Oct. 25, 1949. H. J. RIBLET 2,485,920

ANTENNA

Filed April 26, 1944

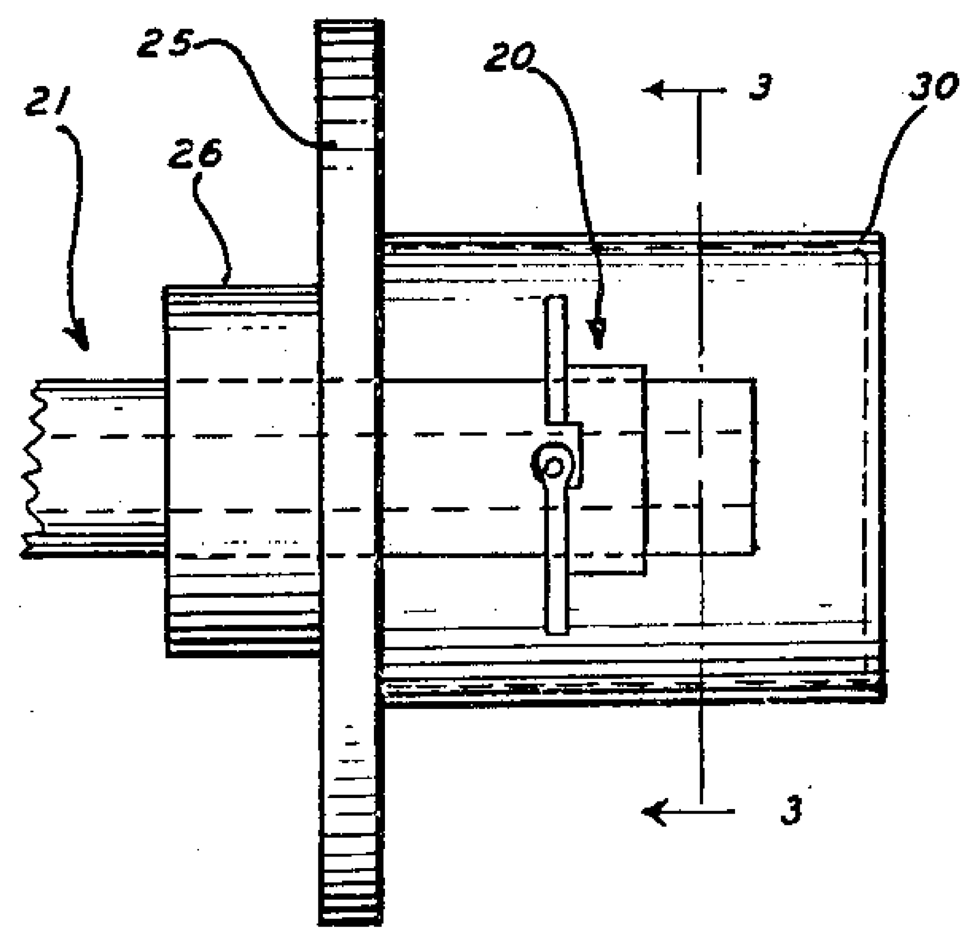

FIG-2

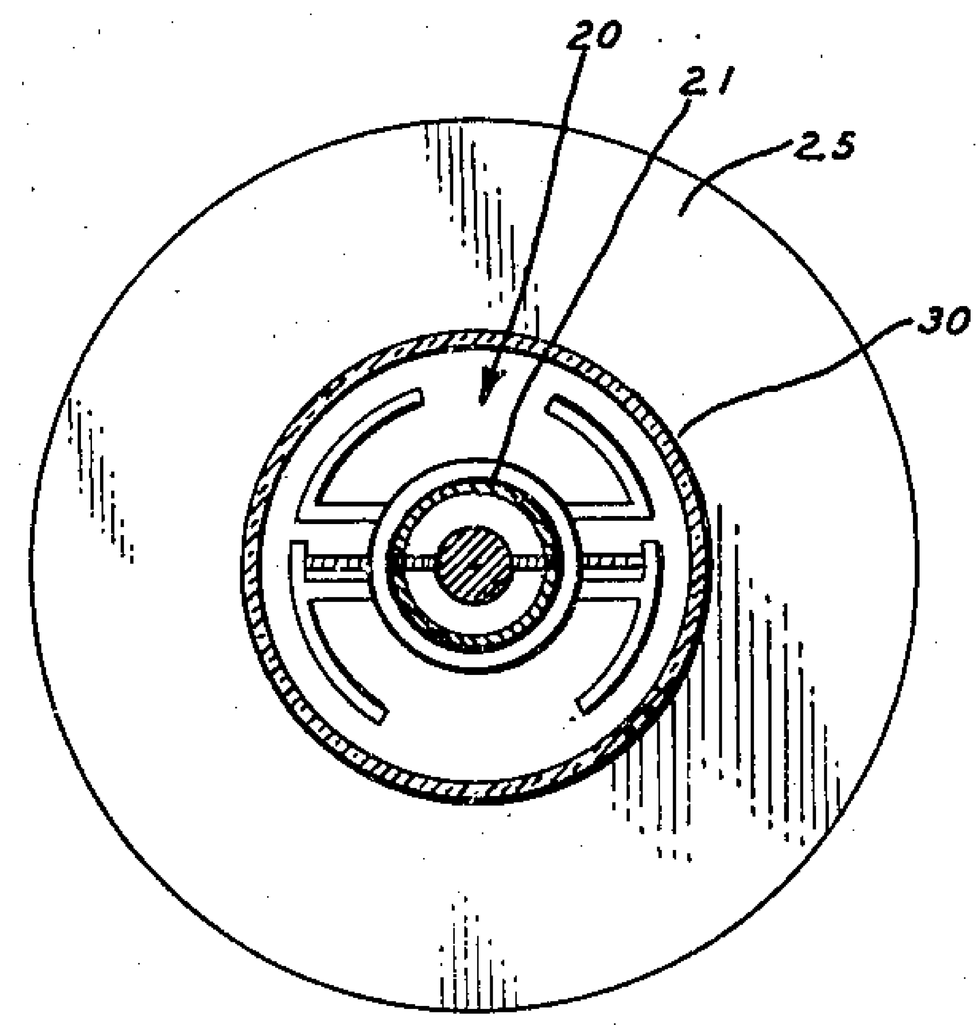

FIG-3

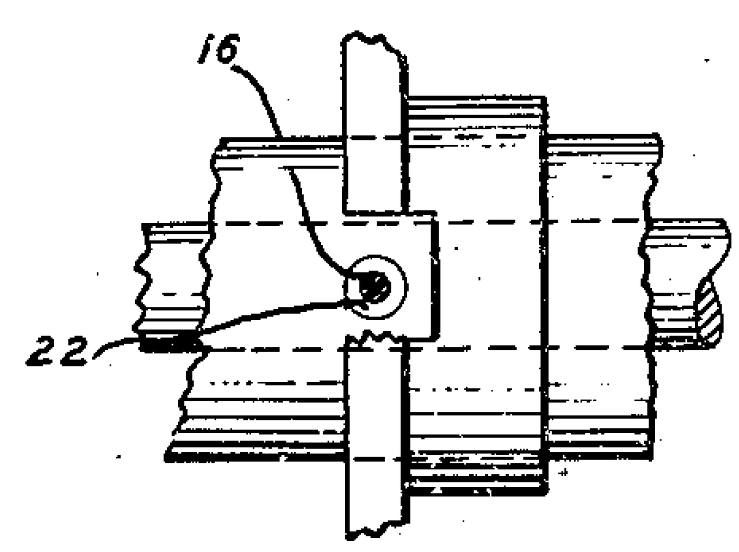

FIG-4

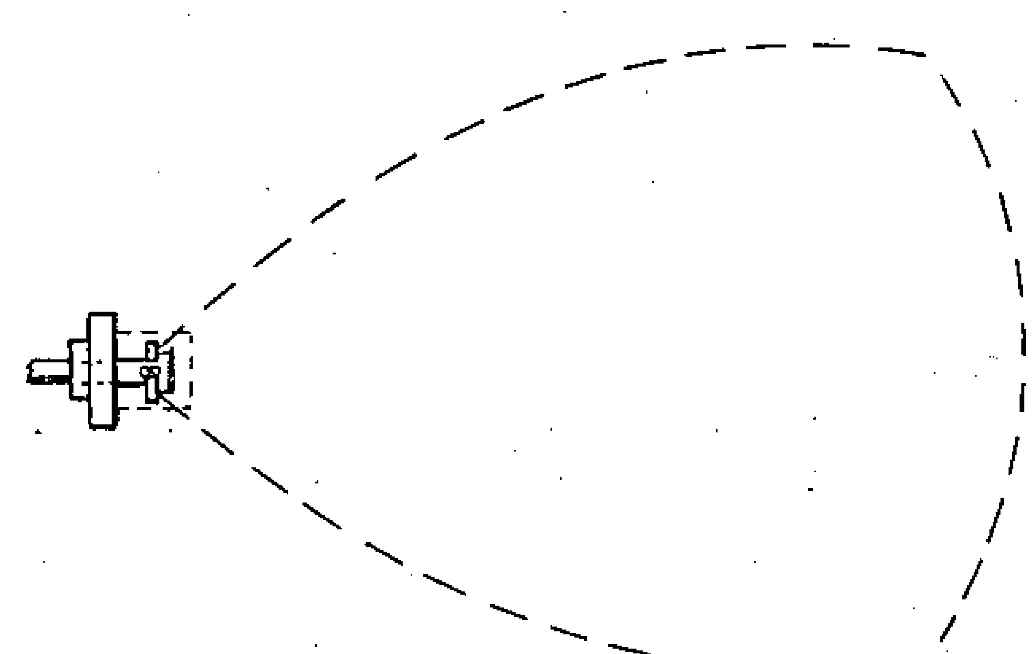

FIG-5

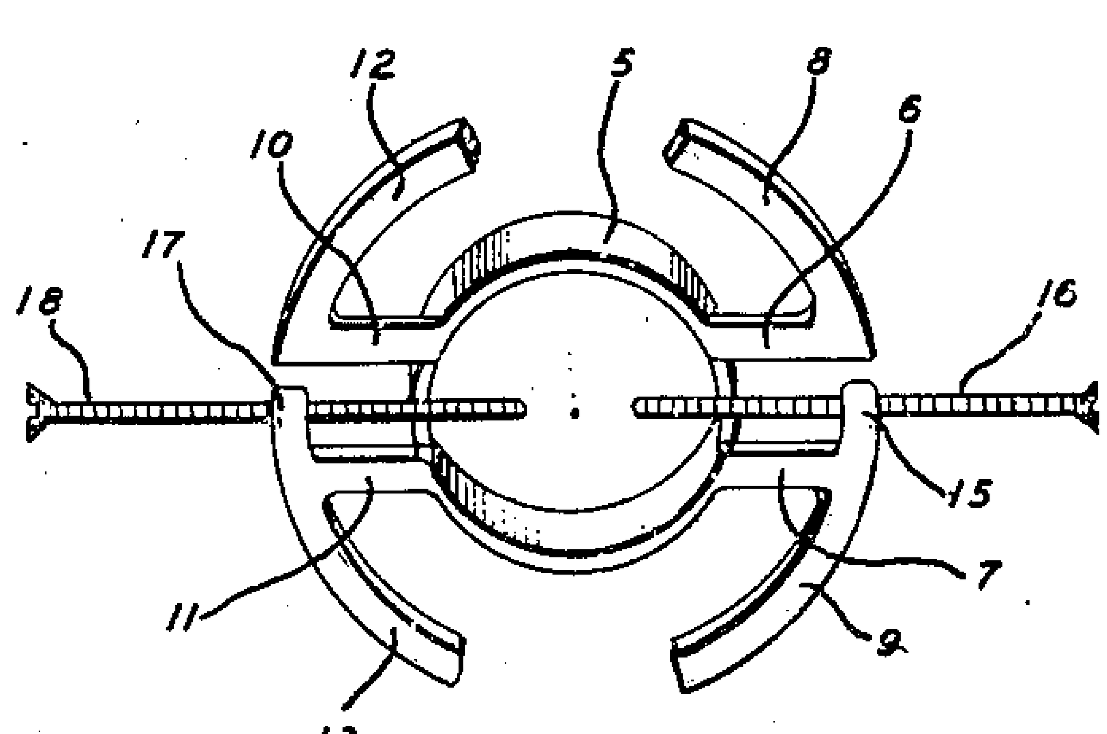

FIG-1

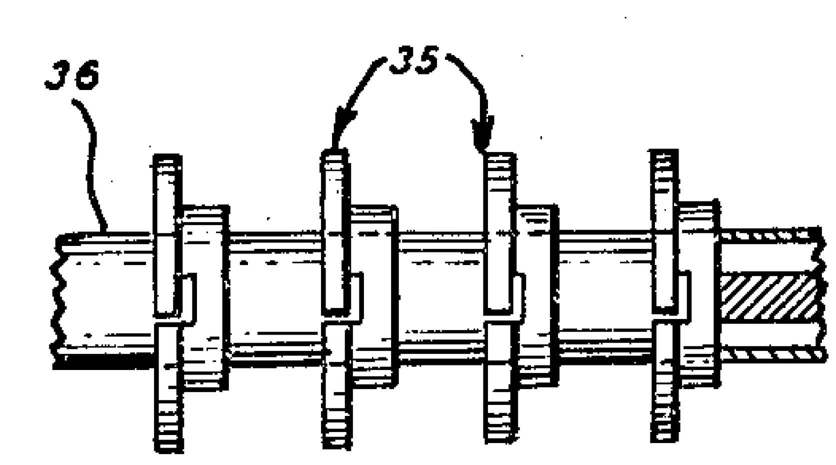

FIG-6

INVENTOR.

HENRY J RIBLET

BY

William D. Hall.

Attorney

Patented Oct. 25, 1949

2,485,920

UNITED STATES PATENT OFFICE

2,485,920

ANTENNA

Henry J. Riblet, Cambridge, Mass., assignor, by mesne assignments, to the United States of America as represented by the Secretary of War

Application April 26, 1944, Serial No. 532,793

5 Claims. (Cl. 250—33.65)

1

This invention relates to an antenna and more particularly to a directional type antenna adapted for use generally in high frequency communication systems. An antenna of this character will have a wide variety of applications, particularly in instances where size and weight are important considerations, such as in the case of airborne radio apparatus.

The principal object of the present invention is to provide a broad band antenna having a predetermined directional pattern of radiation, in the illustrated instance a uni-directional pattern defining a fairly wide angle of coverage both in the horizontal and vertical planes. Another object contemplates an antenna of this character adapted for service in difficult locations. Other objects involve considerations of small size, light weight and ease of manufacture.

The invention provides an end-fire type antenna mounted directly on an associated feeder transmission line, in this instance shown as a coaxial cable. The antenna construction comprises a plurality of dipoles extending outwardly from the cable. Any reasonable number of dipoles, such as 2, 3, or 4, may be used with the invention, the number used depending generally upon the radiation pattern desired. In the illustrated form of the invention, two dipoles are provided. The dipoles are disposed a half wave length apart so that maximum radiation therefrom is directed generally along an axis normal to the plane of the dipoles. A parasitic reflector may be mounted on the cable and spaced behind the dipoles in order to provide a predetermined uni-directional radiation characteristic, and to increase the antenna gain in the desired direction. The dipoles are excited in phase with each other by means of adjustable probes extending into the region of propagation within the cable. The probes may physically contact the central cable conductor, or they may be spaced a predetermined distance therefrom to provide capacitive coupling if desired. The dipoles because of their small size and shape may easily be weatherproofed by encloseure in a suitable energy transparent housing.

A modification of the invention involves use of a plurality of the above described dipole units to make up an antenna array. For example, a number of such units may be mounted in predetermined spaced relation on a coaxial cable or hollow wave guide, the spacing and probe adjustment used depending generally upon the radiation pattern desired. Such an array has been

2

found to give an unexpectedly high gain for an end-fire type antenna.

In the drawing, Fig. 1 is a perspective view of the dipole unit; Fig. 2 is a plane view of the invention showing the dipole unit and a reflector mounted in position on a coaxial cable, the dipole unit being enclosed in a suitable transparent housing; Fig. 3 is a sectional view on the line 3—3 of Fig. 2; Fig. 4 is a fragmentary cutaway view of a portion of Fig. 2; Fig. 5 is a view showing the approximate radiation pattern provided by the illustrated single unit antenna; and Fig. 6 is a modification showing use of a plurality of dipole unit in an array.

Referring now to Fig. 1 (lower left-hand corner), the dipole unit comprises a metallic central collar **5** of proper diameter to snugly fit over the outer conductor of an associated feeder transmission line. Spaced parallel dipole supporting arms **6** and **7** extend laterally from collar **5** and carry at their ends dipole sections **8** and **9**. As will be understood, sections **8** and **9** comprise one dipole of the unit.

A second dipole comprising spaced arms **10** and **11** and associated sections **12** and **13** extends in a symmetrical manner from the opposite side of collar **5**. If more than two dipoles are used, they may be spaced at regular intervals about the collar. Preferably the collar, arms and sections are cast as an integral metallic unit, aluminum being a particularly good material for this purpose.

Section **9** of the first dipole has an integral extension **15** projecting somewhat into the space between arms **6** and **7**. Extension **15** has an aperture centrally located with respect to arms **6** and **7**. An adjustable probe **16** is threaded through said aperture, the probe being arranged to extend inwardly to a predetermined position within the space enclosed by collar **5**. A shallow recess may be provided in collar **5** to insure suitable clearance between the collar and probe **16**. Similarly, section **13** of the opposite dipole has an extension **17** and an associated probe **18**.

While it has been found that the dimensions of the above-described dipole unit are not particularly critical, best results ordinarily are obtained when the effective distance between the two dipoles, i. e. the distance between extensions **15** and **17**, corresponds generally to a half wave length. This is the distance customarily used in antenna arrays to minimize radiation in the plane of the array. The size of collar **5**, of course, is dependent upon the diameter of the associated transmission line, the diameter being usually less than a quarter wave length. Consequently, the physical length of supporting arms 6, 7 and 10, 11 will be somewhat less than a quarter wave length.

Dipole sections 8, 9, 10, and 11, as shown in the drawing, have generally a circular configuration. It is to be noted that this circular shape is provided generally to simplify manufacture, and also to reduce the size of the assembly.

Referring to Fig. 2, a dipole unit 20 is rigidly mounted on the end of a coaxial cable 21, solder or other suitable means being used to insure a good electrical and mechanical connection. Although a coaxial cable may be preferred in most instances, it will be understood that the dipole unit could be used with a hollow wave guide type transmission line, if desired. Spaced apertures 22 (Fig. 4) are provided in the outer cable conductor in aligned relation with probes 16 and 18. The probes enter the space within the conductor through the apertures, and may be adjusted radially for the coupling desired. Thus the probes may contact the central cable conductor for direct coupling, or they may be spaced therefrom for capacitive coupling. After adjustment of the probes, the head ends thereof can be cut off at extensions 15 and 17 (best shown in Fig. 3). Solder may be used at the extensions to insure a good electrical connection and to prevent subsequent displacement of the probes.

Also mounted on cable 21 is a metallic plane reflector 25, the diameter of reflector 25 being somewhat greater than that of the dipole unit. Reflector 25 is preferably in the form of a circular disc, a supporting collar 26 being associated therewith to rigidly mount the reflector on cable 21. The surface of disc 25 facing dipole unit 20 is spaced therefrom to provide a desired energy distribution pattern in accordance with the usual practice for parasitic reflectors. As is well known, a metallic reflector positioned behind a radiating antenna is excited thereby. Currents induced in such a reflector cause radiation therefrom which has an effect on the radiation pattern of the antenna proper. Wave energy radiated by the reflector in the direction of the antenna generally is in phase with the direct radiation of the antenna. Therefore, the two fields combine in an additive manner to increase the intensity of radiation in that direction. Good antenna gain is thereby obtained. Conversely, respective radiations in the opposite direction are generally out of phase, the two combining therefore in a subtractive manner to substantially eliminate radiation in that direction. Thus the radiation produced by such an antenna-reflector combination is uni-directional, the line of maximum radiation corresponding generally to the axis of cable 21 extended beyond the dipole unit.

A cup-shaped housing 30, which is transparent to the radiated energy, may enclose dipole unit 20 and the associated end of cable 21. Housing 30, which may be made of such materials as are commonly known by the trade names Plexiglas or Lucite, serves to weather-proof the unit as well as to seal the end of cable 21 in a pressure-proof manner.

The approximate energy distribution pattern obtained from the two dipole antenna with a reflector is shown in Fig. 5. The substantially pear-shaped pattern shown is generally circular in section. Other distribution patterns may be obtained through appropriate choice of the number of dipoles provided and their disposition about the conductor.

An array comprising a plurality of dipole units is shown in Fig. 6. Here, a number of units 35 are arranged longitudinally in spaced relation on coaxial cable 36. The units are mounted on the cable as above described, the dipoles of each unit being excited in phase. The axial distance between units depends generally upon the radiation pattern desired, the distance usually being the order of a quarter wave length. Other spacings may be used as long as the distance is substantially less than a half wave length. For instance, one-third wave length spacing has been used. As is well understood, the radiation pattern and operation of an array depend upon the phase relationships between the various units of the array. In such an array, desired phasing is obtained through cooperative effects of the physical spacing of the units and adjustment of the probes. In practice, the spacing may be fixed, and the probes are adjusted to obtain the desired phase relationships, as determined by maximum gain in the desired directions. Here again, the antenna may be enclosed in a suitable housing for weatherproofing, and to provide a seal if the system is pressurized.

As one example of such an array, 18 dipole units have been found especially satisfactory in an array adapted for use at wave lengths of the order of 10 centimeters. The dipole units may be spaced and excited, in the usual manner, so that there is a progressive phase difference between adjacent units generally equal in cycles to the spacing between the units in wave lengths. Thus if the adjacent units are a quarter wave length apart, a phase difference of 90° between units generally is used. It may be preferred to vary this arrangement slightly in accordance with the suggestion of W. W. Hansen and J. R. Woodyard (Proc. I. R. E., vol. 26, p. 333, March 1938), wherein the phase difference between adjacent units is increased by π/n radians, where n is the number of units used. Thus the length (in wave lengths) of the array will be a half wave length in excess of the free space electrical length (in wave lengths).

The transmission line associated with such an array may be terminated in any desired manner, such as by absorbing arrangement, or by a simple reflecting termination. The latter may be a short-circuited termination constituting a stub support. The antenna units introduce enough standing waves into the line so that the additional standing waves arising from the short-circuited termination are not substantial. The entire standing wave pattern may be matched as a whole at the input end by a suitable transformer.

The dipoles have been found to operate most efficiently when the probes thereof are so adjusted as to permit approximately 10% of the energy to reach the terminating end of the line. Under this circumstance, all dipole units are in effective operation.

Having thus described the invention, what I claim as new and desire to secure by Letters Patent is:

1. An integral metallic antenna construction for use with a wave guide or coaxial cable, said construction comprising an inner supporting collar carried by said wave guide or outer conductor of said coaxial cable, a plurality of pairs of arms extending outwardly from said collar, a section of a dipole carried at the end of each arm with a pair of arms supporting a dipole, said arms and dipoles all lying generally in a

plane normal to the axis of said guide or cable, a probe carried by the end of one section of each dipole, said probe extending inwardly and being adapted to clear said collar and extend into the region of propagation within the said guide or cable through aligned apertures therein, whereby said dipoles are excited in phase.

2. The combination of claim 1 having two diametrically opposed dipoles, the effective distance between said dipoles being a half wave length whereby the direction of maximum radiation lies along the extended axis of said wave guide or cable.

3. The combination of claim 1 having two diametrically opposed dipoles, the effective distance between said dipoles being a half way length, and a parasitic reflector mounted on said wave guide or cable, the surface of said reflector being parallel to the plane of said dipoles and spaced a predetermined distance therefrom.

4. In combination with a wave guide or coaxial cable, an end-fire antenna array of the character described comprising a plurality of dipole devices defined in claim 1 mounted in spaced relation on said wave guide or coaxial cable, the spacing between adjacent devices and the adjustment of the probes of each device being such as to provide predetermined phase relationships in the successive dipole devices during operation of the array, thus to provide a predetermined energy distribution pattern.

5. An end-fire antenna array in combination with a feeder wave guide or coaxial cable, said array comprising a plurality of dipole units mounted in spaced relation on said wave guide or coaxial cable, each dipole unit including an inner supporting collar carried by said guide or cable, two pairs of arms extending diametrically outward from said collar, a section of a dipole carried at the end of each arm with a pair of arms supporting a dipole, said arms and dipoles lying generally in a plane normal to the axis of said guide or cable, a probe carried by the end of one section of each dipole and extending inwardly to the region of propagation within said guide or cable through aligned apertures therein, the spacing between adjacent units and the adjustment of said probes of each unit being such as to provide predetermined phase relationships in the successive dipole units during operation of the array, thus to provide a predetermined energy distribution pattern.

HENRY J. RIBLET.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,931,980	Clavier	Oct. 24, 1933
2,187,618	Gerhard	Jan. 16, 1940
2,298,449	Bailey	Oct. 13, 1942

Patent No. 2,485,920

Certificate of Correction

October 25, 1949

HENRY J. RIBLET

It is hereby certified that error appears in the above numbered patent requiring correction as follows:

In the grant, line 1, name of inventor, for "Harry J. Riblet" read *Henry J. Riblet*; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of February, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.