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DIELECTRIC CLUTTER FENCE

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FIG. 1
(PRIOR ART)

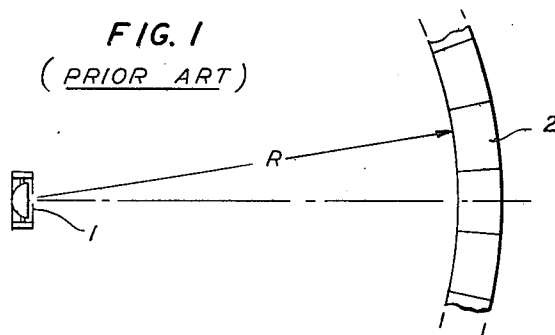


FIG. 2
(PRIOR ART)

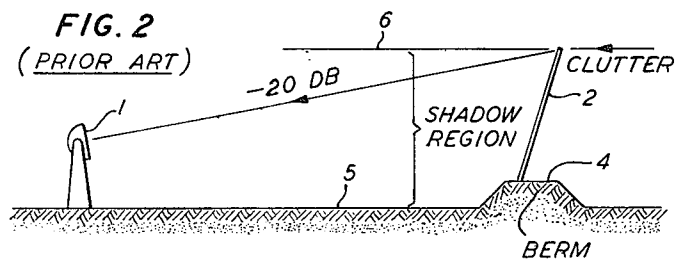


FIG. 3

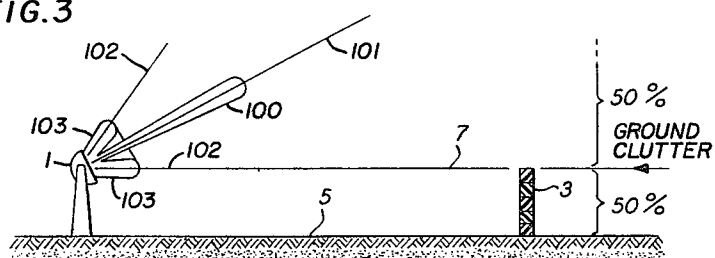


FIG. 4

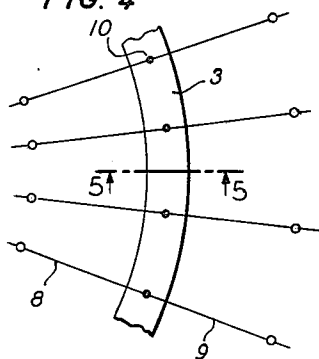
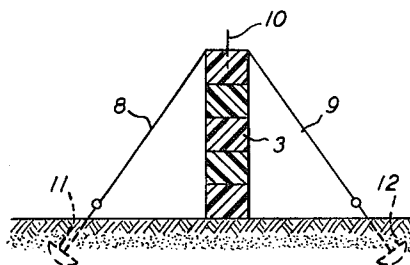


FIG. 5



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DIELECTRIC CLUTTER FENCE

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7 Claims

ABSTRACT OF THE DISCLOSURE

A fence for eliminating ground clutter from an antenna comprising a wall of dielectric material positioned between the antenna and the sources of ground-reflected energy and having a height sufficient to intercept half of the total clutter energy. The dielectric constant and thickness of the fence are such as to reverse the phase of the intercepted energy so that, at the antenna, the energy passing through the fence and that passing around it cancel each other.

This invention relates to the art of reducing the effect of clutter energy reflected into an antenna from ground objects and more particularly to a clutter fence for reducing such effects.

A common means for suppressing ground clutter in a ground-based antenna is to employ a conducting fence interposed between the antenna and the ground reflecting objects. These fences are usually constructed of metal screening having a mesh size which is a sufficiently small fraction of a wavelength to limit the energy transmission through the fence to an acceptable level. Since diffraction inevitably takes place over the top of such a fence, complete cancellation of ground clutter arriving at low elevation angles is impossible. For a given screening angle, the effectiveness of a diffraction fence is improved by making it of larger radius and correspondingly increased height. The allowable cost, therefore, becomes the principal factor in determining the extent of low angle clutter suppression which is possible by means of a diffraction fence. A most serious consequence of the high clutter fence is that it limits the ability of the antenna to receive signals at low angles below which the main beam starts to intercept the fence.

Some improvement in the performance of a metal clutter fence is theoretically possible by serrating its top edge. A clutter signal which returns at very low elevation angles and is diffracted at the top of the fence is divided by the serrated edge into two or more field components which are arranged geometrically, through space-phasing, to cancel each other at the antenna, thus further reducing the clutter. If the fence height is increased to provide the serrations, the increased reduction in clutter is obtained at the expense of a further loss in the low angle receiving capability of the antenna. If the fence height is not increased, very little improvement generally results.

It is an object of this invention to substantially eliminate the effect of ground reflected clutter on an antenna system.

Another object is to simplify and reduce the cost of a clutter fence for an antenna system.

The foregoing objects are achieved by this invention by constructing a fence which employs a principle different from that conventionally employed by the opaque conductive fence. The fence of this invention comprises a wall of dielectric material spaced from the antenna and having sufficient height to intercept half of the total clutter energy arriving at the antenna. The dielectric constant and thickness of the fence are such that the intercepted clutter energy is shifted 180 electrical degrees to cancel the effect of the rest of the energy passing around the fence.

The invention may be better understood by reference to the accompanying drawings, in which:

FIGS. 1 and 2 are plan and elevation views, respectively, of a well known form of clutter fence;

FIG. 3 illustrates an embodiment of the present invention employing a dielectric fence;

FIG. 4 illustrates the plan view of a portion of a dielectric fence embodying the principles of this invention; and

FIG. 5 is a section view on line 5-5 of FIG. 4.

FIG. 1 discloses a conventional arrangement of an antenna 1 protected from clutter energy by a conductive metal fence 2 positioned at radius R from the antenna. Fence 2 frequently consists, in practice, of a plurality of wire mesh sections supported on an earthen berm as indicated in the elevation view in FIG. 2. This fence is secured in place on the top of berm 4 by a suitable truss work, not shown. The antenna 1 is supported on the ground 5 at the center of the arc formed by the fence as indicated in FIG. 1. Clutter energy arriving toward the fence in the direction of the antenna cannot pass through the fence since the mesh size is substantially smaller than a wavelength of the frequencies transmitted. Were it not for the effect of diffraction, the shadow region indicated in FIG. 2 would contain no clutter energy whatever. However, diffraction does take place along the top of the fence resulting in clutter energy being received by the antenna. Usually such fences are designed so that the clutter energy received by diffraction is about twenty db below the energy level passing over the fence. The shadow region extends from a horizontal line 6, level with the top of the fence, to the ground level 5. As previously mentioned, attempts have been made to further reduce the effect of the diffraction by serrating the top of the fence. The object of these serrations is to cause the diffracted energy to be divided in such a way as to produce some destructive interference in the shadow region. These metal fences are quite high and rather expensive to construct and have not been altogether satisfactory in adequately reducing the effect of the clutter return on the antenna.

FIG. 3 illustrates the essential elements of a clutter fence in accordance with the present invention. It is assumed that the clutter energy is arriving at a substantially zero elevation angle and extends from the ground to an infinite height above the ground. The fence 3 in this figure is constructed of dielectric material which has the effect of freely permitting the transmission of radio frequency energy therethrough but nevertheless altering or changing its phase velocity so that energy emerging on the antenna side of the fence will have suffered a phase shift with reference to energy which reaches the antenna without passing through the fence. If the dielectric constant and the thickness of the fence are properly proportioned, this phase shift can be made to equal 180 electrical degrees. The height of the fence is such that 50 percent of the clutter energy which reaches the antenna must pass through the fence while the remaining 50 percent will pass around the fence. The effect of this is that the energy which has passed through the fence to reach the antenna will be exactly out of phase with the clutter energy which has been received by the antenna and which has not passed through the fence. These two energies cancel one another at the antenna thereby eliminating the effect of ground clutter.

While an earthen berm 4 has been illustrated in FIG. 2, it is not necessary that such a berm be used and it may be desirable to have the fence extend to the ground level as shown in FIG. 3. It is also quite possible that the fence may be supported some distance above the ground so that energy may pass both under the fence and

over the fence provided that the height of the fence is sufficient to intercept substantially half of the clutter energy arriving at the antenna. However, in practice, it is generally more economical to support the dielectric wall 3 directly on the ground.

As illustrated in FIG. 3, wall 3 may be constructed of a plurality of blocks of dielectric material which may be arranged in much the manner of an ordinary masonry wall, the joints being secured by a suitable cement. This dielectric material may consist of polystyrene foam blocks with or without artificial loading. The blocks may also be constructed of low loss concrete or dry wood, these three materials illustrating the range of materials which are suitable for this purpose. After erection, the wall should be given a water-proof coating to prevent excessive absorption of rain water which would necessarily alter the phase shift characteristics of the fence. It is well known that unloaded dielectric materials generally result in retarding or slowing down the phase velocity of the energy passing through them. It is also known that, with proper loading of these dielectric materials with metal rods, wires or wire mesh, the phase velocity may be increased over that normally existing in free space. Loaded dielectrics having this property are described in *Microwave Lenses* by J. Brown (1953), pages 59-61. In either case, the dielectric constant and the thickness of the fence must be proportioned to result in a phase reversal of the energy passing through the fence as compared with the energy passing around the fence. As indicated by line 7, the height of the fence is approximately level with the antenna which will cause the fence to intercept approximately half of the clutter energy. This, of course, may have to be altered slightly in a particular installation to better suit the terrain causing the clutter return. It is quite evident that the fence 3 of this invention is much lower than the conventional metal fence 2 and since the material of which it is constructed is also much lighter, it will be considerably more economical to construct.

Antenna 1 in FIG. 3 is shown with the axis 101 of its main lobe 100 directed to such an angle above the horizontal line 7 that the substantially conical axis 102 of its first side lobe 103 has an element coinciding with line 7. Even assuming that no signal energy is actually arriving along axis 101, ground clutter energy entering side lobe 103 along line 7 would, without fence 3, cause the antenna to sense one or more false signals as if they were arriving along axis 101. It is a well known fact that clutter energy reflected from surfaces a few miles from the antenna and entering a side lobe can sometimes be so much stronger than a more distant signal arriving on axis 101 that, without fence 3, the signal is masked by the clutter energy despite the greater sensitivity of the main lobe. The angular separation of lobes 100 and 103 of the antenna pattern in FIG. 3 has been greatly exaggerated for clarity. In a typical pencil beam antenna, the width of the main lobe 100 at its half power points may have an angle in the order of only one or two degrees while the axis of the first side lobe may be displaced from the main lobe axis by only two to four degrees so that a clear polar coordinate showing of these lobes in true scale is virtually impossible. Because of these narrow beam angles, the main beam lobe can receive signals arriving from any elevation angle above the horizontal down to only a few degrees above the horizontal without appreciable side lobe pick up of clutter energy, providing fence 3 of this invention is positioned as shown in FIG. 3.

FIG. 4 illustrates a plan view of a portion of the dielectric fence of this invention showing the manner by which the fence may be further supported against wind loads. If the fence is constructed of large polystyrene foam blocks as previously suggested, these blocks may be laid up in much the same manner as an ordinary brick wall with a suitable adhesive between the blocks. The assembled wall would then be completely coated on its exterior surface with a suitable water-proofing material.

Additional lateral support is provided by a plurality of guys 8 and 9 spaced as required along the length of the wall. These guys may be secured to the top of the wall by means of pins 10. FIG. 5, which is a section view of wall 3 on line 5-5 of FIG. 4, shows the guys 8 and 9 and a pin 10. The lower ends of guys 8 and 9 are secured to suitable anchors 11 and 12 embedded in the earth. Guys 8 and 9 may be made of polyethylene rope or a metal wire. Alternatively, the guys may be secured to the top of pin 10 and the pin may extend entirely through the wall and rest directly on the ground, thereby making it possible to increase the tension in guys 8 and 9 without substantial distortion of the polystyrene wall. While FIGS. 4 and 5 illustrate one suitable way of supporting the wall against wind loads, another method, not shown, may consist of a metal framework for supporting the blocks. The openings in this framework should exceed several wavelengths of the frequencies to be transmitted or received so that the fence will remain substantially transparent to them.

Reflections at the interface between the air and the dielectric wall may be neglected if the dielectric constant does not exceed three or four. For these low dielectric constant materials, design need only provide the required 180 degree phase shift. However, if the dielectric constant exceeds three or four, correction must be made for the reflections to prevent an undesirable reduction in transmission through the wall. Corrective measures may consist of a plurality of layers of decreasing dielectric constant or by employing a tapered dielectric material supported on the outside walls. Another way of reducing the reflections where a narrow band of frequencies are to be employed is to select a wall thickness and a suitable dielectric constant such that they not only provide the required 180 degree phase change for cancelling the clutter energy but the surface reflections also cancel each other by employing a principle analogous to that of the half-wave plate in optics.

From the foregoing description it will be quite evident that the advantages offered by the dielectric fence of this invention over the opaque, non-serrated fence of the prior art are: (1) complete cancellation of clutter energy arriving at substantially zero elevation angle is possible at a single frequency, (2) a 20 db one way suppression may be achieved with a 10 percent bandwidth, (3) the maximum height of the dielectric fence is approximately half of the usual metal clutter fence, and (4) the antenna is able to receive signals at lower elevation angles which approximate half the screened angle of the opaque fence. It is, therefore, evident that this invention affords a substantial improvement both from the standpoint of economy as well as from the standpoint of operational advantages. The embodiment disclosed herein should be considered illustrative only and not in any way restrictive either as to the material that may be employed for construction the fence or the manner of assembling and supporting it.

What is claimed is:

1. A clutter fence for an antenna system adapted for the reception of radio frequency electric energy in which the signal energy received by said antenna has superimposed thereon clutter energy reflected from ground objects, said fence comprising a wall of dielectric material spaced from said antenna and positioned to intercept substantially half of the clutter energy received by said antenna, the thickness of said fence and the dielectric constant of said material being proportioned to shift the phase of the intercepted energy substantially 180 electrical degrees with reference to the phase of the rest of the clutter energy passing around the fence.

2. A clutter fence for an antenna system adapted for the reception of radio frequency electric energy in which the signal energy received by said antenna has superimposed thereon clutter energy reflected from ground objects, said fence comprising a wall of dielectric material spaced from said antenna and positioned to intercept sub-

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stantially half of the clutter energy received by said antenna, said dielectric material having the property of changing the phase velocity of the radio frequency energy passing therethrough, the thickness of said fence and the dielectric constant of said material being proportioned to shift the phase of the intercepted energy substantially 180 electrical degrees with reference to the phase of the rest of the clutter energy passing around the fence and received by said antenna.

3. The combination of claim 2 wherein said dielectric material has the property of reducing the phase velocity of the radio frequency energy passing therethrough so that the phase of the intercepted energy emerging from said wall is retarded with reference to the energy passing around said wall.

4. The combination of claim 2 wherein said dielectric material has the property of increasing the phase velocity of the radio frequency energy passing therethrough so that the phase of the intercepted energy emerging from said wall is advanced with reference to the energy passing around said wall.

5. A clutter fence for an antenna system adapted for the reception of radio frequency electric energy in which the signal energy received by said antenna has superimposed thereon clutter energy reflected from ground objects, said fence comprising a wall of dielectric material spaced at a substantially constant radius from said antenna and extending through an arc commensurate with that through which the antenna receives clutter energy, the height of said wall being sufficient to intercept substantially half of the clutter energy received by said antenna, said dielectric material having the property of changing the phase velocity of the radio frequency energy passing therethrough, the thickness of said fence and the dielectric constant of said material being proportioned to shift the phase of the intercepted energy substantially 180 electrical

degrees with reference to the phase of the clutter energy passing around the fence and received by said antenna.

6. The combination of claim 5 wherein said dielectric material has the property of reducing the phase velocity of the radio frequency energy passing therethrough so that the phase of the intercepted energy emerging from said wall is retarded with reference to the energy passing around said wall.

7. The combination of claim 5 wherein said dielectric material has the property of increasing the phase velocity of the radio frequency energy passing therethrough so that the phase of the intercepted energy emerging from said wall is advanced with reference to the energy passing around said wall.

References Cited

UNITED STATES PATENTS

2,396,096	3/1946	Goldstine	343—100
2,405,992	8/1946	Bruce	343—910 X
2,412,202	12/1946	Bruce	343—841 X
2,599,944	6/1952	Salisbury	343—841 X
2,763,001	9/1956	Bussey	343—909 X

OTHER REFERENCES

Screening Fences for Ground Reflection Reduction, Fritz K. Preikschat, Microwave Journal, August 1964, pp. 46—50.

J. Brown, Artificial Dielectrics Having Refractive Indices Less Than Unity, Proc. I.E.E. (London) vol. 100 Part IV #5, October 1953, pp. 51—62.

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U.S. Cl. X.R.

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