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EVALUATION OF ELLIPTICAL FOCUSING DISH ANTENNA FOR HIGH-POWER D--ETC(U)
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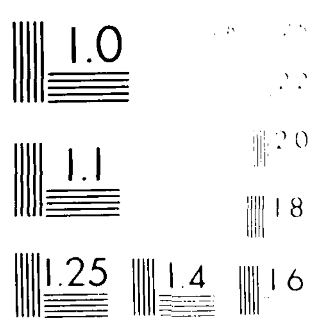

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The operating characteristics of the Elliptical Focusing Dish Antenna, located in the Department of Microwave Research, Walter Reed Army Institute of Research, were measured to confirm its suitability for use in delivering high-power density microwave exposure to a small region on a test animal. A detailed field map confirms the location of the second focus of the antenna to within 0.5 cm. Measured absolute power density was found to agree with the original specifications to within ± 1.8 dB.

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INTRODUCTION

Many irradiation systems have been used in investigations to determine the relationship between microwave exposure and cataracts. Milroy and Michaelson[3] have described many of the systems used in these investigations. These include microwave diathermy applicators, open and closed waveguide, and free space systems. In an attempt to deliver large quantities of radiation selectively to the eye, other systems (including shielding with absorber material, the focusing dielectric lens, and focusing dish antennas) present themselves as alternatives. Investigators at the Walter Reed Army Institute of Research[1] have, in fact, used an Elliptical Focusing Dish Antenna developed and tested by the Georgia Institute of Technology (GIT).[2] The availability of this equipment to AFRRI investigators and a subsequent decision to use the equipment in microwave cataract studies led to an investigation of the Elliptical Focusing Dish Antenna to confirm its operating characteristics and suitability for the proposed experiments.

EQUIPMENT AND METHODS

Elliptical dish microwave antenna. The Elliptical Focusing Dish Antenna (Figure 1) is a 6-ft (91.4 cm) diameter ellipsoidal reflector having a first focal point 32.848 inches (83.43 cm) from the vertex of the dish. The second focal point is located 74.848 (190.1 cm) from the vertex of the dish. The reflector is rigidly mounted to a framework by two back supports, one of which allows adjustment of the reflector tolerances to within ± 0.03 inches (.076 cm) using a template. A feed horn is fed by a waveguide which is supported by a nonmetallic rod support under the feed and a waveguide-mounting structure at the side of the dish. The feed is an oversized circular choke-groove in a disk mounted flush to the end of the waveguide. The feed is aligned to place the E and H plane phase centers at the optimum position with respect to the first focal point of the dish. The focused system was originally calibrated by GIT,[2] with phase and amplitude patterns recorded in several transverse planes

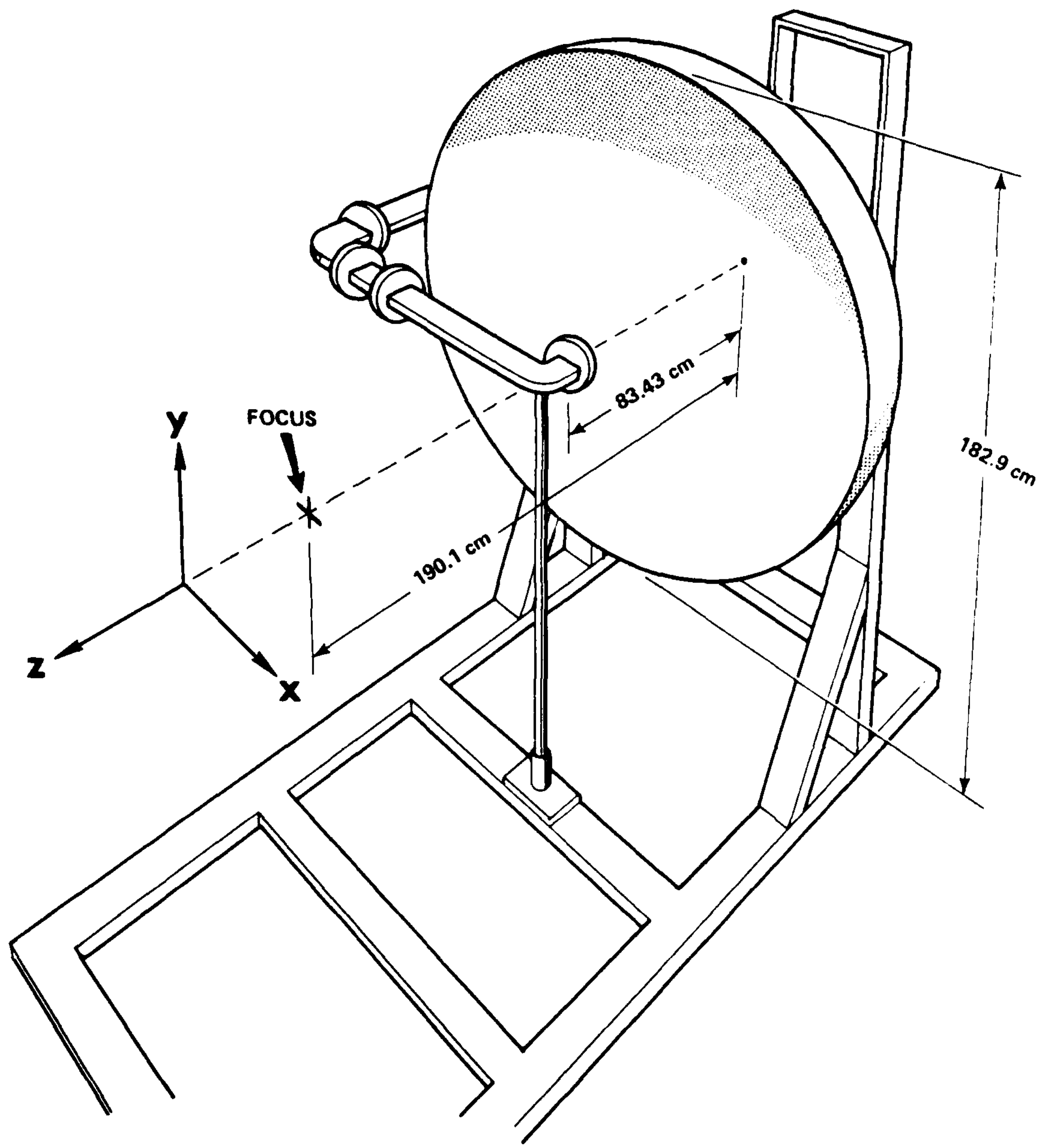

Figure 1. Elliptical Focusing Dish Antenna

orthogonal to the axis of the ellipsoidal reflector. Amplitude patterns were recorded as a function of distance along the reflector axis at the focus, 6 inches (15.24 cm) beyond the focus, and 12 inches (30.48 cm) beyond the focus.

To confirm and expand on the original calibration, the following equipment and methods were used:

Field measurement probe. The microwave probe used throughout was a Model EDM-1B, developed by the National Bureau of Standards (NBS). The probe measures electrical energy density, is isotropic, and has a flat frequency response from 20 to 4000 MHz. The probe has a dynamic range of 0.001-10 $\mu J/m^3$, which corresponds to 0.06-600 mW/cm^2 in the far field, and has an absolute accuracy of $\pm$ 0.5 dB. The dipoles in the probe sensor are 8 mm long, permitting high spatial resolution of the field.

Microwave generator. The microwave energy was generated (Figure 2) by a 10-W traveling wave tube (TWT) amplifier (Alfred Model 501) which was driven by a sweep generator (HP type 8690) operated at a fixed frequency of

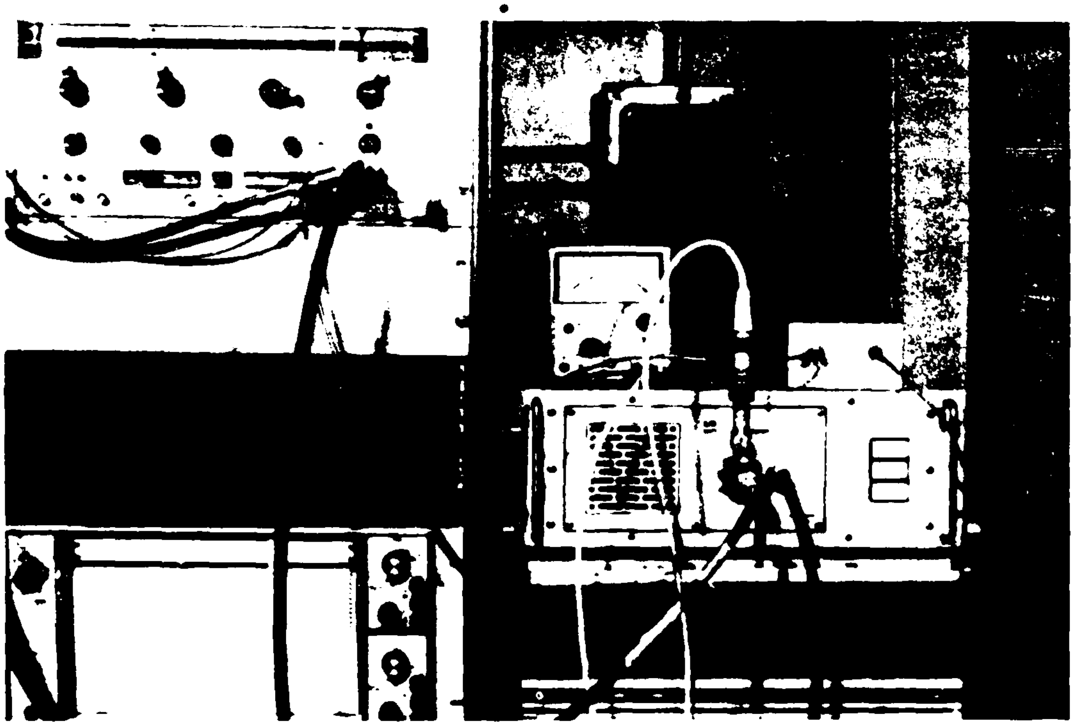

Figure 2. Microwave generation equipment

2450 MHz. Output power was kept constant by a leveling loop fed back to the sweep generator from a power meter (HP type 432A) which monitored the output power of the TWT amplifier through attenuators and couplers. The energy was transmitted to the feed horn of the antenna by coaxial cable and waveguide.

Probe-mounting equipment. Probe location in the horizontal plane (X-Z) was established using optical benches rigidly mounted to the framework of the antenna with a reference point at a known distance from the vertex of the antenna (Figure 3). The rails of the optical benches were scribed at 1-mm intervals. Probe height in the vertical (Y) direction was determined by measuring the distance from the top rail of the X-axis optical bench (which was a known distance from the vertex of the antenna) to 0.5 inches (1.27 cm) below the tip of the probe, which was the location of the center of the dipoles. The probe

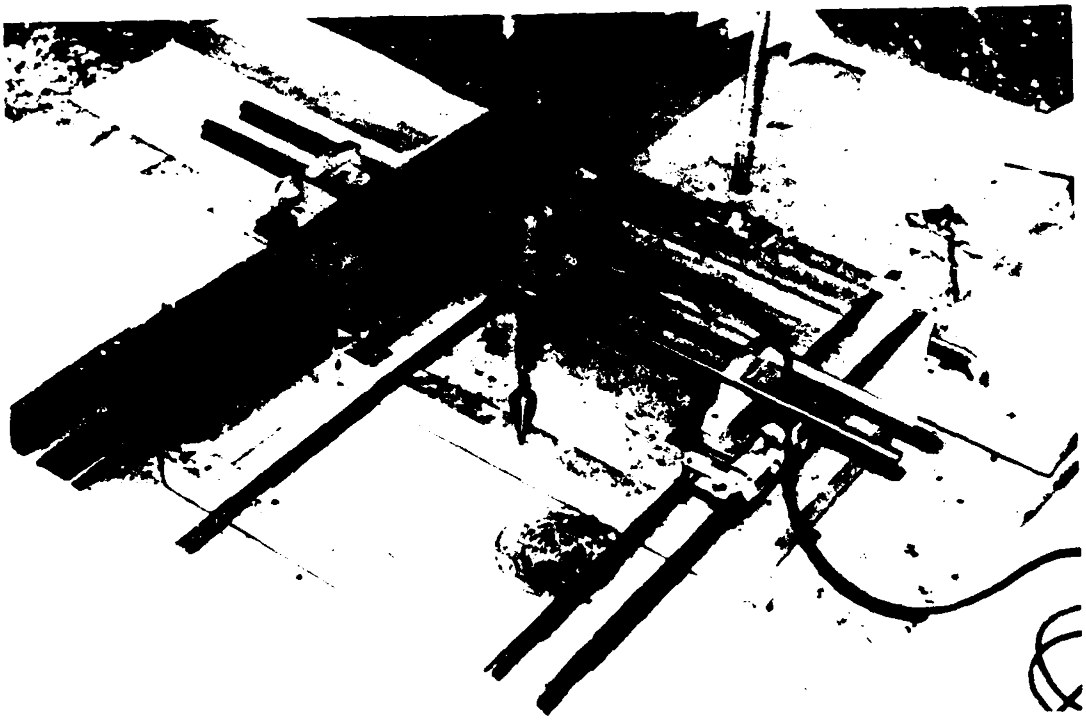

Figure 3. Equipment for mounting probe and establishing stable coordinate system

was motor-driven in the X direction by a long screw with a potentiometer (Figure 4) providing a linear voltage output (location) for driving one axis of an X-Y plotter.

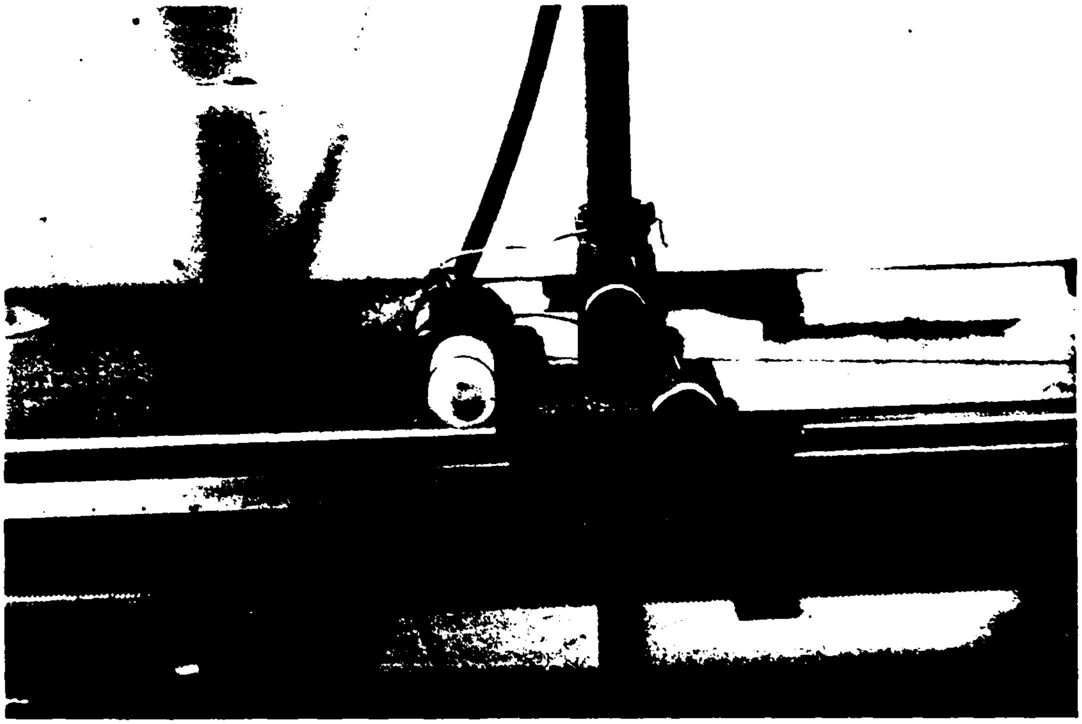

Figure 4. Screw drive and potentiometer for driving and locating probe along the X axis

Although the optical bench slide assemblies were metal, preliminary testing showed that the power density in the vicinity of the assemblies was at least -30 dB from the power density along the axis in the vicinity of the focus. Thus, the presence of these metal assemblies in the field minimally perturbed the field at the location of the measurements.

Mapping procedure. The procedure used in mapping the field was to set the probe at various heights on, above, and below the axis through the vertex of the antenna. With the probe thus set at a fixed Y distance, the slide assembly was moved to a fixed Z distance from the vertex of the antenna. The motor-driven slide assembly was then activated to sweep across the field in the X direction (perpendicular to the axis of the elliptical dish), recording the output of the field probe as the ordinate of an X-Y plot, with the location along the X axis as the abscissa. The slide was then repositioned to a new Z distance and the procedure repeated until a complete run was made in the Z-X plane. The probe was then set to a new Y distance and the procedure repeated for another Z-X plane. By this process, maps were made for Z-X planes at five different probe heights (Y direction) on the axis, at ± 4 cm, and at ± 8 cm vertically from the axis of the elliptical dish. Continuous curves were made from +21 cm to the left and right of the axis (X direction) at 4 cm increments starting at a point 124.4 cm from the vertex of the antenna. The coordinate system and pertinent distances are shown in Figure 1.

RESULTS AND DISCUSSION

Results of mapping the field in the vicinity of the focus of the elliptical dish antenna are shown (Figures 5-9). The figures show power density plotted

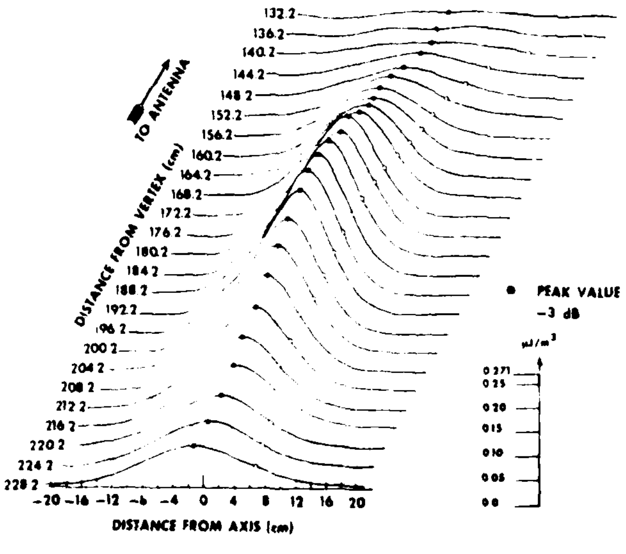

Figure 5.
Power density in the vicinity of the focus. Y = 0 (on the axis of the antenna).

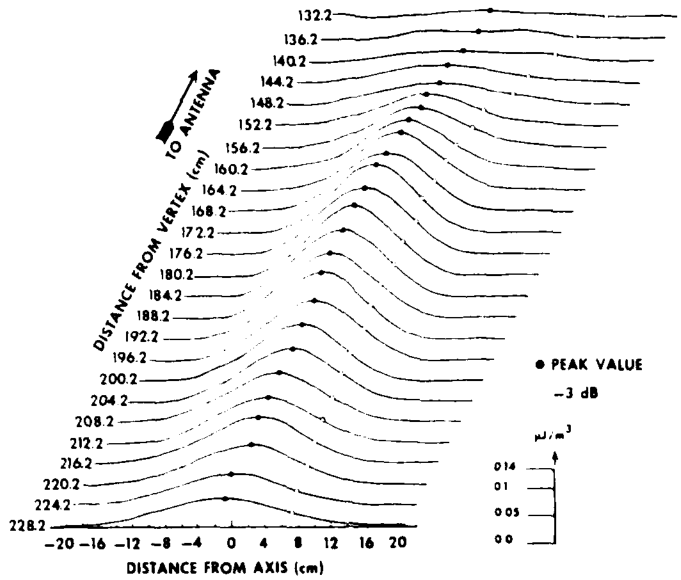

Figure 6. Power density in the vicinity of the focus.
Y = +4 cm (above the axis of the antenna).

at 4 cm increments in the X-Z plane for a given Y with peak values and -3 dB points shown for each increment.

Using Figure 5, the focus may be seen to be between the 192.2 and 188.2 cm curves. Linear interpolation indicates that the focus is at 190.6 cm from the vertex. This distance is within 0.5 cm of the GIT specification.

With the probe set in the center of the focus, a check was made of the absolute power density as compared with the GIT specification. The results are shown in Figure 10. As may be seen, their specification is only accurate to within ± 1.8 dB, if the NBS probe (with its absolute accuracy at 0.5 dB) is accepted as the primary standard for absolute power density.

The Elliptical Focusing Dish Antenna is useful in delivering large quantities of microwave energy to a relatively small area on an experimental animal. Our investigations at 2450 MHz indicate that the original specifications as to location of the focus are accurate to within ± 0.5 cm, and that the original specifications as to power density at the second focal point for a given input power are accurate to within ± 1.8 dB (based on using the NBS probe as a primary standard). Due to this large range in the specified output power density for a given input power, the user of the system should use a calibrated probe in order to determine more accurately the actual power density at the location of the experimental animal.

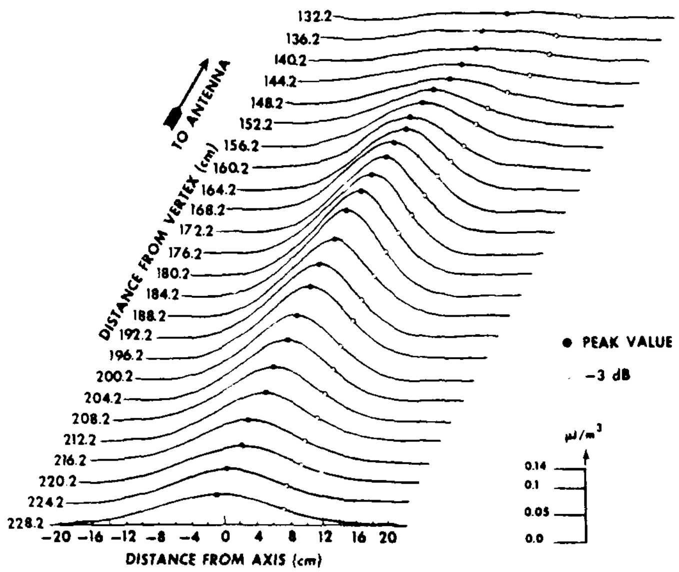

Figure 7.
Power density in the vicinity of the focus. Y = -4 cm (below the axis of the antenna).

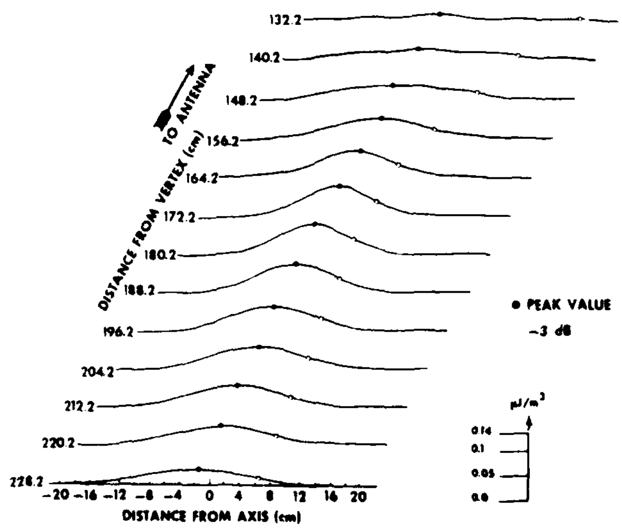

Figure 8.
Power density in the vicinity of the focus. Y = +8 cm (above the axis of the antenna).

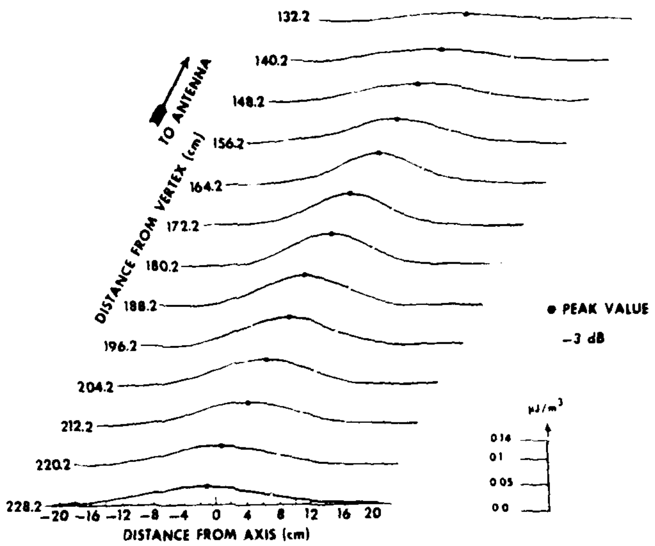

Figure 9. Power density in the vicinity of the focus. Y = -8 cm (below the axis of the antenna).

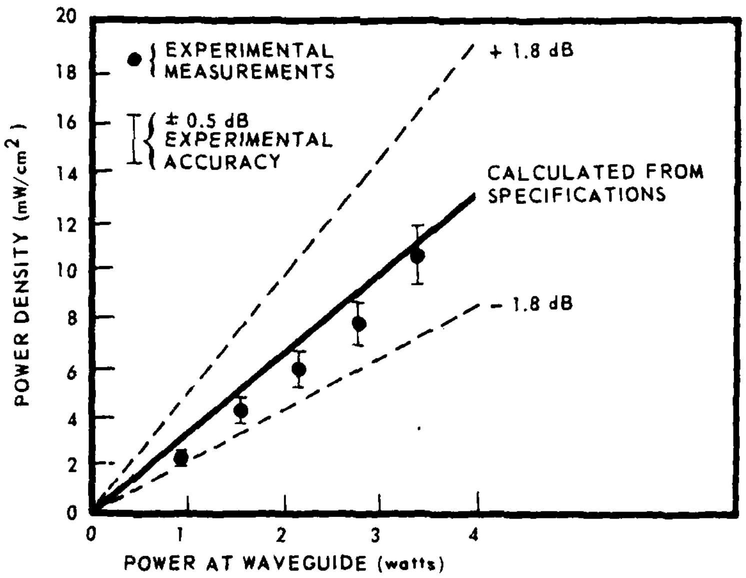

Figure 10. Output power density vs input power

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