

Feb. 16, 1960

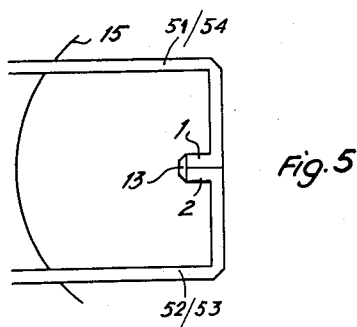
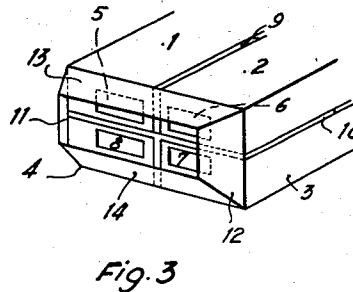
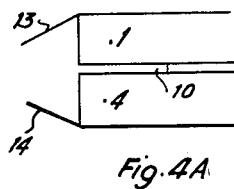
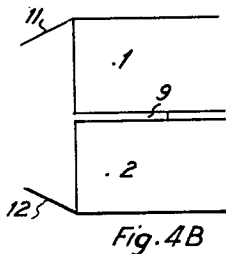
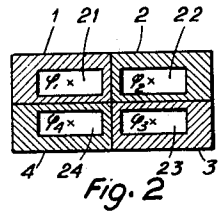
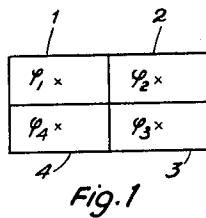
L. THOUREL

2,925,595

MONOPULSE TRANSMITTING AND RECEIVING SYSTEMS

Filed Sept. 11, 1956

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

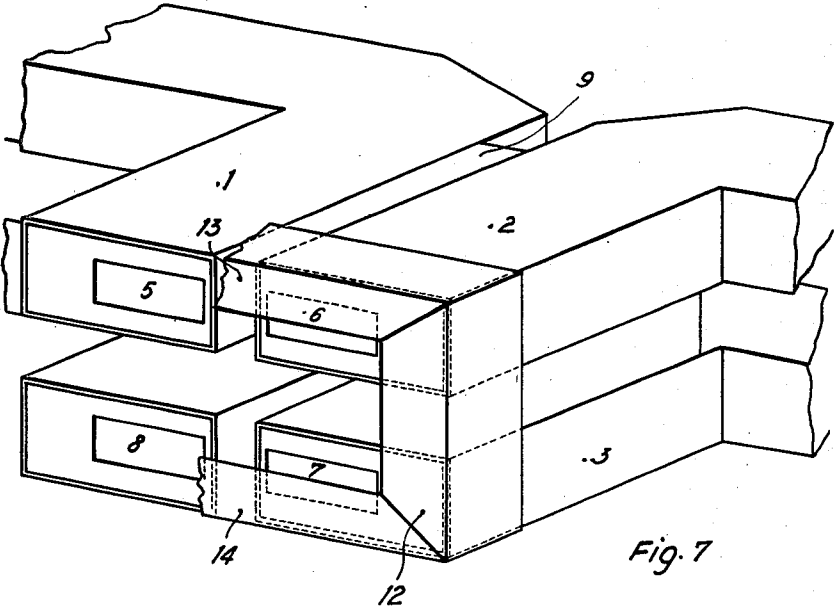


Fig. 7

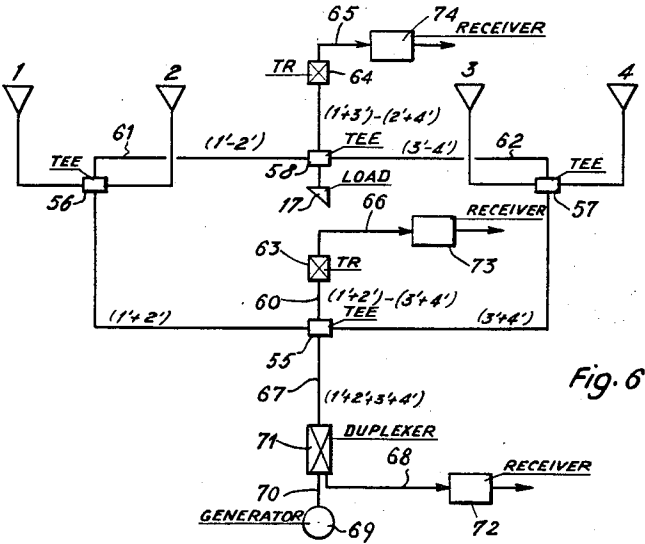


Fig. 6

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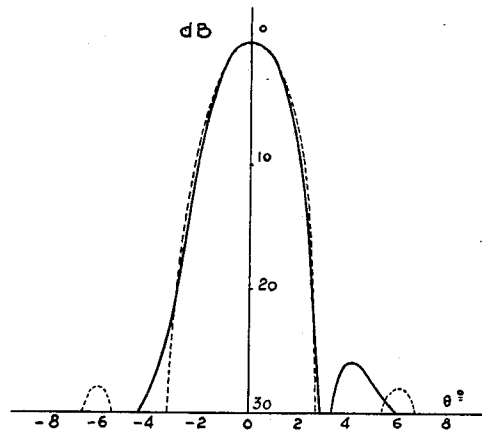


Fig. 8

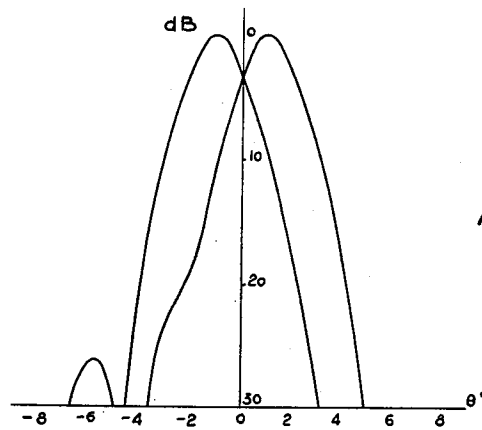


Fig. 9

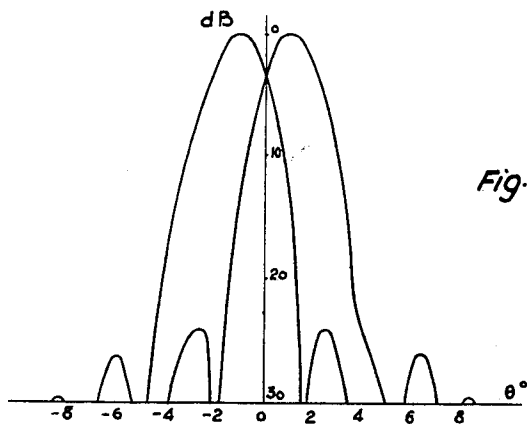


Fig. 10

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MONOPULSE TRANSMITTING AND
RECEIVING SYSTEMS

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1 Claim. (Cl. 343—16)

The present invention relates to aeriels for monopulse type radars.

It is known that, in radars of this type, the antenna must have a transmitting radiation pattern comprising a single directive lobe, and a receiving pattern having four directive lobes intersecting each other, preferably at a level of about 3 db below the level corresponding to the maximum radiation.

The receiving antenna generally comprises a paraboloid illuminated by four horns. The transmitting aerial of the simplest type consists of an additional horn located at the center of a square at the apices of which the four receiving horns are respectively located. However, on account of the required increase in size, such an arrangement is impractical. It should, further, be noted, that the minimum spacing which it is necessary to provide between the four receiving horns, prevents the receiving patterns from intersecting at the desired 3 db level.

It is an object of the present invention to provide a transmitting-receiving device in which these difficulties are avoided. The device according to the invention comprises a reflector illuminated from four different radiators provided with a correcting device for bringing closer to one another their respective phase centers, means for feeding in phase the ultra high frequency pulse energy to said four radiators to combine their respective radiation patterns into a single directive lobe, and, switch means, to make these radiators independent of one another when operating as receiving elements, to provide four individual radiating patterns.

According to a particular embodiment of the invention, the four radiators are four wave-guides placed side by side. These four guides are terminated by resonant windows and the arrangement is completed by a correcting device comprising four inwardly converging flanges, which brings the respective phase centers of the four guides closer to one another. Matching means are preferably provided in the guides, and the windows are uncoupled from each other in any conventional manner.

The construction and operation of the invention will be better understood from the following specification, and the appended drawing, wherein:

Fig. 1 is a diagrammatic view of an end cross-section of the four wave guide radiator used in the device of the invention;

Fig. 2 is the same cross-section, showing the four resonant windows;

Fig. 3 is a perspective view of the wave guides of Fig. 2;

Figs. 4A and 4B are respectively a plan and an elevated view of the system of Fig. 3;

Fig. 5 is a diagrammatic plan view of an embodiment of the invention;

Fig. 6 shows diagrammatically a system according to the invention;

Fig. 7 is a view of a particular embodiment of the device, by way of example;

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Figs. 8, 9 and 10 are the radiation patterns of a system according to the invention;

Fig. 1 shows four open wave-guides 1, 2, 3 and 4 placed side by side, and having phase centers ϕ_1 , ϕ_2 , ϕ_3 , ϕ_4 . When the mouths of such guides are placed at the focus of a paraboloid of conventional focal distance and size, the level at which the lobes respectively radiated by the four guides, intersect, is found to be at least 10 db below the maximum level. If, a paraboloid of greater focal distance is used to decrease this level to about 3 db, the guides which, in this case, are located at a great distance from the paraboloid, would radiate outwardly with respect to the latter. If the respective phase centers of the guides 1 through 4 are brought as close to each other as possible by the provision of resonant windows 21, 22, 23 and 24, as shown in Figure 2, this enables the intersection of the radiation patterns to take place at about 6 db, which, however, is still insufficient.

By means of the invention, the level is readily brought to 3 db.

Referring to Figure 3, the four guides 1, 2, 3 and 4 are closed respectively by means of resonant windows 5, 6, 7 and 8. The distances between the centers of these windows are selected in such a manner that the axis of the four corresponding radiation beams, lie, two by two, in rectangular planes, symmetrically with respect to the focal axis of the paraboloid.

A correcting device is placed in front of this arrangement. This device comprises convergent flanges 11, 12, 13 and 14, arranged to form a deflector, as shown schematically in the plan and elevational views in Fig. 4. The output mouth of this deflector thus presents a substantially smaller surface than the cross-section of the combined four guides. The coupling between the windows 21 to 24 is avoided by means of any conventional device such as quarter-wave traps 9 and 10, as shown in Figs. 3 and 4. Fig. 5 shows diagrammatically and in cross-section the transmitting and receiving device of the invention. It comprises a parabolic reflector 15 and feeding guides 51, 54 and 52, 53.

Since, according to the invention, only four radiators are used (instead of five), it is essential to provide a T.R. switching system, adapted for correctly combining the transmitted energy and dividing or re-arranging the received energy, as the case may be.

This switching arrangement enables the system to pass from the transmitting position, the four guides being fed in phase, to the receiving position, where each of the guides operates independently of one another. The switching is provided, according to the invention, by junctions, T.R. and A.T.R. switches disposed as shown in Fig. 6. Four "magic tees" 55 to 58 are disposed between the radiating elements 1 to 4 and the energy source 69.

When an ultra-high frequency pulse is transmitted, the energy supplied by source 69 is divided into two equal fractions by "tee" 55 each of these fractions being again divided into two further equal fractions by means of "tees" 56 and 57.

Each of the radiators thus receives substantially a quarter of the available energy, and the radiators are fed in phase if the lengths of the guides connecting the "tees" are equal, which condition is easily reached. No energy will pass through the vertical arms 60, 61 and 62 of the "tees." In actual practice, the uncoupling takes place at about 30 db, thus requiring the use of protecting T.R. devices 63 and 64, in the receiving channels 65 and 66.

During reception, and designating by 1', 2', 3' and 4' the energy fractions received by radiators 1, 2, 3 and 4,

respectively, it is easily found that these fractions are distributed as follows:

for tee 56: $1'+2'$ in the arm connecting T56 to T55; and $1'-2'$ in the arm connecting T56 to T53;
for tee 57: $3'+4'$ in the arm connecting T57 to T55; and $3'-4'$ in the arm connecting T57 to T53;
for tee 55: $(1'+2')+(3'+4')$ in the arm 67; and $(1'+2')-(3'+4')$ in the arm 60.

The sum of the voltages supplied by energies $1'+2'+3'+4'$ is used in a receiver 72 connected to guide 68, the latter being coupled to guide 67 by duplexer 71, of a conventional type.

The difference $(1'+2')-(3'+4')$ formed in arm 60 provides, as is well known, the error voltage corresponding to the angle of elevation of the target. This voltage is then used in a second receiver 73, connected to the vertical arm of tee 55 by means of T.R. device 63.

The sum $(1'-2')+(3'-4')$ i.e. the difference $(1'+3')-(2'+4')$, collected in the horizontal arm of tee 58 provides a further error voltage which is used in a conventional manner in a third receiver 74, connected to guide 65 by T.R. device 64. Using such a set of three receivers is well known in the technic of "monopulse" radars.

It will be noted that the energy difference $(1'+4')-(2'+3')$ is collected in the vertical arm of tee 58; however, this difference is not used and is absorbed in a matched load 17.

Figure 7 shows a practical embodiment of the invention, wherein same reference numbers have been used to designate same elements as in the preceding figures.

Curves, shown in Figs. 8, 9 and 10, illustrate the results obtained during tests, with a frequency of 9,375 megacycles. This axis of the radiated beam is directed along the axis of the paraboloid reflector.

As shown in the diagram of Fig. 8 the aperture angle of the transmission beam, measured at a level of 3 db is $2^{\circ} 4'$ and at 10 db is less than 5° .

As shown in Figs. 9 and 10, the four reception patterns intersect at a level of about 3 db. The aperture angles at 3 db and at 10 db were respectively $2^{\circ} 3'$ and less than 5° .

What I claim is:

A transmitting and receiving device of the monopulse type, comprising: a reflector; and a first, a second, a third and a fourth rectangular radiator disposed side by side and having respectively, a first, a second, a third, and a fourth phase centers, said phase centers being located respectively at the four apices of a rectangle; said first, second, third and fourth radiators having respectively a first, a second, a third and a fourth resonant window directed towards said reflector, the respective distances between the centers of said windows being respectively smaller than the respective distances of said phase centers; the outer edges of said radiators thus forming a rectangle, and two pairs of flanges having outer edges converging by pairs, directed towards said reflector and forming the lateral walls of a truncated pyramid whose large base contacts said rectangle formed by said outer edges of said radiators and whose small base is defined by said outer edges of said flanges; and means for feeding in phase to said radiators the ultra high frequency pulse modulated energy to be transmitted, and for separately collecting the energy respectively received by each of said four radiators.

References Cited in the file of this patent

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