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(56) Related Art

EP1012624 B1 (THALES NEDERLAND B.V.) 28 June 2000

US3858208 A (PARKE et al) 31 December 1974

US6043770 A (GARCIA et al) 28 March 2000

US 3587054 A (BYRNE et al) 22 June 1971

EP0954056 B1 (THALES NEDERLAND B.V.) 3 November 1999

EP0440200 B1 (MITSUBISHI DENKI KABUSHIKI) 7 August 1991

EP0972316 B1 (THALES NEDERLAND B.V.) 19 January 2000

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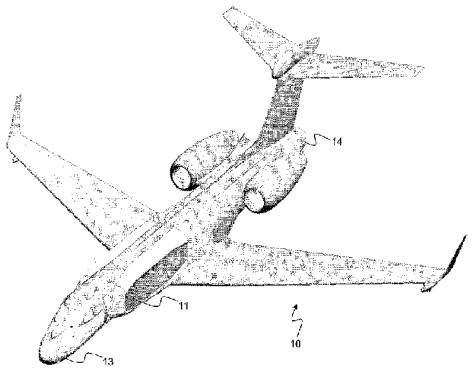
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(54) Title: PHASED ARRAY RADAR ANTENNA HAVING REDUCED SEARCH TIME AND METHOD FOR USE THEREOF



(57) Abstract: A phased array radar antenna includes at least two antennas (11, 12, 13, 14) adapted for simultaneous operation at different non-mutually interfering frequencies. The phased array radar antenna may be fitted to an aircraft having a fuselage supporting first and second radar side antennas (11, 12) on opposite sides thereof, a nose portion supporting a first radar end antenna (13), and a tail portion supporting a second radar end antenna (14). Respective radomes cover the first and second radar end antennas so as to provide a smooth aerodynamic contour, and a radar control unit (15) is disposed within the fuselage and coupled to the first and second radar side antennas and to the first and second radar end antennas for operating the first or second radar side antenna simultaneously with the first or second radar end antenna at respective first and second different frequencies.

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Phased array radar antenna having reduced search time and method for use thereof

FIELD OF THE INVENTION

This invention relates to phased array radar antennas, particularly for airborne radar.

BACKGROUND OF THE INVENTION

Phased array antennas are well known in the art provide for wide bandwidth, low power losses, and have the capability of radiating at multiple frequencies in a given beam direction. The use of the invention is thus not intended to be restricted to any particular type of aircraft. Thus regardless of the size or type of aircraft, some kind of radar system is required. Long range radar with 360°-coverage requires a large antenna mounted above the aircraft fuselage, to minimize airframe interference, and requires high power to give the required long-range detection. These two requirements have so far been to a certain extent mutually incompatible since a large antenna mounted above the aircraft fuselage causes substantial drag and coupled with the high power requirements of the long-range radar only a large aircraft could be used.

US Patent No. 5,097,267 (Raviv) published March 17, 1992, assigned to the present applicant and entitled "*Airborne early warning radar system*" discloses an airborne early warning radar system comprising an automatically controlled pilotless aircraft, a phased array radar antenna disposed in the pilotless aircraft and apparatus for selectably varying the orientation of the phased array radar antenna relative to the aircraft.

All known AEW (Airborne Early Warning) systems, including AWACS, ERIEYE, CONDOR and WEDGETAIL have been based on the traditional architecture of a single-band radar. AWACS employs a mechanically rotating antenna, while the other systems employ an electronically scanned fixed array antenna of the kind described in above-mentioned US Patent No. 5,097,267.

In the mechanically rotating system, the time required to achieve a full 360° scan is dependent on the time taken to steer the mechanical antenna through a complete 360° revolution. Although the steering of a phased array radar antenna is electronic, a complete electronic scan is nevertheless required to achieve full 360° coverage. Once the radar has tracked a point in space, the same point will not be "visible" to the radar during the current cycle. This means that the longer it takes for a complete scan, the easier it is for a foe to penetrate the radar, since it has more time to intercept and having done so, the more time will elapse until it becomes visible to the radar during a subsequent scan. Consequently, it is desirable to reduce the time for a complete 360° scan.

US Patent No. 4,870,426 (Lamberty *et. al.*) published September 26, 1989 and entitled "*Dual band antenna element*" discloses a radar antenna element comprising a lower band waveguide and an array of parallel, dual-polarized, higher band waveguides and dipoles mounted within or directly adjacent an aperture of the lower band waveguide. The lower band waveguide and each higher band waveguide have one cross-sectional dimension less than 0.5 wavelength.

US Patent No. 4,743,907 (Gellekink) published May 10, 1988 and entitled "*Radar system operating in two frequency bands*" discloses a radar system for low-level target tracking comprises a first and a second radar apparatus, both operating at their own frequency, but employing one and the same tracking antenna.

US Patent No. 4,276,551 (Williams *et. al.*) published June 30, 1981 and entitled "*Electronically scanned antenna*" discloses electronically scanned antennas comprising a plurality of frequency scanned antenna sections each of which have a plurality of radiating elements and a plurality of phase shifters individually coupled to the antenna sections. Such an arrangement uses dual frequency for steering the radar beam but does not employ different scan frequencies.

EP 1 505 407 (Hermann et al.) discloses a radar whose functions are divided between two or more structurally-integrated radar subsystems. The first is designed as a panoramic radar, for target acquisition and tracking. The second (ULI) is designed for one or more of the following: subsequent steering of guided missiles, target illumination to assist homing of guided missiles, and supplementary radar.

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EP 0 440 200 (Yanagisawa) discloses a method of managing beams transmitted and received by a plurality of phased array antennas. In a search mode, the phased array antennas transmit searching pulses synchronously in a search mode. In a tracking mode, targets tracked by the phased array antennas are divided to a plurality of groups on the basis of pulse repetition rate. Then, for the respective divided groups, transmission timings of tracking pulses to be sent from the phased array antennas are calculated by using ranges of the targets belonging to the respective groups so that transmission and reception operations do not occur simultaneously, thereby enabling the simultaneous usage of the phased array antennas.

EP 1 012 624 (Thomassen) discloses a method for scheduling radar transmissions for a phased array antenna system having at least two antenna faces, in which each respective antenna face is configured to receive echoes of possible targets corresponding to previous radar transmissions by the respective antenna face. The method includes determining, based on a list of requested radar transmissions, a scheduling process including starting times of radar transmissions for each of the antenna faces for substantially each radar transmission included in the list of requested radar transmissions. Further, the scheduling process is arranged such that the antenna faces are used substantially simultaneously, transmission by an antenna face is prevented when another antenna face is about to receive echoes corresponding to possible targets, and radar transmissions for each antenna face end at substantially the same time. In addition, radar transmissions for the antenna faces are substantially mutually synchronized.

EP 0 972 316 (Thomassen) discloses an arrangement for controlling radar transmissions for a system of antennas disposed on a moving platform. The radar transmissions are allocated to an antenna face for a future transmission. To effect an adequate allocation, a prediction arrangement is provided to predict the angular position of the moving platform and the antenna faces. Preferably an antenna is assigned that realizes the smallest off-broadside angle of the radar transmission.

US 3,587,054 (Byrne *et al.*) discloses a computer-controlled phased-array radar system whose strategy for scheduling operations for performance utilizes two priority hierarchies. Each operation is represented by a format that includes a desired high rate of performance parameter and a lower acceptable rate of performance parameter. With a

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light load, operations are scheduled for performance at their respective desired rates on the basis of a low order priority hierarchy. As the load increases, operations not being scheduled at their desired rates are scheduled at the lower acceptable rates on the basis of a higher priority hierarchy.

US 3,858,206 (Scheidler *et al.*) discloses an airborne radar system utilizing multiple fixed antenna arrays mounted within the periphery of an aircraft to avoid aerodynamic modifications and placed to achieve 360° surveillance coverage. The arrays preferably include a fore mounted array, an aft mounted array, a port mounted array and a starboard mounted array for respectively firing beams in different azimuth sectors relative to the aircraft. Each array is comprised of dipole elements having phase shifters coupled thereto for steering a beam within the corresponding sector. The primary radar antennas time share an exciter, transmitter, receiver and signal processor through switching devices. Antennas are operated at different times according to a time allocation algorithm.

EP 954 056 describes a multiface phased array antenna, with each antenna face being provided with a plurality of T/R modules. To preclude the occurrence of crosstalk among the different antenna faces, caused by the steep edges of transmitted RF pulses, the pulses are delayed per T/R module with a delay selected from a predetermined time interval. Interference between different antenna faces is thus achieved by time synchronization so as to delay operation of one antenna face relative to an adjacent antenna face.

XP010504616 and XP000513126 describe Ericsson's ERIEYE phased array antenna that consists of two equal apertures positioned back to back to provide a total scanning sector of 360°. The two antennas are not adjacent but are disposed on opposite sides of a dorsal unit and are adapted to operate in different frequency bands. The dorsal unit is mounted on top of a commuter aircraft and presents a much lower aerodynamic profile than the well-known AWACS.

There is no suggestion in the above references to employ a phased array antenna comprising at least two cyclically selectable antenna couplets each comprising a pair of adjacent antennas adapted for simultaneous operation at different frequencies.

It is an object of the present to provide a more compact phased array radar antenna that permits a complete 360° coverage to be achieved.

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It is a particular object of the invention to provide such a phased array radar antenna that is amenable for use with vehicles such as aircraft whose ends have a much reduced footprint than their sides.

SUMMARY OF THE INVENTION

This object is realized in accordance with a broad aspect of the invention by a phased array radar antenna comprising at least first and second antennas, said at least first and second antennas being adapted for simultaneous operation at different respective first and second frequencies;

characterized in that:

the first antenna is dimensioned for affixing to a nose or tail portion of an aircraft fuselage;

the second antenna is dimensioned for affixing to a side portion of the aircraft fuselage; and

the first frequency is correspondingly higher than the second frequency so as not to interfere with the first frequency and to compensate for the much reduced footprint of the first antenna relative to the second antenna.

In accordance with a preferred embodiment of the invention, there is provided a phased array radar antenna for a vehicle, said phased array antenna comprising:

first and second radar side antennas adapted for affixing to respective sides of a vehicle;

first and second radar end antennas adapted for affixing to respective ends of the vehicle, said ends of the vehicle having a much reduced footprint relative to the sides of the vehicle; and

a radar control unit adapted for coupling to the first and second radar end antennas and to the first and second radar side antennas for operating the first or second radar end antenna simultaneously with the first or second radar side antenna at respective first and second different frequencies, the first frequency being correspondingly higher than the second frequency so as not to interfere with the first frequency and to compensate for the much reduced footprint of the first antenna relative to the second antenna.

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The first and second radar side antennas and the first and second radar end antennas may be adapted to cover 360°. In a typical application, such a phased array radar antenna permits full 360° coverage to be achieved in less time than a phased array radar antenna employing only a single search frequency. However, the phased array radar antenna according to the invention may also be employed to achieve full or less than 360° coverage in the same time as hitherto-proposed phased array radar antenna in a more compact unit.

The invention also comprises a method for radar scanning using at least two phased array antennas fixed to respective surfaces of a vehicle so as to provide coverage in different directions, said method comprising simultaneously operating at least two of said antennas at different respective first and second frequencies;

characterized by:

dimensioning the first antenna for affixing to a nose or tail portion of an aircraft fuselage;

dimensioning the second antenna for affixing to a side portion of the aircraft fuselage; and

selecting the first frequency in a frequency band that is correspondingly higher than the second frequency so as not to interfere with the first frequency and to compensate for the much reduced footprint of the first antenna relative to the second antenna.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 is a pictorial representation showing an aircraft fitted with a phased array radar antenna according to an exemplary embodiment the invention;

Fig. 2 is a block diagram showing functionally a phased array radar antenna system according to an exemplary embodiment the invention;

Fig. 3 is a flow diagram showing operation of the phased array radar antenna system shown functionally in Fig. 2; and

Figs. 4 to 6 are pictorial representations showing how dual frequency scanning of a phased array radar antenna is implemented according to different embodiments of the invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Fig. 1 is a pictorial representation showing an aircraft 10 fitted with phased array radar antennas. A first radar side antenna 11 is adapted for affixing to one side of the aircraft fuselage and a second radar side antenna 12 (shown in Fig. 2) is adapted for affixing to an opposite side of the aircraft fuselage. A first radar end antenna 13 is adapted for affixing to a nose of the aircraft (constituting a front end thereof) and a second radar end antenna 14 is adapted for affixing to a tail of the aircraft (constituting a rear end thereof).

Fig. 2 is a block diagram showing functionally a phased array radar antenna system 20 according to an exemplary embodiment the invention. The system 20 includes a radar control unit 15 adapted for coupling to the first and second radar side antennas 11, 12 and to the first and second radar end antennas 13, 14 for operating the first or second radar side antenna simultaneously with the first or second radar end antenna at respective first and second different non-mutually interfering frequencies. The radar control unit 15 is coupled to a display 16 for displaying processed data.

Fig. 3 is a flow diagram showing operation of the phased array radar antenna system 20 shown in Fig. 2. Thus, full 360° coverage is achieved by operating successive adjacent pairs of antennas at different frequencies. By way of example, during a first area of coverage the radar control unit 15 operates the first side antenna 11 at first frequency simultaneously with the first end antenna 13 at second frequency. This provides coverage of 180° as shown pictorially in Fig. 4. A second area of coverage also spanning 180° is then achieved by operating the second side antenna 12 at the first frequency simultaneously with the second end antenna 14 at the second frequency. Since two antennas are operated simultaneously, the time to achieve a complete 360°

scan is approximately half the time required using a single frequency radar system, where each antenna must be operated discretely. By keeping the same scan time, the single frequency radar range performance can be achieved while reducing the antenna dimensions. Since the side antennas 11, 12 have a much greater area than the end antennas 13, 14, the first frequency with which the end antennas operate must be correspondingly higher than the second frequency with which the side antennas operate so as to compensate for the much reduced footprint of the end antennas. In a preferred embodiment, the first frequency is S-band and the second frequency is L-band.

Fig. 4 shows pictorially a practical angular coverage of the antennas when the side antennas 11 and 12 are operated at L-Band and the nose and tail antennas 13 and 14 are operated at S-Band. It is seen that the angular coverage of the side antennas 11 and 12 is approximately twice that of the nose and tail antennas 13 and 14. By such means, the S-Band radar can reach a sufficient performance relative to the L-Band radar despite of the reduced dimensions.

It should also be noted that the frequencies at which the side antennas 11 and 12, on the one hand, and the nose and tail antennas 13 and 14, on the other hand, are operated must be sufficiently distinctive to prevent mutual interference. In practice, this may require that the frequencies occupy non-overlapping frequency bands although frequencies at opposite extremes of the frequency band may be sufficiently distinct as be mutually non-interfering.

Although the invention has been described with particular regard to an aircraft early warning radar system, it will be understood that the invention is also applicable to other vehicle early warning radar systems and the same principles may be applied to ships, for example, and other vehicles. In saying this, it is nevertheless noted that the particular advantages of the invention over hitherto-proposed early warning radar systems are most manifest in aircraft early warning radar systems owing to the need to provide a radar system that offers a low aerodynamic footprint. In the invention, this is achieved owing to the planar construction of the two side antennas 11 and 12, which lend themselves to being mounted on the fuselage of the aircraft without affecting the aerodynamics of the aircraft. Likewise, the two end antennas 13 and 14, being configured to operate at a higher frequency have a low footprint that allows them to be mounted in suitably shaped radomes at the front and rear ends of the aircraft that is

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specially designed so as to provide a smooth aerodynamic contour. The mechanical construction of the radomes is within the skill of those versed in the relevant art and is not a feature of the invention. Clearly, such considerations are less important for maritime applications.

Although a particular embodiment of the invention has been described employing four antennas, it will be appreciated that the principles of the invention may be applied more generally to the use of two or more antennas that are operated simultaneously at different non-mutually interfering frequencies. For example, two antennas may be configured each to provide coverage of non-overlapping 180° sectors, thus allowing both antennas to be operated simultaneously thereby halving the time to achieve full 360° coverage. Likewise, as shown in Fig. 5, three antennas F1, F2 and F3 may be configured each to provide coverage of non-overlapping 120° sectors, thus allowing the antennas to be operated simultaneously at respective non-mutually interfering frequencies thereby reducing the time to achieve full 360° coverage by a factor of 3.

It should also be noted that while the invention has been described with particular regard to full 360° coverage, not always is full 360° coverage required. For example, Fig. 6 shows two antennas L1 and S1 adapted to be operated simultaneously at respective non-mutually interfering frequencies so as to provide in combination partial coverage of 180°. To the extent that such reduced coverage is achieved by operating two or more antennas simultaneously at different non-mutually interfering frequencies, this also is embraced by the present invention.

It will also be understood by those skilled in the art that the invention is equally applicable for both manned and unmanned aircraft.

The invention also contemplates a vehicle, particularly an aircraft that is constructed with the radar system according to the invention.

It will also be understood that the radar system 20 according to the invention may include a suitably programmed computer. Likewise, the invention contemplates a computer program being readable by a computer for executing the method of the invention. The invention further contemplates a machine-readable memory tangibly embodying a program of instructions executable by the machine for executing the method of the invention.

EDITORIAL NOTE

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- This specification does not contain claim no 6 as per file record of conversation. Dated 28/3/2011.

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CLAIMS:

1. A phased array radar antenna system comprising at least a first antenna array and a second antenna array, said at least first and second antenna arrays being configured for simultaneous operation at different respective first and second frequencies;

wherein:

the first antenna array is dimensioned for affixing to a nose or tail portion of an aircraft fuselage;

the second antenna array is dimensioned for affixing to a side portion of the aircraft fuselage; and

the first frequency is correspondingly higher than the second frequency so as not to interfere with the first frequency and to compensate for the reduced footprint of the first antenna array relative to the second antenna array.

2. The phased array radar antenna system according to claim 1, comprising at least two cyclically selectable antenna array couplets each comprising a pair of adjacent antenna arrays adapted for simultaneous operation at the first or second frequency.

3. The phased array radar antenna system according to claim 1 or 2, further comprising a radar control unit for operating the first frequency at S-band and for operating the second frequency at L-band.

4. The phased array radar antenna system according to claims 1 to 3, wherein the first antenna array is mounted in a radome having a smooth aerodynamic contour.

5. A phased array radar antenna system comprising at least two antenna arrays, said at least two antenna arrays being configured for simultaneous operation at different respective first and second frequencies; wherein:

the first and second frequencies are sufficiently non-mutually interfering to allow the first and second antenna arrays to scan at least two objects simultaneously in different sectors.

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7. The phased array radar antenna system according to claim 5 being configured for mounting on a vehicle , said phased array antenna comprising:

first and second radar side antenna arrays configured for affixing to respective sides of a vehicle;

first and second radar end antenna arrays configured for affixing to respective ends of the vehicle, said ends of the vehicle having a reduced footprint relative to the sides of the vehicle; and

a radar control unit configured for coupling to the first and second radar end antenna arrays and to the first and second radar side antenna arrays for operating the first or second radar end antenna array simultaneously with the first or second radar side antenna array at respective first and second different frequencies, the first frequency being correspondingly higher than the second frequency so as not to interfere with the first frequency and to compensate for the reduced footprint of the first antenna array relative to the second antenna array.

8. The phased array radar antenna system according to claim 7, wherein the radar control unit is configured to operate the first frequency at S-band and the second frequency at L-band.

9. The phased array radar antenna system according to claim 7 or 8, wherein the vehicle is an aircraft and the first and second radar side antenna arrays are configured for fixing to a fuselage of the aircraft.

10. The phased array radar antenna system according to claim 9, wherein the aircraft is unmanned.

11. The phased array radar antenna system according to claims 5 to 10, wherein the first antenna array is mounted in a radome having a smooth aerodynamic contour.

12. Dual band early warning radar system comprising a phased array radar antenna system that includes at least first and second antenna arrays, said at least first and second antenna arrays being configured for simultaneous operation at different respective first and second frequencies; wherein:

the first antenna array is dimensioned for affixing to a nose or tail portion of an aircraft fuselage;

the second antenna array is dimensioned for affixing to a side portion of the aircraft fuselage; and

the first frequency is correspondingly higher than the second frequency so as not to interfere with the first frequency and to compensate for the reduced footprint of the first antenna array relative to the second antenna array.

13. A method for radar scanning using at least two phased array antenna arrays fixed to respective surfaces of a vehicle so as to provide coverage in different directions, said method comprising simultaneously operating at least two of said antenna arrays at different respective first and second frequencies, said method comprising:

dimensioning the first antenna array for affixing to a nose or tail portion of an aircraft fuselage;

dimensioning the second antenna array for affixing to a side portion of the aircraft fuselage; and

selecting the first frequency in a frequency band that is correspondingly higher than the second frequency so as not to interfere with the first frequency and to compensate for the reduced footprint of the first antenna array relative to the second antenna array.

14. The method according to claim 13, for use with at least four phased array antenna arrays fixed to respective sides and ends of the aircraft fuselage, the method comprising:

cyclically selecting successive antenna array couplets each comprising a pair of adjacent antenna arrays; and

simultaneously operating the adjacent antennas in the selected couplet at the first and second frequencies so that the antenna array affixed to the nose or tail portion of the aircraft is always operated at the first frequency.

15. The method according to claim 13 or 14, wherein the first frequency is S-band and the second frequency is L-band.

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16. A method for radar scanning using at least two phased array antenna arrays fixed to respective surfaces of a vehicle so as to provide coverage in different directions, said method comprising simultaneously operating at least two of said antenna arrays at different respective first and second frequencies, the method comprising:

selecting the first and second frequencies in sufficiently non-mutually interfering frequency bands to allow the first and second antenna arrays to scan at least two objects simultaneously in different sectors.

17. The method according to claim 16 for use with at least four phased array antenna arrays fixed to respective surfaces of the vehicle, the method comprising:

cyclically selecting successive antenna array couplets each comprising a pair of adjacent antenna arrays; and

simultaneously operating the adjacent antenna arrays in the selected couplet at the first or second frequency.

18. A vehicle having mounted thereon the dual band early warning radar system comprising a phased array radar antenna system that includes at least first and second antenna arrays, said at least first and second antenna arrays being configured for simultaneous operation at different respective first and second frequencies; wherein:

the first antenna array is dimensioned for affixing to a fore or aft portion of the vehicle;

the second antenna array is dimensioned for affixing to a side portion of the vehicle; and

the first frequency is correspondingly higher than the second frequency so as not to interfere with the first frequency and to compensate for the reduced footprint of the first antenna array relative to the second antenna array.

19. The vehicle according to claim 18, being an aircraft comprising:

a fuselage supporting said first and second radar side antenna arrays on opposite sides thereof,

a nose portion supporting the first radar end antenna array,

a tail portion supporting the second radar end antenna array, and

a radar control unit disposed within the fuselage and coupled to the first and second radar end antenna arrays and to the first and second radar side antenna arrays for

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operating the first or second radar end antenna array simultaneously with the first or second radar side antenna array at respective first and second different frequencies, the first frequency being correspondingly higher than the second frequency so as not to interfere with the first frequency and to compensate for the reduced footprint of the first antenna array relative to the second antenna array.

20. The aircraft according to claim 19, comprising:

respective radomes covering the first and second radar end antenna arrays so as to provide a smooth aerodynamic contour.

21. The phased array radar antenna system according to claim 7, wherein the vehicle is an aircraft and the first and second radar end antenna arrays are configured for fixing to a nose or tail portion of the aircraft.

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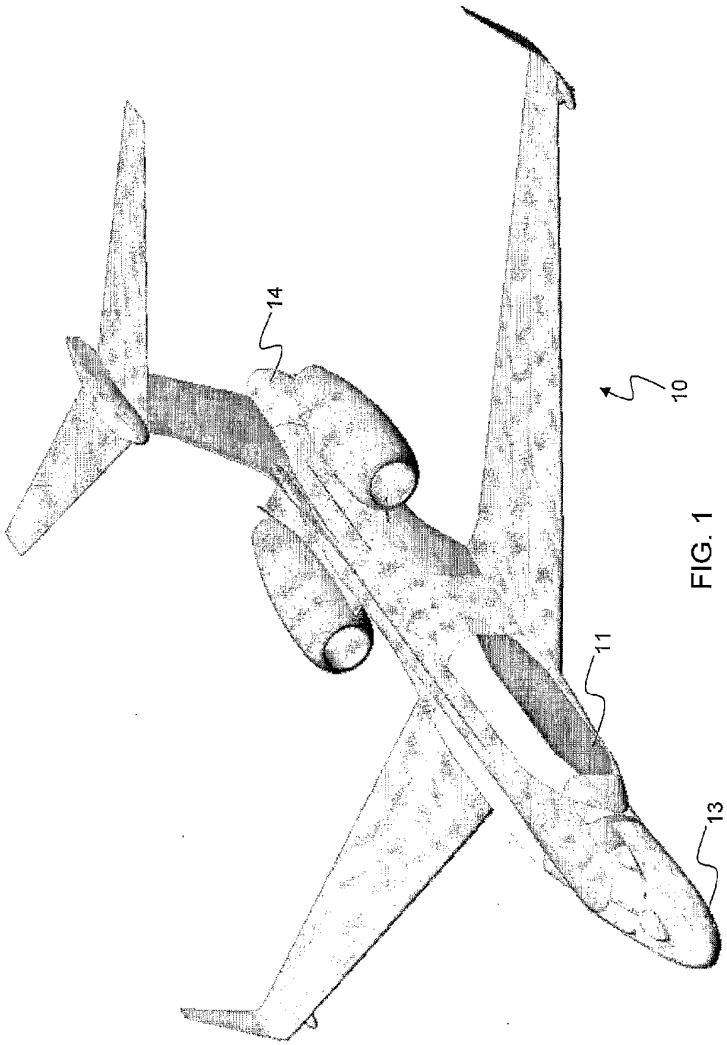


FIG. 1

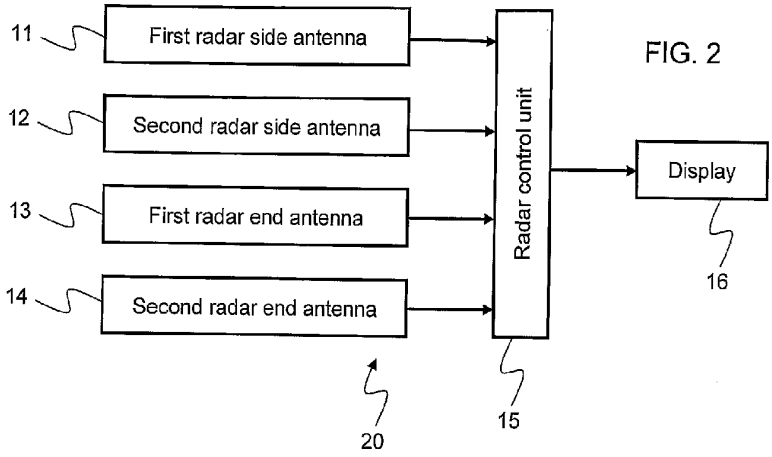

11
First radar side antenna
12
Second radar side antenna
13
First radar end antenna
14
Second radar end antenna
Radar control unit
Display
16
15
20

FIG. 2

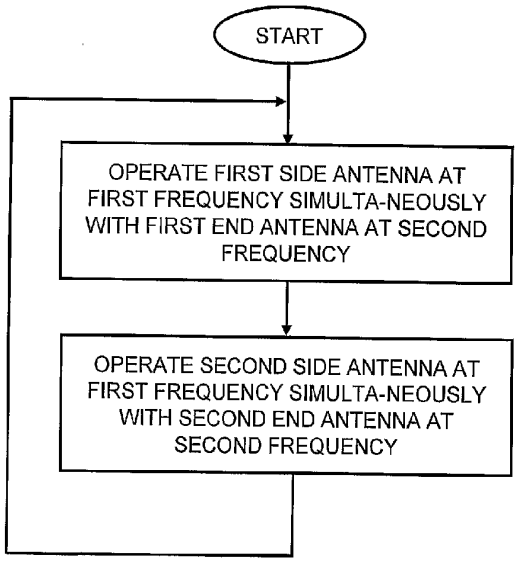

START
OPERATE FIRST SIDE ANTENNA AT FIRST FREQUENCY SIMULTA-NEOUSLY WITH FIRST END ANTENNA AT SECOND FREQUENCY
OPERATE SECOND SIDE ANTENNA AT FIRST FREQUENCY SIMULTA-NEOUSLY WITH SECOND END ANTENNA AT SECOND FREQUENCY

FIG. 3

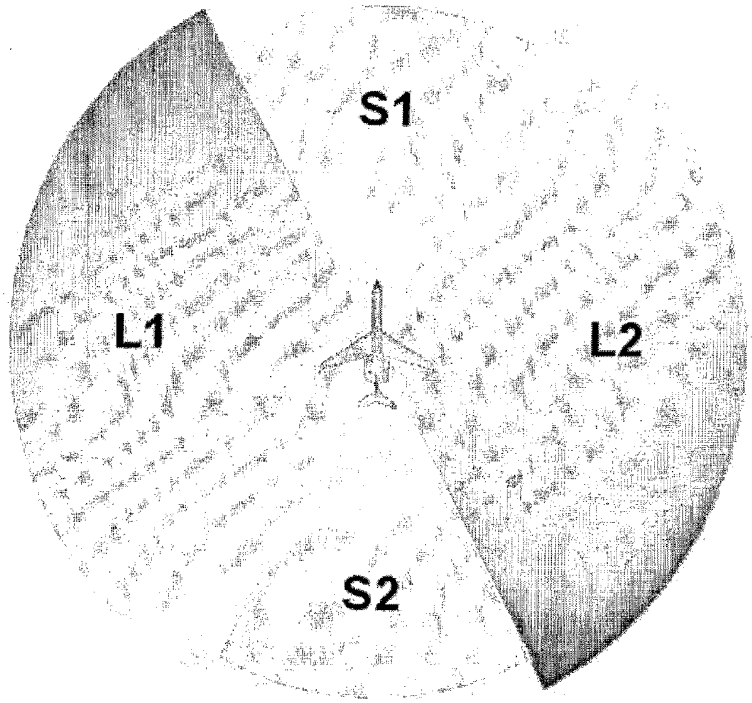


FIG. 4

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FIG. 5

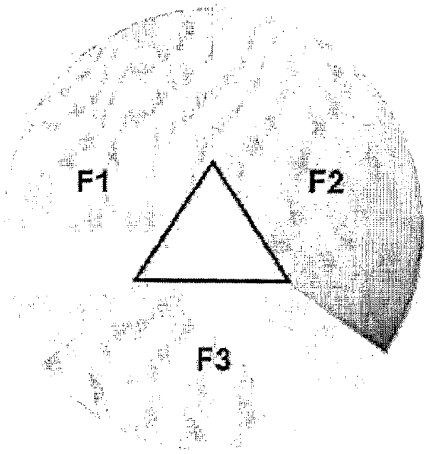


FIG. 6

