[54] **RECTILINEAR POLARIZATION ANTENNAS**

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[56] **References Cited**

FOREIGN PATENTS OR APPLICATIONS

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[57] **ABSTRACT**

The elementary antenna, allowing the obtention of a radiation pattern similar to that of an infinitely short dipole in the E-plane comprises two metal tubes inserted between two plates closing off their ends. A coaxial cable passing through one of the tubes has its inner conductor connected to the outer surface of the other tube.

A four-tube arrangement allows the obtention of a radiation pattern such as provided by two crossed dipoles and may be used for radio-beacons.
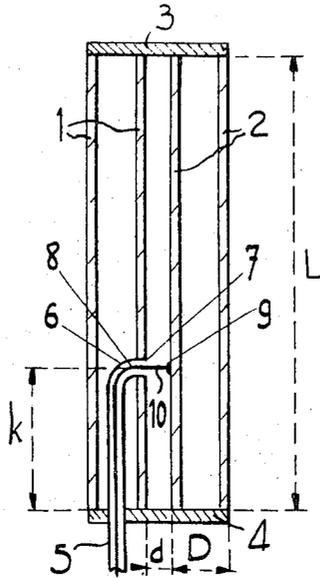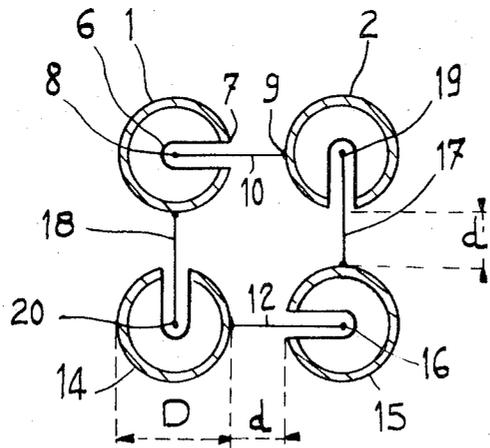
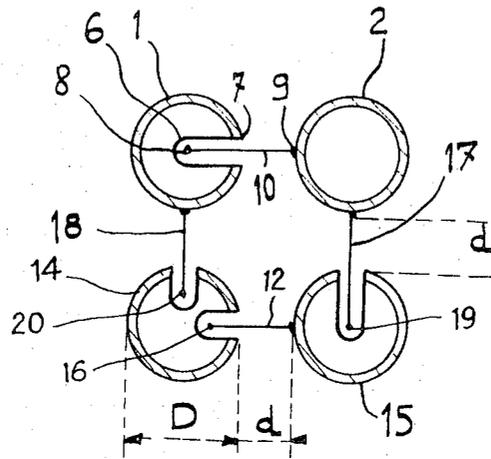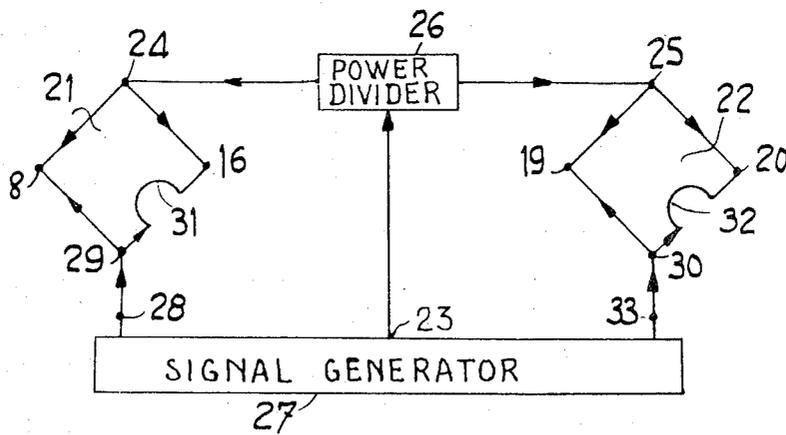9 Claims, 6 Drawing Figures
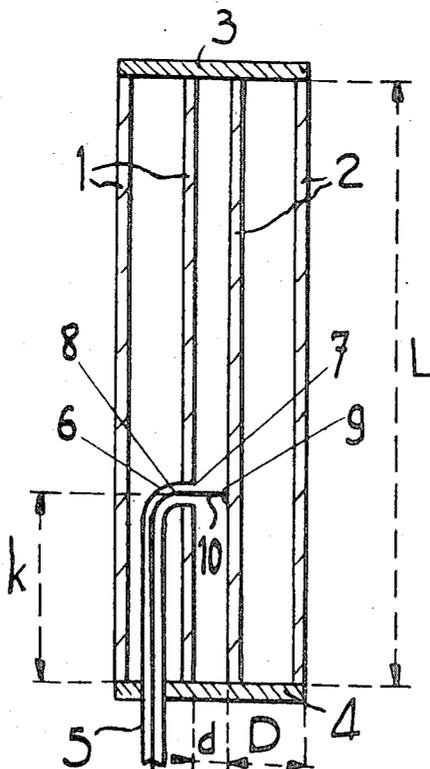
Fig. 1

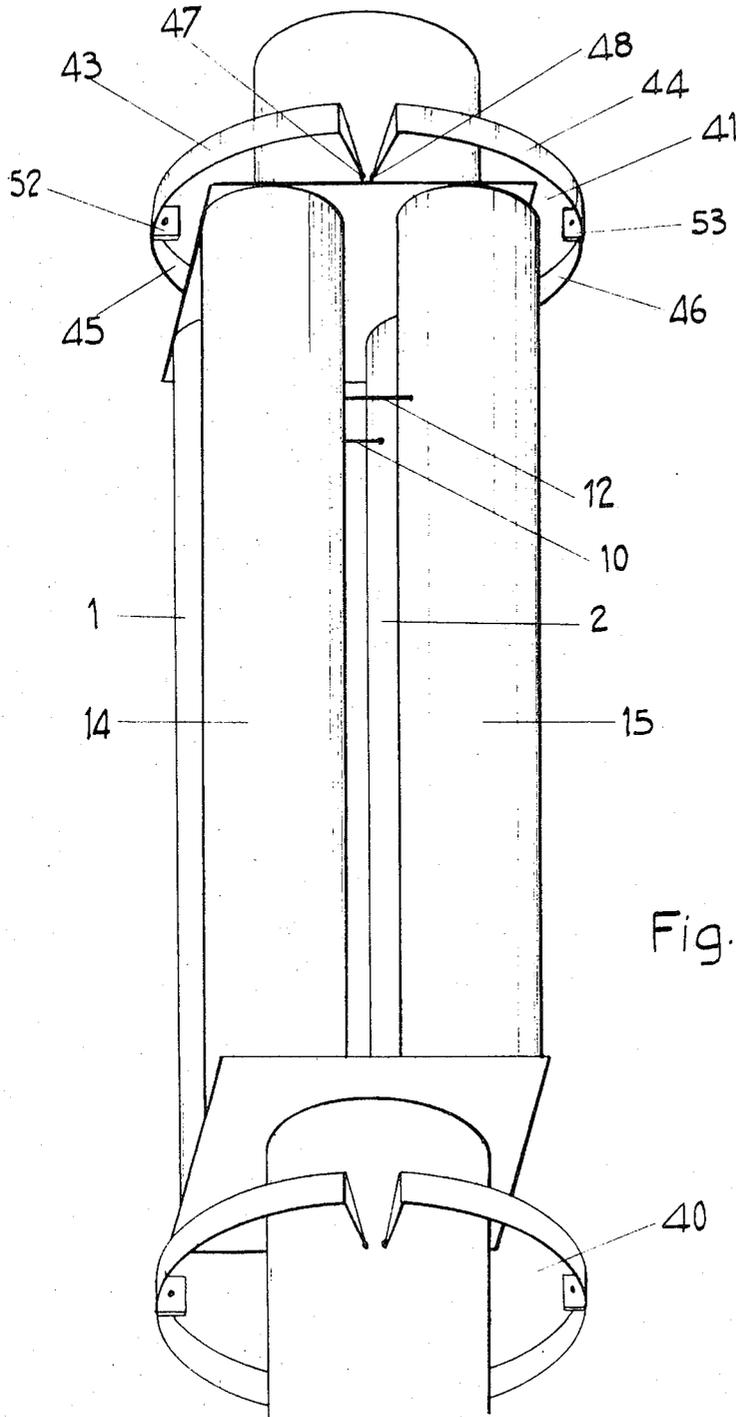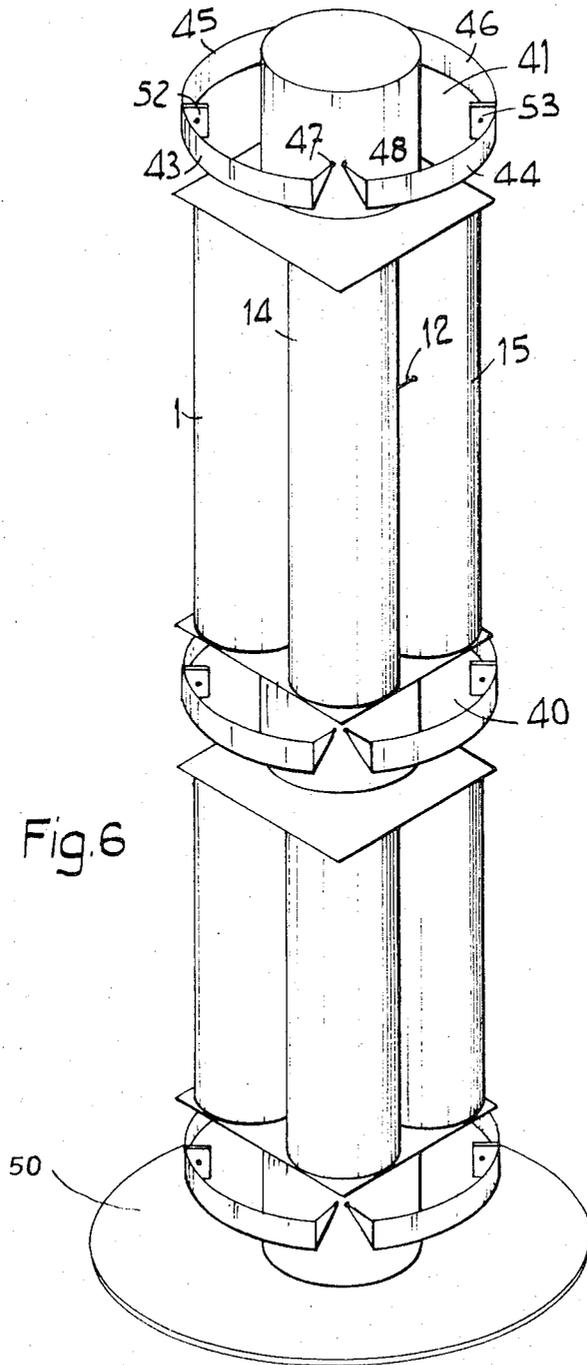Fig. 2

Fig. 5

Fig. 3

Fig. 4

Fig.6

RECTILINEAR POLARIZATION ANTENNAS

The present invention has for its object a rectilinear polarization antenna making it possible to obtain in the E-plane a radiation pattern similar to that of an elementary dipole, or to that of several such dipoles and, in the second case, to avoid undesired coupling between the different elementary radiation patterns.

According to the invention a rectilinear polarization antenna comprises at least two parallel metal tubes, which will be referred to as the first and second tubes, closed at their ends by two metal plates perpendicular to their axes, and a conductor associated with said two tubes, passing through said first tube and connected to a point of the external surface of said second tube.

The invention will be better understood and other of its features rendered apparent from a consideration of the description and the attached drawings in which :

FIG. 1 is a longitudinal section through a two-tube antenna in accordance with the invention;

FIG. 2 is a transverse section through an antenna in accordance with the invention, usable for obtaining a cardioid radiation pattern;

FIG. 3 is a block diagram of a supply circuit for the antenna of FIG. 2;

FIG. 4 is a perspective view of a variant embodiment of the antenna of FIG. 2;

FIG. 5 is a transverse section of another variant embodiment of the antenna of FIG. 2 , and

FIG. 6 is a perspective view of a group of two antennas according to FIG. 4.

FIG. 1 shows, in the form of a vertical section taken through their axes, two cylindrical metal tubes 1 and 2 of the same length L and diameter D , closed off at their ends by two plates 3 and 4 , perpendicular to their axes.

They are spaced apart by a distance d . A coaxial cable 5 passes through the plate 4 to the inside of the tube 1 ; its outer conductor 6 is connected to the periphery of an opening 7 formed in the tube 1 , at a distance k from the plate 4 , and its inner conductor 8 is connected at 9 to the external surface of the tube 2 through a connection 10 . The points 7 and 9 are preferably located in the plane passing through the axes of the tubes and at the same distance from the plate 4 .

The radiating element thus created presents characteristics similar to those of an elementary dipole in the E-plane provided the distance d is sufficiently small as compared with the operation wavelength λ . In the H-plane the radiation pattern depends upon the length L and, for $L = \lambda/2$, approximates that of a dipole of the same length.

By way of example, the following dimensions may be used :

$$d \approx 0.03 \ \lambda \ ; L \approx \lambda/2 \ ; D \approx 0.06 \ \lambda \ ; \tag{1}$$

there is thus obtained a highly attenuated vertically polarized field component (attenuated by more than 30 db in relation to the horizontally polarized radiation).

The matching of the coaxial cable 5 can readily be achieved by an appropriate choice of the distance k .

Such an antenna lends itself particularly well to the formation of groups, in particular for the antennas of phase-measuring omnidirectional radio beacons designed for radio-navigation and more particularly to the antennas of O.R.B.'s or V.O.R.'s (V.H.F. omnidirectional radio range).

Those skilled in the art will be aware that the antenna system of a radio beacon of the V.O.R. type for exam-

ple, which enables low-frequency phase-measurement characteristic of the azimuthal angle to be carried out, radiates simultaneously at the same carrier frequency two horizontally polarized electromagnetic field components.

The azimuthal radiation pattern of the first component is ideally at a given moment that of a frame antenna of infinitesimal dimensions, taking the form of two identical circles tangenting at a point identical with said frame, said radiation pattern rotating for example at a rate of 30 revolutions per second.

The azimuthal radiation lobe of the second component is omnidirectional.

These two lobes should have the same phase center and the same elevation pattern.

By an appropriate choice of the ratio of the amplitudes of each lobe, combination of the two makes it possible to obtain a rotating cardioid pattern in the azimuthal plane, which will give rise, in a given direction of observation, to amplitude-modulation at 30 cycles per second the phase of which is independent of the elevation in the said direction, but characterizes the azimuth thereof, this being measured by comparison of said phase with the reference phase of the modulating signal, which is transmitted in the second lobe, for example by means of a double modulation.

The rotating pattern of the first lobe is generally obtained by producing two identical patterns with fixed orientations, perpendicular to one another, the radiated fields being obtained by means of high-frequency signals having the same frequency and phase and being amplitude modulated by a signal the frequency of which determines the rotation speed of the resultant lobe, for example 30 cycles per second, the modulating signal being applied in quadrature to the two HF signals.

It is known, to this end, to use for the radiation of the rotating lobe a combination of constant-current loops, or two crossed dipoles, or a cylinder of revolution provided with four slots.

The first two solutions lead to a distortion of the radiation pattern, as seen from an aircraft, as a function of its elevation and the inclination of its antenna. The third solution requires critical adjustments, inasmuch as each of the two radiation patterns having a fixed orientation is obtained by the superimposition of two substantially omnidirectional patterns.

The four-tube antenna according to the invention eliminates the drawbacks of these different solutions while preserving the advantages of each one.

In FIG. 2 , four elementary antennas, similar to that in FIG. 1 , have been shown in horizontal section, the section being taken at the level of the supply points. Two additional cylindrical tubes 14 and 15 , make it possible, with the tubes 1 and 2 , to form four identical antennas.

The axes of the four tubes intersect an horizontal plane at the four apices of a square.

A first elementary antenna comprises the tubes 1 and 2 , the same numerals as those of FIG. 1 being used to designate similar elements of this antenna; a second antenna comprises the tubes 14 and 15 , a third antenna the tubes 1 and 14 , and a fourth antenna the tubes 2 and 15 . The last three antennas are respectively provided with connections 12, 18 and 17 corresponding to the connection 10 of the first one, and respectively connected to the inner conductors 16, 20 and 19 of co-

axial cables respectively passing through the tubes 15, 14 and 2 .

The antennas with the connexions 10 and 12 form a first pair, and the two others form a second pair.

To simplify the language, the four cables will be hereinafter designated by the same reference numbers as their inner conductors.

The feeding in phase opposition of the cables 8 and 16 makes it possible to obtain in the E-plane a radiation pattern which has a null in the direction of the straight line, joining, in the cross-section of FIG. 2 , the points marked 8 and 9, and a maximum in the direction perpendicular to the aforesaid direction. This pattern is for all practical purposes identical to that which is obtained with a two-tube antenna. In the same way the feeding, in phase opposition, of the cables 19 and 20 , makes it possible to obtain a pattern derived from the preceding one by a 90° rotation. This antenna structure has this advantage that the shape of each one of the two radiation patterns is independent of the phase and amplitude variation of the feeding currents.

In FIG. 3 , the opposite terminals 8 and 16 of the hybrid bridge circuit 21 and those 19 and 20 of another such circuit 22 , are respectively connected to the similarly numbered coaxial cables of FIG. 2. The output 23 of a signal generator 27 supplies the terminals 24 and 25 of the respective circuits 21 and 22 across the power divider 26.

The signal generator 27 supplies the fourth terminal 29 of the circuit 21 through its second output 28 and the terminal 30 of the circuit 22 through its third output 33 , with signals which have the same HF and phase as those delivered at the output 23 and which are modulated by two signals of the same low frequency and in phase quadrature. All the arms of the circuits 21 and 22 have an electrical length of one quarter wave, except the arms 31 (16–19) and 32 (33–20) whose electrical length is three quarters of a wavelength.

It is clear that this circuit enables the four cables 8, 16, 19 and 20 (FIG. 2) to be supplied in phase through the corresponding connecting points 8, 16, 19, 20 (FIG. 2) by the output 23 of the signal generator 27 , provided that all the cables have appropriate lengths. The output 28 of the generator 27 supplies in phase opposition the cables 8 and 16 and the output 33 supplies in phase opposition the cables 19 and 20.

It may be desirable to limit the radiation of the antenna at the level of, and below, the horizon. Those skilled in the art will be aware, in other words, that this portion of the radiation promotes the reception of parasitic signals due to reflection from ground obstacles. Already, it is current practice to employ a counterpoise to avoid these drawbacks but it has to be given a substantial diameter to be effective. The results is excessive cost and size, which can be avoided by increasing the gain of the antenna in the vertical plane. This can be achieved quite simply, in a conventional manner, by vertically stacking several antennas identical to that described in FIG. 2, whose corresponding elements are then supplied in parallel by the circuit of FIG. 3, the length of the coaxial feeder cables being chosen in such a way as to introduce a given phaseshift between the signals supplying each antenna with the result of a corresponding tilt in the radiated lobe, above the horizon. Calculation and experiment show that a stack of four antennas, the phaseshift between whose supplies is adjusted to limit the radiated field loss at zero elevation

to 6 db in relation to the maximum field, enables the field radiated at a negative angle of 4° to be attenuated by about 12 db.

It is observed, however, that the adjustment difficulties increase with the number of antennas stacked in this fashion, these difficulties arising chiefly from coupling between the feeds at the output 23 of the generator 27.

It is possible to remedy these drawbacks without having to use circulators by using a variant embodiment in which the omnidirectional radiation of the second electromagnetic field component is obtained by means of radiator elements which differ from those radiating the lobe of the first component.

In FIG. 4 , the four tubes 1, 2, 14 and 15 and the visible connections 10 and 12 , identical to those shown in section in FIG. 2, are inserted between two identical radiator frames 40 and 41 whose centers of symmetry coincide with the axis of symmetry of the four-tube arrangement. Each frame is made up of four quadrants. The quadrants 43 and 44 form a curved dipole, which is small as compared with the wavelength, $\lambda/6$ for example. This dipole is fed at its center, at 47 and 48 , by a two-wire line and its two ends form two capacitors with the ends of a second identical curved dipole formed by the quadrants 45 and 46.

The second curved dipole is also fed at its center by the same two-wire line as the first one, the quadrants 43 and 46 being connected to a wire of this line, and the quadrants 44 and 45 to the other wire. The two-wire line is coupled through a balun to a coaxial cable passing through one of the four tubes.

This use of separate radiators for obtaining the second lobe, on the other hand, makes it possible to substitute the two hybrid circuits of FIG. 3 by simple power dividers if the four-tube antenna used is as shown in FIG. 5. Relatively to FIG. 2 , the differences consist in a change of the direction of the connections 12 and 17 : the cable 16 passing through the tube 14 and its inner conductor being connected to the tube 15, and the cable 19 passing through the tube 15 and having its inner conductor connected to the tube 2 .

It will readily be seen that this connection structure directly achieves in-phase radiation patterns for the two antennas of each pair.

The construction of the antenna array by vertical stacking is effected in the same fashion as that already described but it has been found possible to combine in a single radiator frame the two frames which were located side by side in the stacked arrangement, the single frame being identical to these two aforementioned frames.

In FIG. 6 , a stack of two antennas identical to that of FIG. 4 is shown, the frame 40 being common to the two stacked antennas. The figure also illustrates a circular counterpoise 50.

Due to the properties hereinbefore indicated, the latter can be reduced to a diameter of between 2 and 3 wavelengths.

In addition, this latter variant embodiment makes it possible to obtain a gain of some 2 db in relation to that quoted hereinbefore in respect of small elevational angles, due to the flattening of the radiation pattern in relation to the omnidirectional pattern obtained with the four tubes.

The invention is of course not limited to the embodiments which have been described.

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In particular the tubes themselves may be used to form the outer conductors of the coaxial cables, provided only one cable corresponds to one tube. However, it may be technologically preferable to use outer conductors distinct from the tubes.

It will be noted on the other hand that the four-tube antenna may be simplified by using only one two-tube antenna such as shown in FIG. 1 to radiate each one of the two radiation patterns having fixed orientations. The four tubes forming the two antennas are then arranged in a square as in FIG. 2 , but one antenna being formed by the tubes 1 and 15 and the other one by the tubes 2 and 14 . Only two cables are then associated thereto, for example, the cables 8 and 20 of the FIG. 2 , the inner conductors of which being now connected to the tubes 15 and 2 respectively.

In this case, of course, the omnidirectional radiation pattern is obtained by other means, for example in the same way as for the antenna of FIG. 4 .

What is claimed, is :

1. A rectilinear polarization antenna comprising at least two parallel metal tubes having respective external surfaces and respective ends, said tubes being located side by side, and the diameter of said tubes being greater than their spacing, two metal plates closing said tubes at their ends perpendicularly to their axes, and a feed conductor passing through one of said two tubes and connected to a point of the external surface of the other of said two tubes.

2. An antenna as claimed in claim 1, comprising a coaxial cable located inside said one tube, and having an outer conductor and an inner conductor, said inner conductor being said feed conductor and said outer conductor being connected to said one tube at the same distance, relatively to said plates, as said connection point.

3. A group of antennas comprising at least two vertically stacked antennas as claimed in claim 1.

4. An antenna for radiating, with horizontal polariza-

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tion, a rotating lobe, comprising four vertical metal tubes having respective external surfaces and respective ends, the diameter of said tubes being greater than their spacing, two horizontal metal plates closing off said ends, four conductors each of which passes through one of said four tubes, said tubes being so located that their axes intersect a horizontal plane at the apices of a square, each of said conductors being connected to the external surface of one of said tubes other than the one through which it passes.

5. An antennas as claimed in claim 4, wherein each of said tubes is connected to a single one of said conductors.

6. An antenna as claimed in claim 4, wherein two of said conductors pass through one and the same tube and are respectively connected to two other ones of said tubes.

7. An antenna as claimed in claim 4, further comprising two identical radiating frames, each of which is formed by two curved dipoles and forms a constant current loop for the production of an omnidirectional radiation.

8. A group of antennas comprising at least two vertically stacked antennas as in claim 4.

9. A group of two antennas, each of said antennas comprising two parallel metal tubes, having respective ends and respective external surfaces, the diameter of said tubes being greater than their spacing, and a feed conductor passing through one of said two tubes and connected to a point of the external surface of the other of said two tubes, said group of antennas comprising two metal plates closing off the four tubes of said two antennas at their ends, the intersection of the axes of the four tubes of said antennas with an horizontal plane being the apices of a square, and the intersection of the axes of the two tubes of each antenna being at two diagonally opposite apices of said square.

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