

Oct. 21, 1969

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3,474,452

OMNIDIRECTIONAL CIRCULARLY POLARIZED ANTENNA

Filed Feb. 16, 1967

3 Sheets-Sheet 1

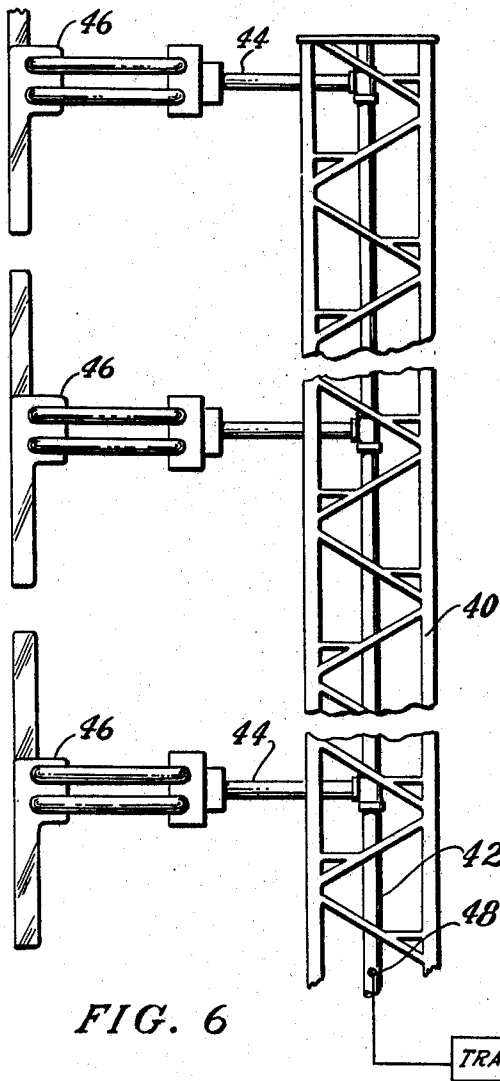


FIG. 6

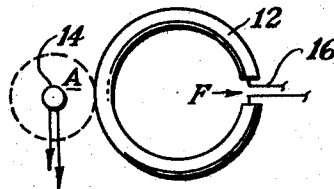


FIG. 1

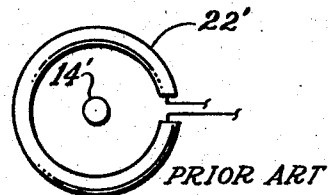


FIG. 2

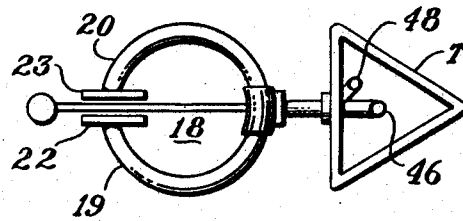


FIG. 3

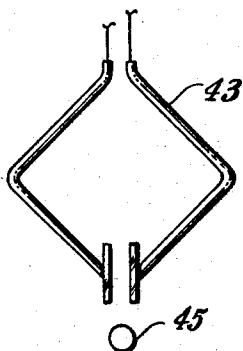


FIG. 10

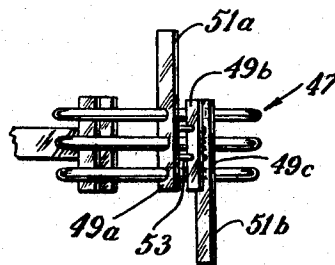


FIG. 11

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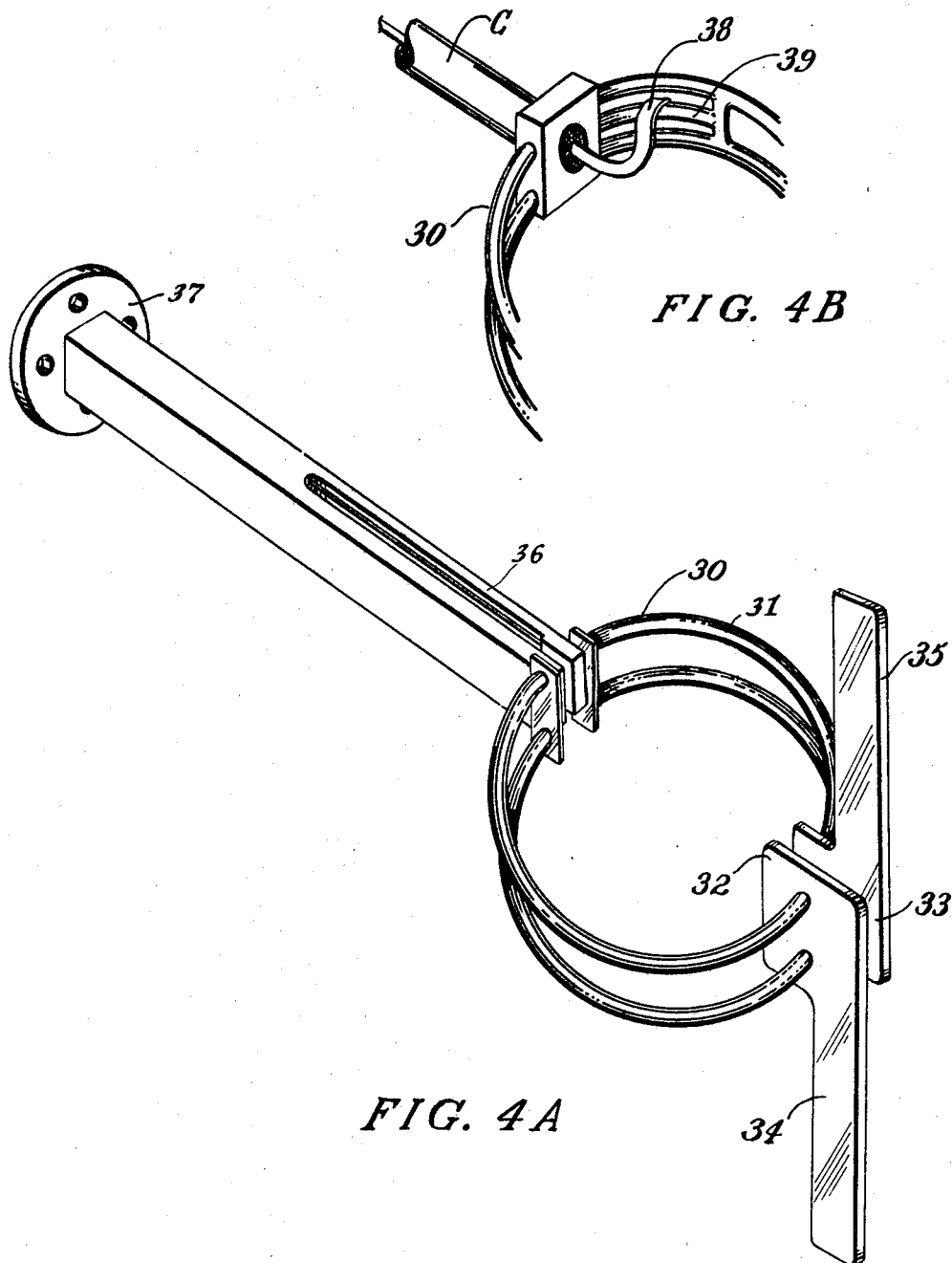


FIG. 4A

FIG. 4B

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3 Sheets-Sheet 3

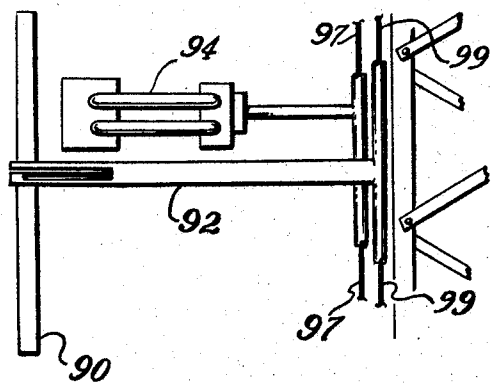


FIG. 9

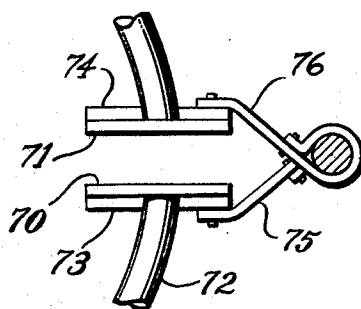


FIG. 8

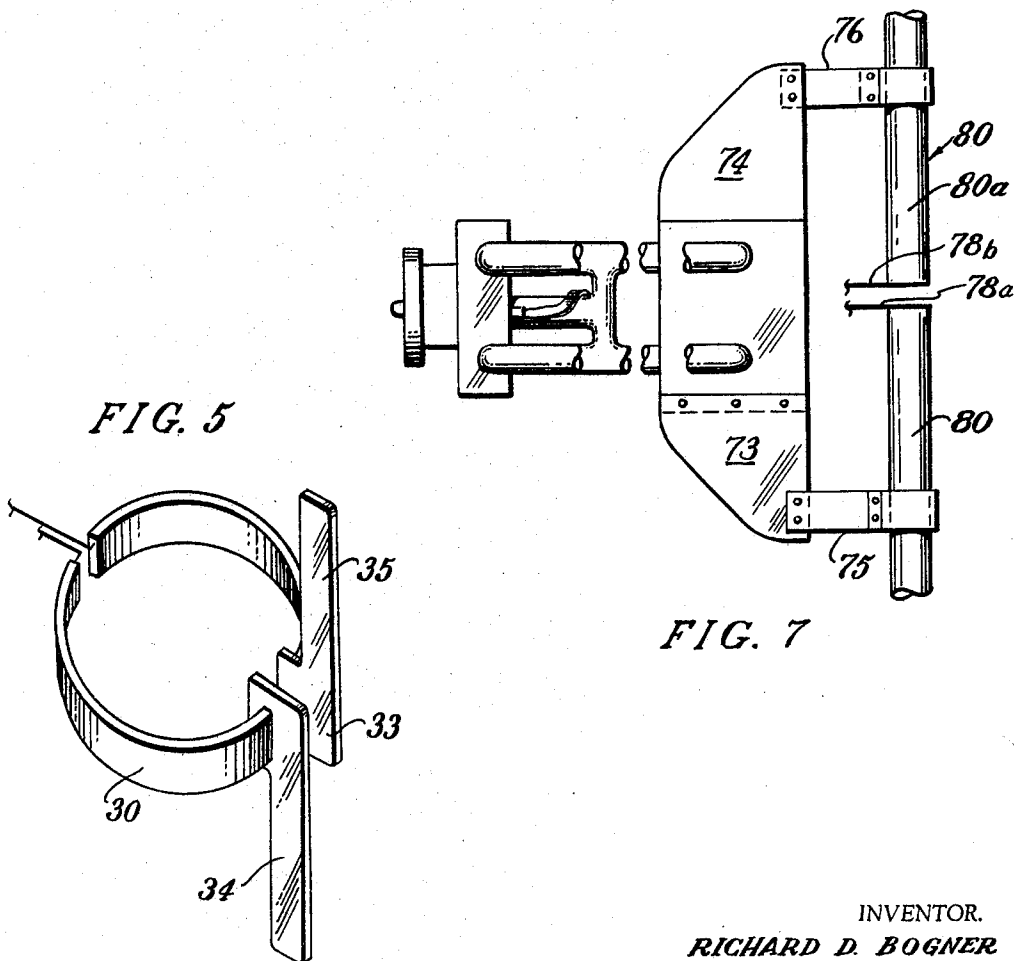


FIG. 5

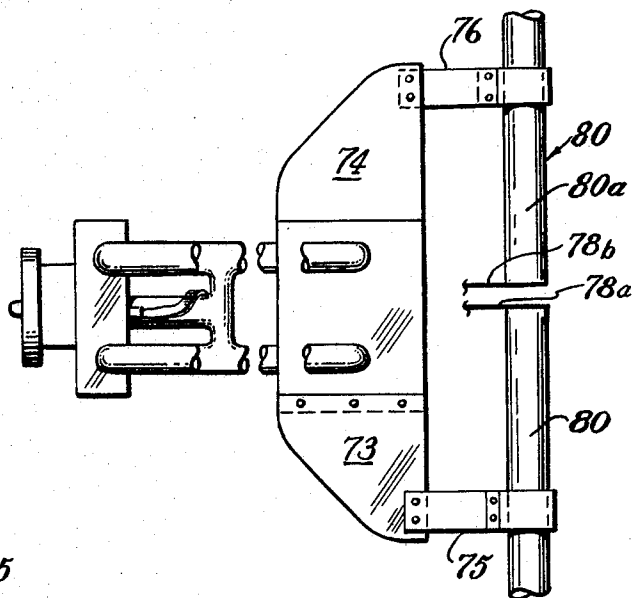


FIG. 7

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## OMNIDIRECTIONAL CIRCULARLY POLARIZED ANTENNA

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17 Claims

### ABSTRACT OF THE DISCLOSURE

A horizontally polarized loop and a vertically polarized dipole are combined to provide a single omnidirectional circularly polarized antenna.

### BACKGROUND OF THE INVENTION

It is well known that a combination of vertical and horizontal polarization (with respect to some reference plane, e.g., the earth's surface) will result in circular or elliptical polarization of radiation, depending upon the relative phase and amplitude relationship. Vertically polarized radiation may be obtained from a vertical antenna such as a vertically oriented dipole; horizontally polarized radiation may be obtained from a horizontal antenna such as a horizontally oriented dipole or loop. The loop may be bent into a complete circle, or be peripherally incomplete with the open ends of the semicircular conductors being connected together electrically by capacitance plates. Either loop form has a toroidal radiation pattern polarized in the plane of the omnidirectional pattern and of the loop. A vertical dipole has the same radiation pattern but polarized transverse to the plane of the omnidirectional pattern.

It has been suggested in the literature that these two antenna types with identical radiation patterns when orthogonally polarized be combined to form a circularly polarized antenna, omnidirectional in one plane, usually the horizontal plane. To do this, it is necessary to so locate the loop and dipole that their phase centers are essentially coincident, and then to feed the two with equal signal, and 90° phase difference. It is usually assumed that the dipole in the center of the loop is the proper arrangement. This arrangement is taught for example, in the following U.S. Patents: 2,45,379 to Armig G. Kandorian; 2,460,260 to Paul J. Kibler; 2,953,782 to Denis Byatt; and is discussed in the Antenna Engineering Handbook, edited by Dr. Henry Jasik ©1961, McGraw-Hill Book Company, sec. 17.2, p. 17-9, FIG. 17-8.

I have found that in practice, contrary to theory and general opinion as being "obvious," the arrangement with the dipole at, or even near, the loop center does not provide circular polarization in every direction in the loop plane. In fact, for this case, with any relative phase and amplitude between the dipole and the loop, the polarization departs radically from circular, and is in fact linear or near linear, in one or more directions in the omnidirectional pattern plane.

I have further found, however, that there does exist an arrangement of the loop and dipole wherein proper relative phase and amplitude provides equal signal and circular polarization in every direction in the plane of the loop. This arrangement is quite an unexpected one, since it requires the dipole to be actually external to the loop, a small distance from the loop, and on the opposite

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side from the loop feed point. Often such a loop has a small gap opposite the feed point possibly with capacitance plates as described above, and if such a loop gap is used, the dipole should be placed just beyond it.

If a loop and dipole are so arranged and fed with proper, usually near equal amplitude, and proper relative phase as determined by experiment, then a circularly polarized omnidirectional pattern is obtainable, within the 3 db variation limits generally accepted in the art.

Accordingly, it is a principal object of this invention to provide an improved circularly polarized omnidirectional antenna.

A principal object is to provide a modified loop antenna having a circularly polarized transmission pattern.

Another object is to provide a single structure having the characteristics of a horizontal loop antenna and a vertical dipole antenna operating in unison.

Still a different object is to provide a horizontal loop antenna and a vertical dipole antenna having a circularly polarized pattern and which is energized by a single feed.

These and other features, objects and advantages of the invention will, in part, become obvious from the following more detailed description of the invention taken in conjunction with the accompanying drawing which forms an integral part thereof.

### SUMMARY OF THE INVENTION

It has been found that a capacitance plate type loop antenna, having dipole elements extending from the capacitance plates, can provide an omnidirectional radiation pattern in one plane circularly polarized in every direction in that plane. The dipole elements may be electrically connected to the capacitance plates for direct feed, or mechanically supported from the capacitance plates but electrically isolated from the plates with independent feed. Alternatively, the dipole may be independently supported and fed, provided the dipole is maintained proximate to the capacitance plates.

### BRIEF DESCRIPTION OF THE DRAWING

In the various figures of the drawing, like reference characters designate like parts.

In the drawing:

FIG. 1 is a plan view of a vertical dipole antenna and a horizontal loop antenna combined in accordance with this invention;

FIG. 2 is a plan view of a vertical dipole antenna and a horizontal loop antenna combined in accordance with the prior art;

FIG. 3 is a plan view of a vertical dipole and a folded loop antenna combined in accordance with this invention;

FIG. 4A is a pictorial showing of a preferred combined loop-dipole structure;

FIG. 4B is a pictorial showing of the loop-dipole structure of FIG. 4A with a different feed;

FIG. 5 is a pictorial showing of an alternative combined loop-dipole structure;

FIG. 6 is a side elevational view of an array of dipole-loop antennas;

FIG. 7 is a side elevation of a vertical dipole antenna mounted on a horizontal loop antenna;

FIG. 8 is a plan view of the structure of FIG. 7;

FIG. 9 is a side elevation of another combined vertical dipole antenna;

FIG. 10 is a plan view of an alternative loop-dipole antenna; and

FIG. 11 is an elevational view of a loop-dipole antenna.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1, there is shown a capacitance plate loop antenna 12 with a dipole 14 located opposite the loop feed point 16. In contrast, FIG. 2 shows the prior art configuration with the dipole 14 placed at the center of the loop 12. The art has generally recognized the obviousness of the arrangement of FIG. 2 and it has been generally assumed that by locating the dipole at the center, the phase centers would coincide. This has not been found to be true for practical loops.

With the dipole located outside the loop and just forward of the loop opposite the loop feed point F, substantial coincidence of the phase centers is obtained and the polarization is close to circular in every direction. The location of the dipole should be generally within an area A of  $\lambda/4\pi$  diameter in front of the loop, centered at a point furthest from the supporting tower. In addition, it is advantageous to maximize the distance between the vertical dipole and the supporting tower. The arrangement of the loop and dipole in FIG. 1 accomplishes this goal. The half wave form of the loop 18, shown in FIG. 3, is generally preferred by the industry because it is smaller. The ends of the conductors 19 and 20 terminate in capacitance plates 22 and 23. Loops are generally  $\lambda/2$  in circumference which corresponds to a diameter of  $\lambda/2\pi$ .

In FIG. 4 there is shown the presently preferred embodiment. A loop antenna 30, shown by way of example as a double ring type and comprising a loop section 31 which terminates in a pair of capacitor plates 32, 33 and a conductive dipole arm 34 of approximately  $\lambda/4$  in length is electrically and structurally secured to plate 32 and a like arm 35 is similarly secured to plate 33. The overall length of the vertical dipole is therefore about  $\lambda/2$ . For the purpose of connecting the antenna to a coaxial transmission line, a balun 36 is employed. The balun may be mounted on a tower by means of flanges 37 and fed from a coaxial line.

In the embodiment of FIG. 4B, the dipole-loop antenna 30 is fed from coaxial line C. The outer conductor of the coaxial line being directly connected to the loop and the inner conductor an inductive strap 38 is attached to a suitable point on member 39 for the purpose of impedance matching.

The loop configuration is not critical. By way of example, there are shown other configurations. In FIG. 5, a cylindrical loop configuration 41 is shown. A rhombic loop 43 with a dipole 45 is shown in FIG. 10. A tripling loop antenna 47 is shown in FIG. 11. The capacitor plates needs not be one-piece and indeed as shown in FIG. 11, may be separate segments 49a, 49b and 49c. Dipoles 51a, 51b, are shown extending from opposite plates 49a and 49c. Plate 49b is supported by dielectric spacers 53.

The dipole-loop of this invention may be conveniently arrayed, as shown in FIG. 6. Tower 40 carries a transmission line 42 which is tapped by lines 44 to feed dipole-loops 46. It is to be noted that only a single feed line is required which represents a great cost advantage over an antenna system requiring a pair of feeds.

In FIGS. 7 and 8, there is shown still another method of mounting the dipole 80 in front of the loop antenna. Capacitance plates 70 and 71 of loop antenna 72 have affixed to them insulator plates 73 and 74. A suitable material for the insulator plates is, by way of example, polyester bonded glass fiber board. Arms 75 and 76 extending from the insulators 73 and 74 support the dipole. A two-line feed is used to energize the dipole. One conductor 78a is attached to one arm 80a and the other conductor 78b to the other arm 80b at the opposed faces.

If desired, conductive straps can be run from respective ones of the plates 70 and 71 to the dipoles for direct feed. The separate feed may be used where phase adjustment means between the horizontal and vertical elements is desired.

Still another construction is shown in FIG. 9 wherein the vertical dipole 90 is fed by means of a balun 92 suspended directly below the loop antenna 94. The balun 92 and the loop antenna are fed through respective coaxial lines 97 and 99. The feed means employed for this purpose may be those conventionally employed in this art. It is to be understood that while separate feed lines are shown, a common feed line may be employed.

Generally, the loop would be kept horizontal with respect to the earth's surface and the dipole at right angles to the loop. However, for many applications the loop may be positioned at an angle to the earth's surface.

There has been disclosed heretofore the best embodiment of the invention presently contemplated and it is to be understood that various changes and modifications may be made by those skilled in the art without departing from the spirit of the invention.

What I claim as new and desire to secure by Letters Patent is:

1. An omnidirectional circularly polarized antenna comprising:
  - (a) a loop antenna lying in a principal plane and having a feed point for energizing said loop antenna from a transmission line;
  - (b) a dipole antenna having a principal axis orthogonal to the plane of the loop said dipole being supported within a circle having a diameter of  $\lambda/4\pi$ , the circle being tangent to and outside the said loop, the point of tangency being diametrically opposite the feed point with the center of the said dipole proximate the plane of the loop, where  $\lambda$  is the frequency of operation of said loop and dipole antenna; and
  - (c) means to energize said dipole antenna from a transmission line.
2. The antenna of claim 1 including a capacitor comprising a pair of opposed plates, said loop being in the form of two arms, each of said arms terminating in a respective one of said opposed capacitor plates.
3. The antenna of claim 1 including a capacitor inserted into said loop at a point diametrically opposite the feed point and in series with the loop.
4. The antenna of claim 1 wherein said loop and dipole antennas are energized from the same transmission line.
5. The antenna of claim 2 wherein said dipole is mechanically supported by said capacitor plates.
6. The antenna of claim 2 wherein said dipole has two arms each of which is electrically connected to a respective one of said capacitor plates.
7. The antenna of claim 5 wherein said dipole and said loop are energized from independent transmission lines.
8. The antenna of claim 3 wherein said vertical dipole comprises a pair of arms each of which is mechanically supported from a respective one of said capacitor plates by an electrically conductive member for energization therefrom.
9. In combination with a vertical tower, a plurality of the antennas of claim 1 arranged in a vertical column.
10. In combination with a vertical tower, a plurality of the antennas of claim 2 arranged in a vertical column.
11. In combination with a vertical tower, a plurality of the antennas of claim 3 arranged in a vertical column.
12. In combination with a vertical tower, a plurality of the antennas of claim 4 arranged in a vertical column.
13. In combination with a vertical tower, a plurality of the antennas of claim 5 arranged in a vertical column.
14. In combination with a vertical tower, a plurality of the antennas of claim 6 arranged in a vertical column.
15. In combination with a vertical tower, a plurality of the antennas of claim 7 arranged in a vertical column.

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16. In combination with a vertical tower, a plurality of the antennas of claim 8 arranged in a vertical column.

17. In combination with a vertical tower, a plurality of the antennas of claim 9 arranged in a vertical column.

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HERMAN KARL SAALBACH, Primary Examiner

5 F. PRINCE BUTLER, Assistant Examiner

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U.S. Cl. X.R.

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