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(54) **WIDEBAND RADIO FREQUENCY
DIRECTIONAL ANTENNA ADAPTOR**

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(52) **U.S. Cl.**

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(2013.01); *H01Q 15/16* (2013.01); *H01Q*
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(57)

ABSTRACT

An antenna system, comprising: an omni-directional antenna element; and a directional adapter having an electromagnetic reflector. The directional adapter detachably coupled to the omni-directional antenna element. The electromagnetic reflector being offset from the omni-directional antenna element. The directional adapter may be configured to be coupled to the antenna to convert a radiation pattern from an omni-directional antenna radiation pattern to a directional antenna radiation pattern, and configured to be decoupled from the antenna to convert the radiation pattern back into the omni-directional antenna radiation pattern.

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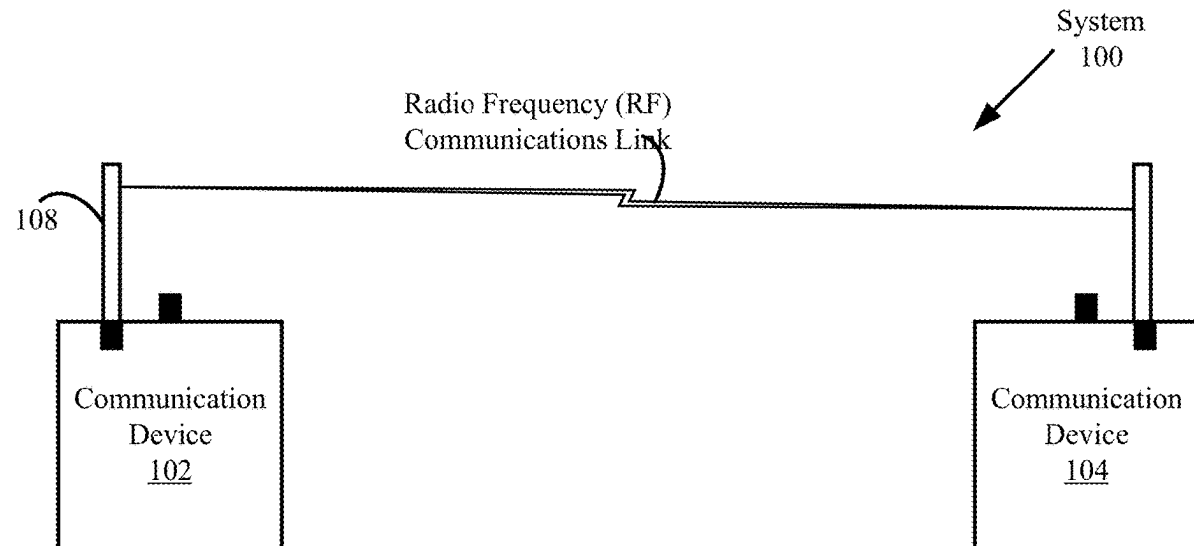
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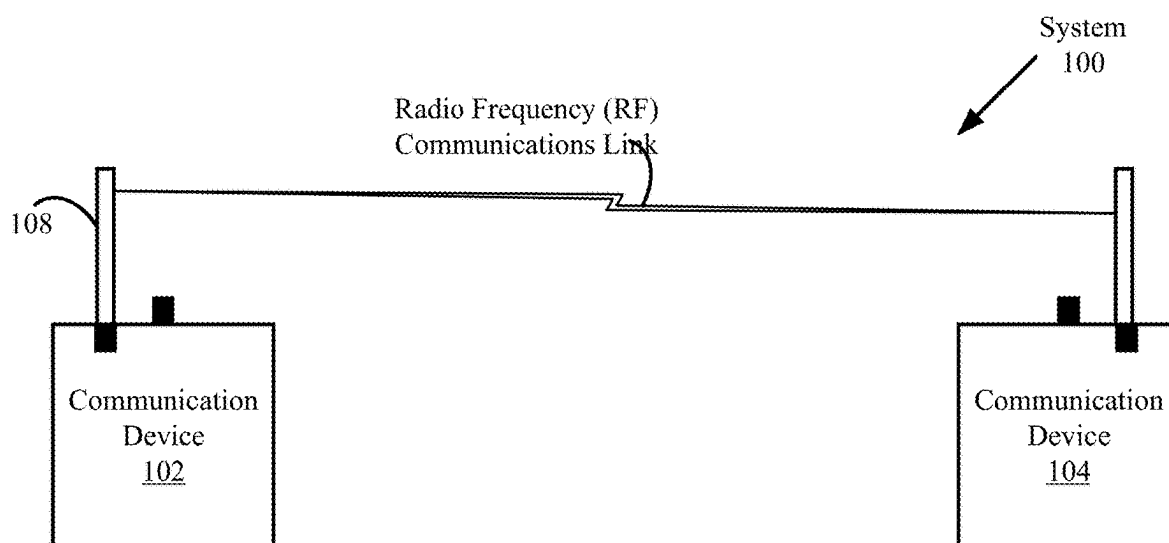


FIG. 1

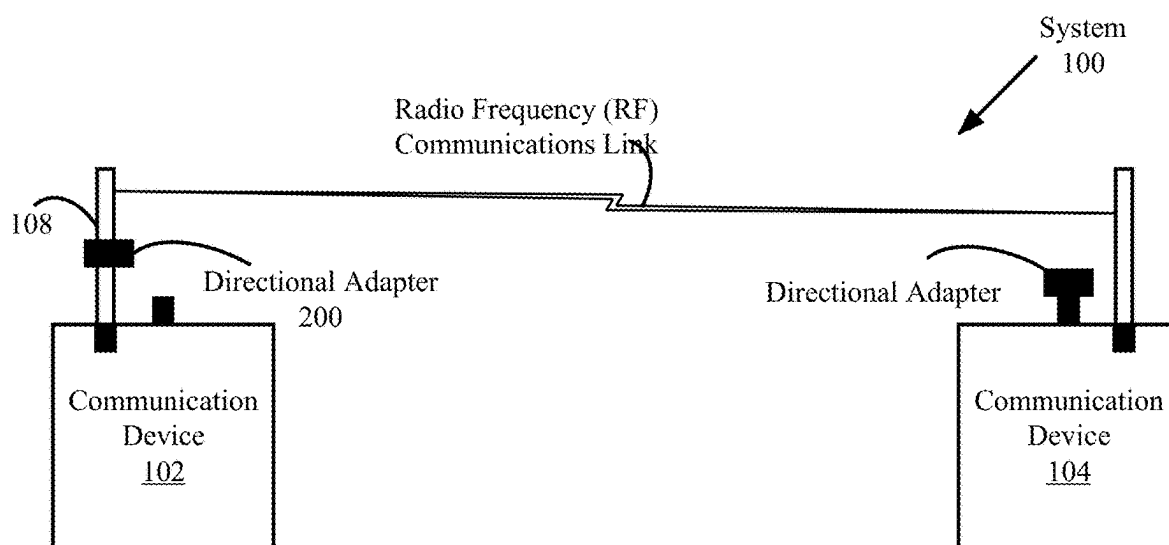


FIG. 2

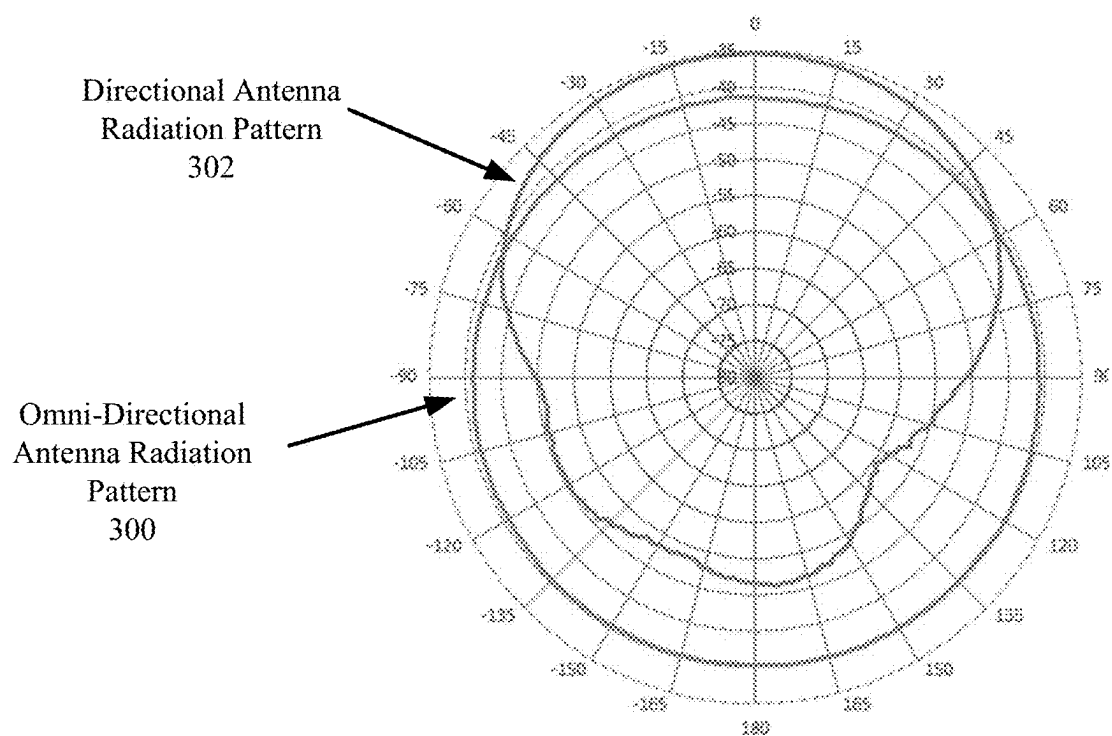


FIG. 3

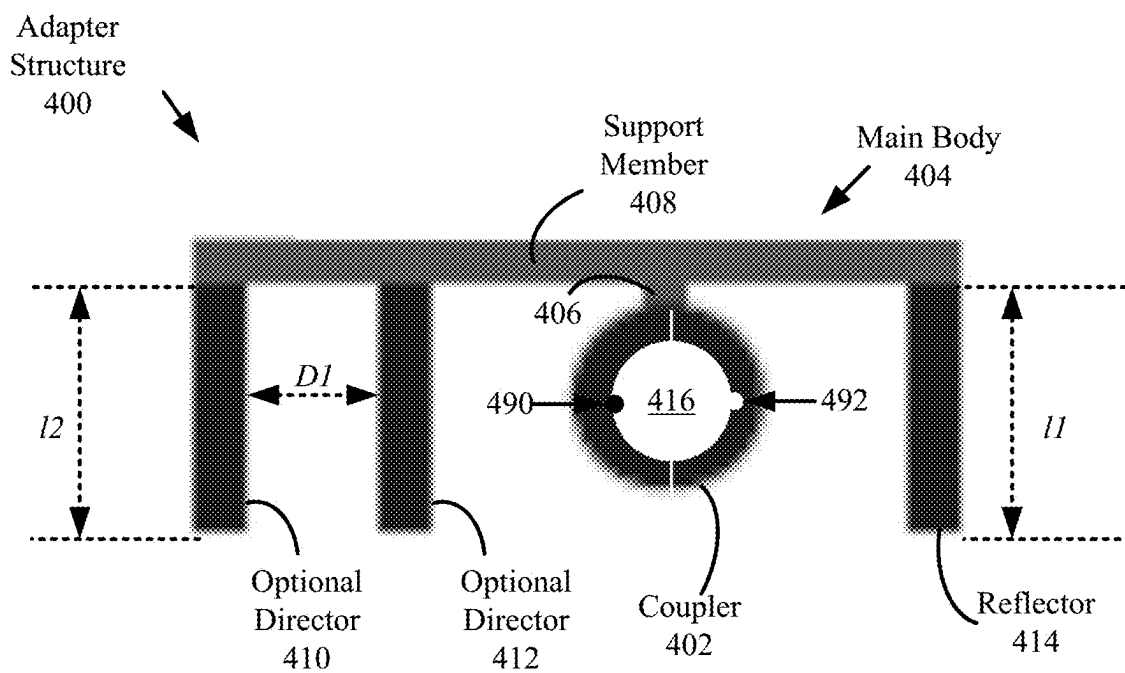


FIG. 4A

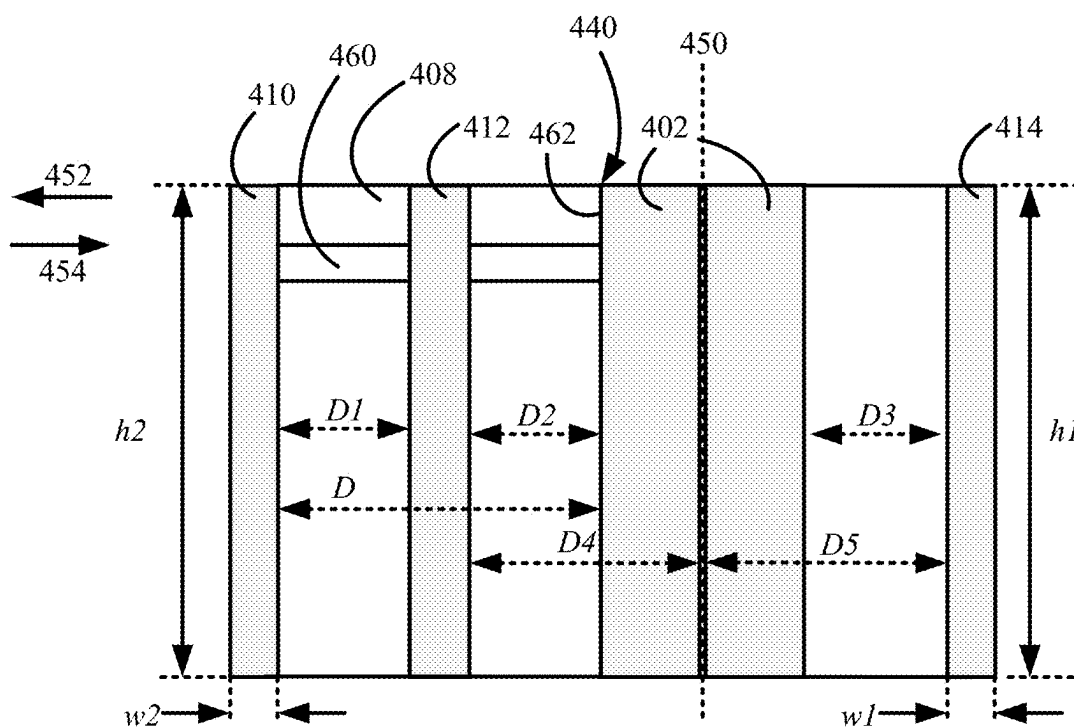


FIG. 4B

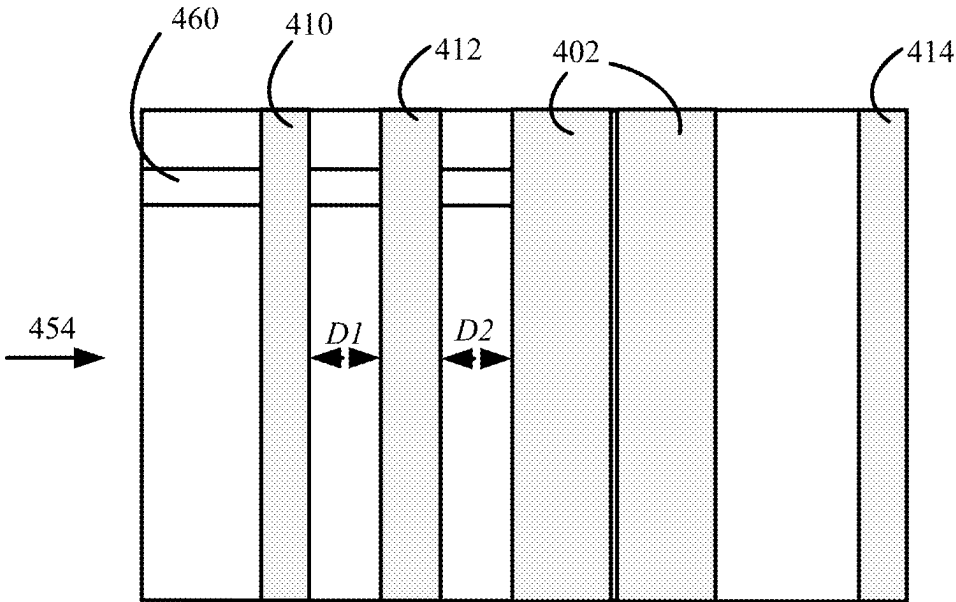


FIG. 4C

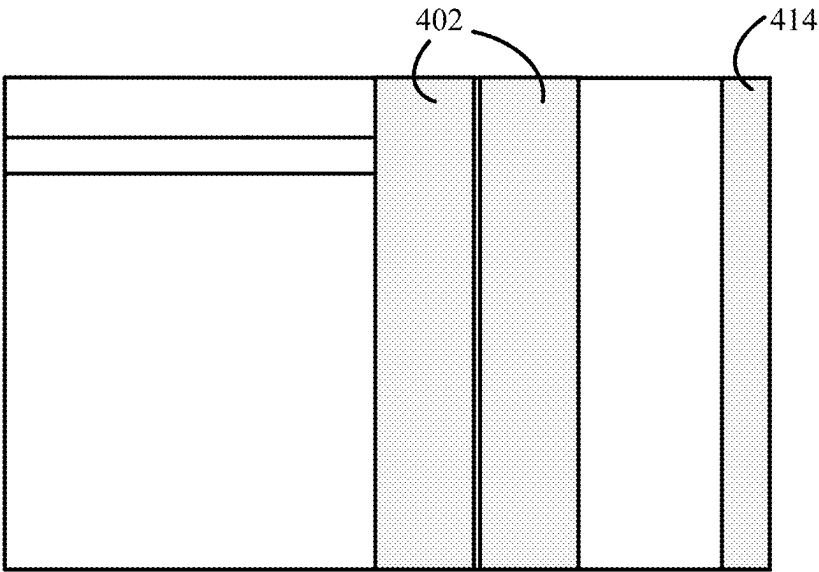


FIG. 4D

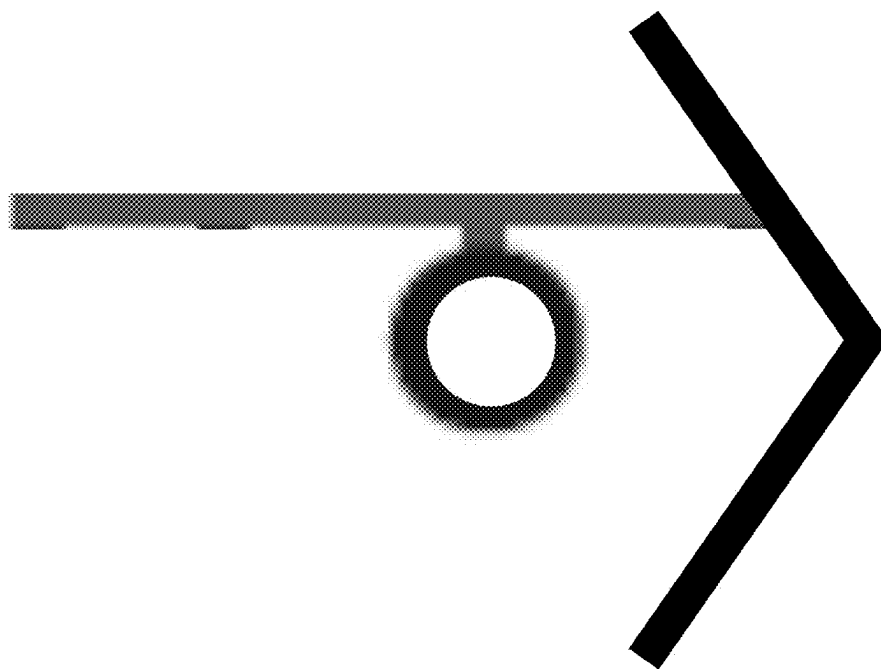
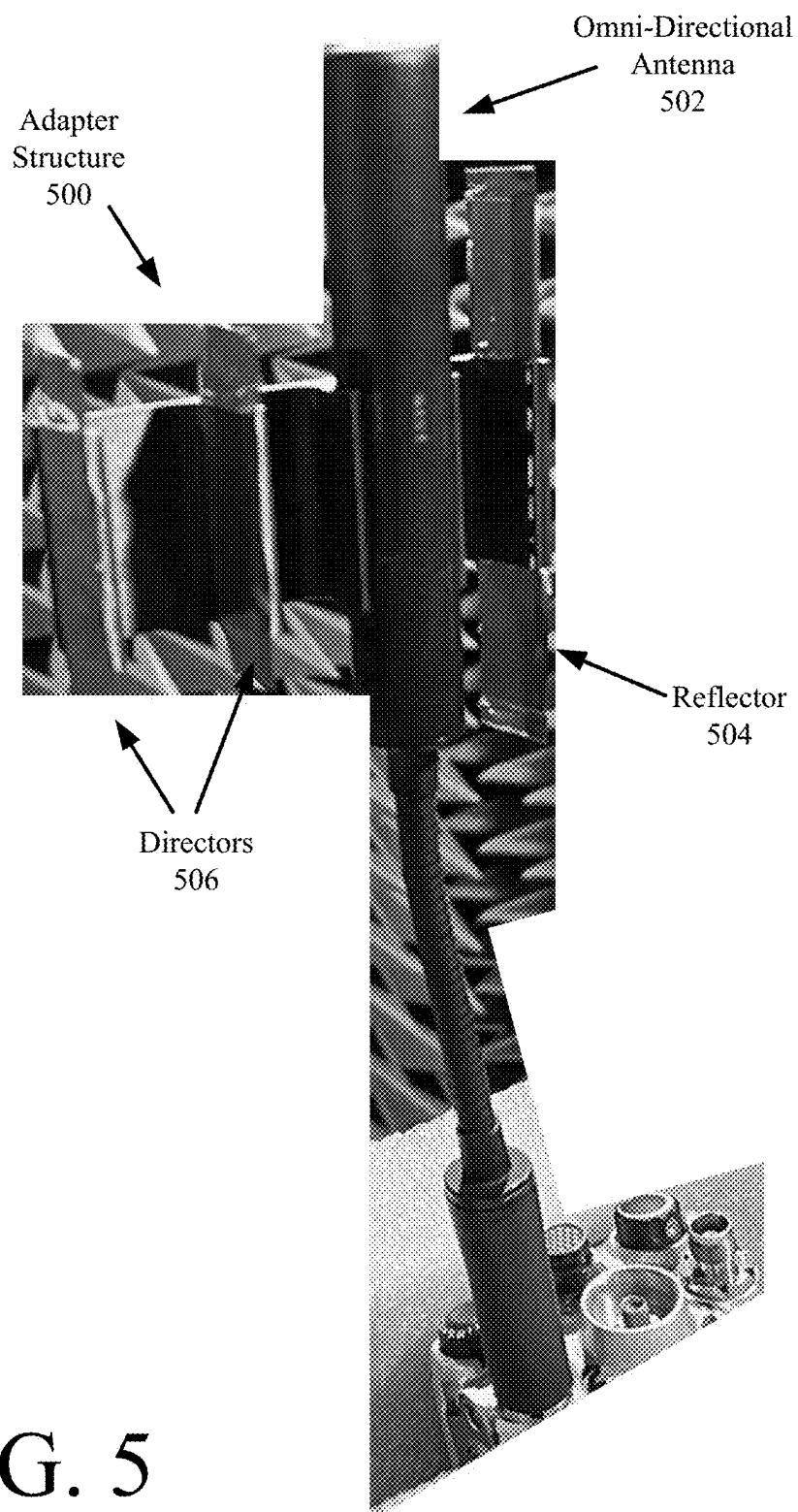


FIG. 4G



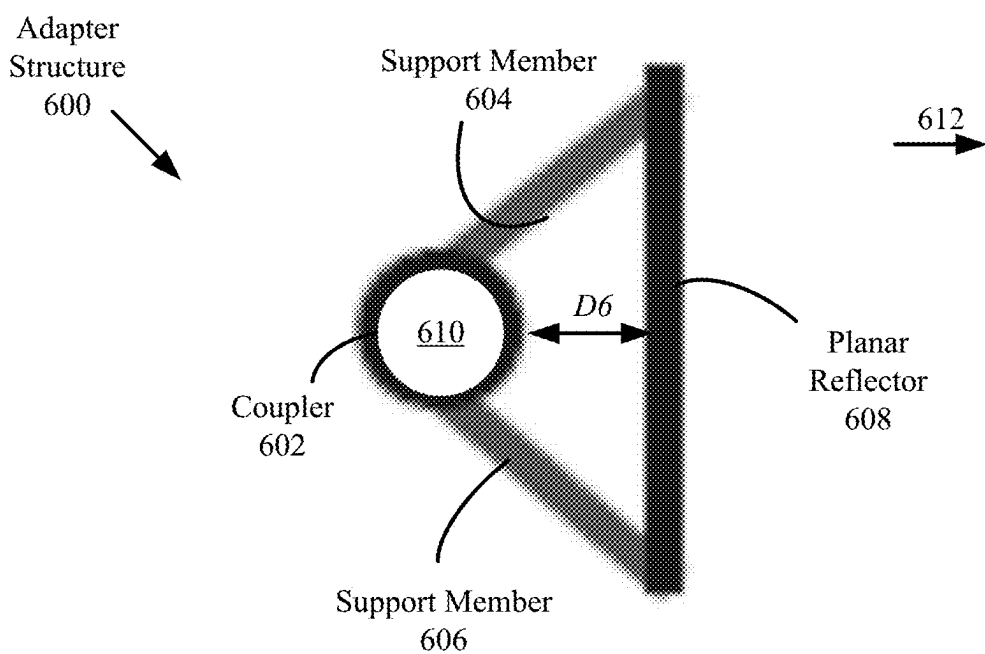


FIG. 6A

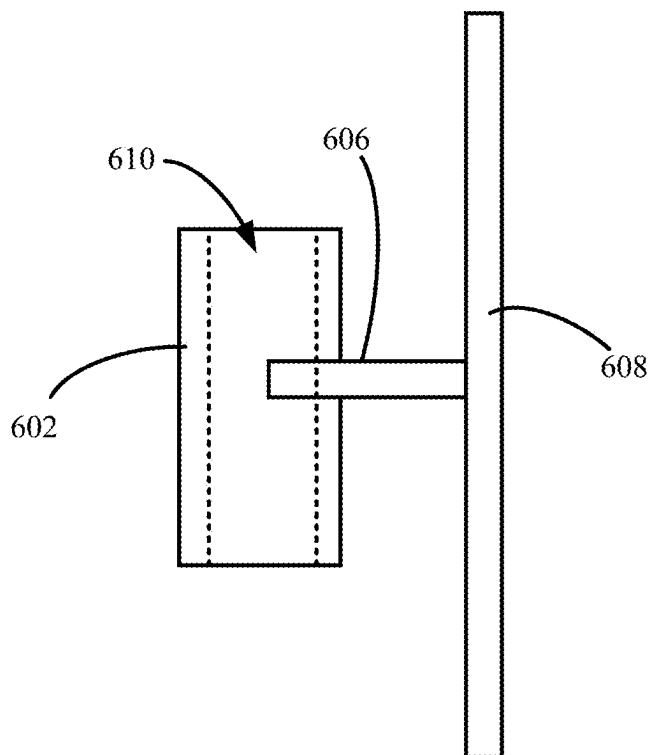


FIG. 6B

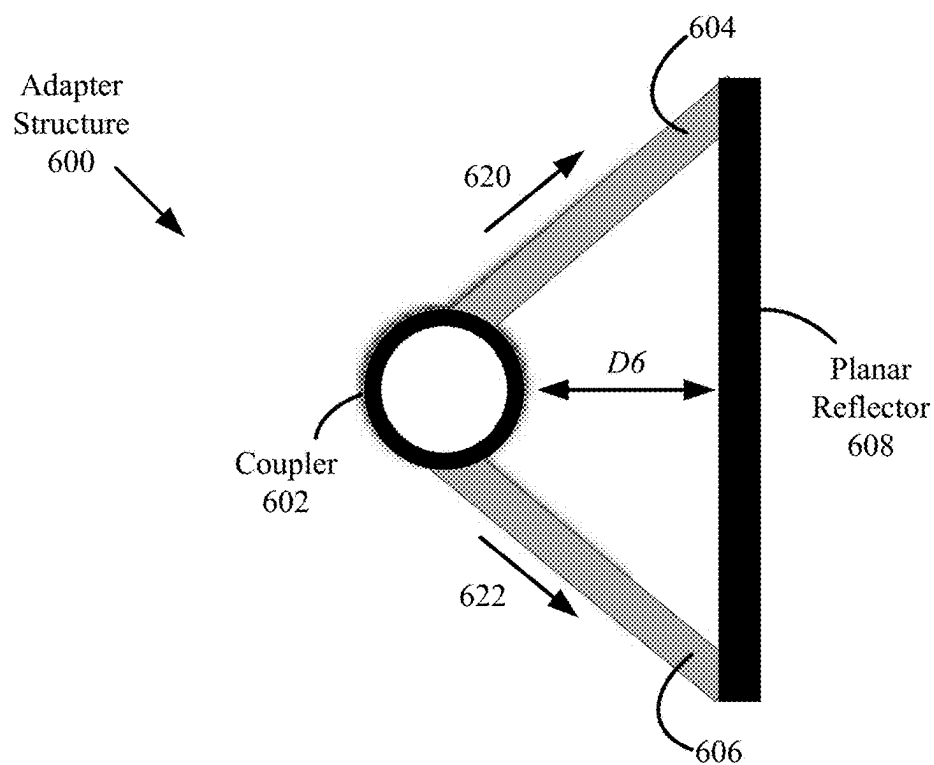


FIG. 6C

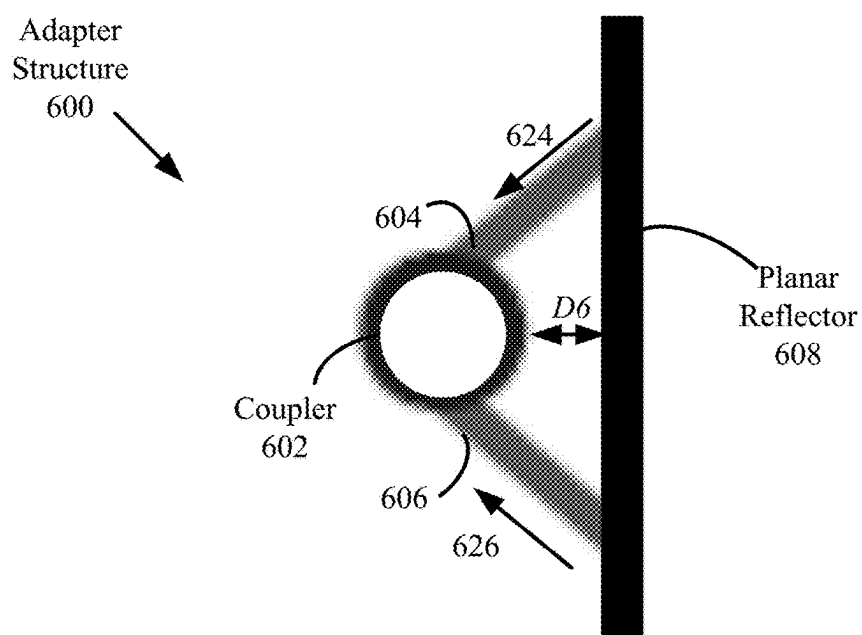


FIG. 6D

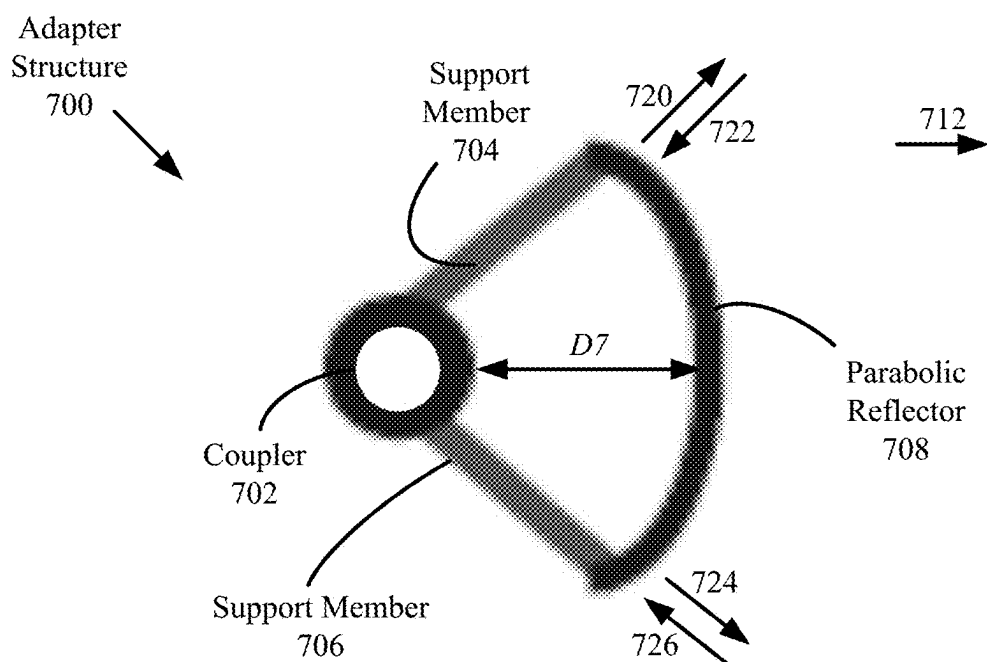


FIG. 7A

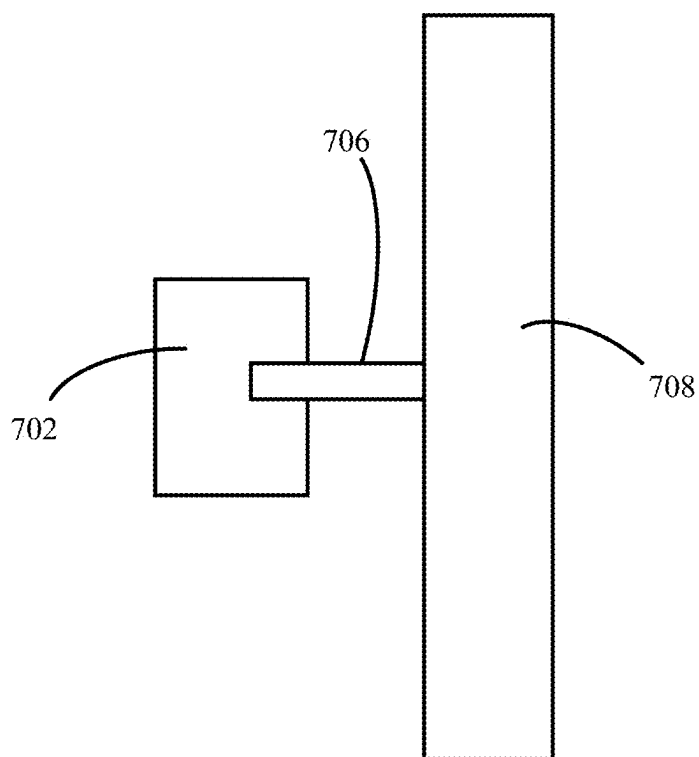


FIG. 7B

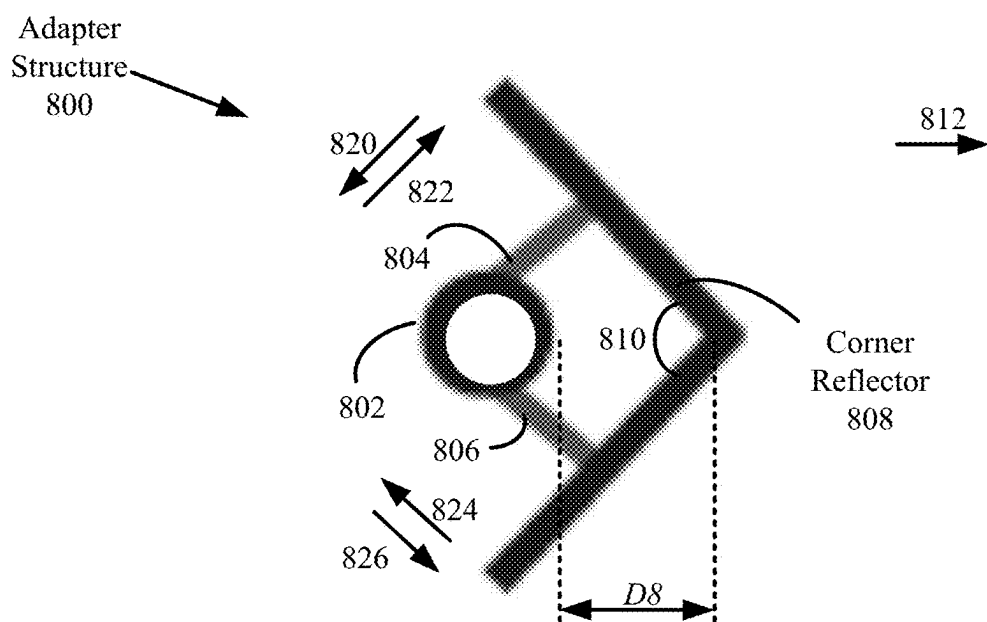


FIG. 8A

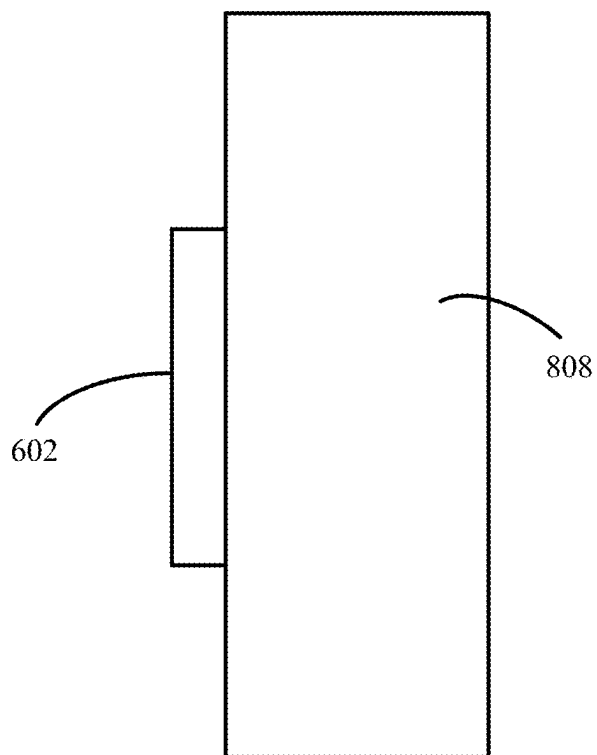


FIG. 8B

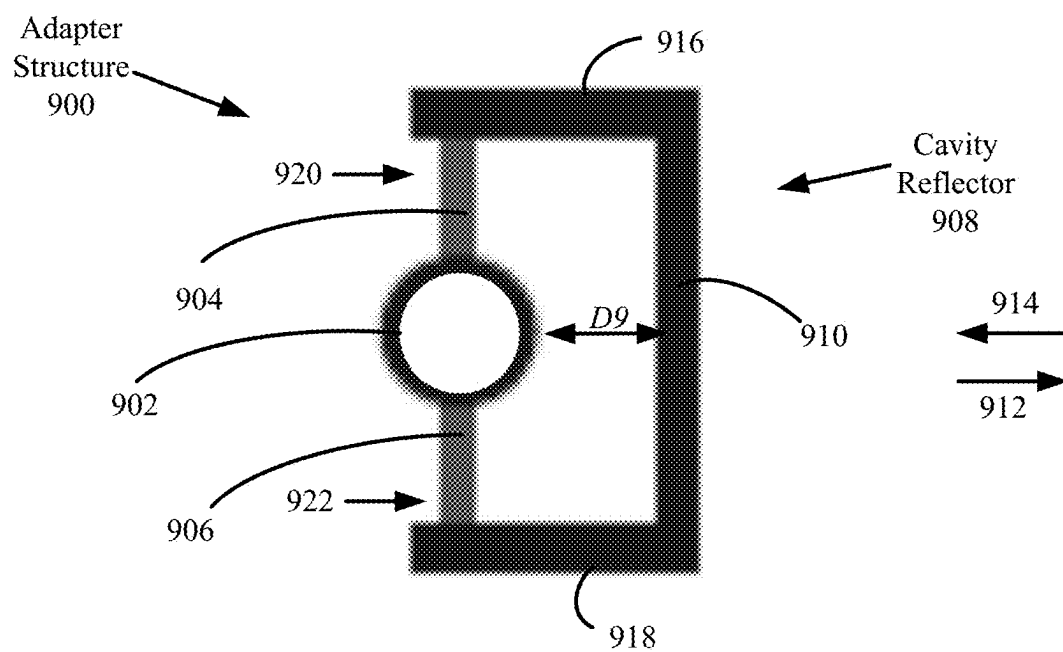


FIG. 9A

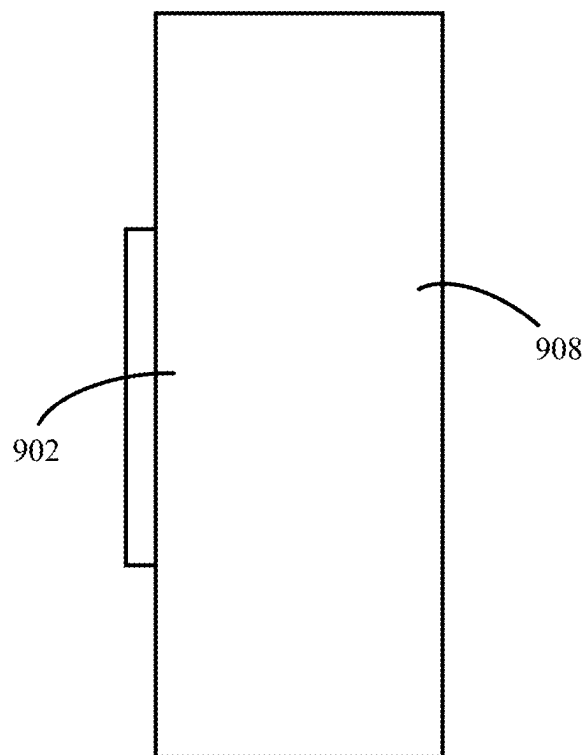


FIG. 9B

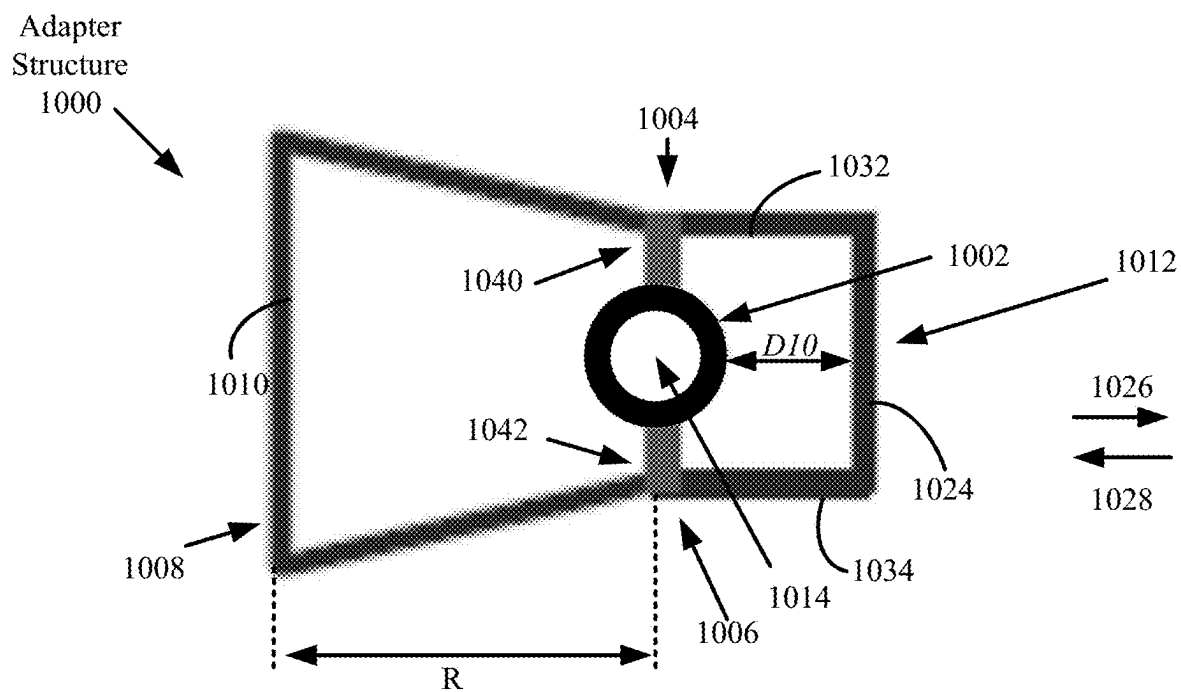


FIG. 7A

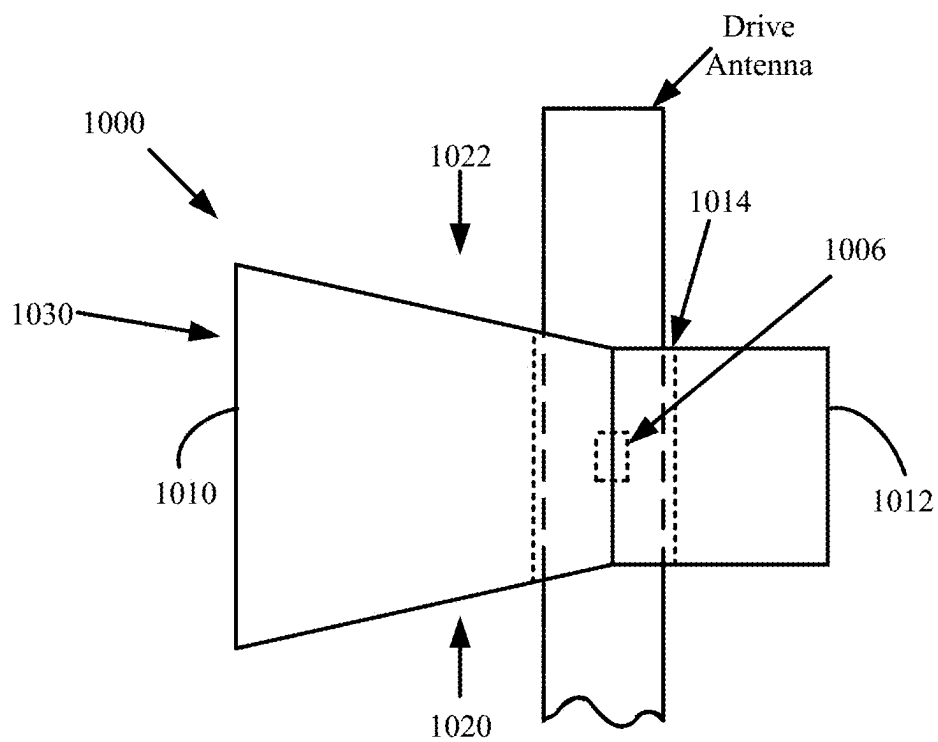


FIG. 7B

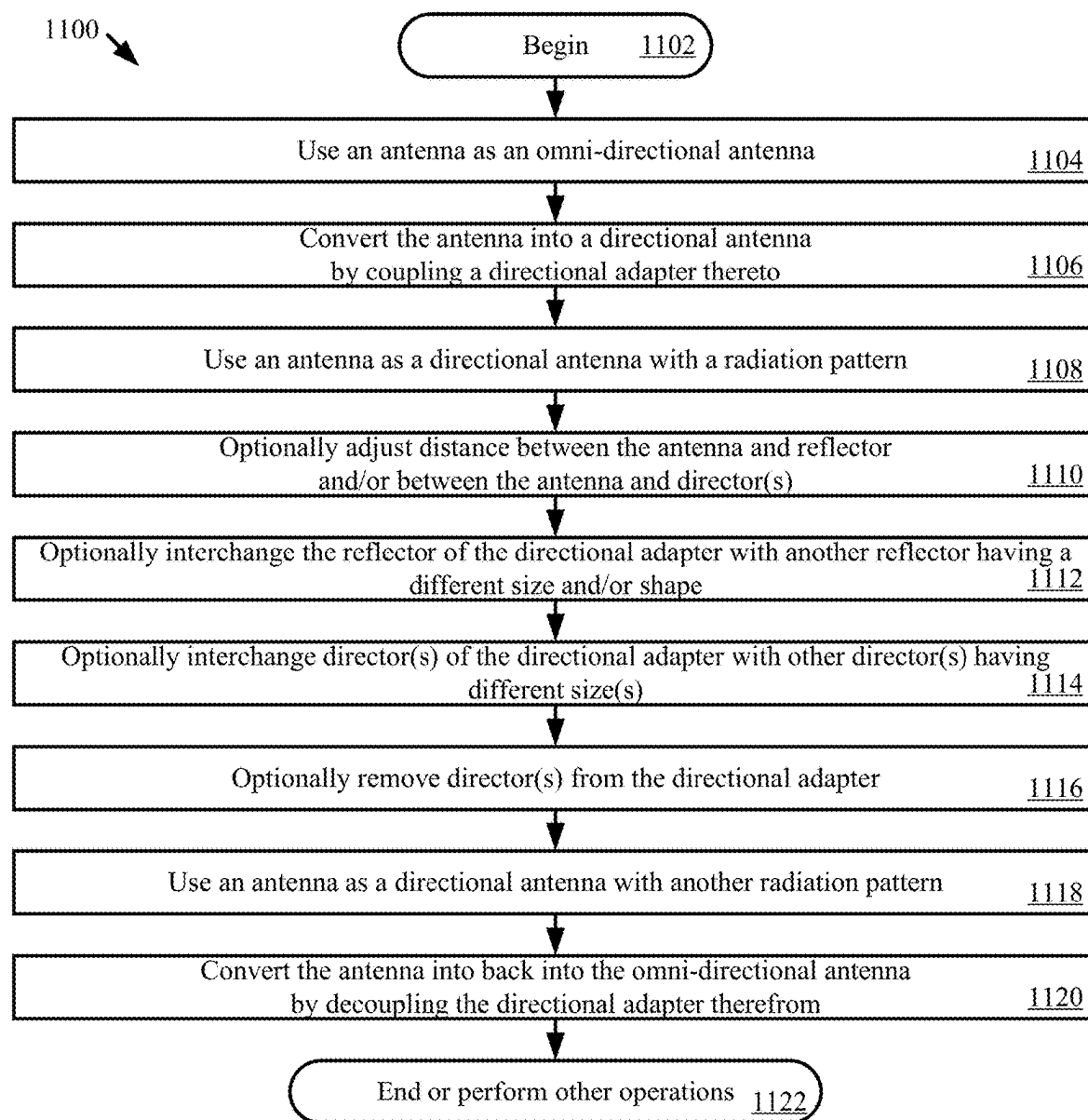


FIG. 11

WIDEBAND RADIO FREQUENCY DIRECTIONAL ANTENNA ADAPTOR

BACKGROUND

Description of the Related Art

[0001] Radios use antennas. Some antennas have omnidirectional radiation pattern. Some antennas have a directional radiation pattern.

SUMMARY

[0002] This document concerns an antenna system. The antenna system comprises: an omni-directional antenna element; and a directional adapter having an electromagnetic reflector. The directional adapter is detachably coupled to the omni-directional antenna element. The electromagnetic reflector is offset from the omni-directional antenna element. The directional adapter has a director offset from the omni-directional antenna element and on the opposite side of the electromagnetic reflector. The directional adapter has a structural element disposed between the reflector and the omni-directional antenna element. The structural element is generally electromagnetically nonconductive. The directional adapter is detachably coupled indirectly to the omni-directional antenna element.

[0003] This document also concerns an antenna adapter. The antenna adapter comprises: a mechanical coupler attachable to an antenna; and an electromagnetic reflector offset from the coupler. The antenna adapter is configured to be coupled to the antenna to convert a radiation pattern from an omni-directional antenna radiation pattern to a directional antenna radiation pattern, and configured to be decoupled from the antenna to convert the radiation pattern back into the omni-directional antenna radiation pattern.

[0004] This document also concerns implementing systems and methods for operating an antenna. The methods comprise: using the antenna as an omni-directional antenna to radiate equal radio power in all directions perpendicular to a center axis of the antenna; converting the antenna into a directional antenna by coupling a directional adapter thereto; using the antenna, with the directional adapter coupled thereto, to radiate greater radio wave power in a specific direction; and converting the antenna back into the omni-directional antenna by decoupling the directional adapter therefrom.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] This disclosure is facilitated by reference to the following drawing figures, in which like numerals represent like items throughout the figures.

[0006] FIGS. 1-2 each provides an illustration of a communication system.

[0007] FIG. 3 shows an omni-directional antenna radiation pattern and a directional antenna radiation pattern.

[0008] FIGS. 4A-4G (collectively referred to herein as "FIG. 4") provide illustrations of adapter structure(s).

[0009] FIG. 5 provides an illustration of an adapter structure of the type shown in FIG. 4 coupled to an omni-directional antenna.

[0010] FIGS. 6A-6B (collectively referred to herein as "FIG. 6") provide illustrations showing another adapter structure.

[0011] FIGS. 7A-7B (collectively referred to herein as "FIG. 7") provide illustrations showing yet another adapter structure.

[0012] FIGS. 8A-8B (collectively referred to herein as "FIG. 8") provide illustrations showing yet another adapter structure.

[0013] FIGS. 9A-9B (collectively referred to herein as "FIG. 9") provide illustrations showing yet another adapter structure.

[0014] FIGS. 10A-10B (collectively referred to herein as "FIG. 10") provide illustrations showing yet another adapter structure.

[0015] FIG. 11 provides a flow diagram of an illustrative method for operating an antenna.

DETAILED DESCRIPTION

[0016] A directional adapter **200** may be selectively attached and detached to/from the antenna(s) **108** of the communication device(s) **102**, **104** as shown in FIGS. 1-2. This coupling can be a direct coupling to the antenna or an indirect coupling to the antenna. A coupler may be provided to facilitate the selective attachment of the directional adapter **200** to the antenna or another component of a communication device (e.g., a housing, a rotary knob, any other member protruding out and away from the housing) and the selective detachment of the directional adapter **200** from the antenna or the another component of the communication device. Any known or to be known coupler can be used here. For example, a spring-based clip, clamp, cord(s) and/or friction fit structure can be employed. The attachment of the directional adapter **200** causes the antenna **108** to transition from the omni-directional antenna mode to a directional antenna mode in which the antenna radiates greater radio wave power in a specific direction, as shown by the azimuth pattern **302** of FIG. 3.

[0017] The directional adapter **200** comprises a passive component near the antenna to reflect and/or direct the radiation pattern. The shape, size and spacing of the directional adapter **200** are configured to allow for efficient operation across the effective bandwidth of the antenna **108**. The directional adapter **200** is a portable, compact, removable, light weight and inexpensive accessory for the antenna.

[0018] The directional adapter **200** can have an overall structure to convert the antenna **108** into a yagi antenna, a parabolic antenna, a reflector antenna, a horn antenna, a corner reflector antenna, and/or a cavity antenna. The particulars of such adapter structures will now be discussed in detail in relation to FIGS. 4-9.

[0019] FIG. 4 provides an illustration of an adapter structure **400** configured to convert or otherwise transform an omni-directional antenna (e.g., antenna **108** of FIGS. 1-2) into a yagi antenna. A top view of the adapter structure **400** is provided in FIG. 4A, and a front view of the adapter structure **400** is provided in FIG. 4B.

[0020] The adapter structure **400** comprises a coupler **402** connected or otherwise attached to a main body **404**. The coupler **406** is configured to facilitate the selective coupling and decoupling of the adapter structure **400** to an antenna (e.g., omni-directional antenna **108** of FIG. 1). The coupler **406** can include, but is not limited to, a friction fit structure, a clamp, cord(s) and/or a clip designed to receive and hold the omni-directional antenna in an internal space **416**. The coupler **406** may be formed of an insulating material. The insulating material can include, but is not limited to, plastic

and/or rubber. One or more optional protrusions **490** and/or detents **492** may be provided on an internal surface of the coupler **406** to facilitate the coupling of the adapter structure **400** to an antenna and/or maintain the coupling throughout use of the adapter structure. The protrusion may be configured to use suction to adhere to the omni-directional antenna.

[0021] The main body **404** comprises a support member **408** to which one or more passive components are mounted. The support member **408** may be formed of an insulating material which is the same or different than the insulating material of the coupler **406**. In some scenarios, the support member **408** and coupler **402** are integrally formed as a single piece, for example, via an injection molding process. In other scenarios, the support member **408** and coupler **402** are two separate pieces that are joined, attached, adhered and/or affixed to each other. A weld or an adhesive may, for example, be used to facilitate the coupling of the support member **408** and coupler **402**.

[0022] The passive component(s) include(s) a reflector **414**. The reflector is provided to add gain by reflecting the energy produced at the drive antenna (e.g., antenna **108** of FIG. 1) and cause electromagnetic waves to propagate in a particular direction. One or more directors **410**, **412** may optionally also be provided as passive components. The reflector **414** may be formed of a conductive material. The directors **410**, **412** may be formed of a conductive material. Each director is provided to modify the radiation pattern of the radio waves that hits it and re-radiate the radio waves with a different phase. An illustration showing the adapter structure without any directors is provided in FIG. 4D. An illustration showing the adapter structure with one director is provided in FIG. 4E. An illustration showing the adapter structure with two directors is provided in FIGS. 4A-4B. The adapter structure can include any number of directors selected in accordance with a particular application.

[0023] The reflector **414** is larger in size than the directors **410**, **412**. The directors **410**, **412** are equal in size. In this regard, the reflector **414** may have a length l_1 , width w_1 and/or height h_1 larger than the length l_2 , width w_2 and/or height h_2 of the director(s). The lengths l_1 , l_2 , heights h_1 , h_2 and widths w_1 , w_2 are parameters of the adapter structure **400** which are selected to tune the frequency in which the adapter structure **400** is able to operate while coupled to the drive antenna (e.g., antenna **108** of FIG. 1). The frequency of the adapter structure **400** can also be tuned by changing the distance D_1 between adjacent directors **410-412**, the distance D_2 between the coupler **402** and the adjacent director **412**, and/or the distance D_3 between the coupler **402** and the reflector **414**.

[0024] The reflector **414** has a fixed position relative to the support member **408**. In contrast, each director **410**, **412** can have a fixed position relative to the support member **408** or alternatively a variable position relative to the support member **408**. In the variable position scenario, the director(s) may be slid in an optional track **460** formed in the support member **408** or otherwise move in opposing directions **252**, **254** so as to change distance D_1 and/or distance D_2 . An illustration is provided in FIG. 4C showing the directors **410**, **412** moved in direction **454** so as to decrease distances D_1 and D_2 . This allows for frequency tuning and/or antenna radiation pattern adjustments in the field by a user of the adapter structure **400**.

[0025] The reflector **414** may additionally or alternatively be interchangeable with reflectors having different sizes and/or shapes. An illustration showing the reflector **414** interchanged with a corner reflector is provided in FIG. 4G.

[0026] Each director **410**, **412** may be selectively attachable/detachable to/from the support member **408**, and/or may be interchangeable with other director(s) having different size(s) than directors **410**, **412**. An illustration showing the adapter structure with the directors **410**, **412** replaced with a different sized director **480** is provided in FIG. 4F.

[0027] The components **410**, **412**, **414** are arranged so as to be spaced apart from each other. Adjacent directors **410** and **412** are spaced apart from each other by a distance D_1 . Although two directors are shown in FIG. 4, the present situation is not limited in this regard. In the case that three or more directors are provided with the adapter structure, each pair of adjacent directors are spaced apart from each other by the same distance as that of all other pairs of adjacent directors.

[0028] The distance D_2 from the inner most director **412** to the coupler **402** is the same as distance D_1 . However, distance D_3 between the coupler **402** and the reflector **414** can be the same as or different than distances D_1 and D_2 . The distance between the inner most director **412** and the center axis **450** of the coupler **402** can be the same as or different than the distance between the reflector **414** and the center axis **450**.

[0029] As shown in FIG. 4, an edge **462** of the coupler **402** is aligned with a center **440** of the adapter structure **200**. The coupler **402** extends from the center **440** in direction **454** towards the reflector **414**. The present solution is not limited in this regard. In other scenarios, such as when the adapter structure comprises a single director, a center axis **450** of the coupler **402** may be aligned with the center of the adapter structure **200**. The coupler **402** is shown in FIG. 4 as having the same height as the reflector and/or directors. The present solution is not limited in this regard. The coupler can alternatively have a different height than the reflector and/or director(s).

[0030] An illustration is provided in FIG. 5 showing a directional adaptor **500** coupled to an omni-directional antenna **502**. The adapter structure **500** is configured to convert or otherwise transform an omni-directional antenna **502** into a yagi antenna. The directional adaptor **500** has a structure similar to the adapter structure **400** of FIG. 4. The reflector **504** of directional adaptor **500** has an overall size that is different than the overall size of each director **506**.

[0031] FIG. 6 provides an illustration of another structure **600** for a directional adaptor. A top view of the adapter structure **600** is provided in FIG. 6A, and a front view of the adapter structure **600** is provided in FIG. 6B.

[0032] The adapter structure **600** is configured to convert or otherwise transform an omni-directional antenna (e.g., omni-directional antenna **108** of FIG. 1) into a reflector antenna. Accordingly, the adapter structure **600** comprises a coupler **602** configured to facilitate the coupling and decoupling of the adapter structure **600** to an antenna (e.g., antenna **108** of FIG. 1). Coupler **602** may be the same as, similar to or different than coupler **402** of FIG. 4.

[0033] At least one support member **604** is provided to attach the coupler **602** to a reflector **608**. The reflector **608** is provided to add gain by reflecting the energy produced at the drive antenna (e.g., omni-directional antenna **108** of FIG.

1) and send it in a particular direction. The reflector **608** may be formed of a conductive material and have a generally planar shape.

[0034] The coupler **602** and support member(s) **604**, **606** are formed of insulative material(s). In some scenarios, the support member(s) **604**, **606** and coupler **602** are integrally formed as a single piece, for example, via an injection molding process. In other scenarios, the support members **604**, **606** and coupler **602** are separate pieces that are joined, attached, adhered and/or affixed to each other. A weld or an adhesive may, for example, be used to facilitate the coupling of the support member(s) **604**, **606** and coupler **602**.

[0035] The length, height and width of the reflector **608** are selected to tune the frequency in which the adapter structure **600** is able to operate while coupled to the drive antenna (e.g., antenna **108** of FIG. 1). In some scenarios, the reflector **608** may have a fixed size or a variable size. The reflector may also be interchangeable with other different sized reflectors. The frequency of the adapter structure **600** can also be tuned by changing the distance D6 between the coupler **602** and the reflector **608**.

[0036] Distance D6 is selected based on the frequency in which the directional adapter is to operate. The distance D6 can be smaller or larger than that shown in FIG. 6. Nominally the distance D6 may be equal to or substantially similar to $\frac{1}{4}\lambda$. The distance D6 may be fixed or alternatively adjustable. In the adjustable scenario, the distance D6 can be changed by expanding and/or contracting the support members **604**, **606**.

[0037] The expansion/contraction of the support members **604**, **606** can be facilitated by using a structure in which the support member sub-parts can slide into and out of each other. The structure can include, but is not limited to, a telescoping structure. The support members **606**, **604** are expanded by increasing their lengths respectively in directions **620**, **622** as shown in FIG. 6C. In this case, the size of the planar reflector **608** may be changed as also shown in FIG. 6C. The present solution is not limited in this regard. In other scenarios, a single central support structure is provided that can be expanded without requiring the size of the reflector to change. Thus, the variable size of the reflector is an optional feature of the adapter structure. The support members **606**, **604** may be contracted by decreasing their lengths respectively in directions **624**, **626** as shown in FIG. 6D. The present solution is not limited to the particulars of these scenarios.

[0038] FIG. 7 provides an illustration of another structure **700** for a directional adaptor. A top view of the adapter structure **700** is provided in FIG. 7A, and a front view of the adapter structure **700** is provided in FIG. 7B.

[0039] The adapter structure **700** is configured to convert or otherwise transform an omni-directional antenna (e.g., omni-directional antenna **108** of FIG. 1) into a parabolic antenna. Accordingly, the adapter structure **700** comprises a coupler **702** configured to facilitate the coupling and decoupling of the adapter structure **700** to an antenna (e.g., antenna **108** of FIG. 1). Coupler **702** may be the same as, similar to or different than coupler **402** of FIG. 4.

[0040] At least one support member **704**, **706** is provided to attach the coupler **702** to a parabolic reflector **708**. The coupler **702** and support member(s) **704**, **706** are formed of insulative material(s). The parabolic reflector **708** is provided to add gain by reflecting the energy produced at the drive antenna (e.g., antenna **108** of FIG. 1) and send it in a

particular direction. The parabolic reflector **708** may be formed of a conductive material.

[0041] The coupler **702** and support member(s) **704**, **706** are formed of insulative material(s). In some scenarios, the support member(s) **704**, **706** and coupler **702** are integrally formed as a single piece, for example, via an injection molding process. In other scenarios, the support members **704**, **706** and coupler **702** are separate pieces that are joined, attached, adhered and/or affixed to each other. A weld or an adhesive may, for example, be used to facilitate the coupling of the support member(s) **704**, **706** and coupler **702**.

[0042] The length, height and width of the parabolic reflector **708** are selected to tune the frequency in which the adapter structure **700** is able to operate while coupled to the drive antenna (e.g., antenna **108** of FIG. 1). In some scenarios, the parabolic reflector **708** may have a fixed size or a variable size. The reflector may also be interchangeable with other different sized reflectors. The frequency of the adapter structure **700** can also be tuned by changing the distance D7 between the coupler **702** and the parabolic reflector **708**.

[0043] The distance D7 between the coupler **702** and the parabolic reflector **708** is selected based on the frequency in which the directional adapter is to operate. The distance D7 can be smaller or larger than that shown in FIG. 7. Nominally the distance D7 may be equal to or substantially similar to $\frac{1}{4}\lambda$. The distance D7 may be fixed or alternatively adjustable. In the adjustable scenario, the distance D7 can be changed by expanding and/or contracting the support members **704**, **706**. The expansion/contraction of the support members **704**, **706** can be facilitated by using a structure in which the support member sub-parts can slide into and out of each other. The structure can include, but is not limited to, a telescoping structure. The support members **706**, **704** are expanded by increasing their lengths respectively in directions **720**, **724**, and are contracted by decreasing their lengths respectively in directions **722**, **726**.

[0044] The curvature of the parabolic reflector **708** is selected based on a desired directionality of the antenna when used with the directional adapter. The smaller the curvature the less directional the antenna, and the larger the curvature the more directional the antenna. The curvature of the parabolic reflector **708** may be fixed in some scenarios or variable in other scenarios. In the fixed curvature scenarios, the parabolic reflector **708** may be interchangeable with other parabolic reflectors having different curvatures and/or sizes.

[0045] In the variable curvature scenarios, any known or to be known means for adjusting the curvature of an object can be used. For example, in some scenarios, the reflector comprises multiple parts that can be slid into each other and out from each other. Additionally or alternatively, the reflector can be made of a conductive material that can be bent or otherwise deformed to change the curvature without causing damage thereto. The present solution is not limited to the particulars of this example.

[0046] FIG. 8 provides an illustration of another structure **800** for a directional adaptor. A top view of the adapter structure **800** is provided in FIG. 8A, and a front view of the adapter structure **800** is provided in FIG. 8B. The adapter structure **800** is configured to convert or otherwise transform an omni-directional antenna (e.g., omni-directional antenna **108** of FIG. 1) into a corner antenna.

[0047] As shown in FIG. 8, the adapter structure 800 comprises a coupler 802 configured to facilitate the coupling and decoupling of the adapter structure 800 to an antenna (e.g., antenna 108 of FIG. 1). Coupler 802 may be the same as, similar to or different than coupler 402 of FIG. 4.

[0048] At least one support member 804, 806 is provided to attach the coupler 802 to a corner reflector 808. The coupler 802 and support member(s) 804, 806 are formed of insulative material(s). The corner reflector 808 is provided to add gain by reflecting the energy produced at the drive antenna (e.g., antenna 108 of FIG. 1) and send it in a particular direction. The corner reflector 808 may be formed of a conductive material.

[0049] The coupler 802 and support member(s) 804, 806 are formed of insulative material(s). In some scenarios, the support member(s) 804, 806 and coupler 802 are integrally formed as a single piece, for example, via an injection molding process. In other scenarios, the support members 804, 806 and coupler 802 are separate pieces that are joined, attached, adhered and/or affixed to each other. A weld or an adhesive may, for example, be used to facilitate the coupling of the support member(s) 804, 806 and coupler 802.

[0050] The length, height and width of the corner reflector 808 are selected to tune the frequency in which the adapter structure 700 is able to operate while coupled to the drive antenna (e.g., antenna 108 of FIG. 1). In some scenarios, the corner reflector 808 may have a fixed size or a variable size. The corner reflector may also be interchangeable with other different sized corner reflectors. The frequency of the adapter structure 800 can also be tuned by changing the distance D8 between the coupler 802 and the corner reflector 808.

[0051] The distance D8 between the coupler 802 and the corner reflector 808 is selected based on the frequency in which the directional adapter is to operate. The distance D8 can be smaller or larger than that shown in FIG. 8. Nominally the distance D8 is equal to or substantially similar to $\frac{1}{4}\lambda$. The distance D8 may be fixed or alternatively adjustable. In the adjustable scenario, the distance D8 can be changed by expanding and/or contracting the support members 804, 806. The expansion/contraction of the support members 804, 806 can be facilitated by using a structure in which the support member sub-parts can slide into and out of each other. The structure can include, but is not limited to, a telescoping structure. The support members 806, 804 are expanded by increasing their lengths respectively in directions 822, 826, and are contracted by decreasing their lengths respectively in directions 820, 824.

[0052] The angle 810 of the corner reflector 808 is selected based on a desired directionality of the antenna when used with the directional adapter. The larger the angle 810 the less directional the antenna, and the smaller the angle 810 the more directional the antenna. The angle 810 of the corner reflector 808 may be fixed in some scenarios or variable in other scenarios. In the fixed curvature scenarios, the corner reflector 808 may be interchangeable with other parabolic reflectors having different curvatures and/or sizes.

[0053] In the variable angle scenarios, any known or to be known means for adjusting the angle between two planar sidewalls can be used. For example, in some scenarios, the reflector comprises multiple parts that can rotate relative to each other. Additionally or alternatively, the reflector can be made of a conductive material that can be bent or otherwise

deformed to change the angle without causing damage thereto. The present solution is not limited to the particulars of this example.

[0054] FIG. 9 provides an illustration of another structure 900 for a directional adaptor. A top view of the adapter structure 900 is provided in FIG. 9A, and a front view of the adapter structure 900 is provided in FIG. 9B. The adapter structure 900 is configured to convert or otherwise transform an omni-directional antenna (e.g., omni-directional antenna 108 of FIG. 1) into a cavity antenna.

[0055] As shown in FIG. 9, the adapter structure 900 comprises a coupler 902 configured to facilitate the coupling and decoupling of the adapter structure 900 to an antenna (e.g., antenna 108 of FIG. 1). Coupler 902 may be the same as, similar to or different than coupler 402 of FIG. 4.

[0056] At least one support member 904, 906 is provided to attach the coupler 902 to a cavity reflector 908. The coupler 902 and support member(s) 904, 906 are formed of insulative material(s). The cavity reflector 908 has a generally U-shape and is provided to add gain by reflecting the energy produced at the drive antenna (e.g., antenna 108 of FIG. 1) and send it in a particular direction. The U-shape is defined by three sidewalls 910, 916, 918, wherein each sidewall 916, 918 extends perpendicular to sidewall 910 and extends in direction 914 away from sidewall 910. The cavity reflector 908 may be formed of a conductive material.

[0057] The coupler 902 and support member(s) 904, 906 are formed of insulative material(s). In some scenarios, the support member(s) 904, 906 and coupler 902 are integrally formed as a single piece, for example, via an injection molding process. In other scenarios, the support members 904, 906 and coupler 902 are separate pieces that are joined, attached, adhered and/or affixed to each other. A weld or an adhesive may, for example, be used to facilitate the coupling of the support member(s) 904, 906 and coupler 902.

[0058] The overall size of the cavity reflector 908 are selected to tune the frequency in which the adapter structure 900 is able to operate while coupled to the drive antenna (e.g., antenna 108 of FIG. 1). In some scenarios, the cavity reflector 908 may have a fixed size or a variable size. The cavity reflector may also be interchangeable with other different sized cavity reflectors. The frequency of the adapter structure 900 can also be tuned by changing the distance D9 between the coupler 902 and sidewall 910 of the cavity reflector 908.

[0059] The distance D9 between the coupler 902 and the cavity reflector 908 is selected based on the frequency in which the directional adapter is to operate. The distance D9 can be smaller or larger than that shown in FIG. 9. The distance D9 may be fixed or alternatively adjustable. In the adjustable scenario, the distance D9 can be changed by moving the support member(s) 904, 906 in direction 912 towards from sidewall 910 of the cavity reflector 908 and moving the support member(s) 904, 906 in direction 914 away from sidewall 910 of the cavity reflector 908. This movement can be facilitated by, for example, tracks (not visible in FIG. 5) formed in sidewalls 916, 918 of the cavity reflector 908 and/or rollers (not visible in FIG. 5) provided at distal ends 920, 922 of the support member(s) 904, 906. Other techniques for allowing movement of the support member(s) 904, 906 relative to the cavity reflector 908 can be used here. The further the drive antenna is moved in direction 914 via the support member(s) 904, 906 the smaller the nulls are in the directional antenna pattern, and

the further the drive antenna is moved in direction **912** via the support member(s) **904**, **906** the larger the nulls are in the directional antenna pattern.

[0060] FIG. **10** provides an illustration of another structure **1000** for a directional adaptor. A top view of the adapter structure **1000** is provided in FIG. **10A**, and a front view of the adapter structure **1000** is provided in FIG. **10B**. The adapter structure **1000** is configured to convert or otherwise transform an omni-directional antenna (e.g., omni-directional antenna **108** of FIG. **1**) into a horn antenna.

[0061] As shown in FIG. **10**, the adapter structure **1000** comprises a coupler **1002** configured to facilitate the coupling and decoupling of the adapter structure **1000** to a drive antenna (e.g., antenna **108** of FIG. **1**). Coupler **1002** may be the same as, similar to or different than coupler **402** of FIG. **4**. Coupler **1002** comprises a through-hole **1014** sized and shaped to receive the drive antenna. During use of the adapter structure, the drive antenna extends through the through-hole **1014** from a first side **1020** of the adapter structure to a second side **1022** of the adapter structure, as illustrated in FIG. **7B**.

[0062] At least one support member **1004**, **1006** is provided to attach the coupler **1002** to a horn structure **1008**. The coupler **1002** and support member(s) **1004**, **1006** are formed of insulative material(s). The horn structure **1008** is provided to collect radio waves and cause them to propagate similar to a beam.

[0063] The coupler **1002** and support member(s) **1004**, **1006** are formed of insulative material(s). In some scenarios, the support member(s) **1004**, **1006** and coupler **1002** are integrally formed as a single piece, for example, via an injection molding process. In other scenarios, the support members **1004**, **1006** and coupler **1002** are separate pieces that are joined, attached, adhered and/or affixed to each other. A weld or an adhesive may, for example, be used to facilitate the coupling of the support member(s) **1004**, **1006** and coupler **1002**.

[0064] The horn structure **1008** comprises a waveguide portion **1012** connected to a flared horn portion **1010**. Portions **1010**, **1012** are configured to direct radio waves in a beam. Portions **1010**, **1012** may be formed of a conductive material.

[0065] The dimensions of the horn opening **130**, the horn length **R** and the dimensions the waveguide portion **1012** are selected to provide a particular a radiation pattern when the adapter structure **1000** is used with an omni-directional antenna (e.g., antenna **108** of FIG. **1**). In some scenarios, the size and/or shape of the waveguide portion **1012** and/or horn portion **1010** are fixed, while in other scenarios one or both portions **1010**, **1012** may have a variable size and/or a variable shape. The horn structure **1008** may also be interchangeable with other different sized horn structures, and/or the waveguide portion **1012** may also be interchangeable with other different sized waveguide portions.

[0066] The distance **D10** between the coupler **1002** and a sidewall **1024** of the waveguide portion **1012** is selected in accordance with a given application. The distance **D10** can be smaller or larger than that shown in FIG. **10**. The distance **D10** may be fixed or alternatively adjustable.

[0067] In some adjustable scenarios, the distance **D10** can be changed by moving the support member(s) **1004**, **1006** in direction **1026** towards from sidewall **1024** of the waveguide portion **1012** and moving the support member(s) **1004**, **1006** in direction **1028** away from sidewall **1024** of the waveguide

portion **1012**. This movement can be facilitated by, for example, tracks (not visible in FIG. **10**) formed in sidewalls **1034**, **1036** of the waveguide portion **1012** and/or rollers (not visible in FIG. **10**) provided at distal ends **1040**, **1042** of the support member(s) **1004**, **1006**. Other techniques for allowing movement of the support member(s) **1004**, **1006** relative to the waveguide portion **1012** can be used here.

[0068] In those or other adjustable scenarios, the distance **D10** can be changed by expanding or collapsing the waveguide portion **1012**. The waveguide portion **1012** may, for example, be designed as a telescoping portion of the adapter structure **1000**. Alternatively, the waveguide portion **1012** is an interchangeable component that can be replaced with other waveguide portions having different sizes.

[0069] Referring now to FIG. **11**, there is provided a flow diagram of an illustrative method **1100** for operating an antenna system. Method **1100** begins with **1102** and continues to **1104** where an antenna (e.g., antenna **108** of FIG. **1**) operates as an omni-directional antenna to radiate equal radio power in all directions perpendicular to a center axis (e.g., center axis **110** of FIG. **1**) of the antenna. The antenna is converted into a directional antenna by coupling a directional adapter (e.g., directional adapter **200** of FIG. **2**) thereto, as shown by block **1106**. The directional antenna can include, but is not limited to, a yagi antenna, a parabolic antenna, a reflector antenna, a horn antenna, a corner reflector antenna, or a cavity antenna. In this regard, the directional adapter may comprise a reflector (e.g., reflector **414** of FIG. **4**, **608** of FIG. **6**, **708** of FIG. **7**, **808** of FIG. **8**, or **908** of FIG. **9**) that is offset a first distance (e.g., distance **D3** of FIG. **4**, **D6** of FIG. **6**, **D7** of FIG. **7**, **D8** of FIG. **8**, or **D9** of FIG. **9**) in a first direction (e.g., direction **454** of FIG. **4**, **612** of FIG. **6**, **712** of FIG. **7**, **812** of FIG. **8**, or **912** of FIG. **9**) from the antenna when the directional adapter is coupled thereto. The directional adapter may also comprise at least one director (e.g., director **410** of FIG. **4**) that is offset a second distance (e.g., distance **D2** of FIG. **4**) in an opposing second direction (e.g., direction **452** of FIG. **4**) from the antenna when the directional adapter is coupled thereto. The directional adapter may further comprise another director (e.g., director **412** of FIG. **4**) that is offset a third distance (e.g., distance **D** of FIG. **4B**) in the opposing second direction from the antenna when the directional adapter is coupled thereto. The third distance greater than the second distance.

[0070] The antenna is then used in **1108** to radiate greater radio wave power in a specific direction. Passive components of the directional adapter may optionally be changed and/or removed in the field as shown by blocks **1110-1116**. Blocks **1110-1116** involve: changing the radiation pattern of the directional antenna by adjusting a distance between the antenna and the reflector of the directional adapter and/or adjusting a distance between the antenna and director(s) of the directional adapter; selectively interchanging the reflector of the directional adapter with another reflector having a different size and/or shape and/or selectively interchanging the director(s) of the directional adapter with other director(s) having different size(s); and/or removing the director(s) from the directional adapter to, for example, convert the antenna from the directional antenna of a yagi type to another directional antenna of a reflector type. The antenna may then be used again in **1118** as a directional antenna with another radiation pattern.

[0071] Thereafter, the antenna may be converted back into the omni-directional antenna in block 1120 by decoupling the directional adapter therefrom. Subsequently, method 1100 continues with block 1122 where its ends or other operations are performed (e.g., return to 1104).

[0072] In view of the forgoing, the present solution concerns an antenna system. The antenna system comprises: an omni-directional antenna element (e.g., antenna 108 of FIG. 1); and a directional adapter (e.g., directional adapter 200 of FIG. 2) having an electromagnetic reflector. The directional adapter is detachably coupled to the omni-directional antenna element. The electromagnetic reflector is offset from the omni-directional antenna element. The directional adapter has a director offset from the omni-directional antenna element and on the opposite side of the electromagnetic reflector. The directional adapter has a structural element disposed between the reflector and the omni-directional antenna element. The structural element is generally electromagnetically nonconductive. The directional adapter is detachably coupled indirectly to the omni-directional antenna element.

[0073] The present solution also concerns an antenna adapter (e.g., directional adapter 200 of FIG. 2) comprises a mechanical coupler (e.g., coupler 402 of FIG. 4) attachable to an antenna (e.g., antenna 108 of FIG. 1 and an electromagnetic reflector (e.g., reflector 414 of FIG. 4) offset from the mechanical coupler. The antenna adapter is configured to be coupled to the antenna to convert a radiation pattern from an omni-directional antenna radiation pattern (e.g., radiation pattern 300 of FIG. 3) to a directional antenna radiation pattern (e.g., radiation pattern 302 of FIG. 3), and configured to be decoupled from the antenna to convert the radiation pattern back into the omni-directional antenna radiation pattern. The antenna can include, but is not limited to, an omni-directional wideband antenna.

[0074] The antenna adapter may be configured to convert the antenna into one or more of a yagi antenna, a parabolic antenna, a reflector antenna, a horn antenna, a corner reflector antenna, and/or a cavity antenna. In this regard, the antenna adapter comprises a reflector (e.g., reflector 414 of FIG. 4, 608 of FIG. 6, 708 of FIG. 7, 808 of FIG. 8, or 908 of FIG. 9) that is offset a first distance (e.g., distance D3 of FIG. 4, D6 of FIG. 6, D7 of FIG. 7, D8 of FIG. 8, or D9 of FIG. 9) in a first direction (e.g., direction 454 of FIG. 4, 612 of FIG. 6, 712 of FIG. 7, 812 of FIG. 8, or 912 of FIG. 9) from the antenna when the antenna adapter is coupled thereto. The reflector may optionally be configured to be interchanged with another reflector having a different size and/or shape. The antenna adapter may additionally comprise at least one director (e.g., director 410 of FIG. 4) that is offset a second distance (e.g., distance D2 of FIG. 4) in an opposing second direction (e.g., direction 452 of FIG. 4) from the antenna when the antenna adapter is coupled thereto. The director(s) may be configured to be removed from the antenna adapter to, for example, (i) convert the antenna from the directional antenna of a yagi type to another directional antenna of a reflector type and/or (ii) be interchanged with another director having different size(s). The antenna adapter may further comprises another director (e.g., direction 412 of FIG. 4) that is offset a third distance (e.g., distance D of FIG. 4B) in the opposing second direction from the antenna when the antenna adapter is coupled thereto. The third distance may be greater than the second distance.

[0075] In some scenarios, the directional antenna radiation pattern is changeable by adjusting a distance between the antenna and a reflector of the antenna adapter and/or adjusting a distance between the antenna and at least one director of the antenna adapter. Additionally or alternatively, the antenna adapter comprises an aperture (e.g., aperture 1014 of FIG. 10) extending therethrough that is sized and shaped to slidably receive the antenna. The aperture may also be configured to maintain the adapter structure (e.g., adapter structure 1000) at a particular position relative to the antenna throughout use of the antenna system.

[0076] The present solution also concerns implementing systems and methods for operating an antenna. The methods comprise: using the antenna as an omni-directional antenna to radiate equal radio power in all directions perpendicular to a center axis of the antenna; converting the antenna into a directional antenna by coupling a directional adapter thereto; using the antenna, with the directional adapter coupled thereto, to radiate greater radio wave power in a specific direction; and converting the antenna back into the omni-directional antenna by decoupling the directional adapter therefrom.

[0077] The antenna adapter may be configured to convert the antenna into one or more of a yagi antenna, a parabolic antenna, a reflector antenna, a horn antenna, a corner reflector antenna, and a cavity antenna. The antenna adapter may comprise: a reflector that is offset a first distance in a first direction from the antenna when the antenna adapter is coupled thereto; at least one director that is offset a second distance in an opposing second direction from the antenna when the directional antenna adapter is coupled thereto; and/or another director that is offset a third distance in the opposing second direction from the antenna when the antenna adapter is coupled thereto, the third distance greater than the second distance.

We claim:

1. An antenna system, comprising:
an omni-directional antenna element; and
a directional adapter having an electromagnetic reflector, the directional adapter detachably coupled to the omni-directional antenna element, the electromagnetic reflector offset from the omni-directional antenna element.
2. The antenna system of claim 1, wherein the directional adapter has a director offset from the omni-directional antenna element and on the opposite side of the electromagnetic reflector.
3. The antenna system of claim 1, wherein the directional adapter has a structural element disposed between the reflector and the omni-directional antenna element.
4. The antenna system of claim 3, wherein the structural element is generally electromagnetically nonconductive.
5. The antenna system of claim 1, wherein the directional adapter is detachably coupled indirectly to the omni-directional antenna element.
6. An antenna adapter, comprising:
a mechanical coupler attachable to an antenna; and
an electromagnetic reflector offset from the coupler;
wherein the antenna adapter is configured to be coupled to the antenna to convert a radiation pattern from an omni-directional antenna radiation pattern to a directional antenna radiation pattern, and configured to be

decoupled from the antenna to convert the radiation pattern back into the omni-directional antenna radiation pattern.

7. The antenna adapter according to claim 6, wherein the antenna adapter is further configured to convert the antenna into one or more of a yagi antenna, a parabolic antenna, a reflector antenna, a horn antenna, a corner reflector antenna, and a cavity antenna.

8. The antenna adapter according to claim 6, wherein the antenna adapter comprises a reflector that is offset a first distance in a first direction from the antenna when the antenna adapter is coupled thereto.

9. The antenna adapter according to claim 8, wherein the electromagnetic reflector is configured to be interchanged with another electromagnetic reflector having a different size and/or shape.

10. The antenna adapter according to claim 8, wherein the antenna adapter further comprises at least one director that is offset a second distance in an opposing second direction from the antenna when the antenna adapter is coupled thereto.

11. The antenna adapter according to claim 10, wherein the at least one director is configured to be removed from the antenna adapter to further convert the antenna from the directional antenna of a yagi type to another directional antenna of a reflector type.

12. The antenna adapter according to claim 10, wherein the at least one director is configured to be interchanged with another director having a different size.

13. The antenna adapter according to claim 10, wherein the antenna adapter further comprises another director that is offset a third distance in the opposing second direction from the antenna when the antenna adapter is coupled thereto, the third distance greater than the second distance.

14. The antenna adapter according to claim 6, wherein the directional antenna radiation pattern is changeable by adjusting a distance between the antenna and the electromagnetic

reflector of the antenna adapter and/or adjusting a distance between the antenna and at least one director of the antenna adapter.

15. The antenna adapter according to claim 6, wherein the antenna adapter comprises an aperture extending there-through that is sized and shaped to slidably receive the antenna.

16. A method for operating an antenna, comprising:

using the antenna as an omni-directional antenna to radiate equal radio power in all directions perpendicular to a center axis of the antenna;

converting the antenna into a directional antenna by coupling a directional adapter thereto;

using the antenna, with the directional adapter coupled thereto, to radiate greater radio wave power in a specific direction; and

converting the antenna back into the omni-directional antenna by decoupling the directional adapter therefrom.

17. The method according to claim 16, wherein the directional adapter is configured to convert the antenna into one or more of a yagi antenna, a parabolic antenna, a reflector antenna, a horn antenna, a corner reflector antenna, and a cavity antenna.

18. The method according to claim 16, wherein the directional adapter comprises a reflector that is offset a first distance in a first direction from the antenna when the directional adapter is coupled thereto.

19. The method according to claim 18, further comprising selectively interchanging the reflector of the directional adapter with another reflector having a different size and/or shape.

20. The method according to claim 19, wherein the directional adapter further comprises at least one director that is offset a second distance in an opposing second direction from the antenna when the directional adapter is coupled thereto.

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