In the frame where the observer has an axial velocity v relative to the medium and waveguide (primed system), a typical field component is proportional to

$$\begin{matrix}\sin\\ \cos\end{matrix}\left(\frac{m\pi x'}{a}\right)\begin{matrix}\sin\\ \cos\end{matrix}\left(\frac{n\pi y'}{b}\right)$$

$$\exp\left[i\Gamma_{mn}'mn'z-i\omega't'\right]$$

where the primed and unprimed coordinates are related through the Lorentz transformations

$$x' = x \quad y' = y \quad z' = \gamma(z + vt)$$

$$t' = \gamma\left(t + \frac{vz}{c_0^2}\right)$$

$$c_0^2 = \frac{1}{\mu_0\epsilon_0}$$

$$\exp[i\Gamma' z' - i\omega' t'] = \exp\left[i\gamma\left(\Gamma'_{mn} - \frac{\omega' v}{c_0}\right)z - i\gamma(\omega' - \Gamma'_{mn}v)t\right]$$

$$\exp\left[i\Gamma_{mn}z - i\omega t\right].$$

Therefore,

$$\Gamma_{mn} = \gamma\left(\Gamma'_{mn} - \frac{\omega' v}{c_0^2}\right) \quad \omega = \gamma(\omega' - \Gamma'_{mn}v)$$

Substituting in (2), we obtain, neglecting second-order terms in v,

$$\Gamma'_{mn} = +\,\omega' v\left(\frac{1}{c_0^2} - \mu\epsilon_{\text{eff}}\right) \pm (k^2 - k_{mn}^2)^{1/2}$$

$$= -\frac{\omega' v}{c^2}\left(1 - \frac{c^2}{c_0^2} + \frac{i\sigma}{\omega\epsilon}\right) \pm (k^2 - k_{mn}^2)^{1/2}$$

essentially equation (74) in Collier and Tai[1]

$$c^2 = \frac{1}{\mu\epsilon}.$$

The same procedure may be carried out for any cylindrical waveguide with similar results.

The field components and wave impedance follow directly from Maxwell's equations. The fact that the modification to the propagation constant and wave impedance is independent of the waveguide dimensions is therefore a direct consequence of the fact that the two problems are connected by a Lorentz transformation.

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Contributors

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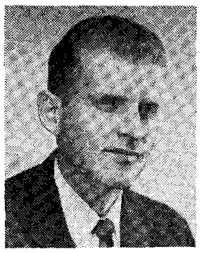

J. R. Christian (M'59) was born in New Brunswick, N. J., on July 25, 1933. He received the B.S. degree in electrical engineering and the M.S.E.E. degree from Rutgers—The State University, New Brunswick, N. J., in 1955 and 1964, respectively.

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Dr. Goubau received the Harry Diamond Memorial Award of the IRE for his basic contribution to the theory of surface waves and the invention of the surface wave transmission line in 1957. He is a member of Sigma Xi, the Administrative Committee of the IEEE Antennas and Propagation Group, and U. S. Commission VI of URSI.

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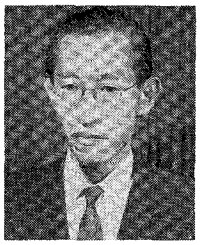

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