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C. A. HACKING ETAL

3,246,333

LOUVERED RADOME

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2 Sheets-Sheet 1

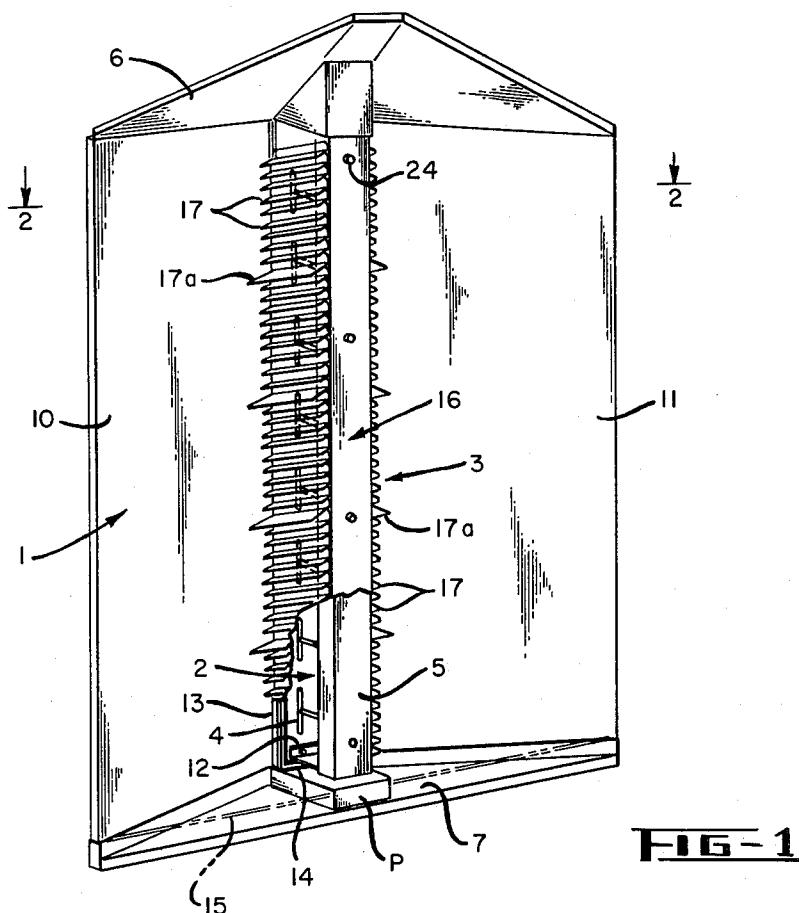


FIG-1

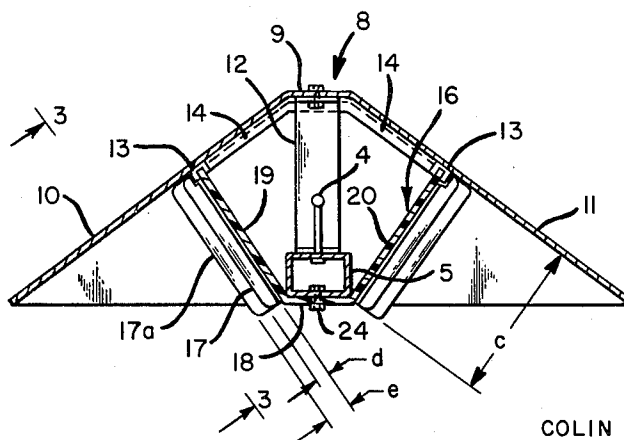


FIG-2

INVENTORS
COLIN A. HACKING
ALEX S. BAUER
SAMMY N. WATKINS

BY *John F. Lawler*
ATTORNEY

April 12, 1966

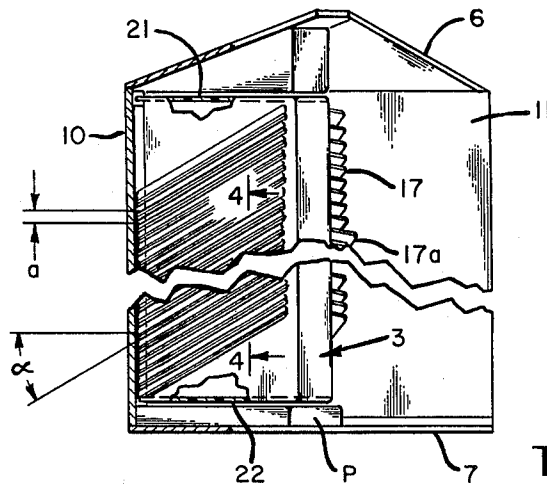
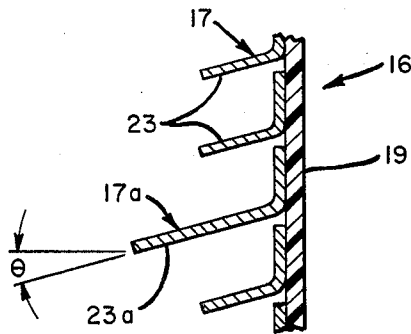
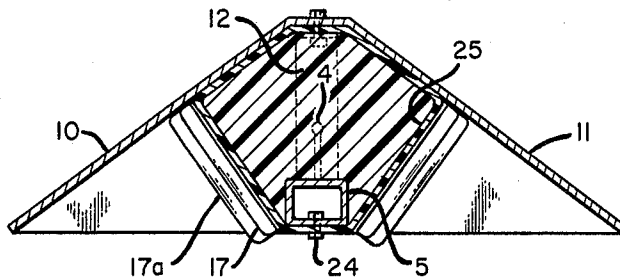
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INVENTORS
COLIN A. HACKING
ALEX S. BAUER
SAMMY N. WATKINS

BY J. Lee L. Lawler
ATTORNEY

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LOUVERED RADOME

Colin A. Hacking, Palo Alto, Alex S. Bauer, Sunnyvale, and Sammy N. Watkins, San Jose, Calif., assignors to Sylvania Electric Products Inc., a corporation of Delaware

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7 Claims. (Cl. 343—872)

This invention relates to intrusion detection systems and more particularly to an improved antenna radome for radio frequency detection systems that are exposed to the weather.

The efficiency of radio frequency intrusion detection apparatus is measured by its response to movement of particular objects, i.e., human intruders, in a protected area with a minimum of false alarms. Rainstorms tend to increase the false alarm rates of such detection systems that protect areas located out-of-doors. In the past, the false alarm rate during rainstorms has been controlled by decreasing the sensitivity of the system with a sacrifice of some detection capability. We have discovered a method of reducing the false alarm rate of the system without decreasing the system sensitivity.

We have determined that raindrops falling on the exposed radome do not diffuse into a thin film of water which runs evenly off the radome surface but rather merge together to form continuous vertical filaments or rivulets which flow across the radome in an erratic pattern. The size and position of these rivulets continually change. We have discovered that these rivulets act as parasitic antennas; when parallel to the polarization of the driven antenna, they absorb maximum energy from the driven antenna and reradiate it. Since the amount and direction of this reradiated energy are continually changing, the "effective gain" of the antenna fluctuates. In other words, electromagnetic energy passing through the radome is essentially amplitude-modulated by water rivulets on the radome surface, and this causes the system to give false alarms.

An object of this invention is the provision, for vertically polarized antennas, of a radome capable of shedding rain and the like with minimum effect on the propagation of electromagnetic waves related to the antenna.

A specific object is the provision of a radome for the antenna of an outdoor radio frequency intrusion detection system which minimizes the false alarm rate of such system due to rain.

In accordance with this invention, a plurality of louvers or slats of low loss dielectric material which is transparent to electromagnetic waves at the operation frequency are secured to the sides of the antenna radome made of like material. The louvers are spaced apart at appropriate intervals to reduce the effective path length of rivulets of water flowing on the radome. The louvers are positioned so that water rivulets running off the radome on the louvers are approximately orthogonal to the polarization of the antenna. The balance of run-off water is broken into droplets which have negligible effect on propagation even when the paths of fall of the droplets are parallel to the direction of polarization.

This invention and these and other of its objects will be more fully understood from the following detailed de-

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scription of an illustrative embodiment thereof, reference being had to the accompanying drawings in which:

FIGURE 1 is a perspective view, partly cut away, of an antenna-radome assembly incorporating this invention;

FIGURE 2 is a section of the assembly taken on line 2—2 in FIGURE 1;

FIGURE 3 is a transverse section taken on line 3—3 in FIGURE 2 showing a side view of the radome;

FIGURE 4 is an enlarged section showing the radome louver construction and taken on line 4—4 in FIGURE 3; and

FIGURE 5 is a modified form the assembly illustrated in FIGURE 2.

The antenna-radome assembly of FIGURE 1 comprises a corner reflector 1 which is illuminated by a collinear dipole array 2 that is protected from the elements by a radome 3. Dipole array 2 preferably comprises a plurality of vertically polarized dipoles 4 which extend in a vertical row for the height of the assembly. Dipoles 4 are rigidly mounted on a channel 5 which houses the electrical feed circuits of the dipoles. Collinear dipole arrays are described in Chapter 11 of "Antennas" by John D. Kraus, McGraw-Hill Book Company, Inc., 1950.

Corner reflector 1 is similar to the type described in Chapter 11 of the "Antenna Engineering Handbook" by Henry Jasik, first edition, 1961, McGraw-Hill Book Company, Inc. As illustrated in FIGURES 1 and 2, the corner reflector comprises a conductive top plate 6, a conductive bottom plate 7, and a unit reflector plate 8 having a back 9 and forwardly divergent sides 10 and 11 with front edges defining the antenna aperture. Conductive top plate 6 shields the radome 3 from rain and is slightly rearwardly inclined in order to drain collected water away from the antenna aperture. The top plate 6 and bottom plate 7 are suitably rigidly mechanically and electrically connected to the reflector plate by bolts, not shown. Bottom plate 7 may also be inclined for drainage purposes.

Dipole array 2 is mounted in corner reflector 1 by vertically spaced flanges, one of which is shown at 12 in FIGURE 2, which are rigidly secured to channel 5 and to the back 9 of the reflector as by bolts. The antenna-radome assembly is elevated above bottom plate 7 by a pedestal P.

As illustrated in FIGURE 2, vertical mounting flanges 13 are rigidly secured to reflector plate sides 10 and 11, and horizontal mounting channels 14 are secured to reflector plate sides 10 and 11 and back 9. The junctions of channels 13 and 14 and the reflector plate are sealed, such as by potting, to prevent seepage of moisture through the junctions. Radome 3 is secured in corner reflector 1 in channels 13 and 14 as described more fully herein-after.

It may be desirable, where the antenna-radome assembly is exposed to snow, to provide a corner reflector without a base wall so as to prevent undue accumulation of snow. For such applications, base plate 7 may be replaced by a narrow support member 15, shown in broken line in FIGURE 1, rigidly secured to reflector side plates 10 and 11 and pedestal P. Such an antenna-radome assembly preferably would be mounted in an elevated position on a vertical support column.

Radome 3 comprises a shell 16 of mechanically strong low loss dielectric material through which electro-mag-

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netic waves freely pass, such as a fiber glass laminate, to which are secured louvers or slats 17 made of the same material. Shell 16 is a vertically extending trough-like enclosure comprising a central forward wall 18, side walls 19 and 20, and top and bottom walls 21 and 22 (see FIGURES 2 and 3). Walls 21 and 22 seat tightly against side walls 19 and 20 and central wall 18 and are supported in the recesses of channels 13 and 14 on reflector plate 8.

The amount of energy coupled from a driven antenna to a parasite antenna is related to the cosine of the angle defined by the direction of polarization of the driven element and the longitudinal axis of the parasite antenna. No energy is induced in the parasite when it is orientated orthogonally to the polarization of the driven element. It has been determined that rivulets of water are efficient parasite antennas when they are parallel to the polarization of the antenna. In order to reduce amplitude modulation of a transmitted or received signal by these rivulets the direction of rivulet movement is made approximately orthogonal to the polarization of the driven antenna or dipoles 4. The longitudinal axes of outwardly extending skirts 23 of adjacent louvers extend transversely of the direction of polarization. The skirts 23 are spaced apart slightly and inclined slightly, as indicated by the spacing a and angle α between the skirt longitudinal axis and the horizontal, respectively, in FIGURE 3. The water is preferably directed toward the back 9 of reflector 8 where it drains from the assembly.

It has been determined empirically that the system operates satisfactorily if the louvers 17 are inclined upwardly and outwardly from shell sides 19 and 20 so as to form a trough and catch water or if the louvers are oppositely inclined so as to shed water, as indicated in FIGURE 4, the angle of inclination being designated θ . Whether the louvers are inclined upwardly or downwardly, they carry the greater part of the water off the radome even during heavy rainstorms. In a preferred form of the invention, the louvers are inclined downwardly, as shown in FIGURE 4, to shed water and to prevent undue accumulation of foreign material such as dirt or ice. The water which falls from the long edges of the louvers is in droplet form that does not effect propagation of electromagnetic waves.

As droplets fall from the long edges of the upper louver skirts and merge with run-off water from lower louvers, there is a tendency for the accumulation of water to form into vertical rivulets which adversely affect antenna gain. In order to avert this occurrence, a few louvers 17a, having enlarged skirts 23a of width e substantially larger than the skirt width a of the remaining skirts 23, are included in the row of louvers at appropriate vertically spaced intervals. For example, the substitution of one enlarged louver 17a for every tenth louver 17 as shown in FIGURE 1 gives satisfactory results. Each enlarged louver shields the smaller louvers immediately below it and prevents excessive build-up of water on them.

In an actual embodiment of the invention, radome 3 was formed of polyester pre-impregnated fiber glass reinforced laminate, shell 16 being formed in a mold and being comprised of several layers of the material. Shell end walls 21 and 22 and center wall 18 were reinforced with additional layers of the material. Louvers 17 and 17a were formed of several layers of this material in a heated press mold and were secured to the side walls 19 and 20 with resin adhesive.

Radome 3 is mechanically secured to the corner reflector 1 by connection of its center wall 18 to dipole circuit channel 5 by bolts 24 (see FIGURE 2). The side walls 19 and 20 seat against vertical mounting flanges 13 and the end walls 21 and 22 are supported in the recesses of horizontal mounting channels 14 and are sealed in place by a waterproof sealant.

A modified form of the invention is shown in FIGURE 5 in which the trough-like shell 16 of FIGURE 2 is replaced by a unit six-sided cup-like tubular shell 25 of

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laminated dielectric material, to the interior of which access is had only through an opening at the top. In other respects the antenna assemblies are the same. Shell 25 may be filled with suitable insulator material such as polyurethane foam to prevent condensation within the shell.

By way of example, the antenna-radome assembly of FIGURE 2, employing a radome having the following dimensions and characteristics, was constructed and successfully operated:

Antenna operating frequency ----- 1.72. gc.

Radome louvers 16:

Number ----- 50.
Incline, angle α ----- 30 degrees.
Slant/slope, angle θ ----- 15 degrees.
Spacing a ----- 0.96 inch.
Length c ----- 6.68 inches.
Skirt width d ----- 0.43 inch.

Radome louvers 16a:

Number ----- 4.
Skirt width e ----- 1.3 inches.

The effective gain fluctuations of this antenna-radome assembly were less than 0.1 db as compared with 0.5 db with a smooth surface radome.

Although this invention has been illustrated and described in relation to a specific embodiment, it is understood that the scope of the invention is not limited thereto, but is determined by the scope of the appended claims.

What is claimed is:

1. An antenna-radome assembly comprising
 - a corner reflector having vertically extending divergent sides with edges defining the reflector aperture,
 - a vertically polarized dipole array for illuminating said reflector comprising a plurality of vertically aligned and spaced dipoles equally spaced from said reflector and located between the reflector and said aperture, and
 - a vertically extending electromagnetic wave transmitting radome enclosing said array comprising
 - laterally spaced side walls extending normally from the reflector sides, respectively, toward said aperture and a center wall connecting the side walls proximate to the aperture,
 - each of said side walls having a plurality of vertically spaced parallel louvers extending from the reflector to the center wall,
 - each of said louvers being inclined downwardly toward the reflector and having a skirt projecting outwardly and down from the side wall,
 - at least one of said louvers having a skirt which extends outwardly from the side wall a substantially greater distance than the skirts of said other louvers.
2. An antenna-radome assembly comprising
 - a corner reflector having vertically extending divergent sides with edges defining the reflector aperture,
 - a vertically polarized dipole array for illuminating said reflector comprising a plurality of vertically aligned and spaced dipoles equally spaced from said reflector and located between the reflector and said aperture, and
 - a vertically extending electromagnetic wave transmitting radome enclosing said array comprising
 - laterally spaced side walls extending normally from the reflector sides, respectively, toward said aperture and a center wall connecting the side walls proximate to the aperture,
 - each of said side walls having a plurality of vertically spaced parallel louvers extending from the reflector to the center wall,
 - each of said louvers being inclined downwardly toward the reflector and having a skirt projecting outwardly and down from the side wall.
3. An antenna-radome assembly comprising

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a corner reflector having sides forming an angle,
 a vertically polarized longitudinal dipole array for
 illuminating said corner reflector, said array being
 symmetrically located in said corner reflector,
 a radome for protecting said dipole array, said radome
 comprising

a shell of low loss dielectric material having shell
 sides extending from said corner reflector sides,
 respectively, and a center wall connecting said
 shell sides,

a plurality of first louvers of low loss dielectric
 material secured to said shell sides, each of said
 first louvers having a skirt inclined to and extend-
 ing from one of said shell sides to shed
 water and having a longitudinal axis approxi-
 mately orthogonal to the vertical polarization
 of said dipole array, and

a plurality of second louvers of low loss dielectric
 material secured to said shell sides, each of said
 second louvers having a skirt extending farther
 from said shell sides, than said first louver's
 skirt, and

means for securing said radome and dipole array to
 said corner reflector.

4. In a system comprising means for operating on
 electromagnetic energy and a radome for protecting said
 operating means, a radome comprising

a shell of low loss material, and

a plurality of low loss louvers secured to said shell,
 each of said louvers having a skirt extending out-
 wardly from said shell,

each of said skirts being inclined to the horizontal
 and having a longitudinal axis approximately
 orthogonal to the polarization of the operating
 means and inclined to the horizontal,

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the skirt of certain of said louvers extending out-
 wardly from said shell farther than said other
 louver's skirts.

5. In a system comprising means for operating on
 electromagnetic energy and a radome for protecting said
 operating means, a radome comprising

a shell of low loss material, and

a plurality of low loss louvers secured to said shell,

each of said louvers having a skirt extending out-
 wardly from said shell,

each of said skirts being inclined to the horizontal
 and having a longitudinal axis approximately
 orthogonal to the polarization of the operating
 means and inclined to the horizontal.

6. In a system comprising means for operating on
 electromagnetic energy and a radome for protecting said
 operating means, a radome comprising

a shell of low loss material, and

a plurality of low loss louvers secured to said shell,

each of said louvers having a skirt extending out-
 wardly from said shell,

each of said skirts having a longitudinal axis ap-
 proximately orthogonal to the polarization of
 the operating means.

7. In a system for operating on electromagnetic energy,
 a radome comprising

a shell of low loss dielectric material, and

a plurality of louvers of low loss dielectric material
 secured to said shell,

each of said louvers having a skirt extending out-
 wardly from said shell.

No references cited.

35 HERMAN KARL SAALBACH, *Primary Examiner.*