343-754. SR
6-4-74 OR 3,815,138

United States Patent [19]

Haley

[11] **3,815,138**

[45] **June 4, 1974**

[54] **PASSIVE RERADIATOR OF RADIO-FREQUENCY ELECTROMAGNETIC ENERGY**

[76] Inventor: **Alan W. Haley,** 3777 Kerner Blvd., San Rafael, Calif. 94901

[22] Filed: **Aug. 23, 1973**

[21] Appl. No.: **391,423**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 228,188, Feb. 22, 1972, abandoned.

[52] **U.S. Cl.** **343/754,** 343/909
[51] **Int. Cl.** **H01q 15/02**
[58] **Field of Search** 343/700, 706, 833, 909, 343/912, 754

[56] **References Cited**

UNITED STATES PATENTS

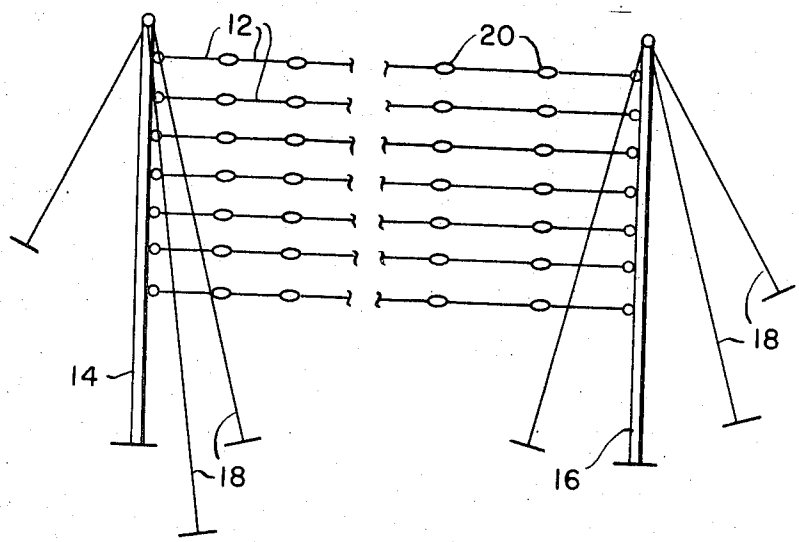
3,453,629 7/1969 Stahler et al. 343/754

Primary Examiner—Eli Lieberman
Attorney, Agent, or Firm—R. S. Sciascia; Philip Schneider; Arthur L. Branning

[57] **ABSTRACT**

A device for reradiating r.f. energy into shadowed areas behind mountains, for example, said device comprising a passive antenna array without reflectors or transmission line and having a plurality of half-wave dipole antennas spaced from each other by electrical insulators, the dipoles being arranged in strings and the strings being arranged in vertically closely spaced rows between side-support members.

10 Claims, 9 Drawing Figures



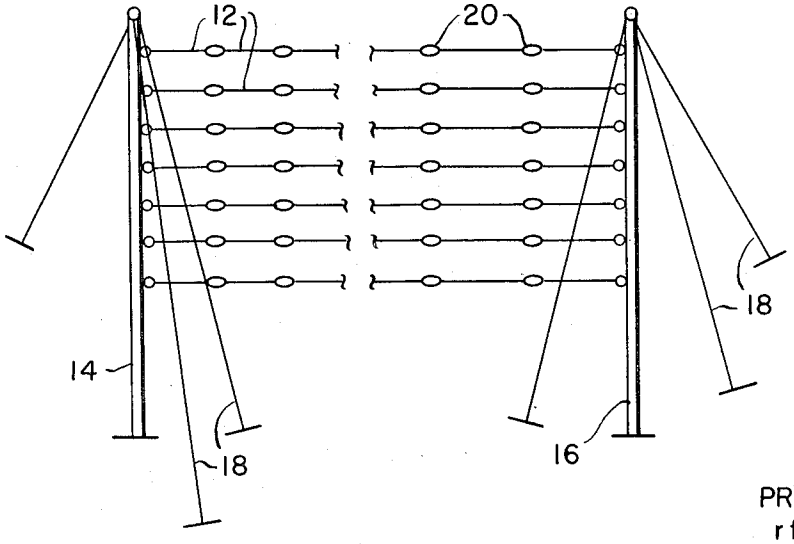


FIG. 1.

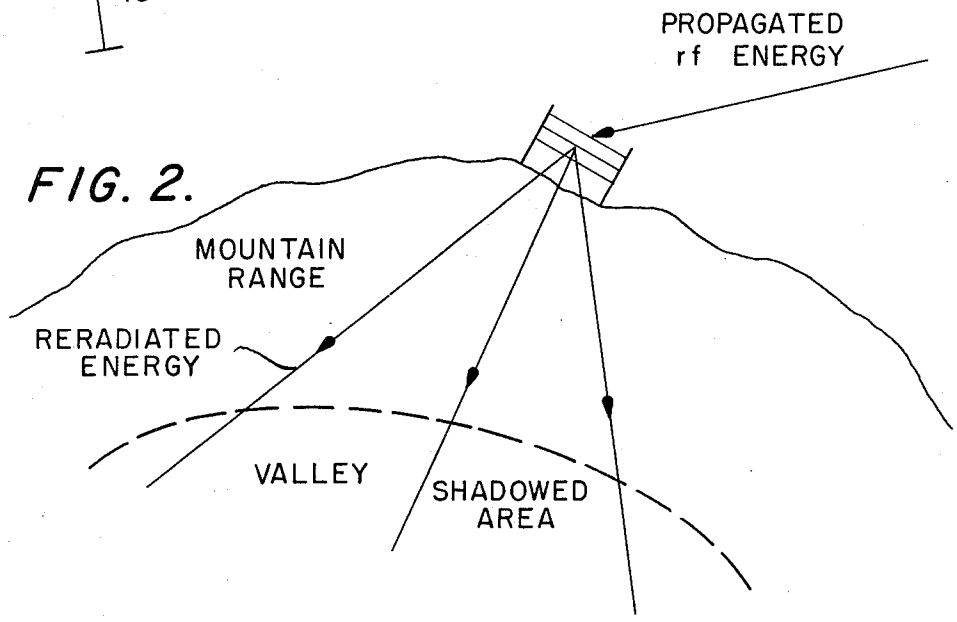


FIG. 2.

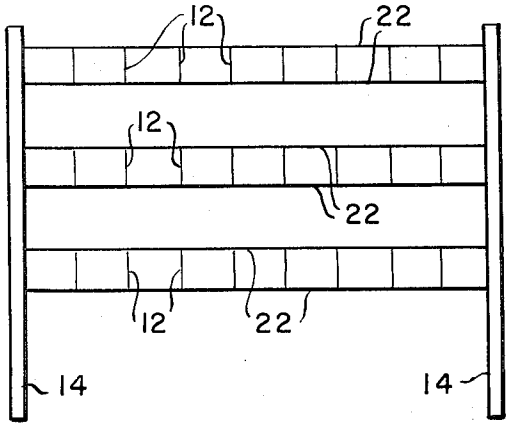


FIG. 3.

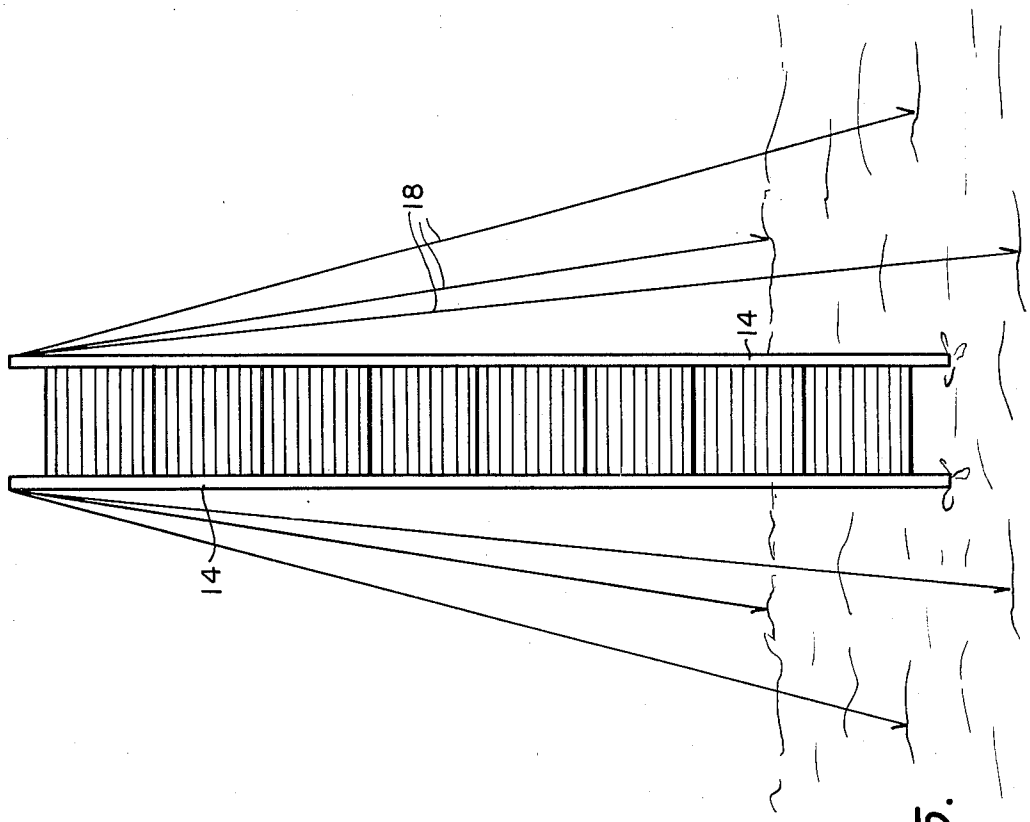


FIG. 5.

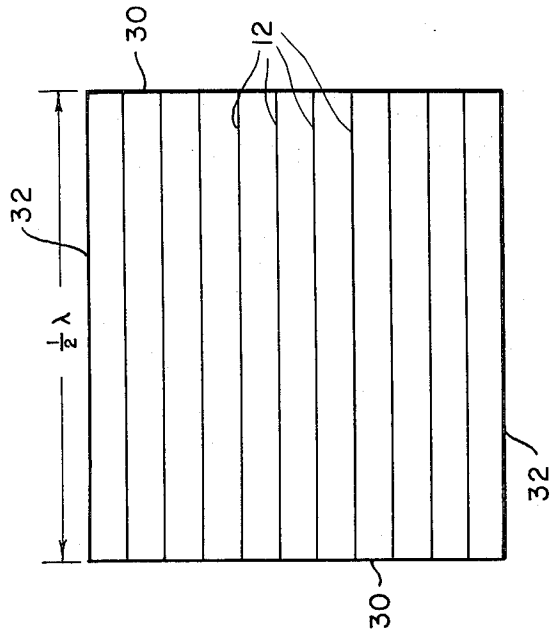


FIG. 4.

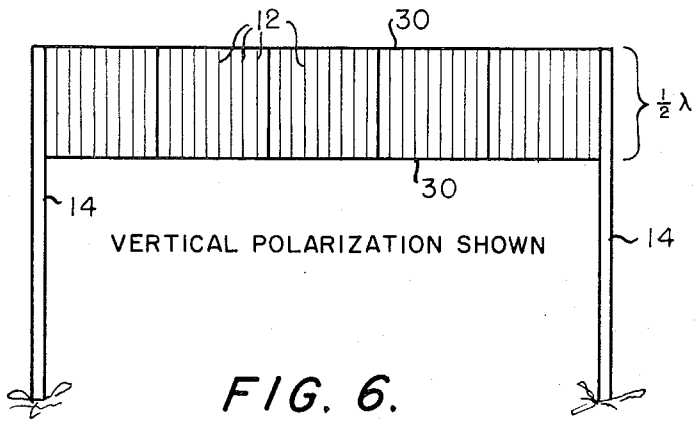


FIG. 6.

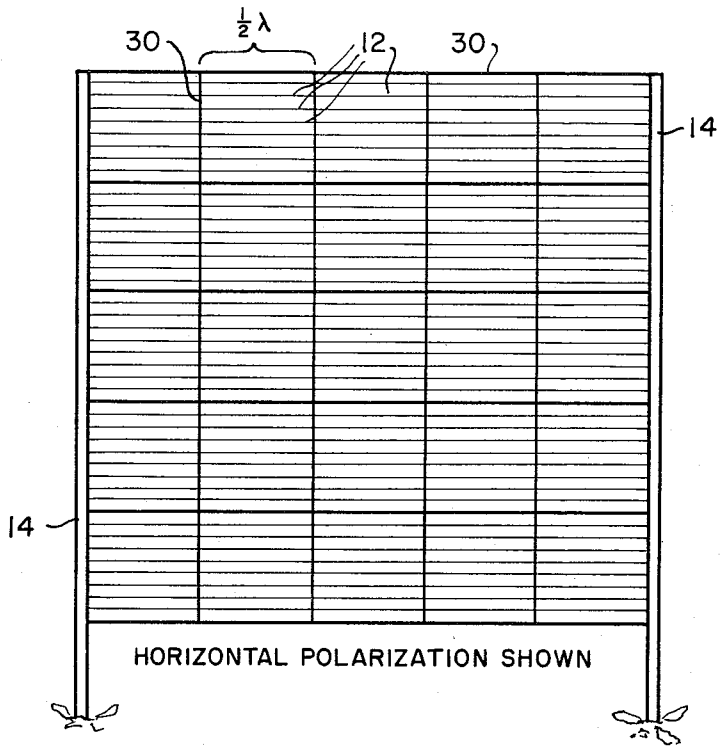


FIG. 7.

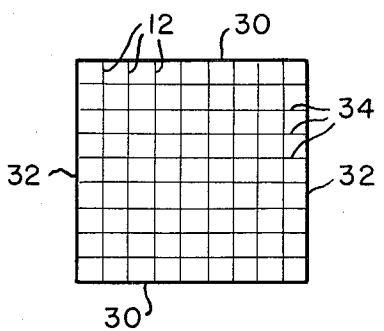


FIG. 8.

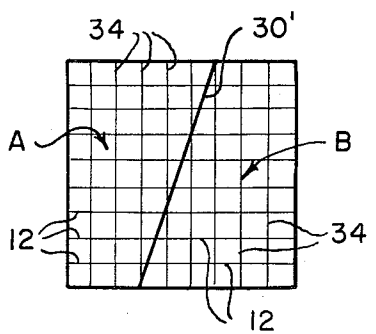


FIG. 9.

PASSIVE RERADIATOR OF RADIO-FREQUENCY ELECTROMAGNETIC ENERGY

This application is a continuation-in-part of application Ser. No. 228,188, filed Feb. 22, 1972, now abandoned.

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to reradiation of propagated r.f. electromagnetic energy and especially redirection of such energy into shadowed areas such as valleys which are shielded by mountains.

Valleys which are shielded by mountains which stand in the path of r.f. electromagnetic waves coming from radio stations, for example, receive very little of the electromagnetic energy, so that reception of signals in such shadowed areas is usually very poor.

Methods which have been employed to direct r.f. energy into such shadowed areas include the use of reflectors for microwave frequencies and translators for lower frequencies. Practical reflectors are limited to frequencies above one gigahertz. Translators are costly, require frequency allocations and licensing in the case of commercial applications, and require power and continual maintenance.

SUMMARY OF THE INVENTION

The present invention, which provides for reradiation of intercepted r.f. electromagnetic energy in a downward direction, comprises an array of strings of, passive, half-wave dipole antennas with close spacing between parallel dipoles.

An object of this invention is to reradiate intercepted r.f. electromagnetic energy into shadowed areas.

Another object is to reradiate r.f. electromagnetic energy intercepted at a high elevation into a lower shadowed area.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of a horizontally polarized embodiment of the invention;

FIG. 2 is an illustration of the manner in which the invention illuminates a shadowed area behind a mountain range;

FIG. 3 is a schematic illustration of a vertically polarized embodiment of the invention;

FIG. 4 is a schematic illustration of another embodiment comprising a basic array element;

FIG. 5, 6 and 7 show stacked array elements having different configurations;

FIG. 8 shows a different basic array element in the form of a screen; and

FIG. 9 shows a basic array element having broadband characteristics.

DETAILED DESCRIPTION

An embodiment of the invention is shown in FIG. 1. Strings of half-wave, dipole antennas 12 are arranged in closely spaced rows between two side-support members such as poles 14 and 16 which are imbedded in the earth and supported by guy wires 18. The dipoles 12 are horizontally spaced from each other by electrical insulators 20 and may be fabricated from any electrical conductor such as No. 12 copper wire, for example. The entire assembly is similar to a broadside antenna array without reflectors and transmission lines. In FIG. 1, the vertical spacing appears to be greater than it is in reality, for clarity of illustration

In one embodiment of the invention, one hundred, half-wave, horizontally polarized dipoles of No. 12 copper wire insulated from each other by ceramic insulators was used. The array was arranged in 10 rows of ten dipoles per row. In one mode of operation, the vertical spacing of the dipole rows was ⅛ of a wavelength of the intercepted radio waves and in a second mode of operation, the vertical spacing was decreased to 1/32 of a wavelength. This close spacing of the dipoles in the parallel direction may be further decreased to 1/1000 of a wavelength and even 1/3000 of a wavelength at some frequencies. Close spacing of the dipoles allows the use of a great number of dipoles for a given capture area, thereby increasing the effective radiated power of the array. It also has the effect of creating a very broad beam lobe given broad coverage to the retransmitted signals as opposed to the narrow point-to-point beam (and lower effective radiated power) achieved by the antenna shown in U.S. Pat. No. 3,453,629. The array of the present invention is thus suitable for relaying communications to mobile tactical units or for extending the coverage of television or FM radio stations in a manner acceptable to the Federal Communications Commission.

The array was set up on a hilltop approximately 450 feet above a valley floor which was in a shadowed area for the signal of interest. Radio-frequency field strength measurements were made at a wide variety of locations on the valley floor before and after installation of the array. In all cases, the signal level increased significantly with an average increase of 100 percent and a maximum increase of over 1,000 percent. All of the energy received or intercepted by the array is reradiated except for a small amount of "copper loss", a portion of the reradiated energy being deflected downward in the direction of signal propagation. This portion enhances the propagated energy which is deflected downward by the "knife edge effect" by which r.f. signals are apparently bent downward toward the earth when passing over a mountin edge which is approximately at a right angle to the direction of propagation of the signal.

The effect of decreased vertical spacing between the rows of the array is to concentrate the reradiated signal into a smaller area.

The array can consist of any number of dipoles and can be curved concavely or convexly with respect to the direction of signal propagation in order to focus or defocus the forward beam lobe.

FIG. 2 is self-explanatory, showing how an array placed on top of a mountain intercepts some of the propagated r.f. signal energy and reradiated it down-

ward to the shadowed area in the valley beyond the mountain.

FIG. 3 illustrates the construction of an array which is vertically polarized. The dipole elements 12 are arranged vertically between horizontal insulating lines which may, for example, be made of nylon line. Insulating poles may also be placed in the middle of the array as necessary to pervent sagging of the insulating lines. Other arrangements are possible to provide for other propagated signal polarizations.

The dipoles 12 are shown as single elements here. However, they may consist of strings of two or more dipoles as shown in FIG. 1. The close spacing with a vertically polarized array is close spaced in the horizontal direction in FIG. 3 as opposed to the vertical direction in FIG. 1. If the dipoles in FIG. 1 are considered paralleled in the vertical direction and those in FIG. 3 paralleled in the horizontal direction, then they both are closely spaced in the parallel direction, or it can be said that there is close spacing between parallel dipoles.

(Again, for clarity of illustration, the dipoles are not shown closely spaced in the parallel direction.)

Another embodiment of the invention is shown in FIG. 4. This comprises a basic array element consisting of a set of parallel, spaced, dipole elements 12 which may consist of ⅛-inch metal rods, for example, each attached rigidly at both ends to a transverse metallic rod 30. Rods 32, similar to rods 30, are welded to rods 30 to form a square (or rectangular) rigid frame. The length of each dipole element 12 is one-half wavelength at the frequency of interest. Since the dipole resonates at this frequency and, at its resonant frequency, a dipole exhibits infinite impedance at its ends, the connections at the frame elements 30 appear to be open circuits — at other frequencies, the connections appear to be low impedances or short circuits. Thus, the array can be easily mounted and the frame can be grounded, if desired.

FIGS. 5, 6 and 7 show stacked arrays of a plurality array elements FIGS. 5 and 7 having horizontal polarization and FIG. 6 vertical polarization. FIG. 7 is a more massive array delivering a higher signal level into the shadow area.

Another type of basic array element is shown in FIG. 8. This is formed in the manner of a common window screen with the strands, or dipole elements 12, in one direction being of metal wire, these being interwoven with plastic strands 34 at an angle of 90°. The framework is formed from metal rods 30 and 32, preferably, the length of the dipole elements 12 being ½-wavelength at the desired frequency.

The embodiment of the basic array element shown in FIG. 9 is an array element that has broadband characteristics. The array is split into two members, adjacent trapezoids A and B, by internal rod 30′ to which the dipole elements 12 are attached. The dipole elements here are of different lengths in an ordered series. Of course, only two dipole elements, one in member A and one in member B, resonate at any particular frequency in the band over which the array is useful.

Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A passive r.f.-electromagnetic-energy, reradiating device comprising, in combination:
a plurality of integral half-wave dipole antennas; and means for supporting said dipoles,
said dipoles being insulated from and disposed between said supporting means parallel to and spaced closely in the parallel direction from each to form an array of dipoles, said spacing being equal to or less than 150 wavelength at the resonant frequency of the dipoles,
said dipoles having no energy feed or energy derivation means connected thereto.

2. A passive reradiating device as in claim 1, wherein:
said means for supporting said dipoles includes a quadrilateral metal frame, said dipoles being strung between two opposite sides of said frame and making electrical contact therewith, the electrical contacts being open-circuits at the resonant frequency of said dipoles.

3. A passive reradiating device as in claim 2, wherein groups of said framed dipoles are vertically stacked.

4. A passive reradiating device as in claim 2, wherein groups of said framed dipoles are horizontally stacked.

5. A passive reradiating device as in claim 2 wherein groups of said framed dipoles are both horizontally and vertically stacked.

6. A passive reradiating device as in claim 2 wherein said dipoles comprise strands of wire, and further including a plurality of strands of insulating material interwoven with and at right angles to said strands of wire.

7. A passive reradiating device as in claim 6, further including a metal rod disposed at an angle within and affixed at both ends of said metal frmae to form a pair of trapexoidal figures therewith, said strands of interwoven wire and insulating material being attached between said frame and said internal metal rod to form two trapezoidal groups of dipoles, the lengths of said dipoles within each said trapezoidal group increasing in an ordered series.

8. A r.f. electromagnetic energy reradiating device comprising, in combination:
a plurality of integral, half-wave dipole antennas;
a plurality of electrical insulators; and
a pair of side-support members,
said dipoles being arranged in strings wherein the dipoles are separated by said insulators, each string extending between and beng attached at its ends to said side-support members, and said strings being arranged in closely spaced rows in the parallel direction,
said spacing being equal to or less than ⅛ wavelength at the resonant frequency of the dipoles,
said dipoles having no energy feed or energy derivation means connected thereto.

9. A device as in claim 8, wherein each string is composed of a series of insulators and horizontal dipoles so that a horizontally polarized array is formed.

10. A device as in claim 8, wherein each string comprises a pair of insulating lines strung horizontally between said side-support members and a plurality of dipoles spaced from each other and standing vertically between said pair of insulating lines.

* * * * *