the plasma density corresponded at its maximum value to about twice the signal frequency, while at a pressure of 50 μ, the loss frequency would be of the order of 1/10 of the signal frequency.

Within the limitations of the experiment, the results show that an electron-free tunnel can be created in a plasma slab and that such a tunnel would provide an attenuation-free path for a microwave signal. Limitations are imposed on the geometry of the grid since it must not appreciably affect the transmission of the signal, and yet its electrodes must be spaced sufficiently close so that excessive power need not be used to create the electron free region. The possibility of using such a device to enable a signal to penetrate a plasma sheath will depend on whether or not a grid can be designed with the restrictions discussed above and at the same time be able to withstand the environmental conditions in which it is to function.

J. Willis
D. W. Czubiak
Dept. of Engrg.
University of California
Los Angeles, Calif.

A Low-Loss Launcher for the Beam Waveguide

The beam waveguide[1] shows great potential for providing an extremely low-loss method of guiding millimeter and submillimeter waves. However, the low-loss mode in the beam waveguide differs considerably in form from the fundamental modes of metal waveguides. This leads to the problem of finding an efficient way to couple from the metal waveguide to the beam waveguide or between the metal waveguide and devices such as resonators utilizing beam waveguide modes.

The usual method used to solve this problem is to use a rectangular horn with a phase correcting plate to launch the low-loss beam mode. However, this technique usually results in launching some of the energy into higher modes which have high losses. The best efficiency reported for launching into the fundamental mode, using this technique, is 85 per cent.

An attempt was made to find a launcher which would excite only the lowest mode and couple almost all of its energy into that mode. This type of device should prove to be a highly efficient launcher and could take full advantage of the low-loss potential of the beam waveguide. Several possibilities for launchers were investigated, optimized rectangular horns, circular horns, and dual-mode horns. The most promising launcher found was the dual-mode conical horn.[2]

The far-field criteria used for determining an efficient launcher were as follows:

1) Amplitude distribution—ϕ independent gaussian
2) Sidelobes—at least 20 db down
3) Polarization—linear
4) Phase front—plane.

Extending the work of Potter[2] it was found that the aperture distributions of the dual-mode conical horn are to a first approximation gaussian nearly ϕ independent and contain very little cross-polarized energy. For circular apertures with ϕ-independent aperture distributions, the far-field radiation pattern can be found by taking the finite Hankel transform of the aperture distribution. However, for this case, the Hankel transform of the ϕ-independent gaussian distribution is another ϕ-independent gaussian distribution.[3] It was also noted that since the aperture distribution has amplitude taper in all directions, the sidelobe level should be very low. Therefore, it was concluded that the far-field pattern of the dual-mode conical horn should essentially satisfy requirements 1), 2), and 3) for an efficient launching device.

To check these predictions, a 34-kMc dual-mode conical horn was constructed by use of the electroforming technique. Comparison of measurements made on the horn with the requirements stated above are summarized in the next few paragraphs.

As an example, a beam waveguide of diameter 20λ is assumed. The required gaussian amplitude distribution for an "a"[4] value of 2.25 (corresponding to a loss of 0.02 db per iteration) is plotted in Fig. 1. Superimposed on this plot are the E plane, H plane, and 45° plane measured data points for the electric field distribution measured at a distance of 24.5 cm from the horn.

It is seen that, at least to the region of very small fields, the dual mode conical horn's amplitude distribution is very nearly gaussian and essentially ϕ independent, satisfying requirement 1).

The measured sidelobe levels of horn were found to be at least 30 db down. This more than amply satisfies requirement 2).

The cross-polarized component of the field was measured and found to be at least 26 db down from the main polarization. This essentially satisfies condition 3) in the above requirements.

The measured deviation from a plane phase front is shown in Fig. 2. This deviation is essentially symmetric in the region from the axis out to about 7 cm radius where it loses its symmetry. The loss of symmetry is not of large importance because it occurs in the region where the fields have fairly small magnitudes (see Fig. 1). In the region of interest, the phase deviation is of a form which easily lends itself to correction to a planar distribution by the use of a physically realizable phase-correcting plate. If this were done, the combined horn and phase-correcting plate would satisfy requirement 4) for an efficient launcher. In practice, this phase plate may be combined with the first lens of a beam waveguide system as shown in Fig. 3.

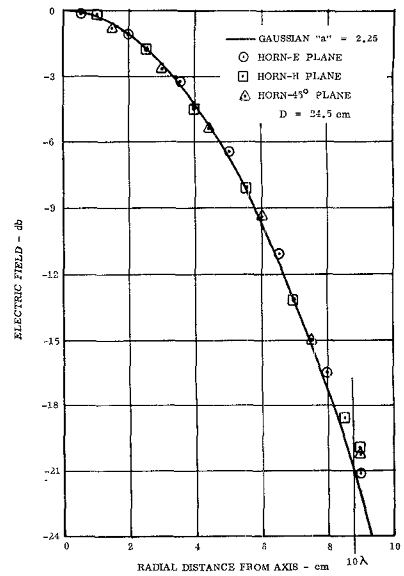

Fig. 1—Amplitude distributions.

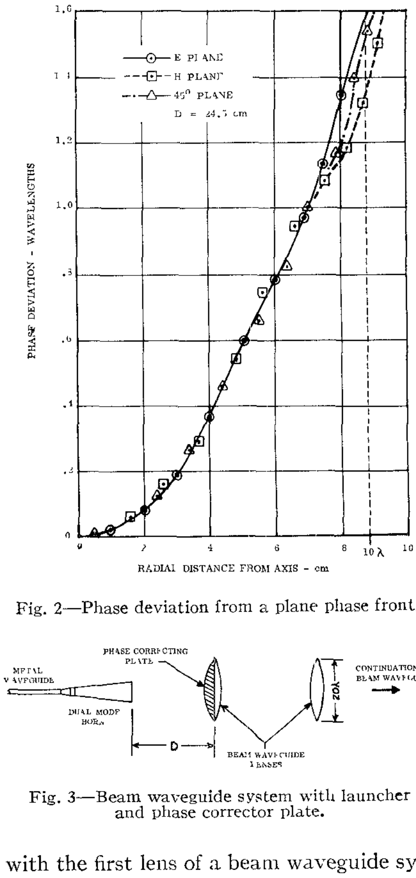

Fig. 2—Phase deviation from a plane phase front.

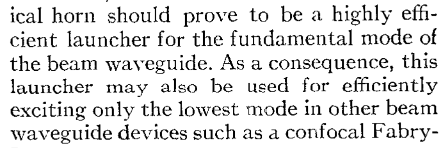

Fig. 3—Beam waveguide system with launcher and phase corrector plate.

Hence, it is seen that the dual-mode conical horn should prove to be a highly efficient launcher for the fundamental mode of the beam waveguide. As a consequence, this launcher may also be used for efficiently exciting only the lowest mode in other beam waveguide devices such as a confocal Fabry-Perot resonator.

R. J. Chaffin
J. B. Beyer
Dept. of Elec. Engrg.
University of Wisconsin
Madison, Wis.

Manuscript received May 27, 1964. This work was sponsored by A.E.C. Contract No. AT (11-1)-1233.

[1] G. Goubau and F. Schwering, "On the guided propagation of electromagnetic wave beams," IRE Trans. on Antennas and Propagation, vol. AP-9, 248–256; May, 1961.

[2] P. D. Potter, "A new horn antenna with suppressed sidelobes and equal beamwidths," *Microwave J.*, vol. VI, pp. 71–78; June, 1963.

[3] J. B. Beyer and E. H. Scheibe, "Higher modes in guided electromagnetic-wave beams," IRE Trans. on Antennas and Propagation (*Correspondence*), vol. AP-10, pp. 349–350, May, 1962.

[4] J. B. Beyer amd E. H. Scheibe, "Loss measurements of the beam waveguide," IEEE Trans. on Microwave Theory and Techniques, vol. MTT-11, pp. 18–22; January, 1963.