macromolecules with superconducting properties at a transition temperature corresponding to living tissue. Such macromolecules may be playing this unique role in insects'[1] sensory hairs, spines, and pit pegs. The reason for this suggestion follows.

The hypotheses of Grant [2], Callahan [3], and Marais [4] concern selective sensing of infrared radiation by insects' hairs, spines, and pit pegs for food searching, navigation, etc., and invoke infrared-frequency "dielectric" waveguide, resonator, and antenna models for these sensory organs. Although the entomologists should have used the results of dielectric waveguide, resonator, and antenna theory [5] instead of the hollow metallic-tube counterparts, their results, fortunately, do not seriously jeopardize their hypotheses. Their results, however, will have to be corrected not only in this respect but also where classical electromagnetic waveguide and resonator theory are concerned with coherent and polarized electromagnetic waves. This is generally not the case in the instance just cited except to the extent that black-body radiation possesses coherence in sufficiently minute space-time [6]. Furthermore, the mode of propagation in the dielectric tubular waveguide and antenna is likely the asymmetric hybrid fundamental, HE_{11}, mode. This mode is proposed in contrast to other modes because the dielectric tubular waveguide and antenna is capable of operating in a single mode provided the ratio of wall thickness to real dielectric constant thereof is reduced to a sufficiently small value. Furthermore, with such a waveguide and antenna, an essentially single-lobed radiation pattern may be realized. In other words, when the wall thickness is small enough to make the tubular dielectric waveguide beyond cutoff for all other modes, the HE_{11} mode is unique. It is appropriate to mention that the wall of the waveguide, resonator, and antenna may be a thin sheath on the supporting tissue or not differentiable from it.

Although there is much promise for the waveguide and antenna model of the sensory spine and hair of the insect and for the resonator model of the pit-peg, there is prospect for considering another model for these sensory organs; the organic superconducting model. This comprises essentially an organic superconducting tubular waveguide and/or "leaky" antenna, "leaky" being defined here as an antenna possessing a longitudinal array of periodic apertures, for which recent evidence seems to be at hand.[2] At the base of the hair, spine, and pit-peg is the peg. The peg seems to function as the detector (or generator) of the selectively received (or transmitted) and enhanced infrared radiation. It is proposed that these pegs not only comprise thermal detectors of essentially the electric component of the incident electromagnetic infrared waves, but also alternately function as a hypersonic [9] detector (or generator) of these waves. It is further proposed that the hair and spine function as a terminating dielectric tubular waveguide and antenna with the HE_{11} mode, or organic superconducting tubular waveguide with the fundamental H_{11} mode or the circular electric H_{01} mode with mode filter, and associated "leaky" (or periodically apertured) waveguide antenna with the latter modes.

The pit of the pit-peg functions as a hollow (or liquid) dielectric or organic superconducting resonator with iris aperture. The wall of the spherical or cylindrical resonator, i.e., pit, may be continuous or of a picket-fence structure with the appropriate modes to match such boundary conditions and terminating aperture or waveguide and antenna, i.e., hair and spine, and probe, i.e., peg.

In addition to these proposed sophisticated models, consideration may seemingly be given to the simple short ($\sim\lambda/10$) dipole superconducting antenna [10] model of the hair and spine of the insect. However, this proposal is not likely even for organic superconducting antenna with transition temperature at or above the insect's body temperature, because of the location of the peg at the base of the hollow (or liquid filled) hair and spine and pit-peg of the insect.

In contrast to the foregoing proposed dielectric and organic superconducting models of the sensory hair, spine, and pit-pegs of insects for ultrasensitive infrared reception and transmission for food searching, navigation, etc., at the associated dominant atmospheric infrared window, it seems extraordinary that nature has not resorted to the presumably simple task of utilizing thin normal metal waveguide and resonator and antennae since she has presumably long ago superbly mastered the technique of depositing thin metallic films [11] on insect[3] tissue. This situation may mean that utilization of a dielectric waveguide[4] is simpler than a metallic one and may be much simpler than a superconducting one.

The proposed electrical models already present formidable experimental and theoretical tasks for physicists and entomologists, because they require determination of pertinent physical, electrical, and optical, i.e., infrared, parameters of the salient micron size, living and dead, components and systems of the extraordinarily developed sensing organs of insects, which evidently function at the dominant infrared atmospheric windows. Nevertheless, this task will have to be done if significant progress is to be made in matching electrical models to the insects' remarkable sensing organs and their extraordinary performances

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[4] It may be necessary to include consideration of Fiber optics [12] too.

Orthogonal Coupling to YIG Delay Lines

Recently, many experiments have been conducted for the purpose of investigating the microwave delay properties of single-crystal YIG [1], [2]. Three forms of delay have been observed: fixed acoustic, variable spin-acoustic, and variable pure spin propagation [3]. At short delays the initiating pulse makes observance of the delay pulse extremely difficult. We have conducted experiments using rod-like YIG samples and a two-port coupling arrangement similar to that employed by Olson [3]. Both the pure-spin and the spin-acoustic delay modes were observed. With this arrangement, the initiating pulse appeared at the output line reduced in amplitude by 25 dB. This signal was due to stray coupling between input and output lines, as it was present with the static magnetic field removed. The pure-spin delayed echoes incurred a transmission loss of 20 dB, and hence, interference between delayed and undelayed pulses was observed at short delays. The output coupling line was then oriented orthogonal to the input line. Both types of delay modes were unaffected by this

Manuscript received April 16, 1965.

change. However, the stray coupling of the initiating pulse was reduced by 30 dB. This invariance of the delay modes with changes in coupling orientation indicates that these spin waves are circularly polarized [4].

The sample employed in this experiment was a parallelepiped, with dimensions of 0.440×0.142×0.117 inch and oriented so that the [111]-direction was parallel to the rod axis. The static magnetic field was applied parallel to the rod axis and the measurements were conducted at a frequency of 2 Gc/s, using pulses of 0.5-μs width and 1-mW peak power.

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Synthesizing Air with a Radome Sandwich

It is possible to design lossless radome sandwiches which have a transmission coefficient of unity and an insertion phase angle of zero. If the magnitude and phase of the electric field within the sandwich approximates that of the electric field in air, the edge diffraction of the sandwich should be small.

Consider the symmetrical sandwich, shown in Fig. 1, consisting of three lossless conducting films or grids of negligible thickness and two layers of an ideal dielectric. Let ϵ denote the relative dielectric constant of the dielectric layers, B_e denote the susceptance of the outside films or grids, B_m denote the susceptance of the center film or grid, θ denote the angle of incidence in air, and λ denote the wavelength in air. It is assumed that the relative permeability of the dielectric is unity. For convenience in notation, let

$$D = 2\pi d/\lambda,$$
$$K = \sqrt{\epsilon - \sin^2\theta},$$
$$k = \cos\theta.$$

For perpendicular polarization, the transmission coefficient is unity and the insertion phase angle is zero if

$$B_e = K \cot KD - k \cot kD,$$
$$B_m = 2K \cot KD - \frac{2K^2 \cos kD \sin kD}{k \sin^2 KD}.$$

The corresponding values for parallel polari-

Manuscript received April 19, 1965.

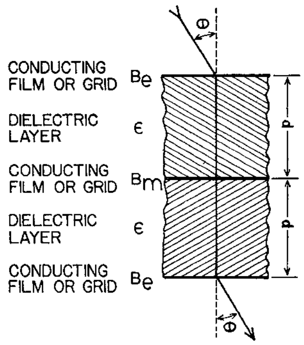

Fig. 1. Symmetrical sandwich.

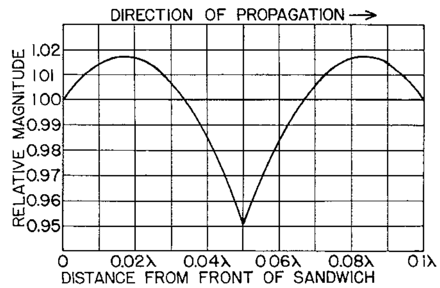

Fig. 2. Relative magnitude of the electric field within the sandwich.

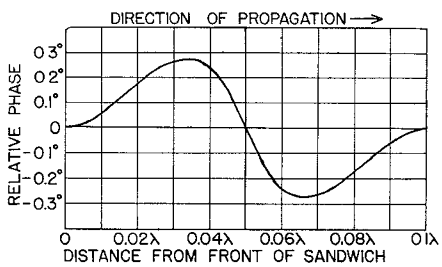

Fig. 3. Relative phase of the electric field within the sandwich.

zation are

$$B_e = (\epsilon/K) \cot KD - (1/k) \cot kD,$$
$$B_m = 2(\epsilon/K) \cot KD - \frac{2k\epsilon^2 \cos kD \sin kD}{K^2 \sin^2 KD}.$$

These equations can be derived by using the transmission-line analogy for radome sandwiches [1], [2].

For $\epsilon=4$ and $\theta=0$, these equations become

$$B_e = -\tan D,$$
$$B_m = 4B_e.$$

A sandwich may be designed for use at a frequency of 9375 Mc/s, using fiberglass laminate with $\epsilon=4$ and parallel wires. Let $d=0.05\lambda=0.062$ inch. Then $B_e=-0.325$, which corresponds to 0.005-inch wires separated approximately 0.45 inch, and $B_m=-1.3$, which corresponds to 0.005-inch wires separated approximately 0.19 inch. Although such wire grids do not satisfy the ideal assumptions, these parameters indicate that an ideal sandwich can be approximated.

The relative magnitude and phase of the electric field within an ideal sandwich with $\epsilon=4$, $\theta=0$, $d=0.05\lambda$, $B_e=-0.325$, and $B_m=-1.4$ compared to that in air are shown in Figs. 2 and 3. It should be observed that the electric field within the sandwich does not deviate greatly from what it would be in air.

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A Variable Harmonic Phase Delay Coaxial Network

A simple, adjustable, harmonic phase delay, equalizer network has been developed in coaxial transmission line. A harmonic equalizer network is defined as a circuit whereby the phase shift or phase delay through the device between two harmonically related or widely separated frequencies differs from an ideal dispersionless circuit. This circuit makes use of the phase shift properties of a reactive cutoff type network as the cutoff frequency is varied. A coaxial low-pass filter type network was chosen because of the mechanical simplicity that this type of transmission medium yields, in addition to the broad range of operating bandwidths available. Figure 1 shows the dispersion relationship between an ideal transmission line and a low-pass filter. Whatever the phase relationship of a fundamental signal f_0 with respect to its harmonic $2f_0$ at the input to the filter, the output phase relationship will be changed by $\phi°$. This relative phase shift is realized due to the characteristics of the filter network near cutoff. For example, in a Constant-k design, the total phase shift through the filter network is a function of the number n of LC filter sections employed and the proximity of the frequency f of interest with respect to the cutoff frequency f_c. If the cutoff frequency is varied as shown in Fig. 1 from f_{c1} to f_{c2}, the relative harmonic phase shift ϕ may be computed, depending on the cutoff condition, according to the general relation

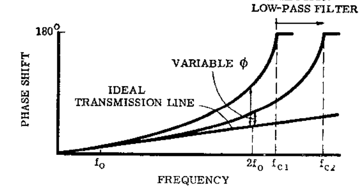

Fig. 1. Phase vs. frequency characteristics of different transmission networks.

Manuscript received April 19, 1965.