US 20250260161A1

(19) United States
(12) Patent Application Publication
Buduson et al.
(10) Pub. No.: US 2025/0260161 A1
(43) Pub. Date: Aug. 14, 2025

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

(71) Applicant: **L3Harris Global Communications, Inc.**, Melbourne, FL (US)

(72) Inventors: **James Buduson**, North Chili, NY (US); **Peter Burke**, Hilton, NY (US); **Barrett Bartell**, Mendon, NY (US)

(21) Appl. No.: **18/436,622**

(22) Filed: **Feb. 8, 2024**

Publication Classification

(51) **Int. Cl.**

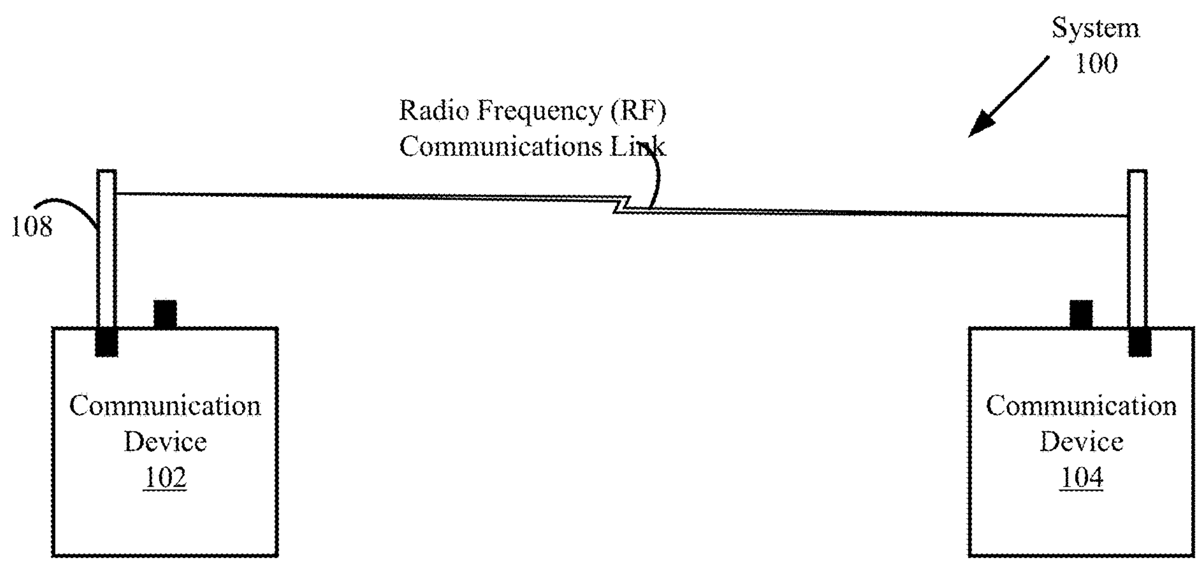
H01Q 3/16	(2006.01)
H01Q 13/18	(2006.01)
H01Q 15/16	(2006.01)
H01Q 19/04	(2006.01)
H01Q 19/10	(2006.01)

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

CPC ***H01Q 3/16*** (2013.01); ***H01Q 13/18*** (2013.01); ***H01Q 15/16*** (2013.01); ***H01Q 19/04*** (2013.01); ***H01Q 19/106*** (2013.01)

(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.



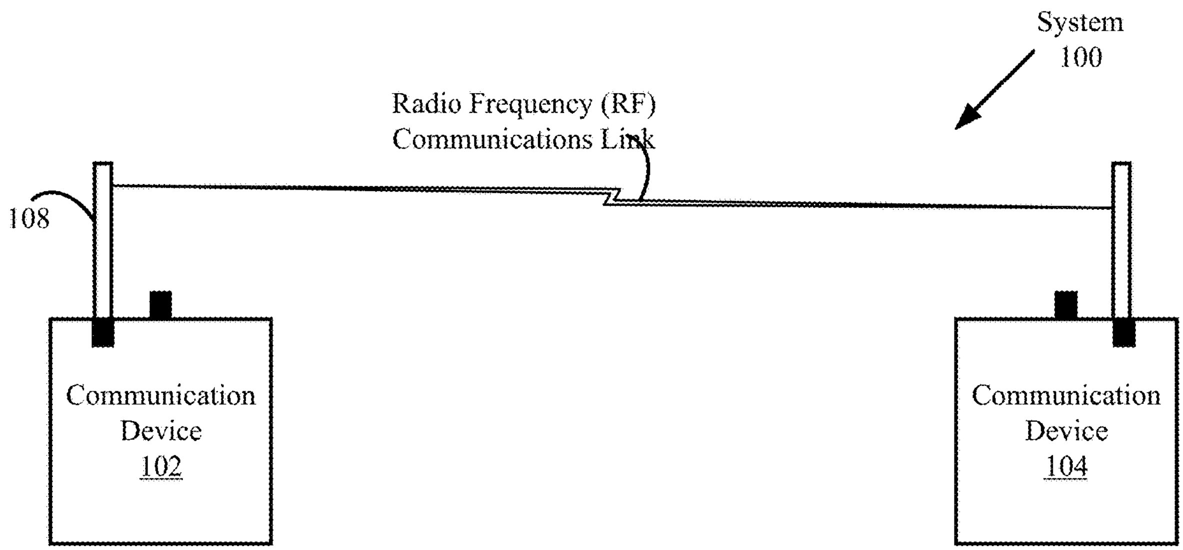

System
100
Radio Frequency (RF)
Communications Link
108
Communication
Device
102
Communication
Device
104

FIG. 1

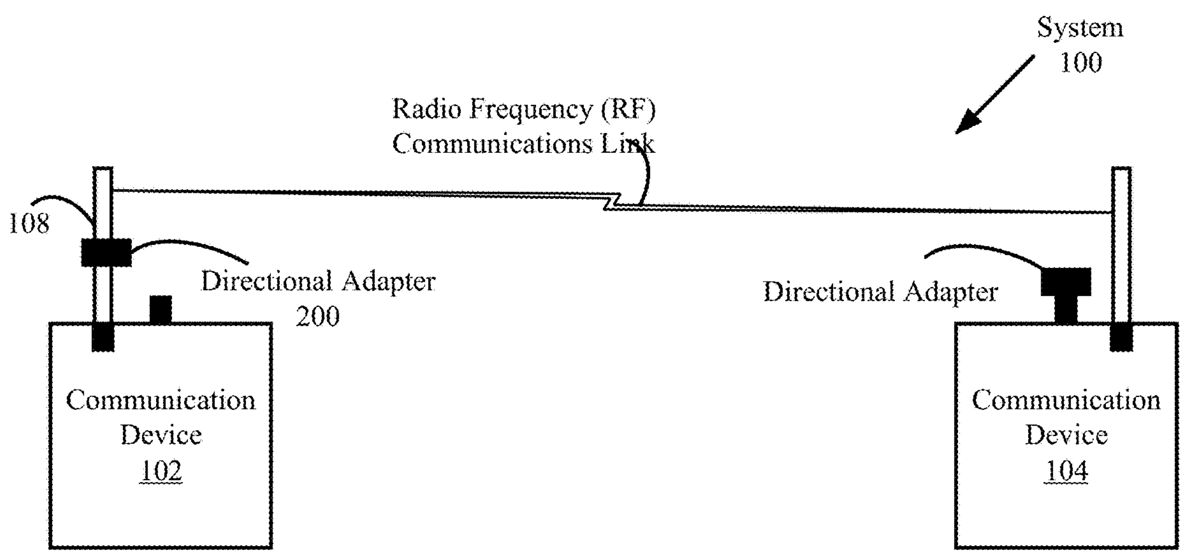

System
100
Radio Frequency (RF)
Communications Link
108
Directional Adapter
200
Directional Adapter
Communication
Device
102
Communication
Device
104

FIG. 2

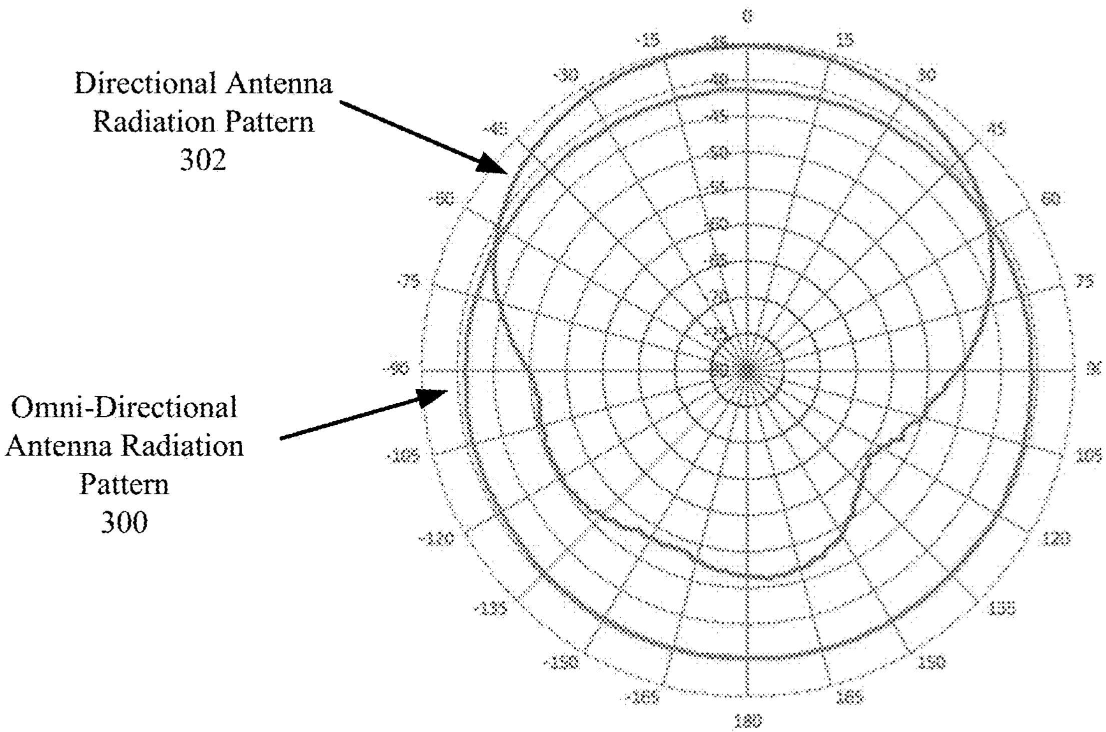

Directional Antenna Radiation Pattern 302
Omni-Directional Antenna Radiation Pattern 300
0
-15
15
-30
30
-45
45
-60
60
-75
75
-90
90
-105
105
-120
120
-135
135
-150
150
-165
165
180

FIG. 3

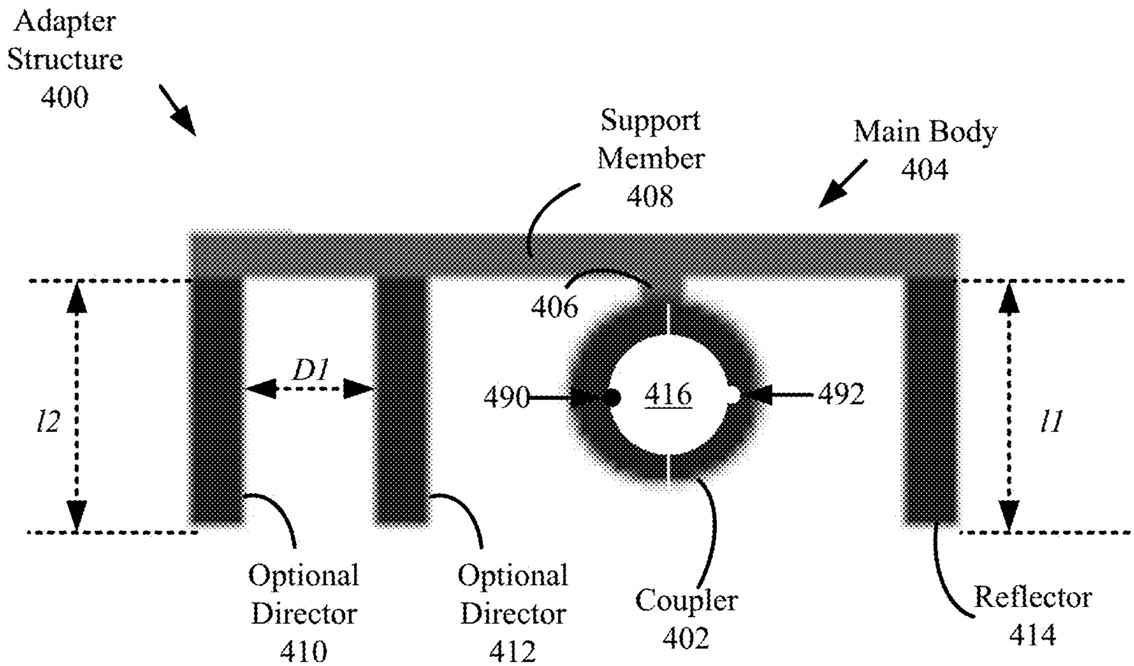

Adapter
Structure
400
Support
Member
408
Main Body
404
406
D1
490
416
492
l2
l1
Optional
Director
410
Optional
Director
412
Coupler
402
Reflector
414

FIG. 4A

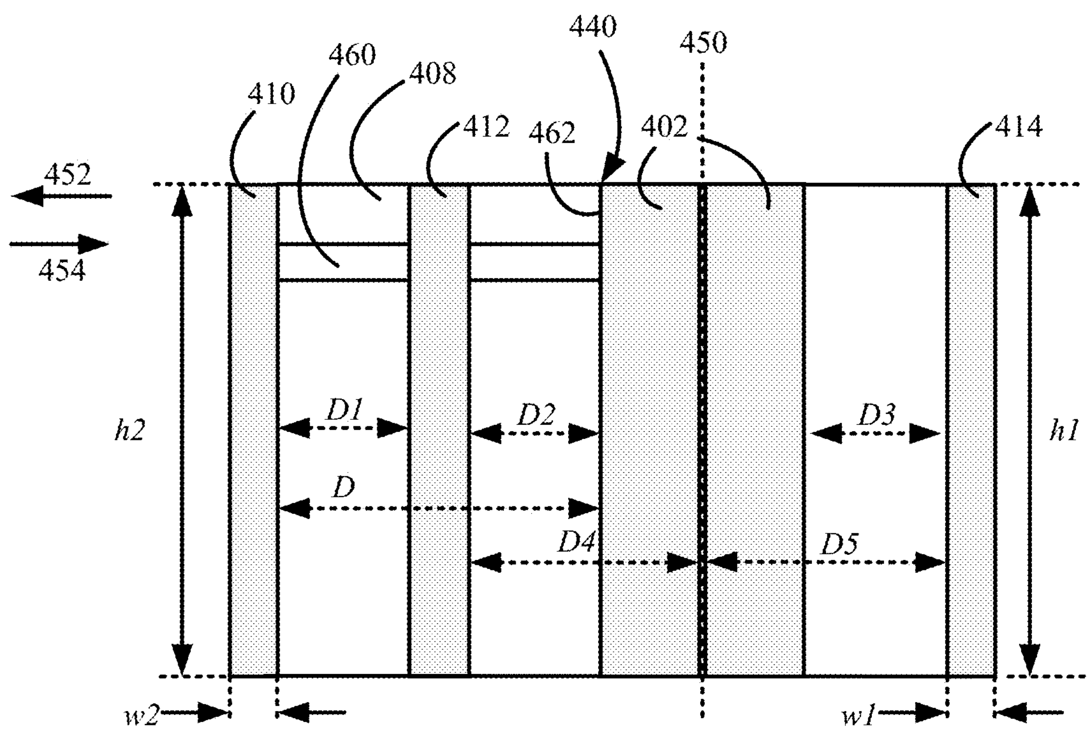

440
450
460
408
410
412
462
402
414
452
454
h2
h1
D1
D2
D3
D
D4
D5
w2
w1

FIG. 4B

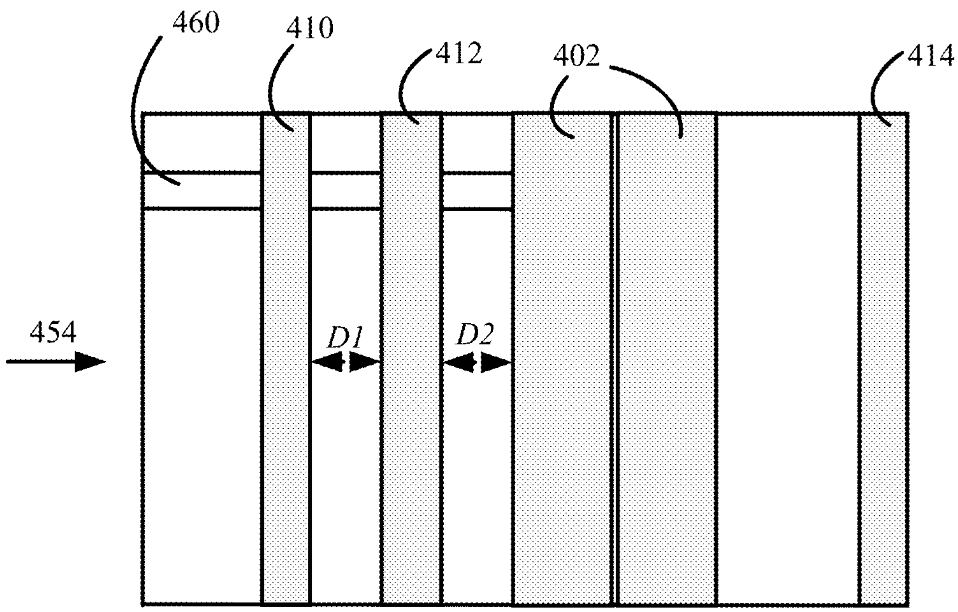


FIG. 4C

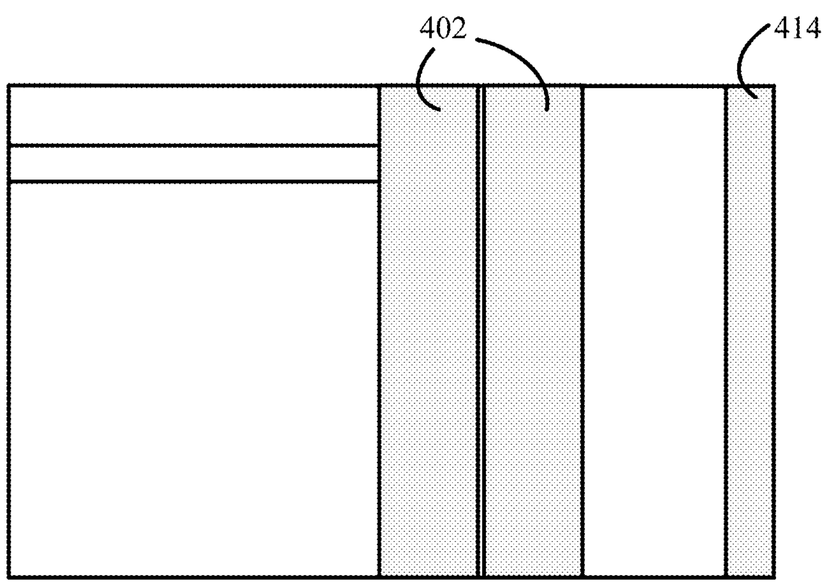


FIG. 4D

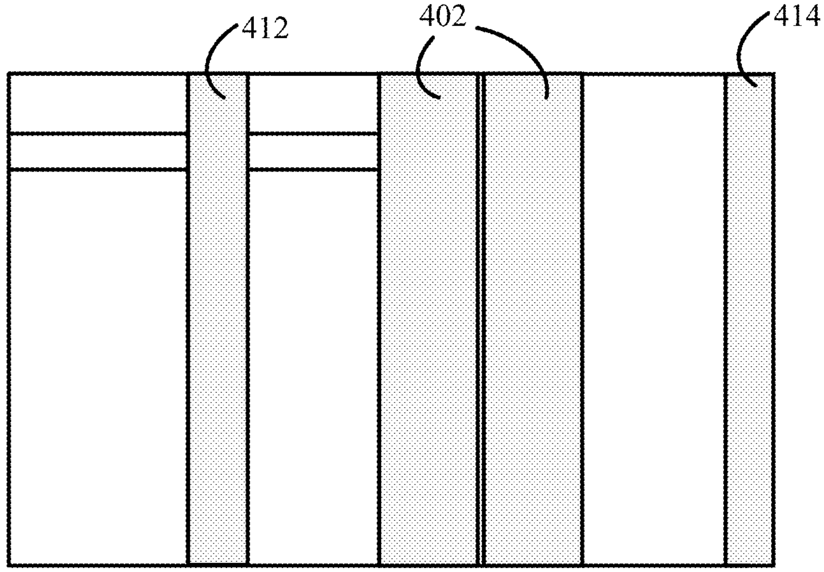


FIG. 4E

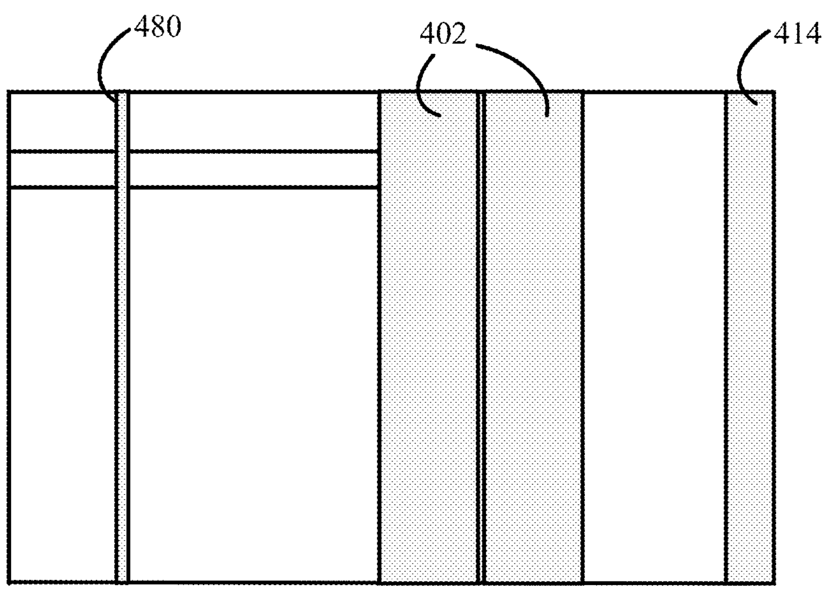


FIG. 4F

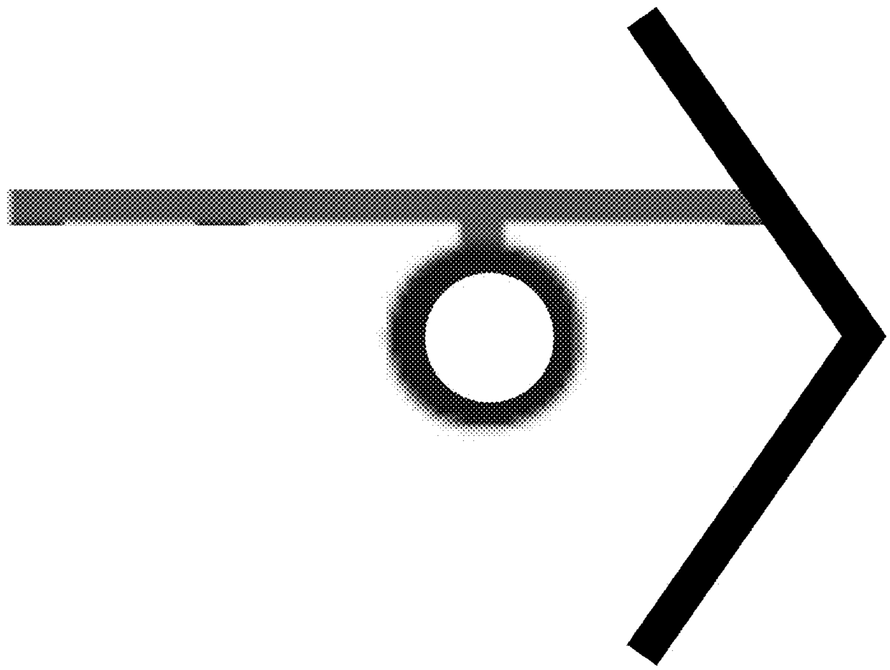


FIG. 4G

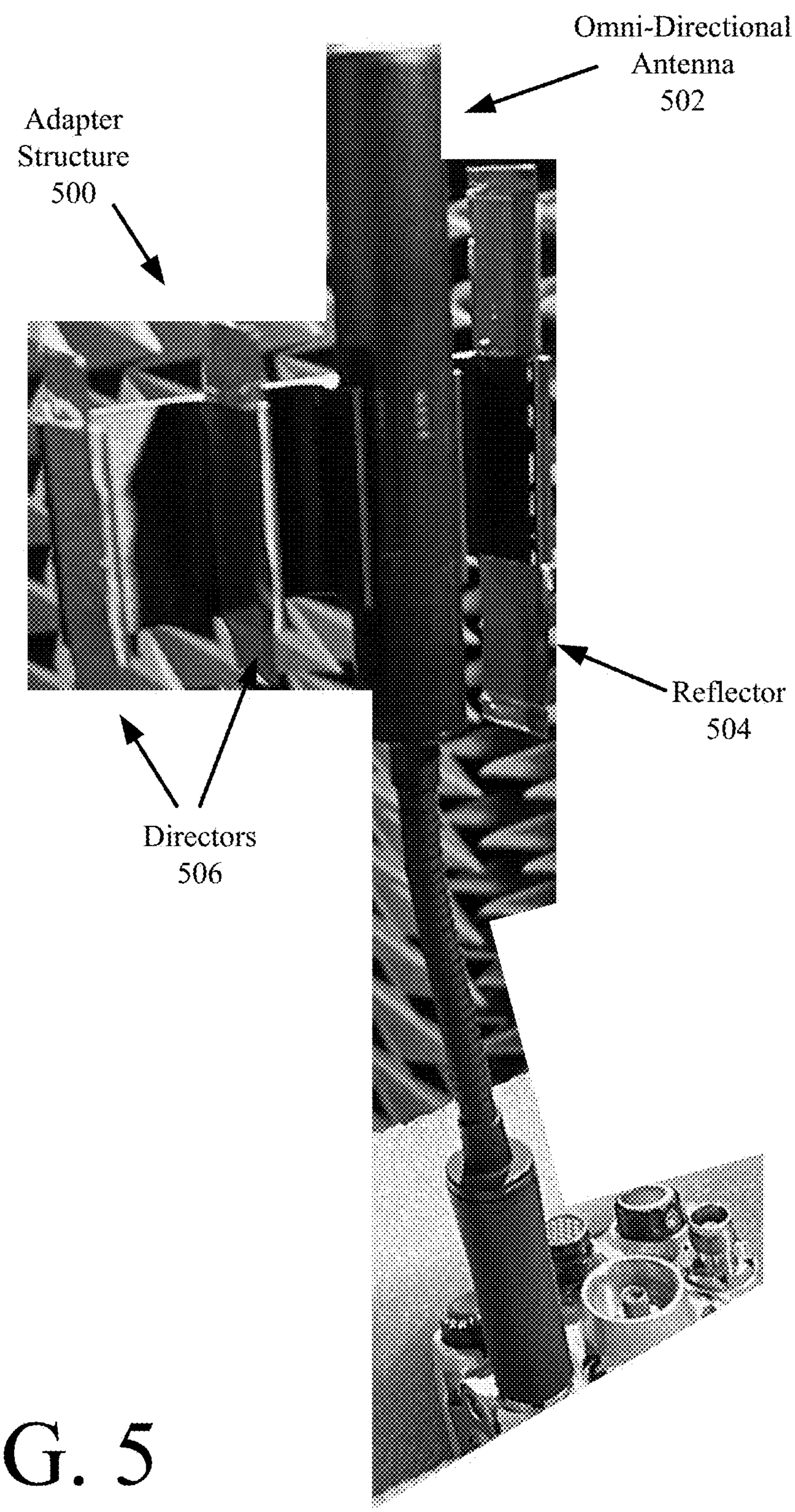

Omni-Directional
Antenna
502
Adapter
Structure
500
Reflector
504
Directors
506

FIG. 5

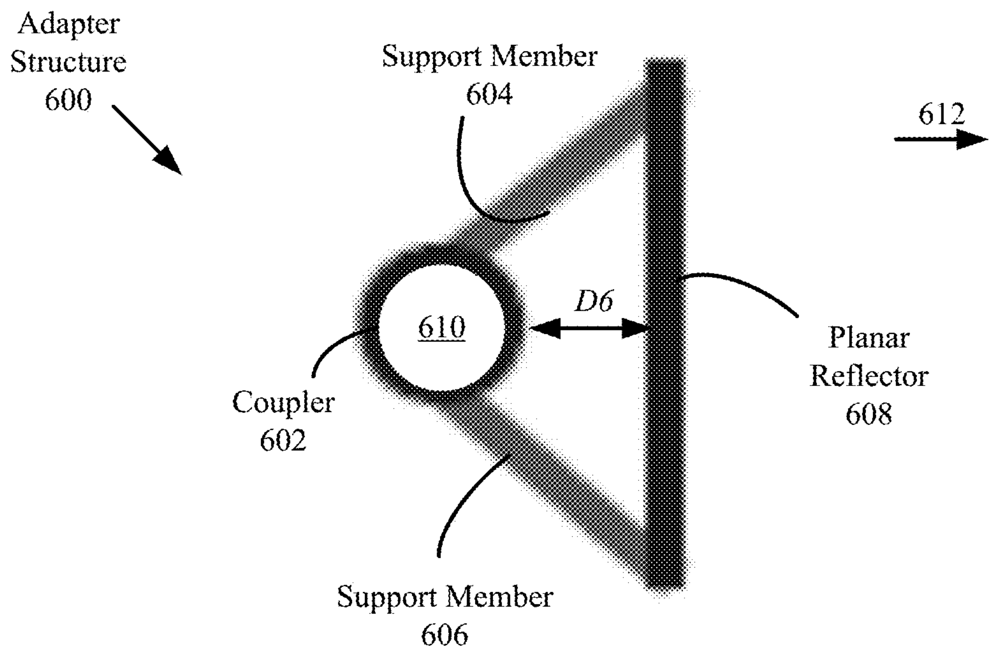

Adapter Structure 600
Support Member 604
612
D6
610
Planar Reflector 608
Coupler 602
Support Member 606

FIG. 6A

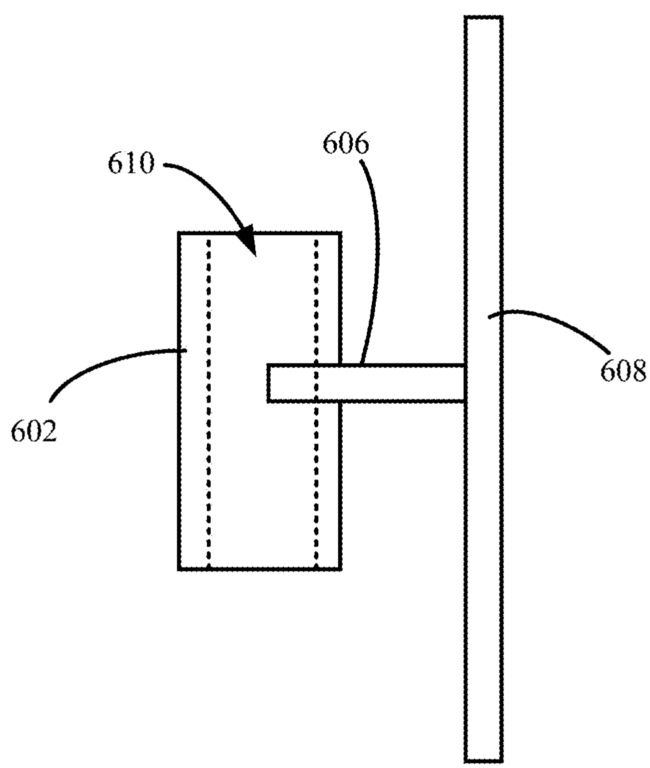
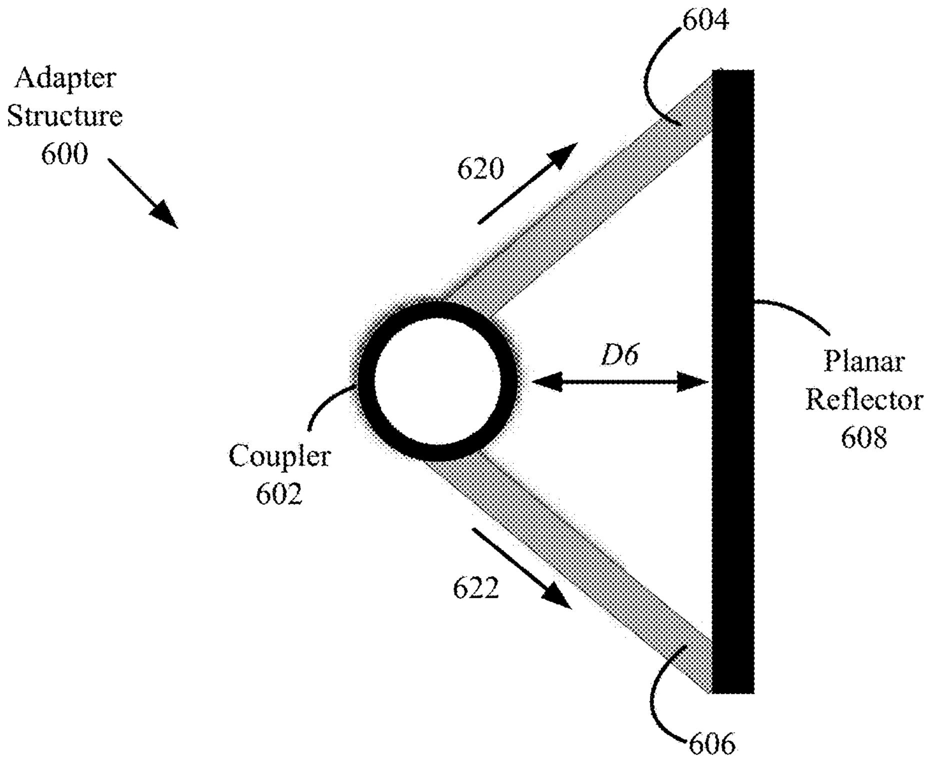
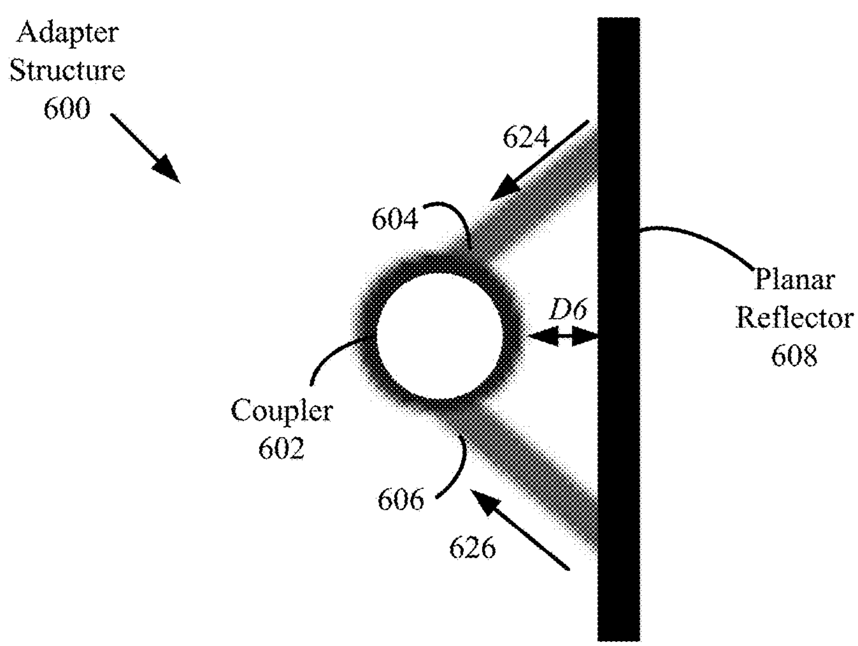

610
606
608
602

FIG. 6B



604
Adapter
Structure
600
620
D6
Planar
Reflector
608
Coupler
602
622
606

FIG. 6C



Adapter
Structure
600
624
604
Planar
Reflector
608
D6
Coupler
602
606
626

FIG. 6D

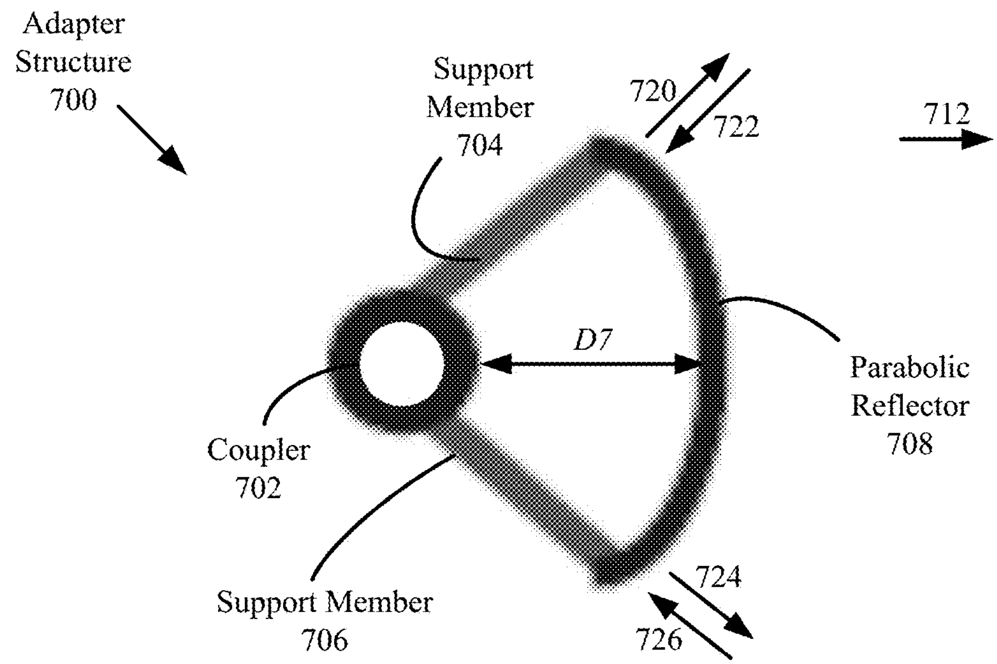

Adapter
Structure
700
Support
Member
704
720
722
712
D7
Parabolic
Reflector
708
Coupler
702
Support Member
706
724
726

FIG. 7A

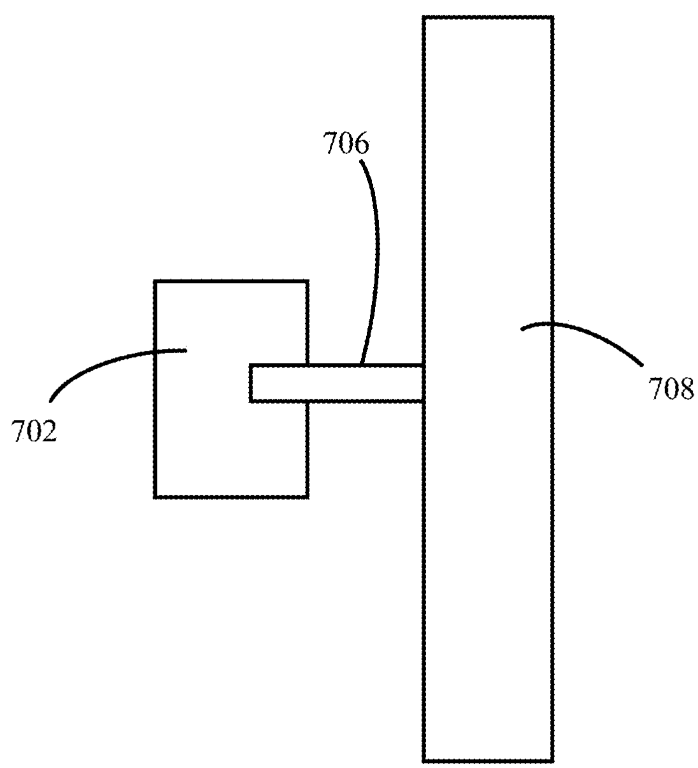

706
702
708

FIG. 7B

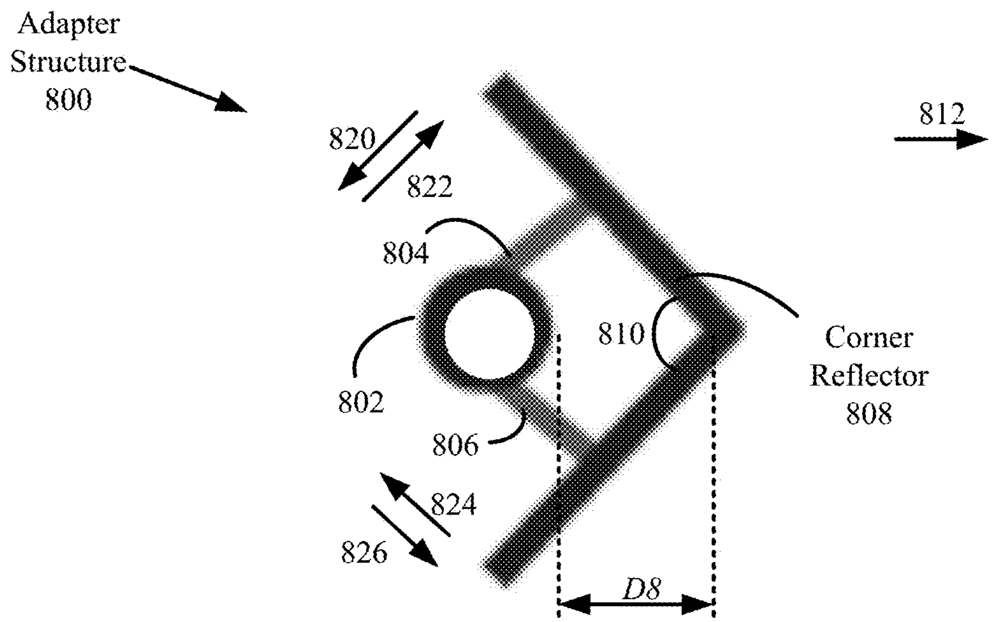

Adapter Structure 800
820
822
804
802
806
824
826
810
D8
Corner Reflector 808
812

FIG. 8A

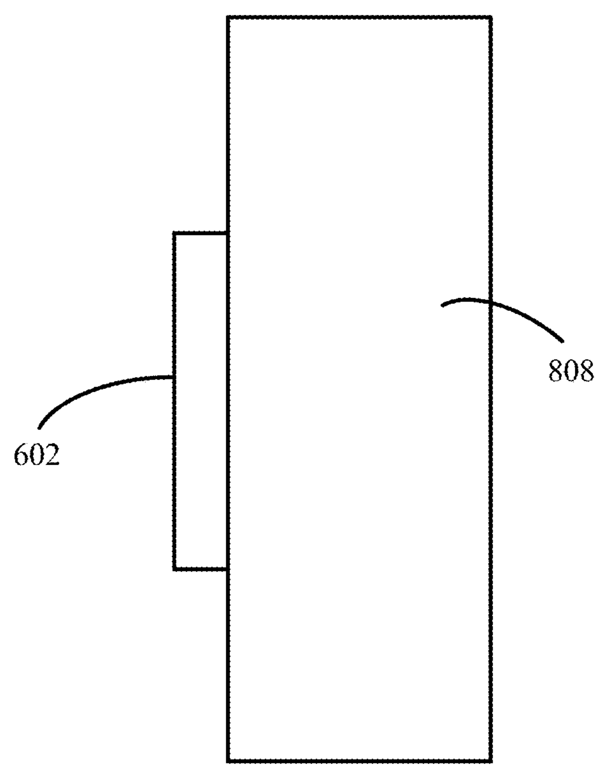

602
808

FIG. 8B

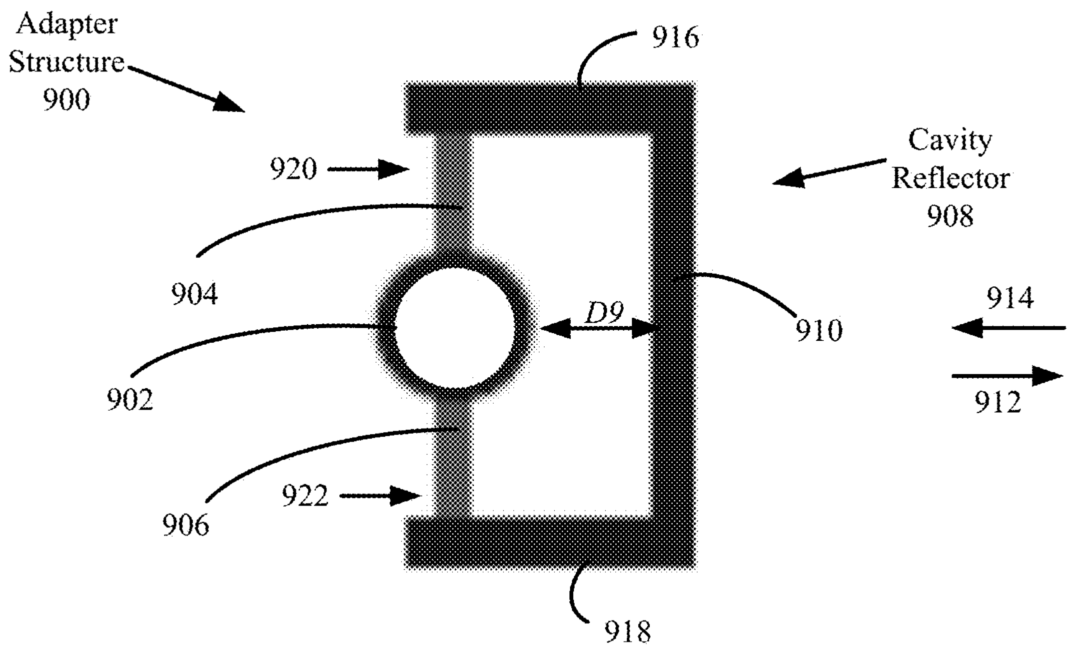

Adapter
Structure
900
916
920
Cavity
Reflector
908
904
D9
914
910
902
912
906
922
918

FIG. 9A

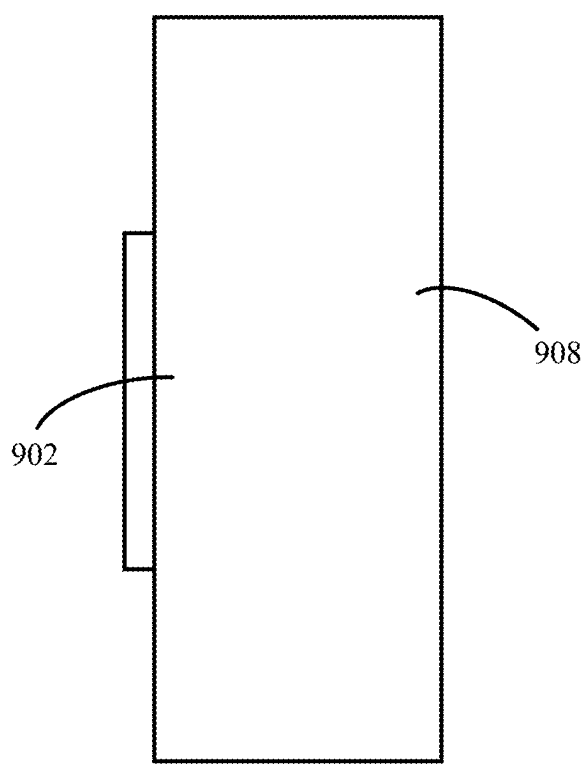

908
902

FIG. 9B

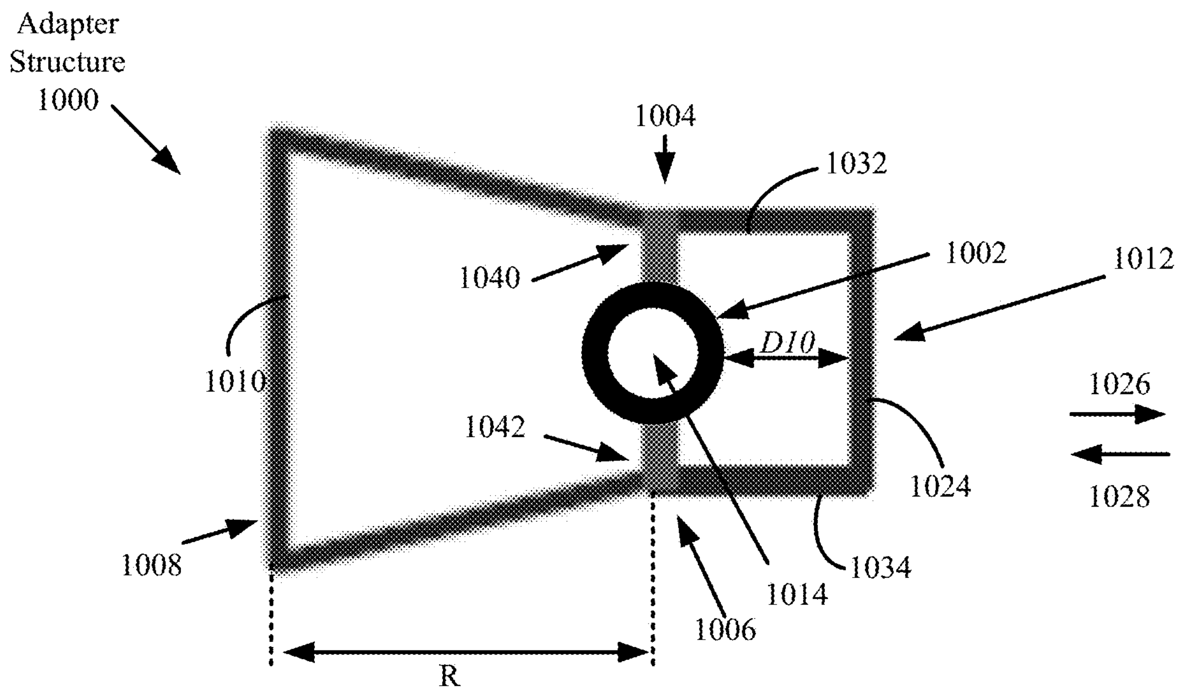

Adapter Structure 1000
1004
1032
1002
1012
1040
D10
1010
1026
1042
1028
1024
1008
1034
1014
1006
R

FIG. 7A

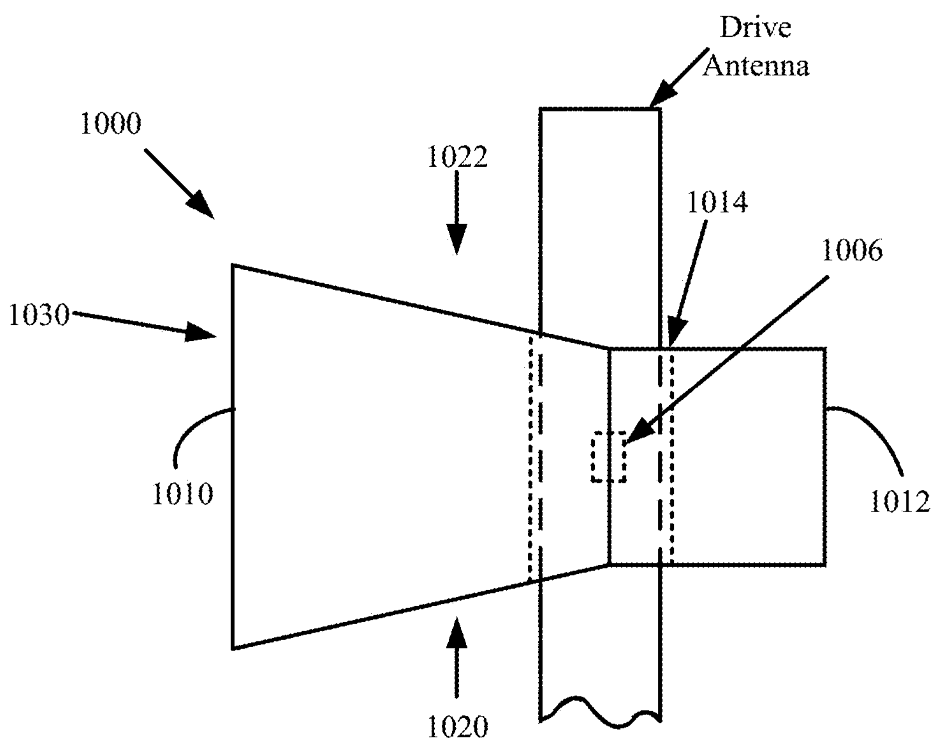

Drive Antenna
1000
1022
1014
1006
1030
1010
1012
1020

FIG. 7B

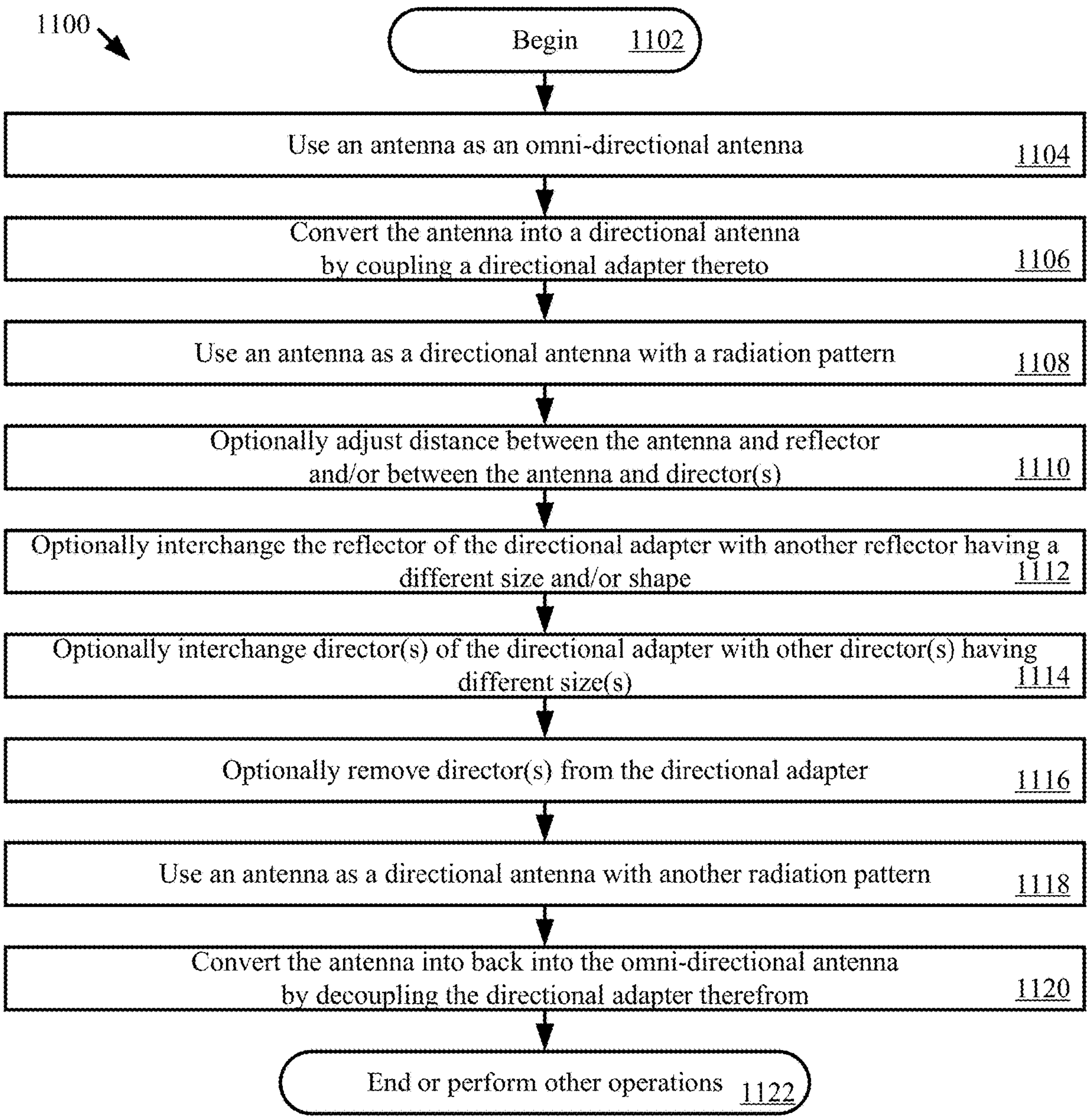

1100
Begin 1102
Use an antenna as an omni-directional antenna 1104
Convert the antenna into a directional antenna by coupling a directional adapter thereto 1106
Use an antenna as a directional antenna with a radiation pattern 1108
Optionally adjust distance between the antenna and reflector and/or between the antenna and director(s) 1110
Optionally interchange the reflector of the directional adapter with another reflector having a different size and/or shape 1112
Optionally interchange director(s) of the directional adapter with other director(s) having different size(s) 1114
Optionally remove director(s) from the directional adapter 1116
Use an antenna as a directional antenna with another radiation pattern 1118
Convert the antenna into back into the omni-directional antenna by decoupling the directional adapter therefrom 1120
End or perform other operations 1122

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. **4**A-**4**G (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. **6**A-**6**B (collectively referred to herein as "FIG. **6**") provide illustrations showing another adapter structure.

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

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

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

[0014] FIGS. **10**A-**10**B (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. **4**A, and a front view of the adapter structure **400** is provided in FIG. **4**B.

[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 formed of an insulating material which is the same or different than the insulting 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. **4**D. An illustration showing the adapter structure with one director is provided in FIG. **4**E. An illustration showing the adapter structure with two adapters is provided in FIGS. **4**A-**4**B. 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. **4**C 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** inter changed with a corner reflector is provided in FIG. **4**G.

[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. **4**F.

[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 adaptor 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. **6**A, and a front view of the adapter structure **600** is provided in FIG. **6**B.

[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 D**6** between the coupler **602** and the reflector **608**.

[0036] Distance D**6** is selected based on the frequency in which the directional adapter is to operate. The distance D**6** can be smaller or larger than that shown in FIG. **6**. Nominally the distance D**6** may be equal to or substantially similar to ¼λ. The distance D**6** may be fixed or alternatively adjustable. In the adjustable scenario, the distance D**6** 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. **6**C. In this case, the size of the planar reflector **608** may be changed as also shown in FIG. **6**C. 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. **6**D. 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. **7**A, and a front view of the adapter structure **700** is provided in FIG. **7**B.

[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 ¼λ. 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. **8**A, and a front view of the adapter structure **800** is provided in FIG. **8**B. 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 D**8** between the coupler **802** and the corner reflector **808**.

[0051] The distance D**8** 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 D**8** can be smaller or larger than that shown in FIG. **8**. Nominally the distance D**8** is equal to or substantially similar to ¼λ. The distance D**8** may be fixed or alternatively adjustable. In the adjustable scenario, the distance D**8** 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. **9**A, and a front view of the adapter structure **900** is provided in FIG. **9**B. 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 D**9** between the coupler **902** and sidewall **910** of the cavity reflector **908**.

[0059] The distance D**9** 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 D**9** can be smaller or larger than that shown in FIG. **9**. The distance D**9** may be fixed or alternatively adjustable. In the adjustable scenario, the distance D**9** 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. **10**A, and a front view of the adapter structure **1000** is provided in FIG. **10**B. 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. **7**B.

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

[0067] In some adjustable scenarios, the distance D**10** 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 D**10** 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 D**3** of FIG. **4**, D**6** of FIG. **6**, D**7** of FIG. **7**, D**8** of FIG. **8**, or D**9** 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 D**2** 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. **4**B) 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 D**3** of FIG. **4**, D**6** of FIG. **6**, D**7** of FIG. **7**, D**8** of FIG. **8**, or D**9** 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 comprises at least one director (e.g., director **410** of FIG. **4**) that is offset a second distance (e.g., distance D**2** 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. **4**B) 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 slidingly 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 therethrough that is sized and shaped to slidingly 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.

* * * * *