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A COAXIAL FEED FOR HIGH APERTURE EFFICIENCY AND LOW SPILLOVER OF PARABOLOID ANTENNAS

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A sector-shaped feed pattern is the almost optimum solution for a high aperture efficiency and low spillover of a paraboloid antenna. In theory[1] it requires an infinitely large circular feed aperture which is illuminated according to the function $J_1(x)/x$. Such a feed pattern can practically be approximated by a coaxial radiator[2]. This radiator consists of a central circular waveguide which is surrounded by one or several conductors with circular cross-sections[3,4]. The problem is to achieve such an excitation in antiphase of the ring-type waveguides and the central circular waveguide so that a good approximation of the $J_1(x)/x$ illumination and the sector-shaped pattern, respectively, is obtained. Theoretical investigations[5] - based on the Kirchhoff's boundary values in the aperture - were made concerning the diameters of the waveguides and the intensity of their exitation by the H_{11} mode in order to ensure that a paraboloid antenna illuminated by this radiator yields the maximum aperture efficiency q_{max}. This maximum aperture efficiency - which was at first determined without making allowance for the aperture blocking - is the higher the smaller the angular aperture ψ_1 of the parabolic reflector (Fig. 1). Moreover, it can be seen that there is a particularly high increase of q_{max}, when changing over from the simple waveguide to a radiator consisting of a central waveguide and one ring, e.g. from 66.6% to 72.3 % for $\psi_1 = 60^0$. For a radiator with two rings q_{max} rises but slightly to 74.8 % and with three rings it rises to 76.2 %. That is why now a radiator with only one ring has been constructed (Fig. 2). When using this radiator with one ring as feed of a parabolic reflector with $\psi_1 = 60^0$ a practical value of 66 % can be expected for an aperture blocking of 0.25 dB (72.3 % ⟶ 68 %). However, the cut-off point in the primary feed pattern does not decrease substantially with respect to that obtained with the optimum circular waveguide. But if the coaxial radiator is so dimensioned that it yields the same aperture efficiency of the paraboloid antenna as an optimum circular waveguide, there is a 10 dB decrease of the cut-off point in the electric plane with respect to that of the circular waveguide. In the case of an adequate dimensioning in a frequency band of about 10 % of the middle frequency the radiation properties remain practically unchanged.

Like the simple circular waveguide these coaxial radiators excited by the H_{11} mode have a different pattern in the E plane and in the H plane, i.e. they are not the optimum solution for the illumination of a parabolic reflector with circular aperture. A rotationally symmetric pattern in conjunction with an almost linearly polarized field in the aperture of the coaxial radiator can, however, be achieved by adequate superposition of H_{11} and E_{11} modes in the central waveguide and of H_{11} and H_{12} modes in the ring-type waveguide[2] (Fig. 4). But in the ring-type waveguide 12 other modes are possible. To avoid this unwanted modes an appropriate excitation could be achieved by a system of 12 probes (for H_{11} mode) and 12 longitudinal slots (for H_{12} mode) in the sheath of the central radiator[6] (Fig. 5). Because of the high degree of symmetry of this excitation system all $H_{m,n}$ and all $E_{m,n}$ modes with $m = 0, 2, 3, 4, 5, 6$ are suppressed.

With such a radiator it is possible to obtain not only a main lobe which is symmetrical with respect to rotation (Fig. 6), but also a uniform phase centre for the E and H planes. In addition, there is a decrease of the crosspolarization by about 10 dB with respect to that of a coaxial radiator or of a circular waveguide , both of which are excited by the H_{11} mode. When making no allowance for aperture blocking, dissipation losses and surface deviations of the reflector, the maximum aperture efficiency of a paraboloid antenna operated by such a feed is q_{max} = 73, 80, 84, 86 % for $\psi_1 = 80^0, 70^0, 60^0, 50^0$. In practice q_{max} = 75 % - 80 % for $\psi_1 = 50^0$ depending on the influence of aperture blocking. However, if the radiator is so dimensioned that it yields the same aperture efficiency as a circular waveguide of optimum dimensions (without aperture blocking q_{max} = 68 %), the cut-off point decreases about 5 dB in the E plane and about 7 dB in the H plane.

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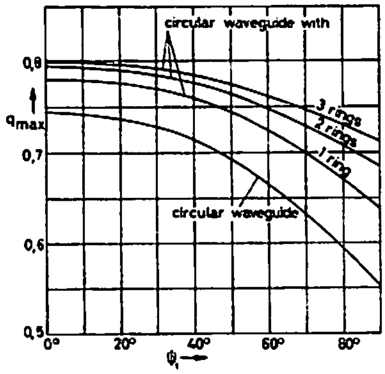

Fig. 1

Maximum obtainable aperture efficiency of paraboloid antennas each of which is illuminated by a coaxial feed excited by H_{11} mode (calculated)

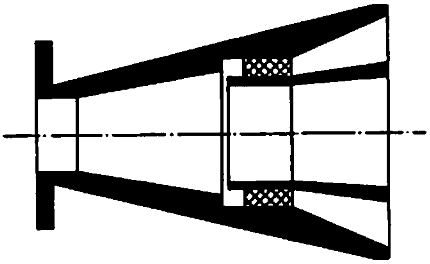

Fig. 2

Coaxial radiator (for $\psi_1 = 60°$) excited by H_{11} modes

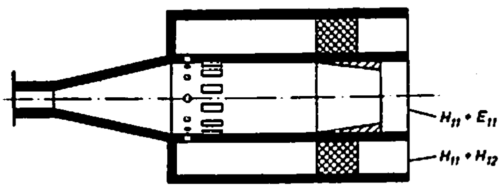

Fig. 5

Multimode coaxial radiator

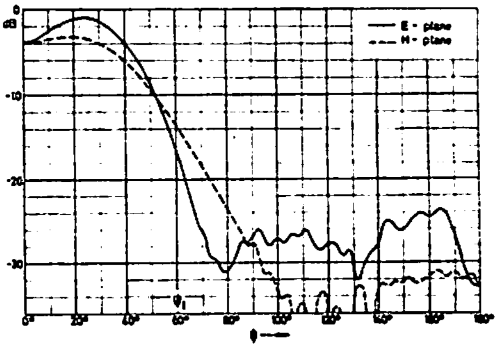

Fig. 3

Measured radiation patterns of the feed of Fig. 2

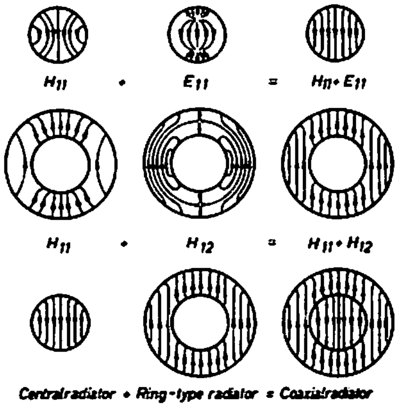

Fig. 4

Superposition of H_{11} and E_{11} modes in the central radiator and of H_{11} and H_{12} modes in the ring-type radiator

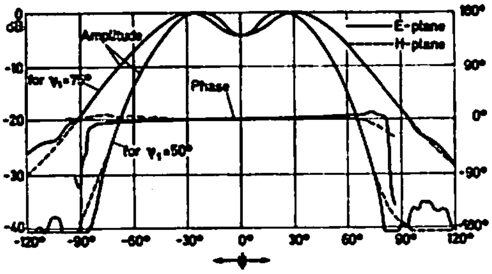

Fig. 6

Measured radiation patterns of the multimode coaxial radiator