CENTRAL INTELLIGENCE AGENCY

INFORMATION REPORT

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THE SOURCE EVALUATIONS IN THIS REPORT ARE DEFINITIVE.
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1. Department TEA[1] (Technical Development of Antennae) of VEB Funkwerk Koepenick has carried out theoretical and experimental research concerning centimeter-wave and micro-wave antennae. The research was under the direction of physicist Rolf Gruss who was assisted in the mathematical aspects of the problems involved by mathematician Kuehn (fnu). Engs. Horst Kiesewald and Arndt (fnu) under Gruss' supervision were engaged in experimental studies of antenna development. Gruss' work included research on the antenna problems involved in the development of a ship-borne anti-collision radar device (Kollisionsschutzgeraet) which was carried out in the laboratory of Rudolf Manthey, part of Department TEA. After Manthey's defection in late December 1954 and Gruss' in late January 1955, Department TEA was practically left without thoroughly trained antenna experts. Since the department mentioned is the only one in East Germany which has done theoretical and practical research on antenna problems, this work, including its theoretical aspects, is outlined below. The outline is based on the theoretical ideas which guided the antenna team at VEB Funkwerk Koepenick and on their practical experiments aiming at resolving the problems involved.

2. Theoretical basis

Following are the fundamental theoretical ideas which guided the antenna team at VEB Funkwerk Koepenick:

a. The theoretical treatment of the problems involved in centimeter-wave antenna research cannot be performed with the means provided by the regular circuit theory because the routine notions of current and voltage are not valid in this field. Accurate computations according to Maxwell's field theory are required. However, since the pure field theory involves problems which as a rule are too complicated for technicians, it is necessary to find a suitable combination between the circuit theory and the field theory. For this purpose the fundamental formula of the circuit theory

$$V = R \cdot I$$ (voltage V, current I, resistance R)

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is adapted to the field theory by making V correspond to $\mathfrak{E}_{ly}$ and I correspond to $\mathfrak{E}_e$ where $\mathfrak{E}_{ly}$ is the electro-magnetic field vector and $\mathfrak{E}_e$ is the electrical field vector of the Maxwell theory.

The following system of equations is valid for an n-pole:

$$\begin{cases} V_1 = R_{11} \cdot I_{11} + R_{12} \cdot I_{12} + \cdots + R_{1n} \cdot I_{1n} \\ V_2 = R_{21} \cdot I_{21} + R_{22} \cdot I_{22} + \cdots + R_{2n} \cdot I_{2n} \\ - - - - - - - - - - - - - - \\ V_n = R_{n1} \cdot I_{n1} + R_{n2} \cdot I_{n2} + \cdots + R_{nn} \cdot I_{nn} \end{cases}$$

The matrix determined by the coefficients R_{ik}:

$$\mathfrak{R} = \begin{pmatrix} R_{11} \cdots R_{1n} \\ - - - - - - \\ R_{n1} \cdots R_{nn} \end{pmatrix}$$

is called the resistance matrix for an n-pole. The coefficients R_{ik} can be computed with the aid of the field theory in the form of boundary problems. Three methods can be used as described by Schwinger:

1) Solution with the aid of differential equations;
2) Solution with the aid of integral equations;
3) Solution according to the variation principle.

All three methods were studied in Department TEA by Gruss and Kuehn.

b. Because the mirror of a micro-wave antenna has a finite opening its radiation cannot be computed as a boundary problem. In view of this, the "Kirchhoff principle of optics" is taken as the starting point. Excitement in one point is given through the formula:

$$U_P = \frac{1}{4\pi} \int \left(\psi \frac{\partial U}{\partial n} - U \frac{\partial \psi}{\partial n} \right) ds$$

where ds is a small surface and ψ and U are scalar functions with known values on the surface. If ψ is interpreted as a space wave the above equation can be applied to field vectors and the following expression[2] results for the electrical field vector of the energy issuing from the antenna opening:

$$\mathfrak{E}_P = -\frac{1}{4\pi} \int \left(\psi \frac{\partial \mathfrak{E}}{\partial n} - \mathfrak{E} \frac{\partial \psi}{\partial n} \right) ds + \frac{1}{4\pi} \oint_{TA} \psi [\mathfrak{E} \, ds] \, ds$$
$$- \frac{1}{4\pi j \omega \varepsilon} \oint \nabla \psi (\mathfrak{s} \, \mathfrak{H}) \, ds$$

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A similar relation is valid for the electro-magnetic field vector $\mathfrak{H}_p$. If the field determined by $\mathfrak{E}$ and $\mathfrak{H}$ is known upon the surface the remote fields of parabola antennae and horn feeds can be computed.

3. Experimental development

a. An antenna with a parabola mirror was developed for the anti-collission radar device. This antenna was for simultaneous reception and transmission. It was made of cast aluminum with the dimensions indicated in figure 2 of annex 1. Feeding was carried out through a horn feed located in the focal point of the parabola. The antenna dimensions show that horizontal focusing was stronger than vertical focusing. Use of the antenna as both a transmitting and receiving antenna was made possible through blocking and opening of the transmission and reception klystrons. The side loop attenuation was about 20 decibels. The Halbwertsbreiten were 1.5 degrees (horizontal) and 13 degrees (vertical). This antenna model had a number of shortcomings:

a. The aluminum material was bad and caused changes in the opening angle of the mirror due to the internal tensions of the material.

b. The antenna was clumsy and heavy.

c. Because of its large opening, it caused excessive air resistance,

d. It needed a large power supply installation.

The antenna described above was used for the first sea tests of the anti-collision radar device.

b. In view of the above-mentioned difficulties, another type of antenna (called Tortenschachtel* antenna) was developed. A laboratory model of this type was completed (see figure 3 of annex 1; dimensions indicated there). The horn feed was changed when the Tortenschachtel type was developed. Figure 4a of annex 1 represents the original form. It was found that part of the radiation issued through the sharp corner as indicated in figure 4a and was lost; therefore, a horn feed of the type represented by figure 4b was developed; this second type was called hog horn feed. The improvement in the radiation pattern is indicated in figure 4b. The hog horn feed type had another advantage in that it attained the required side loop attenuation of about 25 decibels.

c. A difficulty experienced in the development of suitable horn feeds was the problem of covering the mirror completely with the radiation. It was important to keep the reflection factor as small as possible. The energy line which consisted of wave guides, had a characteristic impedance (wave resistance) Z = 400 Ohm. The most favorable value of m reached was m = 1.05 with an operating frequency of 3.2 centimeters or 93,750 mcs. The excitement of the horn feed was carried out with a H_{01} wave (linear-polarized); the generator was a reflex klystron. The theoretical evaluation of m also indicated 1.05 as most favorable value. In a later stage of the development, a Trolituol disk was applied at the opening of the horn feed. This disk was to prevent penetration of water and humidity into the energy line; m was not essentially changed through this disk. In January 1955, systematic investigations concerning the relations between impedance and the dimensions of the horn feed were to begin.

*Note: Literally: Cake box

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d. Use of one and the same antenna for reception and transmission created difficulties connected with the impulse slopes. It was therefore planned to develop another type of antenna with separate transmission and reception operations. This type was a combination of two Tortenschachtel antennae and was called Doppelte Tortenschachtel antenna (see figure 5 of annex 2). As of January 1955, this development was in its initial stage. A preliminary measurement of the decoupling of two Tortenschachtel antennae used for this development gave a result of 30 decibels.

4. Department TEA received an order for the development in 1955 of an antenna for coastal radar. A model was to be completed in the spring of 1955. This antenna was also to be fed by horn feed. Its horisontal width, however, was to be 4 meters (see figure 6 of annex 2 with the dimensions indicated there) as a result of a smaller Halbwertsbreite of about 0.7 degrees.

1. [redacted] Comment. The department was headed by Dr. Erich Schuettloeffel, an antenna specialist who worked in Russia during the postwar period. After his defection in 1954, the department was headed by Horst Geschwinde. [redacted] 25X1

2. [redacted] Comment. The letter designations and the symbols for operators in the above equation are well-known and are not explained here. Refer to figure 1, annex 1. 25X1

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Annex 1

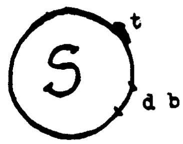


Fig. 1 Open radiator

Fig. 2 Parabola mirror

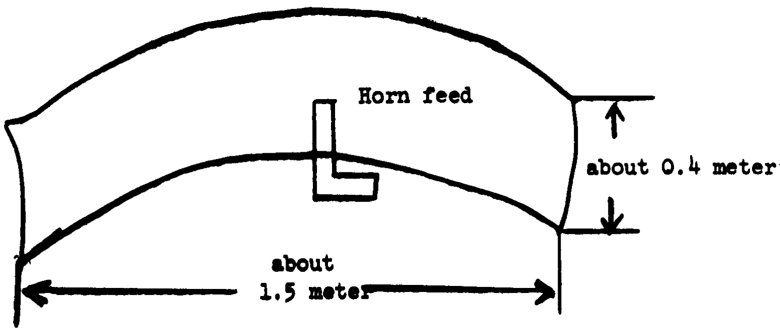
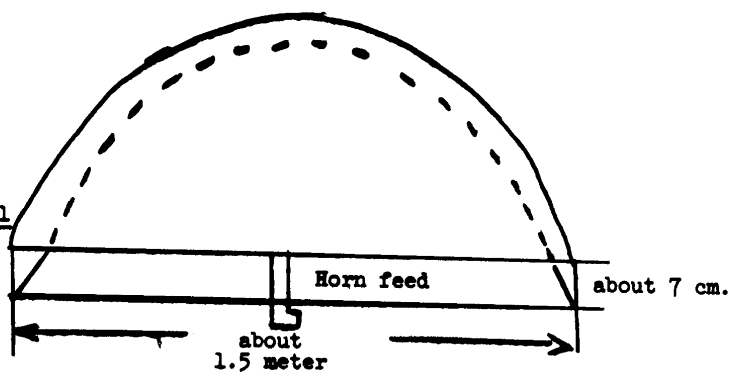


Fig. 3 Tortenschachtel



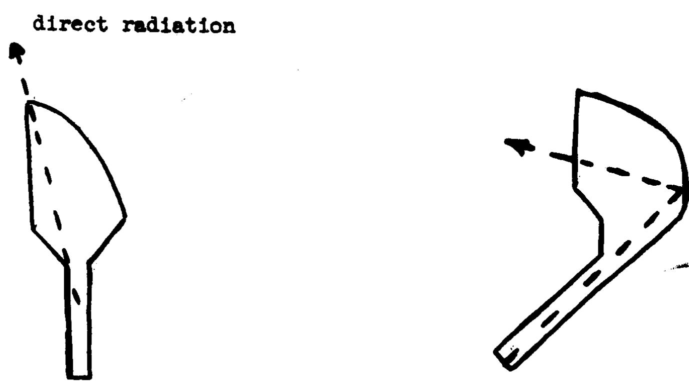


Fig. 4a

Fig. 4b

Horn feeds

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Annex 2

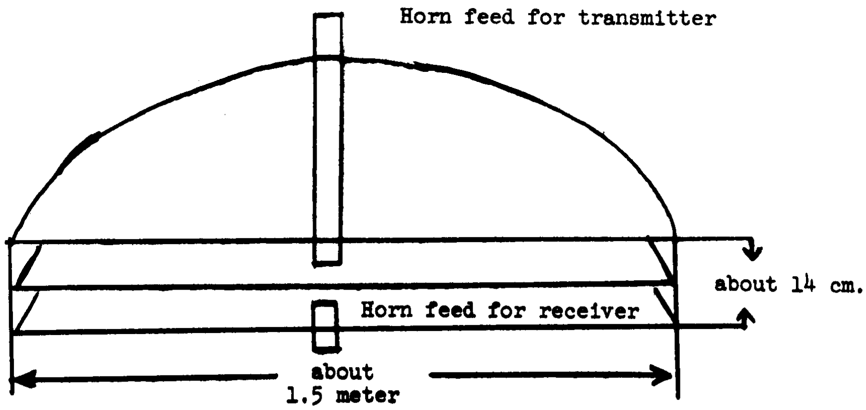

Fig. 5 Doppelte Tortenschachtel

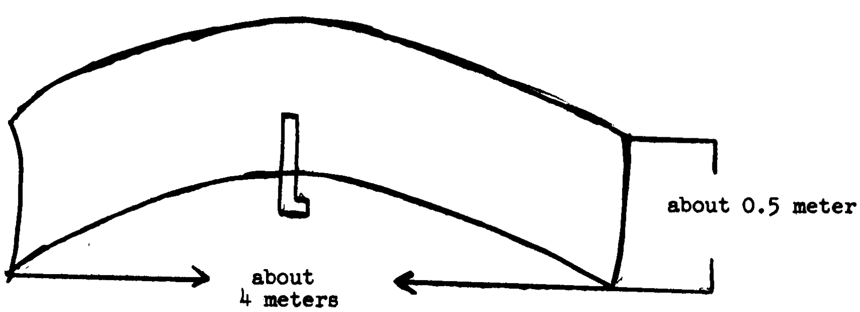

Fig. 6 Parabola antenna for coastal radar