activity mode in a conditional replenishment type codec as shown in Ref. 6.

REFERENCES

1. J. B. Millard and H. I. Maunsell, "The *Picturephone®* System: Digital Encoding of the Video Signal," B.S.T.J., *50*, No. 2 (February 1971), pp. 459–479.
2. R. P. Abbott, "A Differential Pulse-Code-Modulation Coder for Videotelephony Using Four Bits Per Sample," IEEE Trans. Commun. Tech., *COM-19*, No. 6, Part 1 (December 1971), pp. 907–912.
3. M. C. Chow, "Variable Length Redundancy Removal Coders for Differentially Coded Video Telephone Signals," IEEE Trans. Commun. Tech., *COM-19*, No. 6, Part 1 (December 1971), pp. 923–926.
4. R. T. Bobilin, "Prefilters, Sampling, and Transmission Rates for Intraframe Codecs for *Picturephone®* Service," B.S.T.J., *52*, No. 4 (April 1973), pp. 497–525.
5. J. C. Candy, Mrs. M. A. Franke, B. G. Haskell, and F. W. Mounts, "Transmitting Television as Clusters of Frame-to-Frame Differences," B.S.T.J., *50*, No. 6 (July-August 1971), pp. 1889–1917.
6. Y. C. Ching, B. Gotz, D. M. Henderson, and J. B. Millard, "Video Processing System (VPS)—A Conditional Replenishment Interframe Codec for the Digital Transmission of *Picturephone®* Signals at the T1 Rate," unpublished work.
7. W. B. Cagle, R. R. Stokes, and B. A. Wright, "The *Picturephone®* System: 2C Video Telephone Station Set," B.S.T.J., *50*, No. 2 (February 1971), pp. 271–312.

Simultaneous Measurements of Depolarization by Rain Using Linear and Circular Polarizations at 18 GHz

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I. INTRODUCTION

Limitations imposed by attenuation during heavy rain on the reliability of microwave systems are well known[1] and a recent paper[2] discussed observations of depolarization of circular polarization by rain at 18 GHz; it was concluded that depolarization by oblate raindrops poses a serious problem for the use of circular polarization. However, it is desirable that a direct comparison be made by *simultaneous* measurements of linear and circular polarizations on the same propagation path. Continuous measurements have been made during the period June 1972 through April 1973 (a total of 35 rain showers); a discussion of these follows a few remarks on the experimental system.

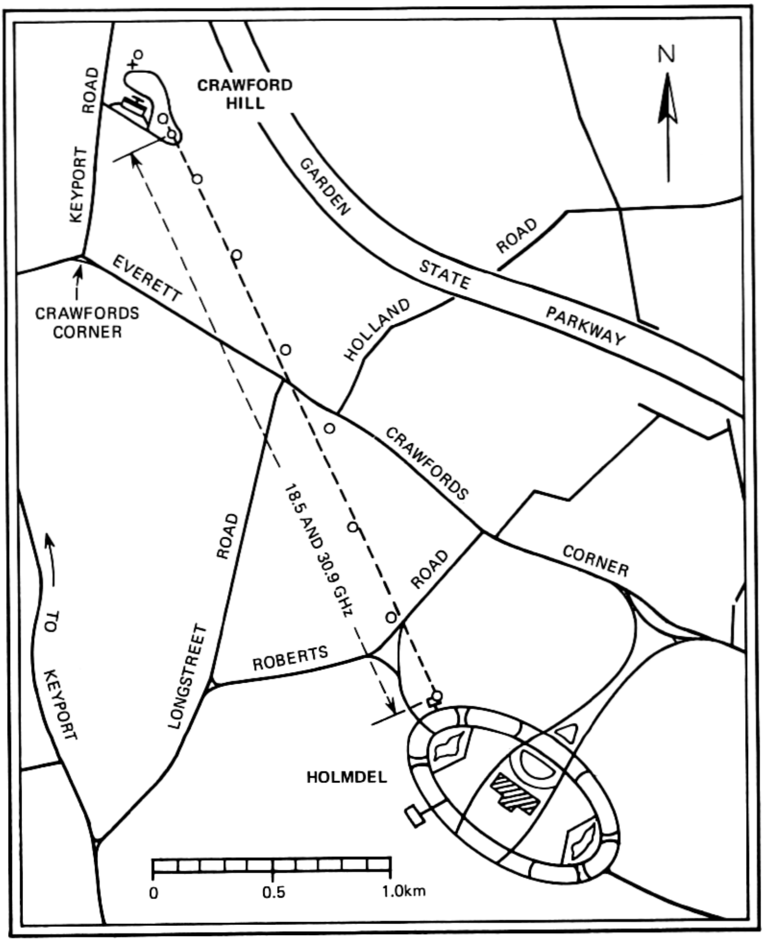

Fig. 1—The 2.6-km propagation path is indicated by the dashed line.

II. EXPERIMENTAL SYSTEM

The 2.6-km propagation path used in the experiment is shown by the dashed line in Fig. 1. Two frequency-swept solid-state transmitters (with separate antennas) are located at the lower right of the path. The circularly polarized transmitter operates at a frequency of 18.65 GHz while the linear horizontally polarized transmitter is at a frequency of 18.35 GHz.

The two receivers (with separate antennas) share a common building at Crawford Hill, Holmdel, New Jersey (upper left of propagation path, Fig. 1). Each system has a ferrite switch which looks sequentially at the received fields; e.g., in the circularly polarized system, the desired circular polarization and then at the depolarized component. Switching rates are of the order of 17 Hz and occur much faster than the changes in attenuation produced by rain. Strip-chart recordings are made of all four components.

The clear-day discrimination for both the circular and linear systems is more than 32 dB, but none of the depolarization data below −32 dB are included.

III. DISCUSSION OF DATA

The extremes of attenuation in linear (horizontal) and circular polarizations are shown in Fig. 2 for the fades induced by the 35 rain showers that occurred during the period of June 1972 through April 1973; they have similar magnitudes but the attenuation in linear (horizontal) polarization is slightly higher than that for circular polarization.* This is as it should be, for it is known[4] that most storms consist of oblate drops whose major axes are predominantly horizontally aligned, resulting in less attenuation for vertical than for horizontal polarization, whereas in circular polarization the attenuation is something like the average of vertical and horizontal.

Comparison of the linear cross-polarization discrimination (XPD) with the simultaneously measured circular polarization discrimination (CPD) is made in Fig. 3; the curve is the median of the data. The depolarization is much stronger in circular than in linear polarization; for example, the former is −15 dB when the latter is −25 dB.

We pursue the comparison further by examining a particular fade associated with a rain shower that occurred April 1, 1973, as presented in Fig. 4. The set of two curves on the left pertains to circular polarization, the set of two curves on the right to linear polarization. The upper curve in each set is a plot of the rain-induced attenuations. As in Fig. 2 the circular polarization shows a slightly smaller attenuation than that for horizontal linear polarization. For example, the maximum attenuation for circular polarizations was 36 dB while that for linear was 38.5 dB. At the same time, from the lower curve of each set, we see that the circular polarization discrimination was only 8 dB while the cross-polarization discrimination for the linear case was 13.5 dB. Let us examine the measurements at time 19:57; for the circular case,

* The sparseness of attenuations greater than 20 dB is, of course, due to the limited number of heavy rain fades that occur during a year. Figure 3 of Ref. 3 shows that this path has rain-induced attenuations that exceed 20 dB about 20 minutes a year.

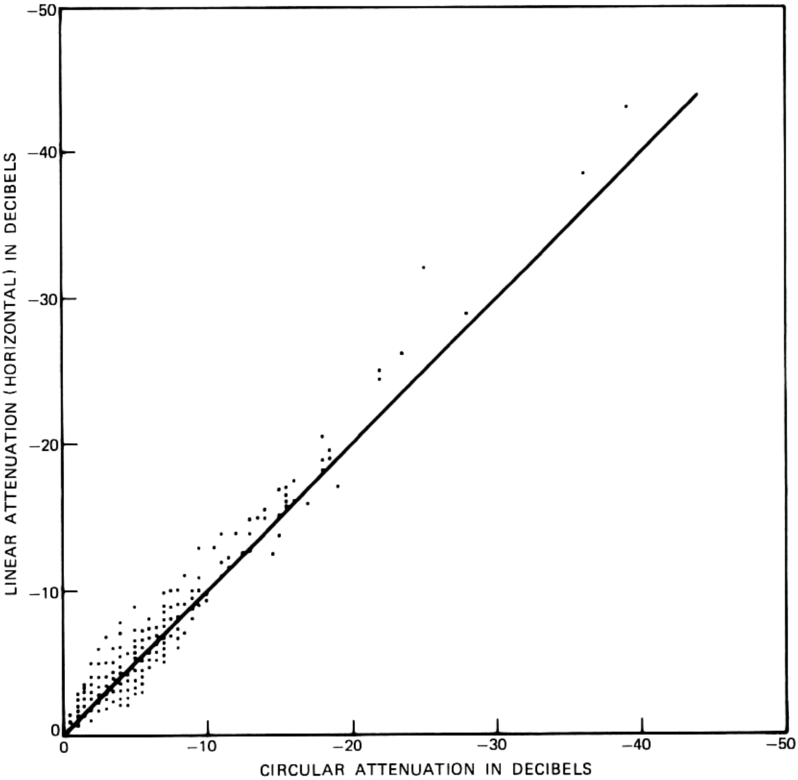

Fig. 2—Data on linear and circular rain-induced attenuation from June 1972 through April 1973.

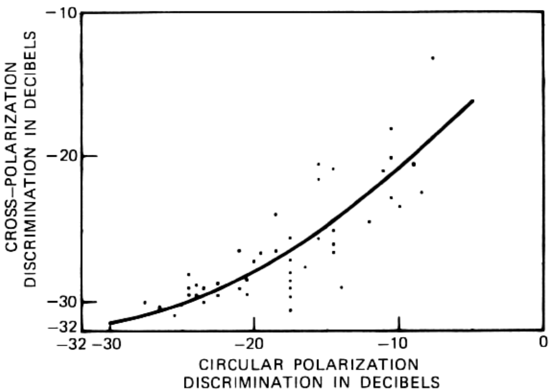

Fig. 3—Comparison of simultaneous measurements of linear polarization discrimination (XPD) and circular polarization discrimination (CPD).

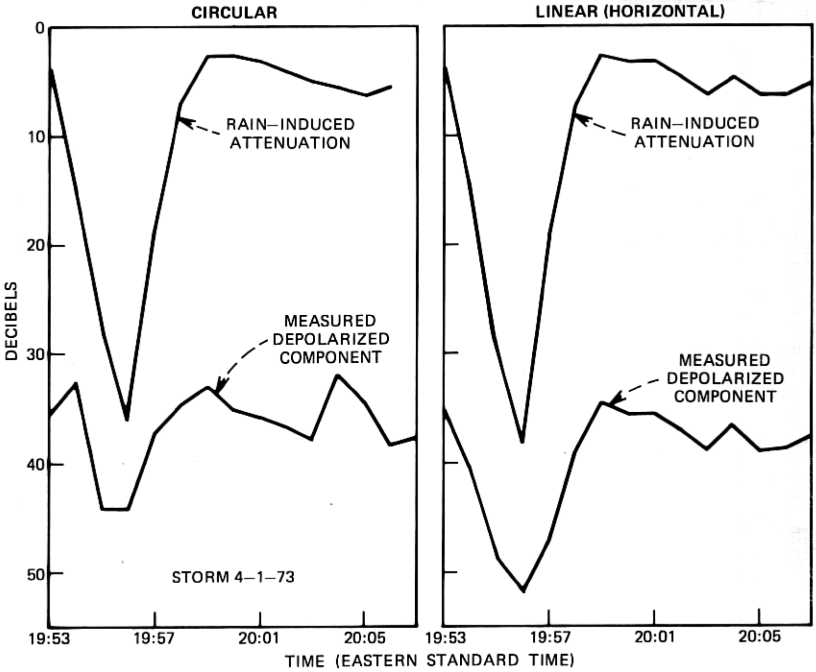

Fig. 4—Rain shower of April 1, 1973. Upper curves are rain-induced attenuation. The lower curves show the level of the depolarized component.

the desired signal was attenuated to a level of −18.5 dB and the depolarized component was only 18.5 dB below that (−37 dB). In the linear case at this same point in time, the rain-induced fade was 19 dB and the XPD was 28 dB. The linear polarization is depolarized significantly less than the circular polarization; therefore, in radio relay systems at frequencies of the order 20 GHz, linear (vertical or horizontal) polarization is believed to be preferable in systems relying on polarization discrimination.

REFERENCES

1. D. C. Hogg, "Statistics of Attenuation of Microwaves by Intense Rain," B.S.T.J., *48*, No. 9 (November 1969), pp. 2949–2962.
2. R. A. Semplak, "The Effect of Rain on Circular Polarization at 18 GHz," B.S.T.J., *52*, No. 6 (July-August 1973), pp. 1029–1031.
3. R. A. Semplak, "Dual Frequency Measurements of Rain-Induced Microwave Attenuation on a 2.6-Kilometer Propagation Path," B.S.T.J., *50*, No. 8 (October 1971), pp. 2599–2606.
4. R. A. Semplak, "Effect of Oblate Raindrops on Attenuation at 30.9 GHz," Radio Science, *5*, No. 3 (March 1970), pp. 559–564.