

Sept. 24, 1968

J. E. HOWELL

3,403,403

ANTENNA FILTER WINDOW

Filed March 8, 1966

2 Sheets-Sheet 1

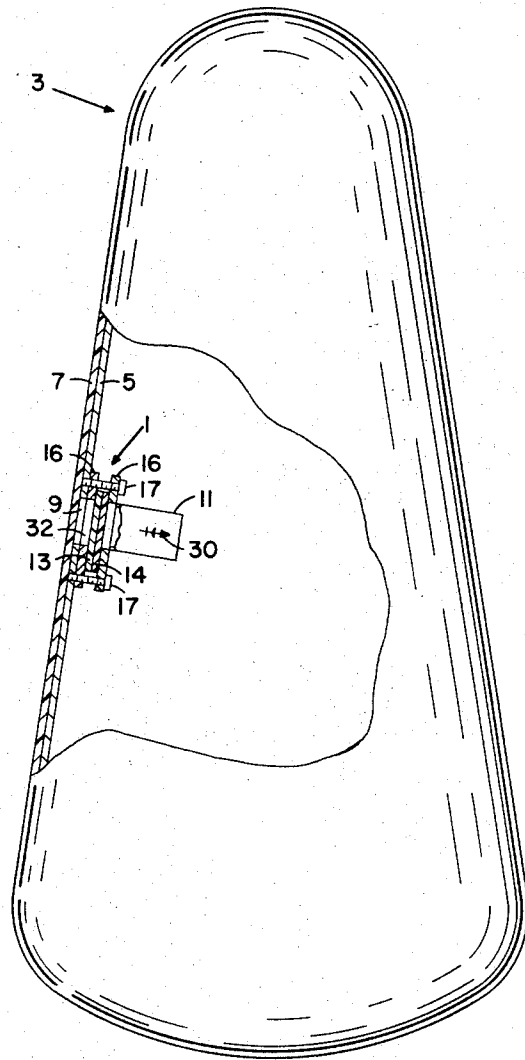


FIG. 1

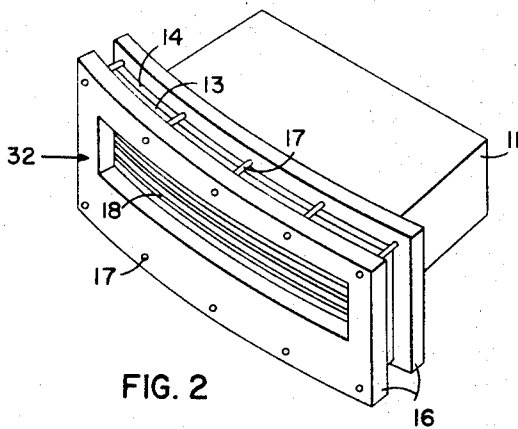


FIG. 2

James E. Howell,
INVENTOR.

BY *Harry M. Saragovitz*
Edward J. Kelly
Herbert Carl
Robert C. Sims

Sept. 24, 1968

J. E. HOWELL

3,403,403

ANTENNA FILTER WINDOW

Filed March 8, 1966

2 Sheets-Sheet 2

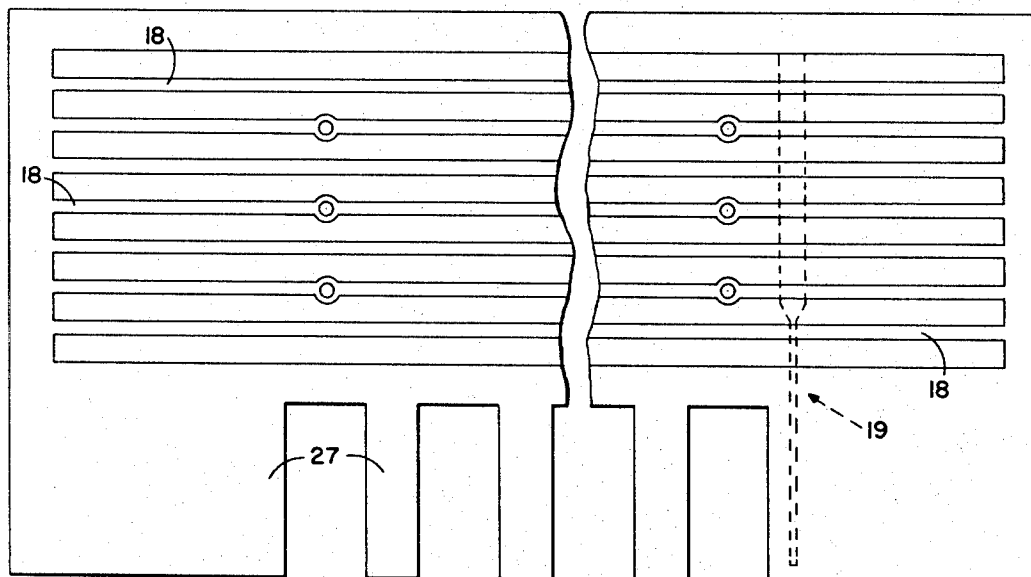


FIG. 3A

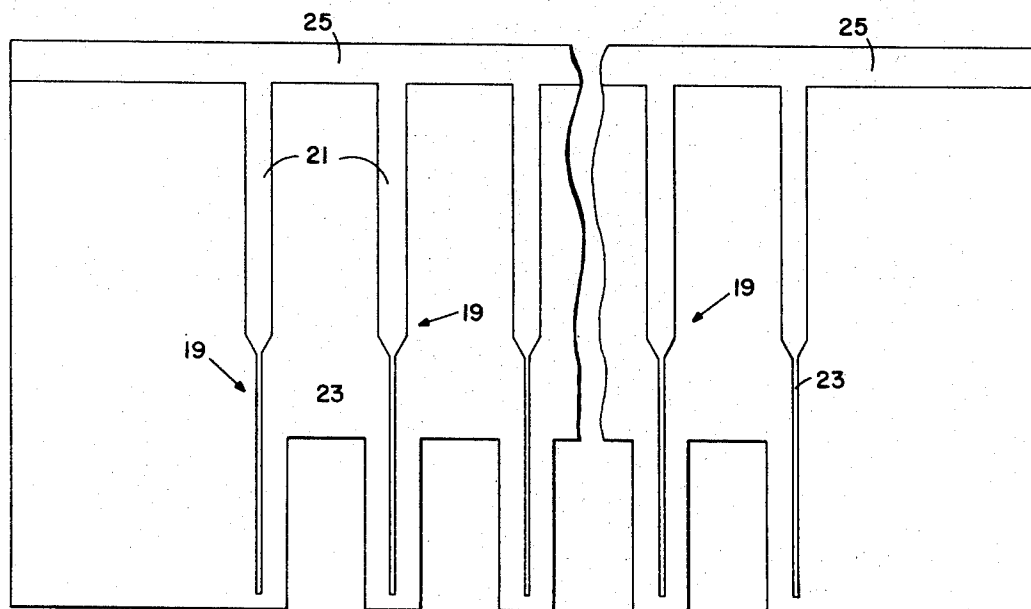


FIG. 3B

James E. Howell,
INVENTOR.

BY *Harry M. Saragovitz*
Edward J. Kelly
Herbert Paul
Robert C. Sims

1

3,403,403

ANTENNA FILTER WINDOW

James E. Howell, Huntsville, Ala., assignor to the United States of America as represented by the Secretary of the Army

Filed Mar. 8, 1966, Ser. No. 534,981

10 Claims. (Cl. 343-708)

This invention relates generally to an antenna filter window device. Specifically, the invention is a device which allows radiation from an antenna, but at the same time "hiding" the antenna from radar sets when the antenna is installed in a metal body such as a re-entry vehicle. The antenna filter window of the present invention accomplishes this by employing a system of grids and transmission line elements.

In the AMRAD program a ground radar system was to make measurements of the cross section of special re-entry bodies. Antennas were needed for the telemetry system to be carried by the re-entry bodies, but they could not interfere with the known radar cross section of the body. Particularly, these antennas could not change the cross section as the body spun. Two solutions are possible: The antenna can be located at the rear of the body, or the antenna can be located at the forward end of the body.

If the antenna is located at the rear of the body, it is impossible to get a desirable antenna pattern as the ground station will be forward of the body for the most part of the trajectory. However, since the ground station is forward of the body, the change in radar cross section due to the insertion of the antenna (as seen by the ground station) is minimized. If the antenna is located at the front of the body, the ground station will see an appreciable change in the radar cross section due to the insertion of the antenna in the body. However, by locating the antenna forward on the body, a desirable antenna pattern is obtained.

The better solution to the problems is to locate the antenna forward in the body and provide a means to hide the missile antenna from the ground radar system. In order to accomplish this a filter window which allows telemetry signals from the antenna in the body to pass through while reflecting any outside radar signals. The filter window must reflect these outside radar signals in such a manner that it appears to be a solid sheet of metal. Such a filter window would, of course, be of great value in any system where cross sections are being studied and it is desirable to install antennas without changing the radar cross section signature of the body being studied. One example of such a system would be in a penetration aid study.

It is an object of the present invention to provide an effective antenna filter window.

A further object of this invention is an antenna filter window which allows radiation from one radar source to pass, while reflecting radiation from another radar source.

A still further object of the present invention is to provide an antenna filter window which employs a system of grids and transmission line elements to hide an antenna in a re-entry body.

The invention further resides in and is characterized by various novel features of construction, combinations, and arrangements of parts which are pointed out with particularity in the claims annexed to and forming a part of this specification. Complete understanding of the invention and an introduction to other objects and features not specifically mentioned will be apparent to those skilled in the art to which it pertains when reference is made to the following detailed description of a specific embodiment thereof and read in conjunction with the

2

appended drawing, the drawing which forms a part of the specification presents the same reference characters to represent corresponding and like parts throughout the drawing, and wherein:

FIGURE 1 is a diagrammatic representation in cross section of a re-entry body containing the antenna and the filter window;

FIGURE 2 is a pictorial showing of the assembled filter window of the present invention; and

FIGURES 3A and 3B show the sides of a preferred embodiment of a filter window in accordance with the invention.

FIGURE 1 shows the placement of the filter window assembly 1 in a missile 3 such as a nose cone or the like. The nose cone has a shell 5 which is covered by an ablative material 7. A slot 9 is cut in the shell of the nose cone so as to accommodate electromagnetic energy emitted from a slot antenna 11. It is this slot 9 in the cone's shell that must be hidden from outside radar.

The filter window assembly shown in FIGURES 1 and 2 comprises two filter window boards 13 and 14 which are held in place by a special bracket 16. This bracket is incorporated as a part of slot antenna 11. The bracket is fitted by screws 17 which extend into the shell so as to support the assembly and to hold together the two filter window boards.

The structure of one of the filter window boards is shown in FIGURES 3A and 3B. The complete filter window consists of two printed circuit boards (13 and 14 shown in FIGURES 1 and 2) etched in copper or the like on both sides as shown in FIGURES 3A and 3B. Each board has one side etched as shown in FIGURE 3A and the other side as shown in FIGURE 3B. The filter boards 13 and 14 should be mirror images of each other in any nonsymmetrical embodiment of this invention. Also, one filter board should have a slightly smaller curvature than the other.

The filter window is assembled by mating the sides of the boards shown in FIGURE 3B so that there will be electrical contact all along the printed circuit on those sides. These boards will be held in position by bracket 16. With this done, the filter window will consist of outside surfaces containing horizontal strips of copper 18 as shown in FIGURE 3A and an inside surface which contains vertical strips of copper 19 as shown in FIGURE 3B.

The outside surfaces of the filter window short-circuit any horizontal polarized electromagnetic radiation, due to the horizontally etched copper strips 18 thereon. Therefore, to any horizontal polarized electromagnetic radiation, the filter window appears as if it were a continuous sheet of copper. The inside surfaces of the board, which are placed face to face, contain vertical strips 19 of copper which vary in thickness. The wider portions 21 of the vertical strips are shorting grids at 1300 mc. (this is the frequency of the ground radar used in the AMRAD program). This is accomplished by forming quarter-wave open circuit transmission lines at 1300 mc. with the lengths of the fine portions 23 of the pattern. By so doing the wide strips 21 are electrically connected to each other (at 1300 mc.) at their bottoms by the transmission lines formed by the fine copper portions 23, and strips 21 are physically connected (and electrically) at their tops by the copper portion 25. Therefore, the vertical strips appear to be shorted at 1300 mc. This arrangement causes electromagnetic waves which are polarized in a direction parallel to these elements to be reflected in a manner very similar to that which would occur if slot 9 were covered with a continuous metal sheet at the design frequency. These elements along with strips 18 will cause a 1300 mc. wave to be reflected at the mouth

of slot 9 regardless of polarization as the two form a grid or mesh.

At the telemetry frequency 245.3 mc. of the antenna 11 of the transmission lines appear as small value capacitors which are distributed across the face of the antenna. Therefore, the vertical strips appear to be shorted at 1300 mc. but offer only capacitive loading at the operation frequency of slot antenna 11. The impedance of the quarter-wave sections 23 (at 1300 mc.) control the amount of capacitive loading, and it is held to a minimum by making the lines 23 as fine as possible. The width of each of these fine portions of the transmission lines is .005".

Although the specific embodiment shown in the drawing and described herein has its circuits as printed circuits, such need not be the case. The grids can be formed by any type radiation pick up conductors which are electrically connected into grids as shown in the drawing. For example, a round copper wire may be used. Likewise the transmission line may be any conventional type, such as a coaxial cable. The grids formed thereby may be held in their 90° position by conventional devices other than a printed circuit board.

In order to determine the electrical effect of the .005" width transmission lines upon antenna 11 at 245.3 mc., one must first solve for the characteristic impedance of the line. The transmission line of this invention is like that of a shielded-strip transmission line having a narrow centerstrip. The centerstrip would be element 23, while the ground planes would be the copper plated portions 27. These ground planes are not formed in the region of the wider strips 21; therefore wider strips 21 are not part of the transmission line. The two copper portions 27 of the assembled filter window are electrically connected to each other by a strip of foil or the like which is bent around the top of the window. The characteristic impedance of such a line using Rexolite 2200 boards having a dielectric constant of 2.59, 0.125" thick, and a 2 oz. copper (0.0027" thickness) is 148 ohms. Solving for the capacitance gives 1.34 $\mu\text{mf.}$ for each of the transmission lines at 245 mc. Therefore, at 245 mc. strips 21 are connected electrically at the bottom by a 1.34 $\mu\text{mf.}$ capacitance and are physically connected at the top. This results in capacitive loading of slot 9 (FIGURE 1) and means that less capacitance is needed in the tuning capacitor 30 of antenna 11 for resonance. Any number of transmission lines may be used, but in our preferred embodiment 10 and 15 gives a desired operation.

When the filter window is assembled and held by bracket 16 in the missile 3, the slot 9 in the shell lines up with the slot 32 in bracket 16. The strips 18 will be aligned with the slot 9, and the wide portions 21 of the strips 19 will be in line with slot 9. However, portion 23 of strips 19 are below the slot. In operation the antenna 11 will operate at 245.3 mc. and will be polarized vertically with respect to the filter window.

A preferred embodiment of the invention has been chosen for purposes of illustration and description. The preferred embodiment illustrated is not intended to be exhaustive nor to limit the invention to the precise form disclosed. It is chosen and described in order to best explain the principles of the invention and their application in practical use to thereby enable others skilled in the art to best utilize the invention in various embodiments and modifications as are best adapted to the particular use contemplated. It will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention as set forth in the disclosure, and that in some cases certain features of the invention may sometimes be used to advantage without a corresponding use of other features.

It is, therefore, to be understood that within the scope

of the appended claims, the invention may be practiced otherwise than as specifically described. Accordingly, it is desired that the scope of the present invention be limited only by the appended claims.

I claim:

1. A filter means comprising a device having a first plurality of radiation pickup means, each of said pickup means having a first and a second end, first means electrically connecting the first ends to each other, a plurality of transmission line means individually connected to the second ends of said pickup means, and each transmission means being a quarter-wave open circuit transmission line for a predetermined frequency, whereby for radiation at said frequency each of said pickup means will appear to be short circuited.

2. A filter means as set forth in claim 1, wherein said plurality of radiation pickup means are in the form of strips and are aligned in parallel so as to form a first grid.

3. A filter means as set forth in claim 2, further comprising a second plurality of radiation pickup means, and each of said second pickup means being short circuited.

4. A filter means as set forth in claim 3, wherein said second plurality of radiation pickup means are in the form of strips and are aligned in parallel so as to form a second grid.

5. A filter means as set forth in claim 4, wherein said first and second grids are aligned 90° with respect to each other.

6. A filter means as set forth in claim 5, further comprising a first printed circuit board, said first grid being a printed circuit on a first side of said board, and said second grid being a printed circuit on a second side of said printed circuit board.

7. A filter means as set forth in claim 6, further comprising a second printed circuit board having printed circuits which are mirror images of the printed circuits on said first printed circuit board, and said first and second boards being fitted together so that the first grids are in direct contact and are aligned face to face.

8. A filter means as set forth in claim 7, wherein said grids are all located in an area in which radiation is to enter and exit by way of a slot, said first and second printed circuit boards having a center conductor of said quarter-wave open circuit transmission line means as part of the printed circuit on the first side of the boards and located outside of said area, and ground planes of the transmission means being formed as printed circuits on the second faces of said boards.

9. A system as set forth in claim 5, further comprising a radiation reflecting container having a slot therein, an inside source of radiation means aligned such that its radiation will pass through said slot, said filter means being located inside said container so that its grids are all located in an area in which outside radiation would enter and exit through said slot, and said filter means being further located between said inside source of radiation means and said slot.

10. A system as set forth in claim 9, wherein said inside source of radiation means has a radiation which is substantially different in frequency from said predetermined frequency, and is polarized in the direction of said first grid, whereby said first grid will only have a capacitance loading effect on said inside source of radiation means, and said second grid will have no loading thereon.

References Cited

UNITED STATES PATENTS

3,142,808	7/1964	Gonda	333—73
3,213,456	10/1965	Korvin	343—756

HERMAN KARL SAALBACH, *Primary Examiner.*

M. NUSSBAUM, *Assistant Examiner.*