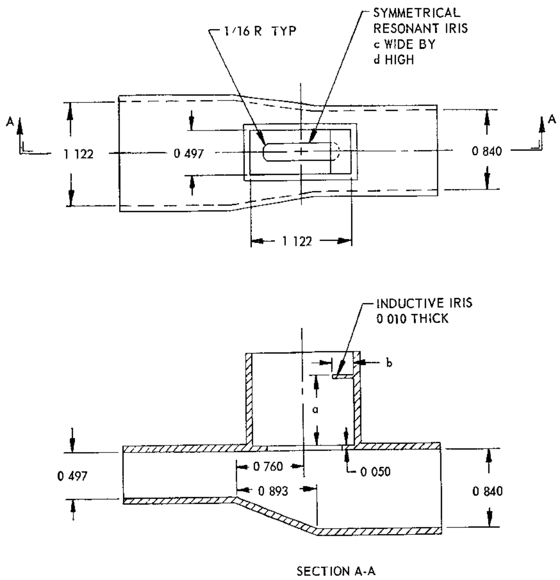

Fig. 1. Configuration of the dual-mode coupler.

TABLE I

VALUES OF LETTER DIMENSIONS FOR THE COUPLER OF FIGURE 1

Dimension	Model 1 (inches)	Model 2 (inches)
a	0.765	0.465
b	0.200	0 196
c	0.780	0.910
d	0.230	0.406

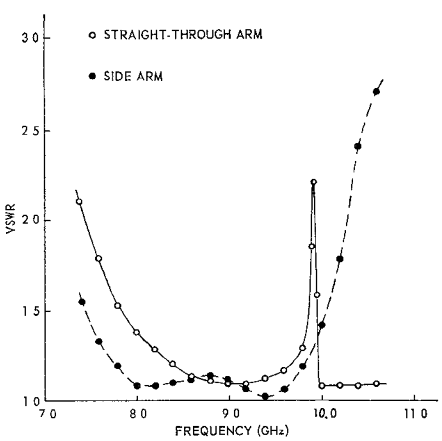

Fig. 2. VSWR versus frequency for Model 1 of the dual-mode coupler.

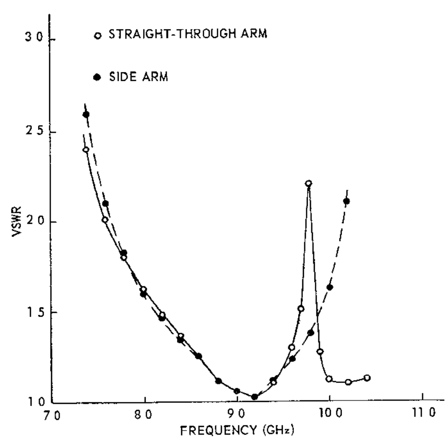

Fig. 3. VSWR versus frequency for Model 2 of the dual-mode coupler.

Two models were designed and tested. Their configuration including dimensional information is shown in Fig. 1; specific dimensions of the irises are given in Table I. The smaller resonant iris in Model 1 yields a wider bandwidth; however, it reduces the power-handling capabilities of the side arm.

Both models were tested for VSWR, power handling capabilities, and isolation. The VSWR versus frequency characteristics are shown in Figs. 2 and 3. Both couplers were tested at atmospheric pressure with a pulsed power source having a pulse length of 1.0 μs, a pulse repitition frequency of 600 Hz, and a frequency coverage from 8.5 to 9.6 GHz. The straight-through arm of both models handled over 250 kW peak; the side arm handled over 125 kW peak in Model 1 and over 250 kW peak in Model 2. In both couplers, the isolation between the rectangular arms exceeded 50 dB over the test frequency bands of 8.2 to 9.8 GHz and 8.4 to 9.6 GHz for Models 1 and 2, respectively.

The performance reported here does not necessarily represent the ultimate limits for this type of coupler. It is felt that with changes in the taper and with a different shape for the resonant iris the coupler would perform well over a broader frequency band.

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REFERENCES

[1] F. E. Ehlers, "Lowest mode in the waveguide transitions," in *Microwave Transmission Circuits*, G. L. Ragan, Ed., M.I.T. Radiation Lab. Ser., vol. 9. New York: McGraw-Hill, 1948, p. 369.

[2] D. J. LeVine and W. Sichak, "Dual-mode horn feed for microwave multiplexing," *Electronics*, pp. 162–164, September 1954.

[3] S. G. Komlos, P. Foldes, and K. Jasinski, "Feed system for clockwise and counterclockwise circular polarization," *IRE Trans. Antennas and Propagation (Communications)*, vol. AP-9, pp. 577–578, November 1961.

[4] J. Y. Wong, "A dual polarization feed horn for a parabolic reflector," *Microwave J.*, vol. 5, pp. 188–191, September 1962.

[5] W. A. Cumming, "A dual-polarized line source for use at *S*-band, *Microwave J.*, vol. 6, pp. 81–87, January 1963.

[6] M. W. Long, "A 35,000-Mc multiple polarization radar system," presented at the Conf. on Millimeter Wave Research and Applications, Office of Naval Research, Washington, D.C., September 1953.

[7] H. D. Ivey and M. W. Long, "Polarization characteristics of radar targets," Georgia Institute of Technology, Atlanta, Quart. Rept. 1, Contract DA-36-039-sc-56761, August 1954. (AD 64958)

[8] C. H. Currie, R. D. Hayes, H. D. Ivey, and M. W. Long, "Polarization characteristics of radar targets," Georgia Institute of Technology, Atlanta, Final Rept., Contract DA-36-039-sc-56761, March 1955. (AD 55124)

[9] A. J. Simmons, "3-millimeter waveguide components," TRG, Inc., East Boston, Mass., Final Rept., Contract DA-36-039-sc-88979, August 1964.

[10] A. J. Simmons and O. M. Giddings, "Ferrite Devices for the 3-mm band," *WESCON Rec.*, pp. 25–28, August 1964.

[11] A. J. Simmons, "Faraday rotation devices for the 3-mm band," *Microwave J.*, vol. 8, pp. 65–69, April 1965.

[12] B. F. LaPage, "The West-Ford antenna system," M.I.T. Lincoln Lab., Lexington, Mass., Tech. Rept. 338, Contract AF 19(628)-500, December 6, 1963. (AD 438879)

[13] R. C. Johnson, "Design of linear double tapers in rectangular waveguides," *IRE Trans Microwave Theory and Techniques*, vol. MTT-7, pp. 374–378, July 1959.

Comment on "Isolation of Lossy Transmission Line Hybrid Circuits"

I should like to call attention to several errors appearing in the above correspondence.[1] These errors are presumably typographical, and indeed do not affect the calculated isolation values. However, they could impair the utility of the correspondence to the reader wishing to extend the analysis to calculate the remaining properties of the two hybrid types. The errors are listed in the following.

Equation (13) should read

Manuscript received May 31, 1967.

[1] R. M. Kurzrok, *IEEE Trans. Microwave Theory and Techniques (Correspondence)*, vol. MTT-15, pp. 127–128, February 1967.

TABLE I

	Square Hybrid						Rat Race Hybrid			
Q	αL	Isolation (dB)	Coupling (dB)	Insertion Loss (dB)	Input VSWR	Isolation (dB)	Coupling to port 2 (dB)	Coupling to port 4 (dB)	Input VSWR
10	0.0785	22.0	4.52	4.52	1.17	33.6	4.17	3.77	1.04
100	0.00785	40.6	3.17	3.17	1.02	51.4	3.15	3.12	1.005
1000	0 000785	60.5	3.03	3.03	~1.001	71.1	3 03	3.03	~1.000
∞	0	∞	3.00	3.00	1.000	∞	3.00	3.00	1.000

$$M_{+\pm} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} = j\begin{bmatrix} \frac{\alpha_1 L}{\sqrt{2}} + \alpha_2 L \pm j\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \pm j\sqrt{2}\,\alpha_1 L \pm j2\alpha_2 L + \frac{1}{\sqrt{2}} & \frac{\alpha_1 L}{\sqrt{2}} + \alpha_2 L \pm j\frac{1}{\sqrt{2}} \end{bmatrix}.$$

Equation (17) should read

$$A_4 = -\frac{j}{2}\left[\frac{\alpha_1 L + \sqrt{2}\,\alpha_2 L}{1 + \alpha_1 L + \sqrt{2}\,\alpha_2 L}\right]$$

leading to

$$I(\text{dB}) = 20\log_{10}\frac{2[1 + \alpha_1 L + \sqrt{2}\,\alpha_2 L]}{\alpha_1 L + \sqrt{2}\,\alpha_2 L}.$$

However, if we make the approximations $\alpha_1 L$, $\alpha_2 L \ll 1$, the error disappears and (19) remains correct.

Equation (22) should read

$$Y_{2++} = \frac{3\alpha L - j}{\sqrt{2}}$$

leading to

$$Y_{2+\pm} = \frac{3\alpha L \mp j}{\sqrt{2}}$$

together with (25).

The author calculates the isolation only of the square and rat race hybrid junctions. It is instructive to extend the analysis in order to obtain the theoretical coupling, transmission loss, and input VSWR of these hybrids, as follows

For the Square Hybrid

Assuming $\alpha_1 = \alpha_2 = \alpha$

$$A_1 = -\frac{\alpha L(1 + \sqrt{2})}{2[\alpha 1(1 + \sqrt{2}) + 1]}$$

$$A_2 = -j\frac{1}{\sqrt{2}[\alpha L(1 + \sqrt{2}) + 1]}$$

$$A_3 = -\frac{1}{\sqrt{2}[\alpha L(1 + \sqrt{2}) + 1]}$$

and

$$A_4 = -j\frac{\alpha L(1 + \sqrt{2})}{2[\alpha L(1 + \sqrt{2}) + 1]}.$$

Here it is seen that A_2 and A_3 are of equal amplitude and in phase quadrature, as in the lossless case.

For the Rat Race

$$A_1 = \frac{\sqrt{2}\,\alpha L}{4[3\sqrt{2}\,\alpha L + 1]}$$

$$A_2 = -j\frac{3\sqrt{2}\,\alpha L + 2}{2\sqrt{2}[3\sqrt{2}\,\alpha L + 1]}$$

$$A_3 = \frac{-\sqrt{2}\,\alpha L}{4[3\sqrt{2}\,\alpha L + 1]}$$

and

$$A_4 = -j\frac{2\sqrt{2}\,\alpha L + 1}{\sqrt{2}[3\sqrt{2}\,\alpha L + 1]}.$$

Here it is noticed that the outputs A_2 and A_4 are in general no longer equal, due to the asymmetry of the hybrid, but remain in phase.

Using the author's own values for Q and αL, the results can be expressed in Table I.

Thus, in addition to the 10 dB superiority in isolation achieved by the rat race hybrid, the coupling to ports 2 and 4 are closer to the theoretical value of 3 dB than are the coupling and insertion loss of the square hybrid, and the input VSWR is also improved. However, the rat race suffers from the disadvantage that in the lossy case the power division is uneven which may be a serious drawback when the hybrid is to be used as the basis for a balanced mixer.

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Author's Reply[2]

The author is grateful to McGough for pointing out the errors in the preceding letter. Errors in (13) and (22) are typographical. The error in (17) which is carried through to (19) appears to be the result of faulty algebraic manipulation. Equation (15) is correct as shown; however, it can be simplified as follows:

$$\Gamma_{+\pm} = \frac{\mp j[\sqrt{2}\,\alpha_1 L \mp 2\alpha_2 L]}{\sqrt{2} + \sqrt{2}\,\alpha_1 L + 2\alpha_2 L \pm j[\sqrt{2} + \sqrt{2}\,\alpha_1 L + 2\alpha_2 L]}.$$

This is of the form

$$\Gamma_{+\pm} = \frac{\mp jA}{B \pm jB}$$

where

$$A = \sqrt{2}\,\alpha_1 L + 2\alpha_2 L = \sqrt{2}(\alpha_1 L + \sqrt{2}\,\alpha_2 L)$$

$$B = \sqrt{2} + \sqrt{2}\,\alpha_1 L + 2\alpha_2 L = \sqrt{2}(1 + \alpha_1 L + \sqrt{2}\,\alpha_2 L).$$

Use of this modified (15) will permit determination of vector amplitudes such as A_4 with minimal algebraic effort. For example

$$A_4 = \frac{-j}{2}\left[\frac{A}{B + jB} + \frac{A}{B - jB}\right] = \frac{-j}{2}\left[\frac{A}{B}\right].$$

Substituting for A and B quickly provides McGough's corrected version of (17).

McGough's extension of the analysis to other properties of the hybrids has provided useful results.

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[2] Manuscript received June 26, 1967.