fig. 4 shows a second example of an antenna system according to the invention, comprising two antenna arrangements being mounted at respective tips of two booms that are arranged on opposite sides of a platform of the antenna system.

Fig. 5 shows a third example of an antenna system according to the invention, comprising two antenna arrangements being mounted at the tips of two booms and an additional third antenna being arranged on or close to the platform.

[0020] Fig. 1 shows a first example of a known space borne antenna system. The antenna system comprises a platform 10, a boom 20, a feed system 30 and a passive radiating element 40a. The platform 10 may be, for example, a satellite or a spacecraft. The boom 20 can be, for example, a mast or a telescopic arm. The boom 20 comprises a first end 21 and a second end 22. While the first end 21 is attached to the platform 10, the second end 22 which constitutes a tip of the boom 20 bears the radiating element 40a. This means, the radiating element 40a is mounted at the tip of the boom.

[0021] In the embodiment of Fig. 1, the radiating element 40a is a flat reflector, such as a reflecting plane, or a reflect-array which typically have a surface which is within one plane. The feed system 30 is arranged on or close to the platform 10. The feed system 30 may comprise one or more antenna elements. The combination of feed system 30 and radiating element 40a is called an antenna arrangement. An electronics or control unit of the feed system 30 which is not shown in the figures can be mounted in close vicinity of the platform 10 or directly into the platform 10.

[0022] The feed system 30 and the radiating element 40a are arranged such that the radiating element 40a can receive electromagnetic waves from the feed system 30 and redirect them in a different direction (beam direction 50). As a result, the antenna arrangement constitutes a transmit (Tx) antenna.

[0023] Furthermore, the antenna arrangement could be realized such that electromagnetic waves received by the radiating element 40a may be directed to the feed system to constitute a receive (Rx) antenna. Likewise, the antenna system may be adapted to both receive and transmit electromagnetic waves, such that the antenna system constitutes a receive and transmit antenna.

[0024] Fig. 2 shows a second known embodiment of a space borne antenna system which differs from the embodiment of Fig. 1 only in that, that the passive radiating element is a reflector 40b which may have a concave surface. The reflector may be a parabolic reflector or of any other shape.

[0025] In the first embodiment according to the invention and illustrated in Fig. 3 the feed arrangement is a secondary antenna 44 consisting of a reflector 43 and a feed system 30 directed to the reflector or reflect-array. The feed system 30 may comprise one or more antenna elements. The reflector 43 may be realized alternatively as reflect-array. In this antenna system, the reflector 40b (or alternatively flat reflector (e.g. reflecting plane or reflect-array) at the tip of the boom 20 constitutes a primary antenna and the antenna 44 a secondary antenna. For transmission, the primary antenna 42 on the tip of the

boom receives electromagnetic waves from the secondary antenna 44 and forwards them in the direction of intention (beam direction 50). For reception, the primary antenna element 42 receives electromagnetic waves from the beam direction 50 and directs them in the direction of the secondary antenna 44.

[0026] Providing a feed arrangement on or close to the platform 10 and the first end 21 of the boom, respectively, and a radiating element at the second end 22 of the boom 20 ensures that no RF (radio frequency) signals need to be routed along the boom via cables or waveguides. This approach avoids laying RF waveguides along the fixed or deployable boom, and minimizes calibration efforts and electrical losses in these waveguides.

[0027] An antenna system according to a second embodiment illustrated in Fig. 4 comprises two antenna arrangements. The first antenna arrangement comprises a first boom 20-1, a first passive radiating element 40b-1 (constituting a first primary antenna 42-1) at the tip of the first boom 20-1 and a first feed arrangement (i.e. first secondary antenna 44-1) close to or arranged in the platform 10. The second antenna arrangement comprises a second boom 20-2, a second passive radiating element 40b-2 (constituting a second primary antenna 42-2) at the tip of the second boom 20-2 and a second feed arrangement (i.e. a second secondary antenna 44-2) close to or arranged in the platform 10. The first and second booms 20-1 and 20-2 are arranged on opposite sides of the platform 10. A baseline (distance) between the two radiators 40b-1 and 40b-2 is depicted with 60. Both feed arrangements (first secondary antenna 44-1 and second secondary antenna 44-2) consist of a reflecting element 43-1 and 43-2 as well as a feed system 30-1 and 30-2.

[0028] In this antenna system, one of the antenna arrangements may be used as transmit (Tx) antenna while the other antenna arrangement may be used as receive (Rx) antenna. Alternatively, at least one of the antenna arrangements might be adapted to be a receive and transmit antenna.

[0029] The third embodiment of an antenna system according to the invention (Fig. 5) is based on the second embodiment illustrated in Fig. 4. In addition, a further antenna 70 is mounted on or in close vicinity to the platform 10. The antenna 70 comprises a reflector or reflect-array 72 and a feed system 71. While the further antenna 70 is adapted to receive electromagnetic waves (receive Rx antenna), the two other antenna arrangements are configured to transmit electromagnetic waves (transmit Tx antennas). Alternatively, receive and transmit direction might be interchanged between the antenna arrangements.

[0030] An antenna system as illustrated in Figs. 4 and 5 may be used as across track and/or along track interferometric SAR.

LIST OF REFERENCE SIGNS

[0031]

10	platform
20	boom
20-1	first boom
20-2	second boom
5 21	first end of boom
22	second end of boom
30	feed system
30-1	first feed system
30-2	second feed system
10 40	radiating element
40a	reflecting plane / reflect-array
40b	reflector
40b-1	first reflector
40b-2	second reflector
15 42	primary antenna
42-1	first primary antenna
42-2	second primary antenna
43	reflector / reflecting plane / reflect-array
43-1	first reflector / reflecting plane / reflect-array
20 43-2	second reflector / reflecting plane / reflect-array
44	secondary antenna
44-1	first secondary antenna
44-2	second secondary antenna
50	beam direction
25 60	geometric baseline
70	antenna or antenna system
71	feed system
72	reflector / reflect-array
Rx	receive beam direction
30 Tx	transmit beam direction

Claims

- 35 1. A space borne antenna system, comprising
 - a platform (10) having at least one boom (20; 20-1, 20-2);
 - at least one feed arrangement arranged on or close to the platform (10) wherein the feed arrangement comprises at least one reflecting element; and
 - at least one radiating element (40; 40a, 40b; 40b-1, 40b-2) being mounted at the tip of the at least one boom which is remote to the platform (10), wherein the at least one radiating element (40; 40a, 40b; 40b-1, 40b-2) is adapted to receive electromagnetic waves from the feed arrangement and to redirect it in a different direction and/or vice versa.
- 40 2. The antenna system according to claim 1, wherein the radiating element (40; 40a, 40b; 40b-1, 40b-2) comprises a reflecting plane or a reflector or a reflect-array.
- 45 3. The antenna system according to claim 1 or 2, wherein the feed arrangement comprises at least

one secondary antenna (44, 44-1, 44-2) comprising at least one reflector antenna or reflect-array antenna or antenna elements.

4. The antenna system according to one of the preceding claims, wherein the feed arrangement comprises at least one secondary antenna system, comprising a feed system (30; 30-1, 30-2) and one or more reflectors or one and more reflect-arrays (43; 43-1, 43-2). 5 10
5. The antenna system according to claim 4, wherein the feed system (30; 30-1, 30-2) comprises one or more antenna elements. 15
6. The antenna system according to one of the preceding claims, wherein the at least one boom (20; 20-1, 20-2) is a fixed or deployable or extractable structure with arbitrary shape and configuration. 20
7. The antenna system according to one of the preceding claims, wherein a further antenna or antenna system (70) is arranged on or close to the platform (10), wherein the antenna or antenna system (70) is adapted for reception and/or transmission of electromagnetic waves. 25

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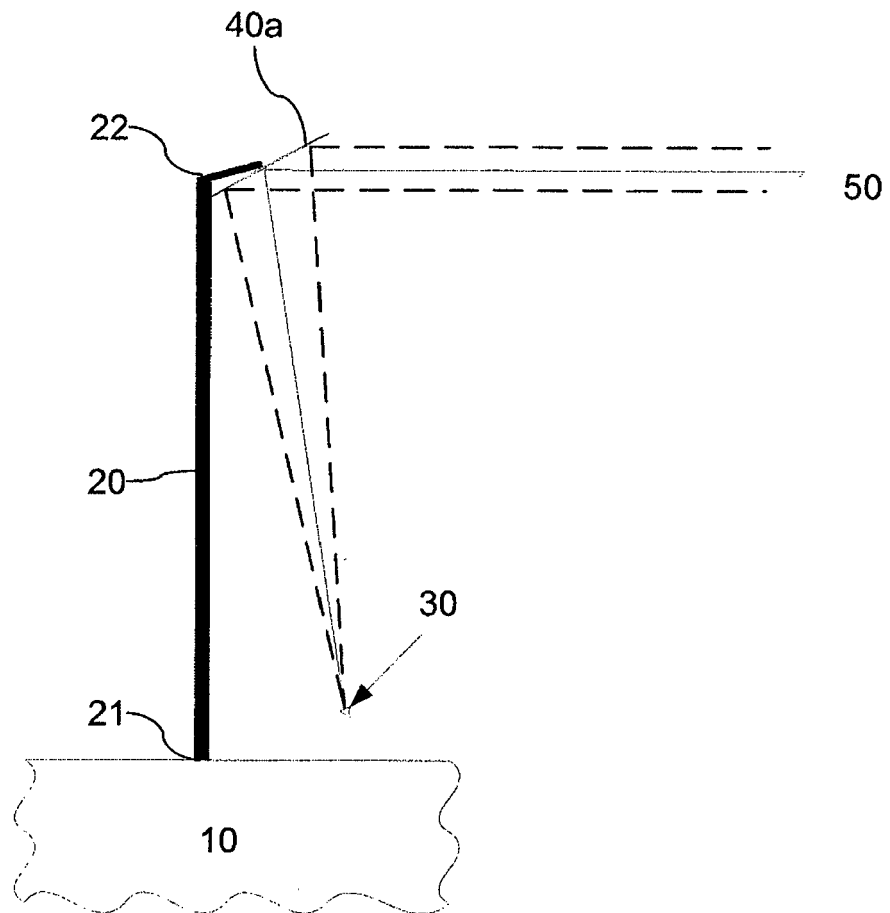


Fig. 1

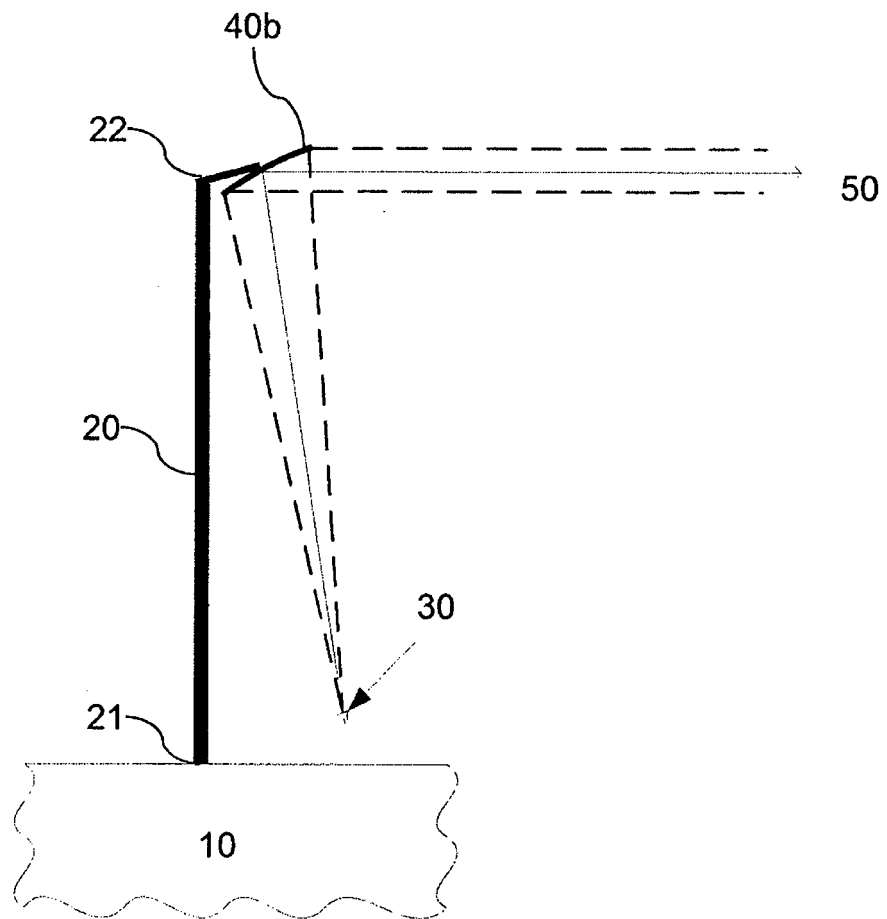


Fig. 2

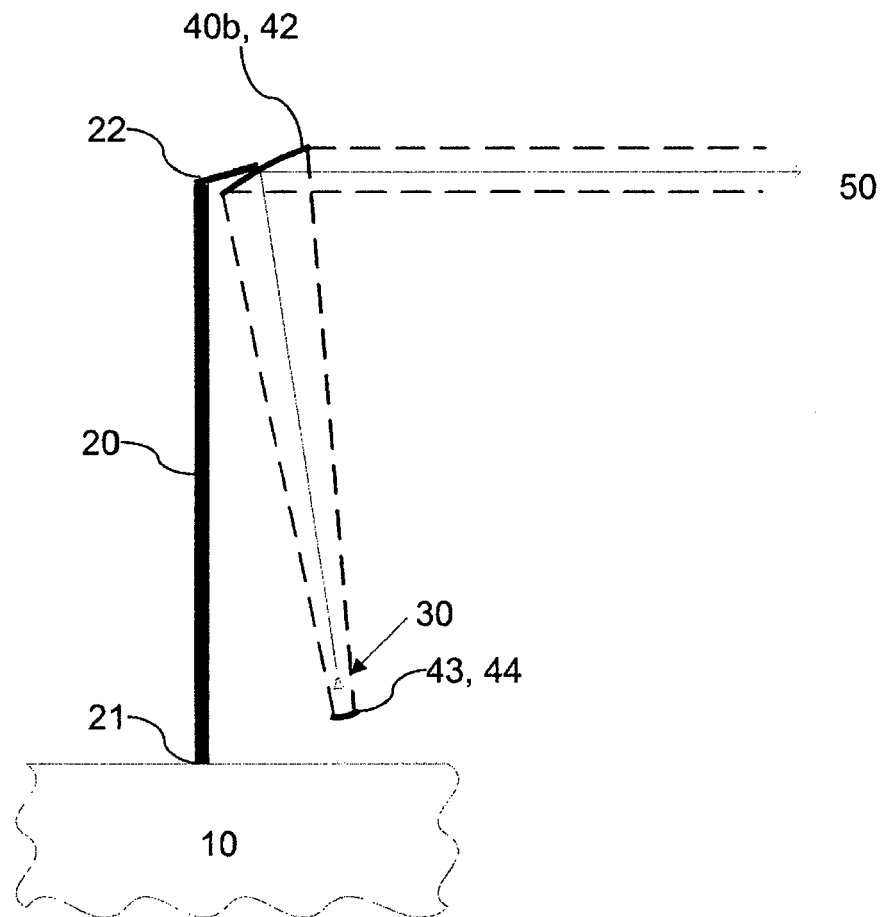


Fig. 3

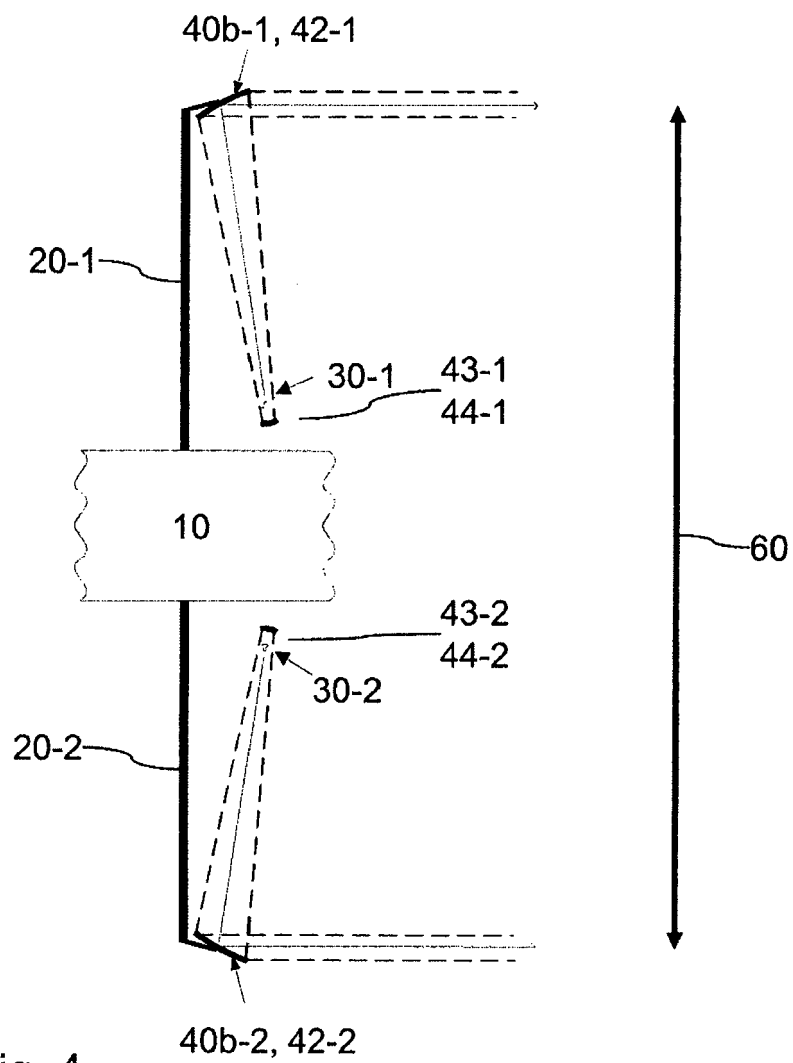


Fig. 4

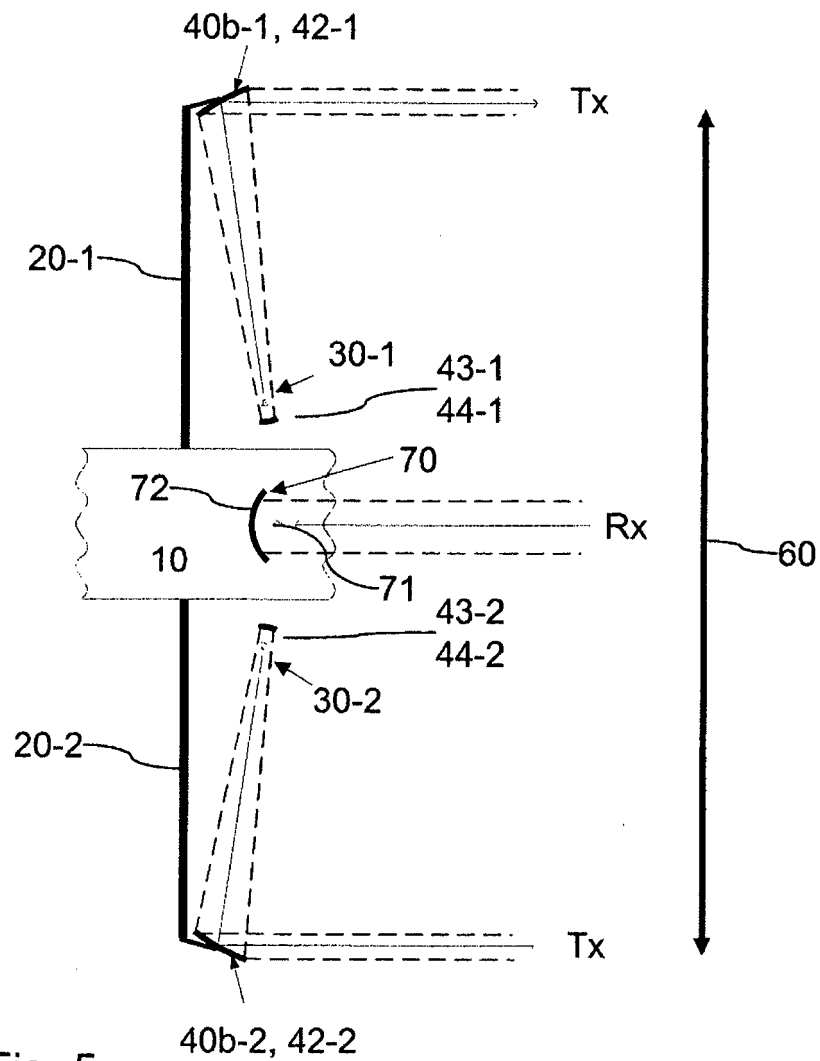


Fig. 5



EUROPEAN SEARCH REPORT

Application Number
EP 12 00 7610

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X	EP 1 119 072 A2 (BOEING CO [US]) 25 July 2001 (2001-07-25) * paragraph [0028] - paragraph [0031]; figures 5A-5E * -----	1-7	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01Q
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 26 February 2013	Examiner Hueso González, J
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 12 00 7610

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