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[11] **3,911,443**

[45] **Oct. 7, 1975**

[54] **SPLIT BEAM ANTENNA APPARATUS FOR DEVELOPING ANGULARLY ORIENTED BEAMS**

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[52] **U.S. Cl.** **343/767**; 343/781; 343/784

[51] **Int. Cl.**[2] **H01Q 19/14**

[58] **Field of Search** 343/767, 784, 786, 781

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Attorney, Agent, or Firm—Andrus, Sceales, Starke & Sawall

[57] **ABSTRACT**

An antenna apparatus to form a pair of angularly oriented radiation lobes at ± 45° with respect to the antenna axis and operating in the X-Band includes a slot radiator in a finite ground plane which generates a multiple lobe radiation pattern generally symmetrical of the antenna axis. A simple rectangular plate reflector is mounted in spaced overlying relationship to the slot radiator. The ground plane has a width of approximately one wavelength and the reflector a width of approximately one and a half wavelength which is separated from the ground plane by approximately one wavelength. The reflector eliminates the on-axis radiation lobe and reinforces the ± 45° lobes to form the 90° operating lobes. The reflector plate is secured to the ground plane by a pair of narrow, pin side mounts or integrally interconnected solid and tapered side walls. A series of integral ground plane and reflector units are formed by severing of a rectangular extrusion at appropriately longitudinally spaced inclined planes. By employing an extremely thin wall, a clearance hole may be formed in the ground plane and the waveguide radiating slot used as the feed. Alternatively, the ground plane opening is covered with a low loss, low dielectric cube and a thin electrically conductive foil tape is secured over the spacer to define a properly spaced reflector.

17 Claims, 14 Drawing Figures

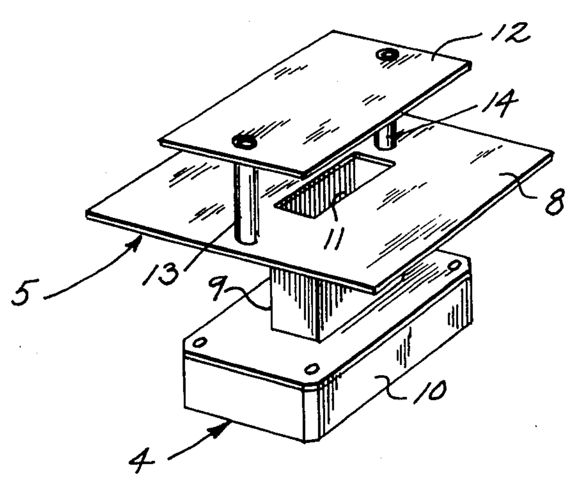


Fig.1

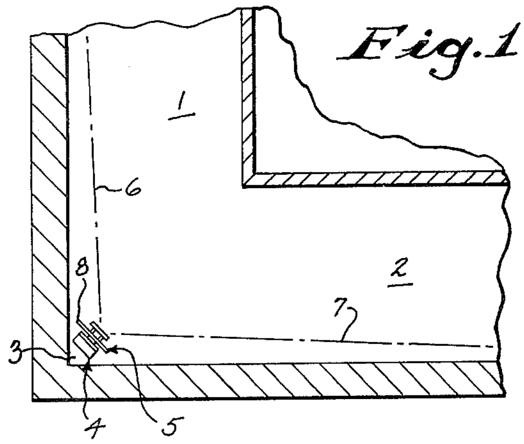


Fig.2

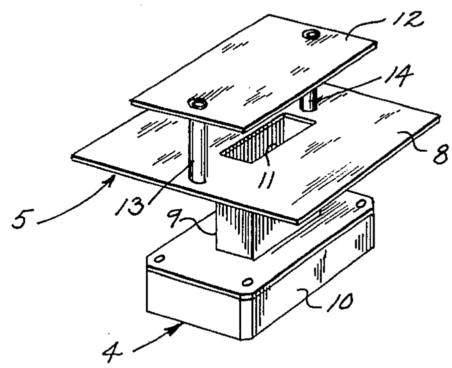


Fig.3

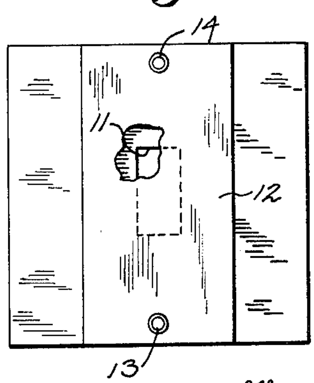


Fig.4

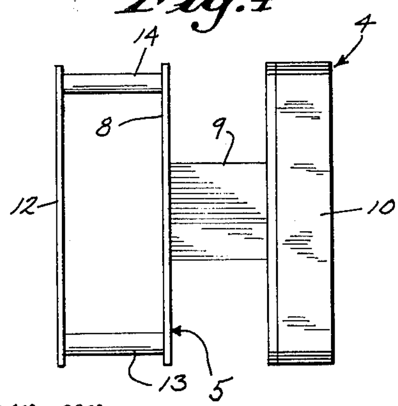


Fig.5

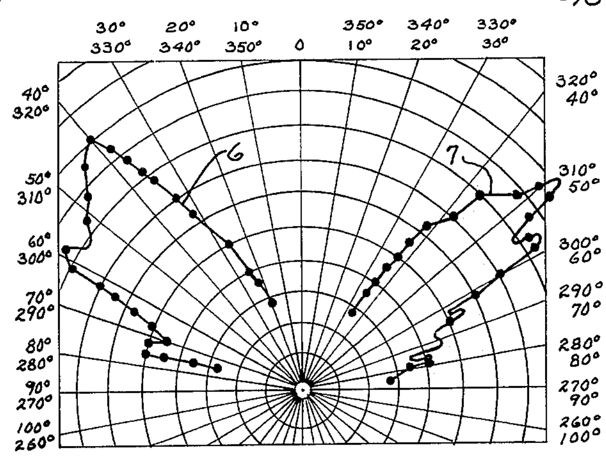


Fig.6

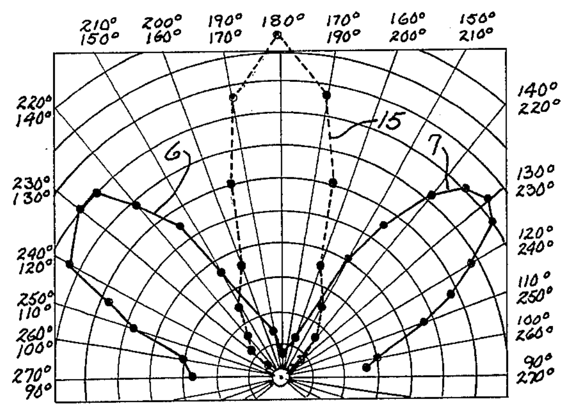


Fig. 7

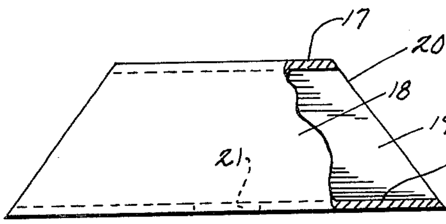


Fig. 9

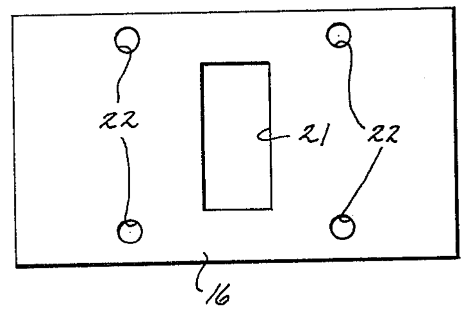


Fig. 8

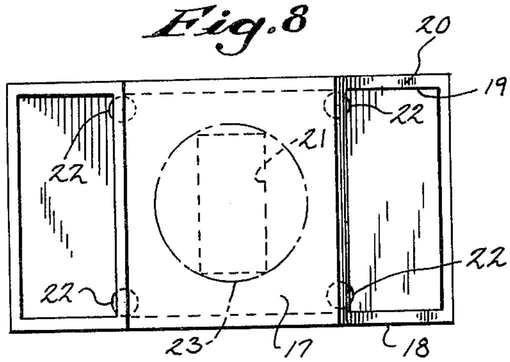


Fig. 10

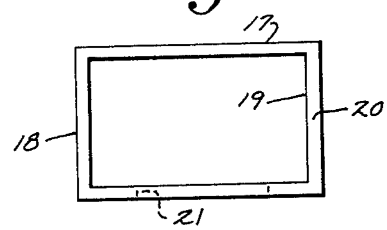


Fig. 11

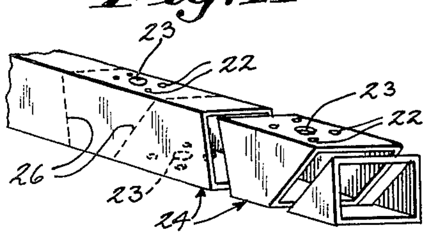
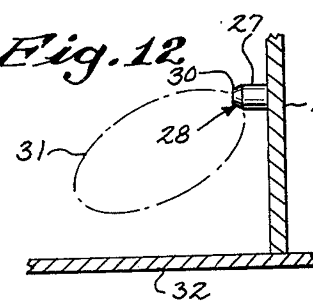


Fig. 12



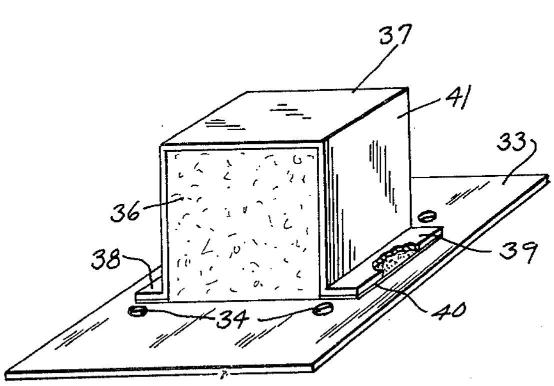
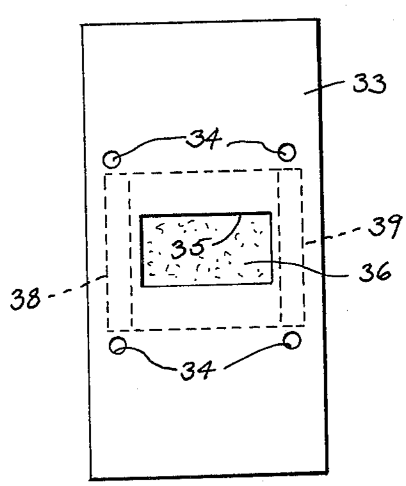


Fig. 13

Fig. 14



SPLIT BEAM ANTENNA APPARATUS FOR DEVELOPING ANGULARLY ORIENTED BEAMS

BACKGROUND OF THE INVENTION

The present invention relates to a split beam antenna apparatus and particularly to a field disturbance detection system employing radiated electromagnetic energy into an area to be monitored.

Various detection systems have been developed to monitor movement into, or within, a protected area. A particularly satisfactory system responds to Doppler motion signals arising from intrusion motion within an electromagnetic field flodding the protected area. Microwave transmission was originally developed to produce electromagnetic radiation beams which scan the horizon to detect airplanes, ships and the like within a transmitted field by processing of the signal energy reflected from such object within the field. Such systems have also recently been designed to provide reliable intrusion detection in more limited areas within institutional, industrial and similar units. The electromagnetic pattern generated will normally consist of either an elliptical pattern producing a relatively long, narrow pattern and range for coverage of an elongated area or a more circular pattern producing a relatively broad area coverage. In various practical applications, the area to be monitored or protected may not be a continuous area which can be directly covered by one such pattern. For example L shaped areas such as the intersecting corridors in a building, perimeter protection of large open areas or the like are encountered in intrusion monitoring applications. Such L shaped patterns can, of course, be readily developed by employing completely separate sources and essentially two complete separate systems. The use of two complete units, however, is a relatively expensive construction particularly where relatively sophisticated signal processing is desired to distinguish between transient or non-alarm intrusion as compared to actual alarm intrusion conditions. One possible alternative to reducing the expense of such a system is to employ a pair of power sources with a signal processing circuit, such, for example, as disclosed in the application of Carl F. Klein et al, now U.S. Pat. No. 3,859,656, issued Jan. 7, 1975 and assigned to the same assignee as this application.

Alternatively, a pair of directional atennas can be coupled to a single microwave oscillator through a power divider with each antenna radiating power equal to one-half of the peak or total output of the source. This reduces the detection range by the familiar "radar range equation" such that the range will be effectively 0.84 of the single beam range. Such is acceptable where the microwave oscillator cost is a significant portion of the total system cost. Such a system, however, remains relatively expensive with present day technology employing the power splitter and separate antennas. A similar concept can also be employed in L shaped areas if the walls or other confining surfaces are highly reflective to microwave energy. In such applications, a pattern from the inner corner is directed to an opposed inside corner of the two intersecting corridors with a division of the transmitted energy by the reflecting walls and with the corridors, in effect, acting as waveguides. Although theoretically possible, such a system is, of course, highly dependent upon the reflective characteristics of the walls and produces, in effect, a limitation on the building materials which can be employed.

If a highly reflective characteristic is not encountered, of course, the energy not reflected is lost, which may result in a significant decrease in the detection range. Further, the system is, of course, highly sensitive to the feed orientation and in-feed pattern of the source. Thus, if it is not very accurately located, a range imbalance will readily arise which might be, at best, troublesome and, in many instances, completely unacceptable.

Thus, although various prior art systems have been suggested, they have all included significant practical problems for consideration of cost, if not from technical capability, and a significant need for a simple, inexpensive beam splitter exists in the art.

SUMMARY OF THE PRESENT INVENTION

The present invention is particularly directed to a relatively simple and relatively inexpensive split beam antenna apparatus for generating of microwave energy patterns which are angularly oriented with respect to each other, and particularly to such an antenna apparatus which can generate major radiation lobes at ± 45° with respect to the antenna axis and thereby generate a pair of lobes spaced by essentially 90°. Generally, in accordance with the present invention, a basic electromagnetic pattern is generated by a slot radiator in a finite ground plane which generates a multiple lobe radiation pattern generally symmetrical of the antenna axis. Selection of a suitable ground plane for the slot radiator generates major radiation lobe at±45° with respect to the antenna axis. Applicants have discovered that the proper placement of a simple reflector means in overlying relationship to the slot radiator results in proper reflection to remove intermediate lobes and, in fact, reinforce the principal angularly related lobes. The reflector means is thus secured to the ground plane in spaced overlying relationship to the radiating slot with the relative size and spacing of the ground plane and reflector selected to produce the desired pair of concentrated major pattern radiation lobes which may be appropriately spaced generally at 90°. The properly related reflector effectively eliminates all other radiation lobes and produces the reinforcement along the±45° lobe axis. The dimentions of the ground plane, the reflector and the separation therebetween produce interrelated influences with a resultant optimum antenna performance for any given operating frequency. Generally, for a highly satisfactory beam splitter operating in the standard X-band range and including a rectangular ground plane of a width of approximately three wavelengths. Applicants have found a reflector should be of a width of approximately one and a half wavelength which is separated from the ground plane by approximately one wavelength and placed symmetrically over the slot. Generally, with this highly satisfactory operating construction, the pattern was found to be sensitive to a deviation of one-eighth wavelength. The reflector spacing is not particularly significant with respect to the principal angle of the two lobes, thus indicating that the ground plane functions as the primary radiator. The reflector spacing, however, significantly influences the on-axis radiation and a detectable increase was noted as the reflector is spaced more or less than the optimum one wavelength.

The reflector is mounted by suitable supporting spacers secured to the ground plane. The spacers are preferably small and/or are removed from the aperture in order to minimize the effect on the primary radiation pattern existing in the electric or E-plane, and the magnetic or H-plane radiation. The spacers should also be less than a quarter wavelength in width and removed from the aperture if minimum effect on the pattern is desired. With proper construction the reflector mounting means have an insignificant effect on the E plane pattern and only a very slight effect on the H plane pattern.

More particularly, in a preferred construction, the ground plane pattern was a square metal plate secured to the transmitting end of an X-band wavelength. A reflector plate was secured to the ground plane by a pair of side members located to the opposite sides of the waveguide opening and in spaced relation to the sides.

In a highly practical beam splitter construction method, in accordance with the present invention, a rectangular extrusion is provided with opposite walls spaced to define the ground plane and the reflector integrally interconnected by side walls. The side walls are tapered, solid metal walls. A series of units are formed by merely severing of the rectangular extrusion at appropriately longitudinally spaced inclined planes which are alternately, oppositely inclined such that the ground and reflector planes are alternately in the opposite walls of the extrusion and minimize waste material. The integral side walls provide some slight improvement in the radiation pattern, particularly in the H plane, but the primary advantage in the system resides in the simplified fabrication technique. Further, by employing a relatively thin wall, for example, of the order of 0.025 inches, the edge effects are minimized. A clearance hole can then be formed in the ground plane with the unit attached to the waveguide, with the actual waveguide radiating slot as the feed. This results in an extremely simple antenna construction which can be produced at minimal cost and properly assembled with the waveguide.

Further, with this configuration the antenna can be readily adapted to a single 45° pattern with appropriate direction. For example, if a suitable cover, such as copper tape, is placed over the one aperture, defined by the tubular formed antenna, energy will be directed from the other aperture with a slight rotation toward the antenna axis. The pattern can be rotated by 90° by merely moving the cover, or by otherwise rotating of the entire unit.

In a further novel construction, the ground plane is covered with a suitable dielectric spacer with a thin conductive foil disposed, appropriately, over the spacer to secure the spacer in place and define a properly spaced reflector. This produces a relatively narrow reflector with a solid plane spacing element spaced quite close to the apertured wall openings or edges of the aperture.

Thus the present invention employs a conventional ground plane slot radiator in combination with a relatively simply mounted spaced reflector to produce the desired concentrated angularly oriented radiation patterns and thereby provides a relatively simple and inexpensive beam forming system for a microwave intrusion detecting or monitoring apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings furnished herewith illustrate preferred constructions of the present invention in which the above advantages and features are clearly disclosed as well as others which will be readily understood from the following description of such illustrated embodiments.

In the drawings:

FIG. **1** is a diagrammatic illustration of the application of the present invention applied to protection of a generally L shaped area defined by a pair of intersecting corridorlike areas;

FIG. **2** is a pictorial view of a split bean antenna unit shown diagrammatically in FIG. **1** and constructed in accordance with the present invention;

FIG. **3** is a front elevational view of the split beam antenna apparatus shown in FIGS. **1** and **2**;

FIG. **4** is a side view of the apparatus shown in FIGS. **1** and **3**;

FIG. **5** is a polar diagram illustrating the normalized radiation pattern of the beam splitter antenna apparatus shown in FIGS. **1 – 4**;

FIG. **6** is a view similar to FIG. **5** illustrating the motion detection pattern of the present invention in relationship to a single pyramidal horn antenna;

FIG. **7** is a side view of an alternate integrated beam splitter reflector constructed in accordance with the present invention with parts broken away and sectioned to more clearly illustrate the details of construction.

FIG. **8** is a top view of the antenna apparatus shown in FIG. **7**;

FIG. **9** is a bottom view of the apparatus shown in FIG. **7**;

FIG. **10** is an end view of the apparatus shown in FIGS. **7 – 9**, inclusive;

FIG. **11** is a pictorial view illustrating a fabrication technique for forming of the beam splitter antenna structures such as shown in FIGS. **7 – 10**;

FIG. **12** is a diagrammatic illustration showing the application of the structure of FIGS. **7 – 10** to generate a downwardly directed pattern;

FIG. **13** is a pictorial view of still a further embodiment of the present invention; and

FIG. **14** is an elevational view of the apparatus shown in FIG. **13**.

DESCRIPTION OF ILLUSTRATED EMBODIMENT

Referring to the drawings and particularly to FIG. **1**, the present invention is illustrated applied to the protecting of a pair of intersecting elongated areas **1** and **2** defining a generally L-shaped configuration. Generally, areas **1** and **2** may be defined by confining wall configurations such as the intersecting corridors of a building as shown, or may be the corner of a large open area where it is desired to establish a pair of microwave energy field patterns across the entrance into the area from the corner.

In accordance with the present invention, a single microwave energy unit **3** is mounted adjacent to the outside corner of the total area defined by the intersecting corridors **1** and **2**. The unit **3** includes an energy beam source **4** coupled to a beam splitter antenna apparatus **5** constructed in accordance with the present invention. The apparatus **5** transmits the microwave energy as two distinct lobes **6** and **7** into the intersecting areas

1 and 2. In the illustrated embodiment of the invention, a single antenna apparatus **5** is illustrated which will function to both transmit the basic lobe patterns in the respective areas **1** and **2** and will also act as a receiving antenna in the event of intrusion into one or both of the patterns **6** and **7**. The source **4** also responds to received signals which are Doppler motion signals and by suitable processing produces a related output. Thus, the present invention, as shown, with the single combined transmitter-receiver configuration may, for example, be constructed as shown in the co-pending application of Bailey et al, now U.S. Pat. No 3,750,165 which issued July 31, 1973 and is assigned to the same assignee as this application. The invention may be employed, of course, with completely separate transmitter and receiver antennas. As such systems are well-known, no further description thereof is given.

Generally, as more clearly illustrated in FIGS. **2** – **4**, the beam source **4** illustrated in FIG. **1** includes a square ground plane **8** secured to the outer end of a rectangular waveguide **9** which is mounted and coupled to the output of an oscillator **10** operating in the standard X-band. The waveguide **9**, for a standard X-band cross section, may have, for example, a height of 0.4 inches and a width of 0.9 inches. The ground plane is a generally square ground plane of a height and width of three wavelengths or approximately 3 inches and is placed symmeteically about slot **11**. Thus, the beam is fed from the radiator slot **11** in the finite ground plane **8**. In accordance with the teaching of the present invention, a microwave energy reflector **12** is mounted in spaced overlying relation to the slot-ground plane radiator **8** and serves to modify the pattern to form the pair of energy lobes **6** and **7** offset by 90°, as illustrated in FIG. **1**. The reflector **12** is shown, in FIGS. **2** – **4**, mounted in fixed spaced relation to the ground plane **8** by a pair of spacer members **13** and **14** and is also placed symmetrically about slot **11**.

The reflector **12** and the ground plane **8** are sized, shaped and positioned relative to each other to essentially remove all but the pair of radiation lobes **6** and **7** and to particularly generate the desired radiation pattern at ±45° from the major axis of the slot radiator **11**.

Generally, it is known that a slot radiator in a finite ground plane of three wavelengths diameter will generate an energy pattern having a main lobe on the axis of the slot radiator and a pair of side lobes with respect to the principal axis. Applicants have found that the square ground plane produces a similar pattern configuration with the lobes approximately ±50°, off the major axis lobe. In accordance with the present invention, the simple reflector **12** is located to remove the radiated energy from the principal axis and to reinforce the angularly offset pattern lobes **6** and **7**, as clearly shown in FIG. **5**. The reflector **12** configuration for optimum operation and separation of the lobes had a length of approximately three wavelengths, and thus equal to the ground plane, and a width of approximately 1½ wavelengths.

The actual length of the ground plane does not essentially effect the E-plane radiation pattern as long as the length is approximately at least equal to 1½ wavelengths. Similarly, length of the reflector has very little effect on the E plane radiation pattern. Those selected are the flange dimensions for standard X-band design. The length of spacers **13** and **14** was found to be, for optimum consideration, approximately one wavelength. The reflector spacing does not materially affect the angular orientation of the operating lobes **6** and **7**, indicating that the ground plane structure functions as the primary energy radiator. The spacing, however, did appreciably influence the on-axis radiation which tended to increase as the reflector spacing was varied to either side of the optimum one wavelength spacement.

Further, as long as the spacing elements were maintained one-quarter wavelength or less in width and removed from the sides of the aperture, no material adverse influence on the patters is detected. Only insignificant influence is found in the primary radiation pattern in the electric or E-plane and only a slight adverse effect in the magnetic or H-plane.

Generally, Applicants have found that the radiating aperture or slot dimensions are not critical although for optimum operation, the feed polarization must be maintained. This teaching is particularly significant where impedance matching considerations are required. Thus, the slot can be now selected to produce a relatively wide range of impedance values without destroying the radiation divider characteristic.

A typical, normalized radiation pattern of a beam splitter antenna apparatus, such as shown in FIGS. **1** – **4**, is illustrated in the polar diagram of FIG. **5**. As illustrated therein, the energy lobe on the axis of the slot radiator has been completely eliminated with the pair of lobes **6** and **7** generated generally rotated ± 50° from the principal axis. This clearly illustrates the highly desired approximately 90° relationship between the two operating lobes as generated by the beam splitter antenna apparatus **5** of the present invention.

A similar illustration for the single head motion detector such as shown in FIGS. **1** – **4** is also shown in FIG. **6**. Superimposed on the illustration of FIG. **6** is an on-axis pattern **15** generated by the use of the same oscillator source with a single 16 db pyramidal horn antenna structure. The illustration of FIG. **6** indicates that the beam splitter antenna apparatus reduces the detection range in either lobe generally to the order of 80% that provided by the pyramidal horn. This is in accordance with the anticipated result based on the radar range equation which interrelates detection range to the square root of the antenna gain for any given single antenna system. The beam splitter antenna structure of the invention is, therefore, the equivalent of a pair of separate power sources feeding two optimum gain 14 db pyramidal horns. Further, the reflector construction of the present invention minimizes mutual coupling between the transmitting apertures formed to the opposite sides of the slot **11** and thereby increases the sharpness of the resultant null axis over that obtained with a pair of horns.

The invention, of course, is applicable to any closed or open area as the beam separation is not dependent upon the existence or sensitivity of any confining portions or wall of the areas **1** and **2**. The system of this invention which employs the formation of the lobes as a direct part of the energy permits accurate factory construction and mounting of the reflector so as to create an accurate beam splitting. The high degree of accuracy which can be readily attained essentially prevents any undesired range imbalance.

Thus, the present invention provides a simple and inexpensive means of accurate formation of a pair of operating energy lobes for portection of angularly oriented areas.

Other methods of forming the interrelated ground plane and reflector with appropriate spacing of the reflector, may, of course, be employed. A particularly practical and simplified production construction is illustrated in FIGS. 7 – 10, and one which is particularly adapted to a mass production process. The structure shown in FIGS. 7 – 10, inclusive, includes an integral rectangular ground plane 16 and reflector 17 connected by a pair of integral solid side walls 18 and 19 instead of the spacers 13 and 16 of FIG. 2. The side walls 18 and 19 provide tapered side edges 20 extending between the outer edges of the reduced width of the reflector 17 and the full width of the ground plane 16. In the illustrated construction, the ground plane 16 includes the radiating slot 21 and a plurality of mounting openings 22 for interconnection of the ground plane to a waveguide.

For simplification of the system, the ground plane 16 may be formed with a clearance hole 23, as shown in phantom in FIG. 8, slightly greater in diameter than the width of the radiating slot in the normal slot position. Applicants have found that if the waveguide and, particularly, the ground plane wall 16 is formed of a relatively thin material, for example, of the order of 0.025 inches, that the edges of the opening 23 will have negligible effect. The unit is mounted on a waveguide as shown in FIG. 1 with a mounting flange, similar to flange 8, provided with openings corresponding to location of openings 22 and the slot formed thereby is used as the feed means. For example, in the assumed ground plane for an X-band signal, the opening 23 may be of a 1 inch diameter with the space between the radiator slot and the clearance opening closed by the mounting flange.

As noted previously, the advantage of this particular beam splitter antenna apparatus is its adaptation to practical production processes.

Thus, as shown in FIG. 11, a rectangular elongated member 24 is formed of a suitable metal for the ground plane and the reflector and a cross section corresponding to the cross section of the integral ground plane and reflector, for example, as shown in FIG. 10. A series of the beam splitter antenna apparatus 25 is formed by merely severing of the rectangular extrusion along appropriate inclined side edge lines 26. Further, the successive beam splitter units 25 are formed with the reflector and ground planes formed from the walls of the rectangular extrusion to eliminate waste material. The opposite walls of the rectangular extrusion 24 are further formed or provided with the properly spaced mounting openings 22 as well as the necessary radiating aperture or clearance opening 23.

This construction may, of course, be readily employed in practical, mass production of the antenna while maintaining the desired accuracy of beam splitting.

Further, such a unit can, of course, be readily adapted to a single lobe radiation pattern which is appropriately directed by the angular orientation of the source and antenna. For example, as shown in FIG. 12, a radiation transceiver 27 having an antenna apparatus 28, such as shown in FIGS. 7 – 10, is mounted to the side wall 29 of an area to be protected. The source and associated antenna apparatus are oriented to locate the transmitting apertures in a vertical plane. The upper aperture is blocked as by a strip of copper tape 30. As a result of the covering of this aperture and the angular orientation, a single operating lobe 31 is provided projecting downwardly toward the floor 32.

If an oppositely directed lobe is desired, the cover 30 can be placed on the opposite aperture, or the total unit can be rotated 180°. Any other angular orientation can, of course, be provided to appropriately direct the protective lobe.

Other configurations can also be employed and a further embodiment of the invention is illustrated in FIGS. 13 and 14. In the illustrated embodiment of the invention, a ground plane member 33 is formed as a suitable plate having the appropriate mounting openings 34 and radiating slot 35. In accordance with the present invention, a cube 36 of a suitable microwave transmitting material, such as a dielectric foam, is mounted in abutting relation to the exterior face of the ground plane 33 and centrally located in overlying relationship to the transmitting aperture 35. A tape 37 of copper or any other suitable energy reflective material is wrapped over the outer periphery of the cube 36 and extends downwardly along the sides of the cube to the top and bottom of the slot 35. The terminal ends 38 and 39 of the tape 37 are appropriately bent over into abutting relation to the outer face of the flange 33 and secured thereto as by suitable adhesive 40. The integral side walls 41 define the spacers, which in the illustrated embodiment of the invention, are quite closely spaced with respect to the edges of the transmitting aperture 35.

The close location of the spacers to the edges does provide a noticeable influence on the pattern and produces a change in the effective size of the reflector. Generally, Applicants have found that the side walls will reduce the E plane lobes while increasing the H plane radiation. For example, employing a one inch cube of low density polystyrene foam (styrofoam) with a one inch wide copper tape of a 0.0035 inch thickness such as 3M X1181 copper foil tape generated a highly acceptable split radiation pattern such as shown in the previous figures. However, the solid plane spacer walls reduced the gain in the E-plane lobe by approximately 1 db while providing a corresponding increase in the H plane radiation, which, for most practical application, is a readily acceptable pattern configuration. Thus, the embodiment of the invention illustrated in FIGS. 13 and 14 produces another simple and practical construction adapted to be a relatively simple fabrication technique which is readily within the scope of present technology. Thus, the dielectric foam material is already largely employed in microwave transmission systems and can be readily formed into appropriately sized cubes. Copper tape, of course, is also readily available and can be easily formed over the dielectric foam cube and appropriately applied to the metal ground plane member.

The present invention therefor provides a relatively simple and inexpensive beam splitter antenna apparatus which creates the necessary directional patterns for microwave motion detectors of offset areas and the like and which can be constructed in many different practical production methods.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims, particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

We claim:

1. A beam splitting antenna apparatus for developing selected angularly related operating radiation lobe means comprising a hollow rectangular waveguide terminating in a slot opening in a finite essentially planar ground plane member terminating in outer free space edges, said waveguide and ground plane member forming a slot radiator developing a radiation pattern inclusive of the slot axis and to the opposite sides of the axis with the pattern projecting laterally outwardly of said free space edge, and a rectangular, planar reflector generally corresponding to the slot opening of the waveguide, mounting means fixedly mounting said reflector in outwardly spaced overlying relationship to said ground plane member with the reflector overlying the slot opening and the adjacent ground plane member and spaced from said slot opening and said ground plane to control the radiation pattern on the axis of the slot and thereby the angularly offset radiation lobes.

2. The beam splitting antenna apparatus of claim 1, wherein said ground plane member is formed to generate a pair of major radiation operating lobes generally at ± 45° from the antenna axis as well as intermediate radiation lobes therebetween, and said reflector essentially eliminates said intermediate radiation lobes and reinforces said operating lobes.

3. The beam splitting antenna apparatus of claim 1, wherein said ground plane member is a square plate having a centrally located slot opening, said ground plane member generates a pair of major radiation operating lobes generally at ± 45° from the antenna axis as well as the intermediate radiation lobes therebetween, and said reflector being a rectangular plate spaced from the ground plane member by essentially one wave length and essentially eliminating said intermediate radiation lobes and reinforcing said operating lobes.

4. In the apparatus of claim 1 including a transceiver for generating of a microwave energy and for detecting reflected microwave energy.

5. The beam splitter antenna apparatus of claim 1 wherein said reflector is a flat plate spaced from the slot opening by one wavelength.

6. A beam splitting antenna apparatus for developing selected angularly related operating radiation lobe means comprising a finite essentially planar ground plane member terminating at least one outer free space edge having a slot for formation of a slot radiator developing a radiation pattern inclusive of the slot axis and to the opposite sides of the axis and projecting laterally outwardly of said free space edge, and a reflector secured in outwardly spaced overlying relationship to said ground plane member with the reflector means overlying the slot opening and the adjacent ground plane member and spaced from said ground plane to control the radiation pattern on the axis of the slot and thereby the angularly offset operating radiation lobes, wherein said ground plane member and said reflector member are integrally connected by solid side wall metal members spaced from said free space edge.

7. The antenna apparatus of claim 1 including a microwave source operating in the X-Band and connected to said rectangular waveguide.

8. The antenna apparatus of claim 7 wherein said waveguide terminates in a mounting flange and said ground plane member is secured to said mounting flange, said ground plane member being formed with a clearance opening aligned with the waveguide slot opening within the mounting flange and said ground plane member is of a sufficiently thin material such that the edges of the clearance hole do not appreciably affect the pattern generated from the combination of the radiating slot opening and the ground plane member.

9. The antenna apparatus of claim 7 wherein said ground plane member has a width of essentially three wavelengths and said reflector has a width of essentially one and one-half wavelengths.

10. The antenna apparatus of claim 7 wherein said reflector is spaced from said ground plane member by essentially one wavelength.

11. The antenna apparatus of claim 8 said clearance opening is located concentrically about said radiating slot opening and of a size to space the opening from the edge of the radiating slot opening.

12. The beam splitter apparatus of claim 7 wherein said reflector is spaced from said ground plane member by essentially one wavelength.

13. The beam splitter antenna apparatus of claim 12 wherein said ground plane member has a width of essentially one and one-half wavelengths.

14. The beam splitter antenna apparatus of claim 13 wherein said reflector eliminates the slot axis radiation lobe and generates said angularly offset operating radiation lobes offset essentially fifty degrees from the slot axis.

15. The apparatus of claim 1 wherein said ground plane opening is covered by a dielectric material defining a microwave energy transmitting medium and with the outer surface thereof spaced in accordance with the location of said reflector, said reflector being formed by a tape member of a microwave energy reflective material secured to the outer surface of said material and to said ground plane member.

16. The apparatus of claim 15 wherein dielectric material is a rectangular cube with one face abutting the back side of the ground plane member and said tape extends across said cube and downwardly along the side walls of the side walls of the cube adjacent the sides of the radiating slot opening, and means securing the ends of the tape to the ground plane member to mount the reflector and cube in overlying relationship to said radiating slot opening.

17. The apparatus of claim 1 wherein said ground plane opening is covered by a dielectric foam cube defining a microwave energy transmitting medium and with the outer surface thereof spaced in accordance with the location of said reflector, said reflector being formed by a tape of a microwave energy reflective material, said tape extending across said cube and downwardly along the side walls of the cube adjacent the sides of the radiating slot opening, and means to secure the ends of the tape to the ground plane to mount the reflector and cube in overlying relationship to said radiating slot opening.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,911,443
DATED : October 7, 1975
INVENTOR(S) : LAWRENCE B. KORTA ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column	1,	Line	13,	after "field" cancel "flodding" and insert --- flooding ---;
Column	3,	Line	15,	cancel "wavelength" and insert --- waveguide ---;
Column	3,	Line	51,	after "moving" insert --- of ---;
Column	9, (CLAIM 3)	Line	32,	after "as" cancel "the".

Signed and Sealed this

twenty-seventh **Day of** *January 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks