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ELECTROMAGNETIC WAVES ON CORRUGATED LINES: PROPAGATION CONSTANT MEASUREMENTS

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PROPAGATION CONSTANT MEASUREMENTS

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I. Introduction

In a previous report[1] an approximate formula for the constant of propagation has been derived from an exact integral equation. It is the purpose of this report to check experimentally the accuracy of our formula.

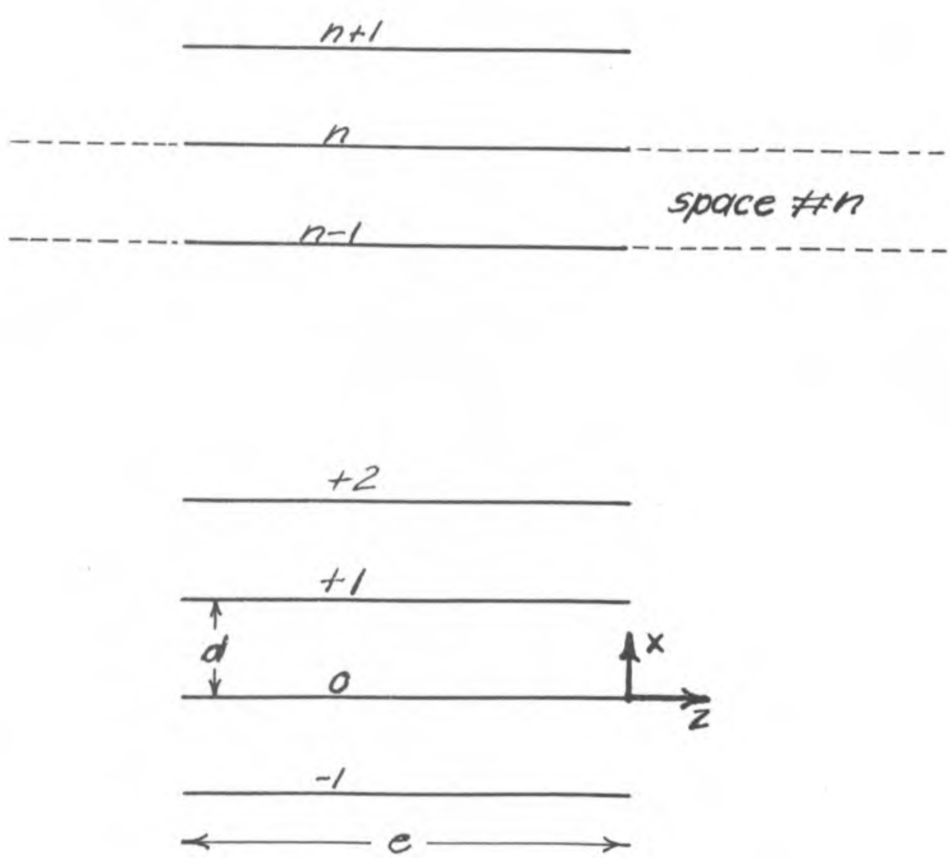

Figure 1.

(1) G. Weill, Propagation of Electromagnetic Waves along Corrugated Lines, (ASTIA Document AD115 049).

Let us recall first that the corrugated line under consideration is made of parallel "infinite" metallic strips. (Figure 1). The strips have length ℓ, spacing d. They are supposed to be infinite in the direction of the axis y, and the line itself is infinite in the direction of the x axis. We are considering here the TM symmetric case (H_y, E_x, E_z). With

$$H_y = u$$

$$E_z = \frac{1}{j\omega\epsilon} \frac{\partial u}{\partial x}$$

we defined the unilateral Fourier transforms:

$$\frac{1}{2\pi i} \int_{c-i\infty}^{c+i\infty} v(s)\, e^{sz}\, ds = \begin{cases} \frac{\partial u}{\partial x}(0,z) & z > 0 \\ 0 & z < 0 \end{cases}$$

$$\frac{1}{2\pi i} \int_{c-i\infty}^{c+i\infty} v(s)\, e^{-s(z+\ell)}\, ds = \begin{cases} 0 & z > -\ell \\ \frac{\partial u}{\partial x}(0,z) & z < -\ell \end{cases}$$

and we obtained the integral equation:

$$v(s)\, L_+^*(s) = \frac{1}{2\pi i} \int_{c-i\infty}^{c+i\infty} \frac{v(w) e^{-w\ell}\, dw}{(w+s) L_-^*(w)}$$

L_+^* and L_-^* have been defined in (1).

A residue expansion gives us an infinite system of linear equations. Taking the first term of the first equation, the only significant one, we get:

$$e^{-\frac{ik_o \ell}{2}} = \sqrt{\frac{d}{1 - \cos \gamma d}}\; \frac{L_+^*(ik_o)}{2i\, k_o}$$

Equating the arguments of both sides we get a relation

$$\ell = f(\gamma, d, k_o) \quad .$$

Putting

$$\frac{k_o d}{2\pi} = K \quad , \quad \frac{\gamma d}{2\pi} = \Gamma \quad , \quad \frac{2\pi \ell}{\lambda_o} = L$$

the relation becomes

$$L = F\left[K, \Gamma\right].$$

Curves have been drawn for

$K = 1/10$: 10 strips per wavelength

$K = 1/3$: 3 strips per wavelength

(See Figures 2 and 3.)

II. Experimental Device.

For the sake of convenience, measurements have been made at microwave frequencies (S band). To measure the propagation constant of the surface wave we used a long "corrugated line". The length of the strips is great compared to their width. The launching of the surface wave is operated by means of a sectoral horn; the other end of the line radiates freely.

To avoid perturbation by the launching device or by end effects, measurements have taken place in the middle section of the line.

The experimental device is schematized on Figure 4 and represented in Figure 5.

Equipment

UHF signal generator	HP model 616A
TWT amplifier	HP model 491A
Detector	HP model 415B
Slotted line	HP model 5810A
Variable attenuator	HP model S375 .

III. Measurement Method.

We compare the phase of the wave propagated on the corrugated line with the phase of a reference wave propagated in a waveguide. The carriage of the slotted line is moved to get a zero on the detector. Then, any

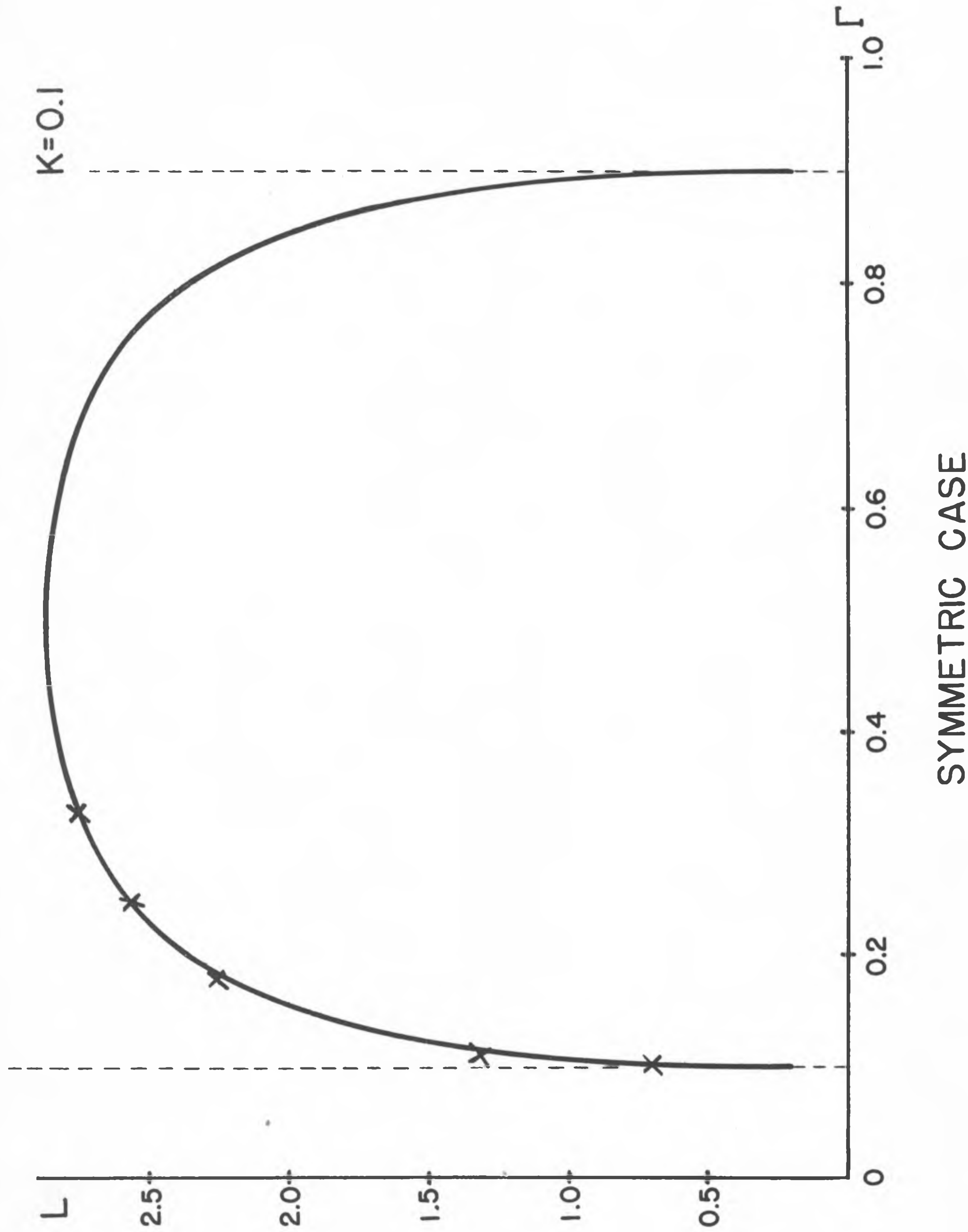

Figure 2.

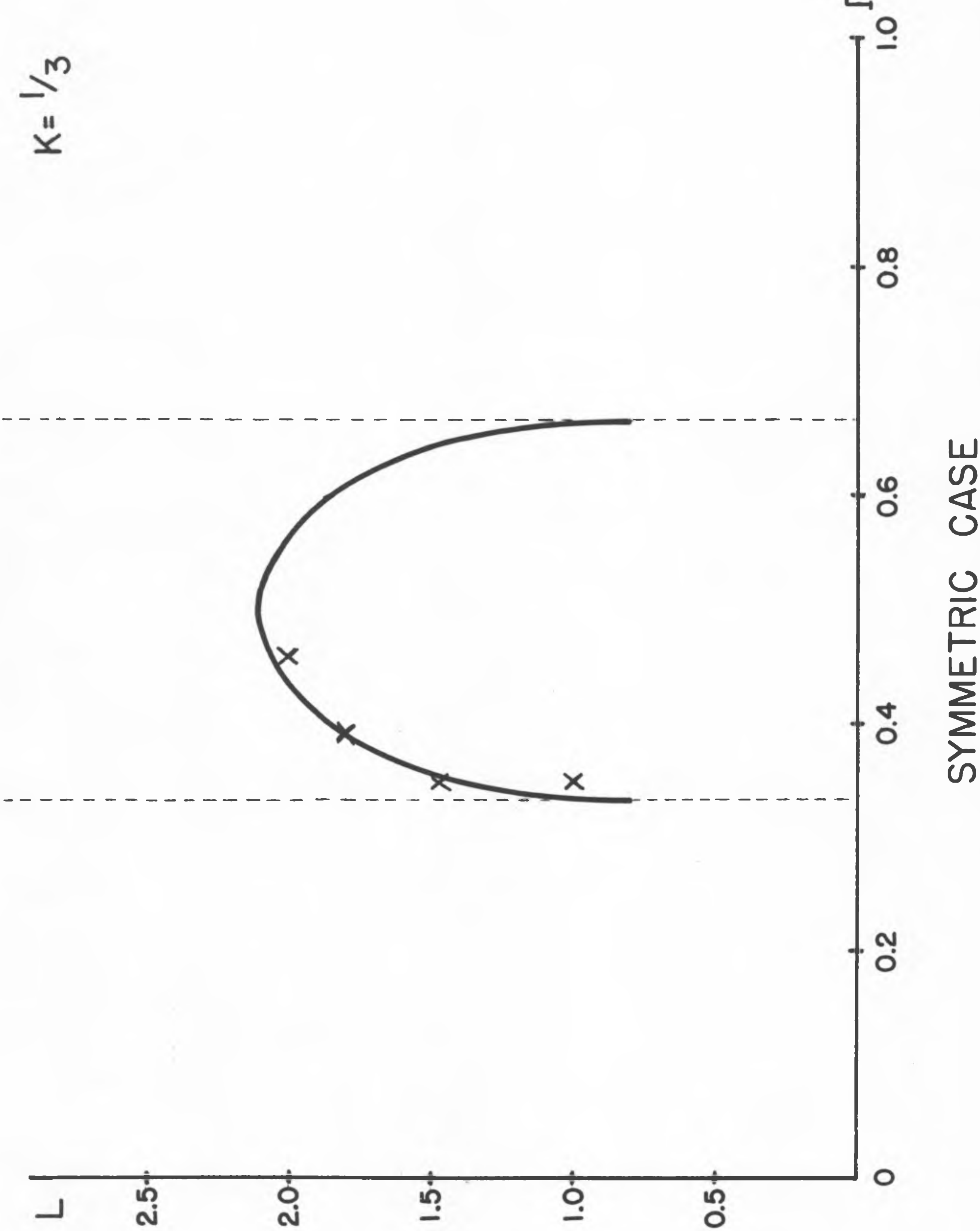

Figure 3.

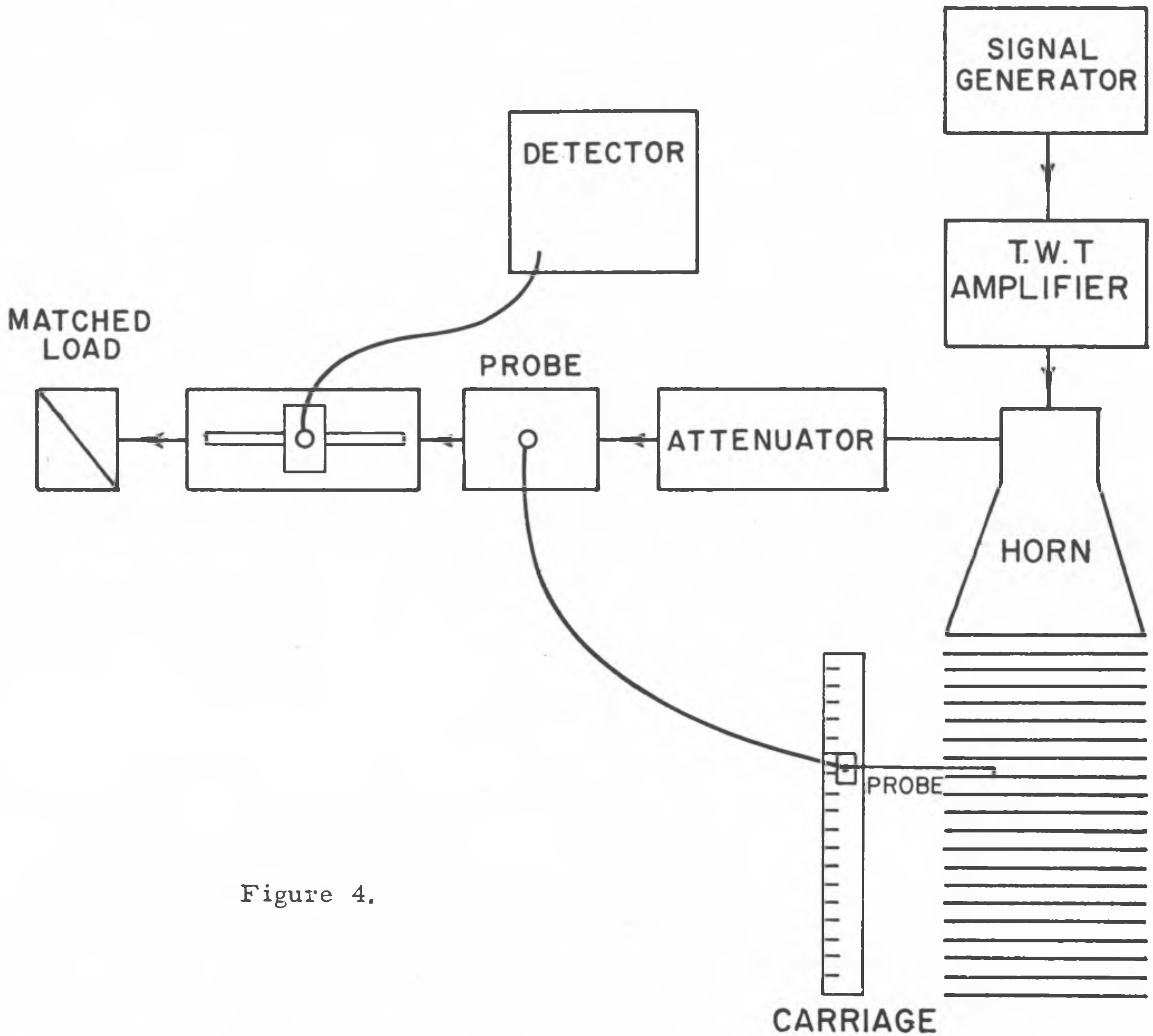
SIGNAL GENERATOR
T.W.T AMPLIFIER
HORN
DETECTOR
MATCHED LOAD
PROBE
ATTENUATOR
PROBE
CARRIAGE

Figure 4.

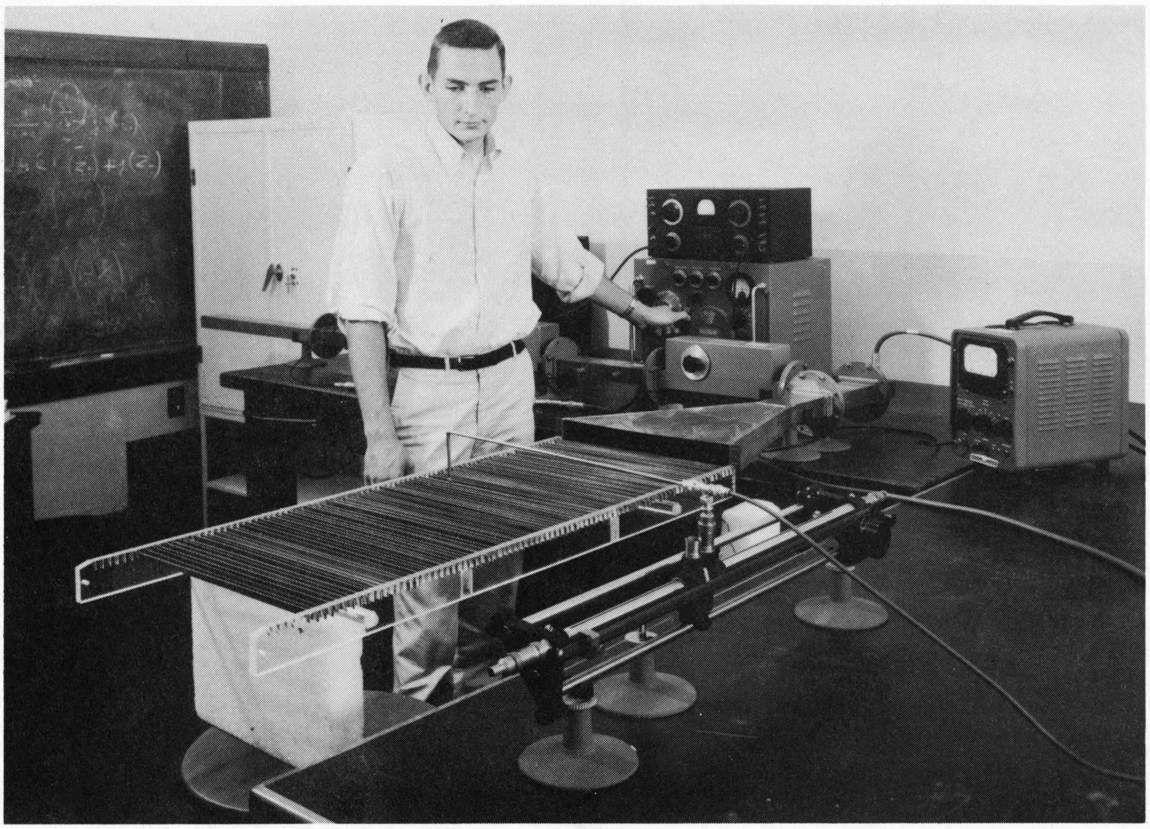

Figure 5

displacement of $n \lambda_g$ (n integer; λ_g guided wavelength) of the probe gives us a zero on the detector meter.

The accuracy which can be expected from the method, taking $n = 5$ is about 5% .

IV. Experimental Results.

To be able to use a smaller set of strips, measurements have been made at $f_1 = 3000$ mc/s for $K = 1/10$, and $f_2 = 3333$ mc/s for $K = 1/3$. The results, summarized in the following tables are represented on Figures 2 and 3, showing a very good agreement with the theoretical ones.

$K = .1$ $d = 1$ cm $f = 3000$ mc

ℓ cm	L	λ_g cm	$\Gamma_{measured}$	$\Gamma_{theoretical}$
1.10	.70	9.8	.10	.10
2.10	1.32	8.8	.11	.115
3.60	2.26	5.4	.18	.185
4.10	2.56	4.0	.25	.250
4.38	2.75	3.0	.33	.335
4.80	3.02	9.5		

$K = 1/3$ $d = 3$ cm $f = 3333$ mc

ℓ cm	L	λ_g cm	$\Gamma_{measured}$	$\Gamma_{theoretical}$
1.43	1.00	8.9	.35	.335
2.10	1.47	8.5	.35	.355
2.58	1.80	7.7	.39	.390
2.86	2.0	6.5	.46	.435
3.6	2.51	8.8		

We have checked points in the non-transmitting band of the structure. We get, as predicted, no guided wavelength but merely the primary excitation wave. (Points 4.80 and 3.6).

V. Conclusion.

The approximate formula for $L = f\left[\Gamma, K\right]$ obtained from our integral equation shows a quite good agreement with experiment; now further approximation seems to be needed, at least for engineering purposes.

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