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Technique Developed for Measuring Transmittance of Optical Birefringent Networks

Procedures have previously been developed for synthesizing optical single-pass and double-pass birefringent networks having arbitrary transmission vs frequency characteristics. This Tech Brief summarizes the results of experiments which were performed on these two types of optical networks. A three-stage network was tested in the single-pass experiments, while three-, five-, and seven-stage networks were used in the double-pass experiments. Each stage of these networks consisted of a calcite crystal (a naturally occurring birefringent crystal) two centimeters in length followed by a quartz compensator. The general form of a single-pass network, with electro-optical crystals, rather than natural birefringent cyrstals, is illustrated in Tech Brief 68-10275. The transmission characteristics of the networks were obtained by measuring network transmission (at a fixed optical frequency) as a function of network temperature.

Since the phase difference between "fast" and "slow" axis light components passing through a calcite crystal has the same functional dependence upon temperature as upon optical frequency, the transmission vs temperature characteristic of a birefringent network will be the same as the transmission vs frequency characteristic. This relationship gives a very convenient, high-resolution method of measuring the transmittance of birefringent networks. The excellent agreement obtained between the measured transmittances and the theoretical values serves both as a verification of the synthesis procedures, and as a demonstration of the utility of the measurement technique.

An important advantage of the temperature-tuning technique is that no spectrometer is needed. Furthermore, the technique is capable of extremely high resolution, being limited only by the linewidth of the illuminating source. If a multi-mode 6328 Å He–Ne laser is used, for example, a resolution of about 0.02 Å is theoretically possible. If a single-frequency, stabilized He–Ne laser were used, resolution would be improved by some three orders of magnitude. There are some instances, however, in which the temperature-tuning technique may not be practical. It is necessary, for example, for the network to tune through at least one period of its transmittance while the temperature is changed by some reasonable amount. For the experiments with the 2-centimeter calcite crystals, the network tuned through one transmittance period with a temperature change of only 3°C. If a network were designed to have a substantially larger period (either by using shorter calcite crystals, or some less birefringent material such as quartz), an impractically large temperature change might be required to obtain one period of the transmittance. Under these conditions, though, the network bandwidth will probably be great enough to allow use of a conventional spectrometer. Finally, if a material is employed whose change in birefringence with temperature is much less than that of calcite, the temperature-tuning technique might also become impractical. This technique appears to be most useful for testing precisely those birefringent networks which are most difficult to test by conventional means; namely, those whose bandwidths and periods are very

(continued overleaf)

small. Larger (possibly impractical) temperature swings would be required by networks designed to have greater periods, or by networks employing crystals whose birefringence is very insensitive to temperature.

Note:

Complete details may be obtained from:
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No patent action is contemplated by NASA.

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