leads to the problem, at present under study, of how to describe symmetries of internal hadron states, when taken to infinite momentum, bearing in mind that in a quark model, for example, there will be quark spin and orbital angular momentum that can mix under Lorentz transformation.

Magnetic monopoles. In an interesting paper Julian Schwinger (Havard) discussed the old problem of magnetic monopoles. From gauge invariance he showed first that $eg/\hbar c$ is an integer (g is the elementary magnetic charge in suitable units). Dirac had previously obtained the weaker result that this quantity should be a half integer. Schwinger's result has as one consequence that if e and g are at rest, the system possesses an integral, rather than half-integral angular momentum along the line joining them, a situation somewhat less jarring to the intuition. Finally, he showed that, contrary to the recent assertions of others, a Lorentz-covariant electrodynamics can be formulated with inclusion of magnetic monopoles.

The conference concluded as the previous two Coral Gables conferences have, with a summary talk by Yuval Ne'eman (Tel Aviv). Pointing out that during the past year we had begun to take a less abstract view of the generators of groups, he mentioned three way in which group theory is now being used: (1) to classify hadron states, (2) to provide operators to connect states, which form algebras relating transitions, and finally, (3) to provide symmetries of the dynamics, when the operators commute with important pieces of the Hamiltonian. It does not matter which form of dynamics (quarks, bootstraps, etc.) is eventually adopted.

Laurie M. Brown
Northwestern University

IEEE ultrasonics symposium

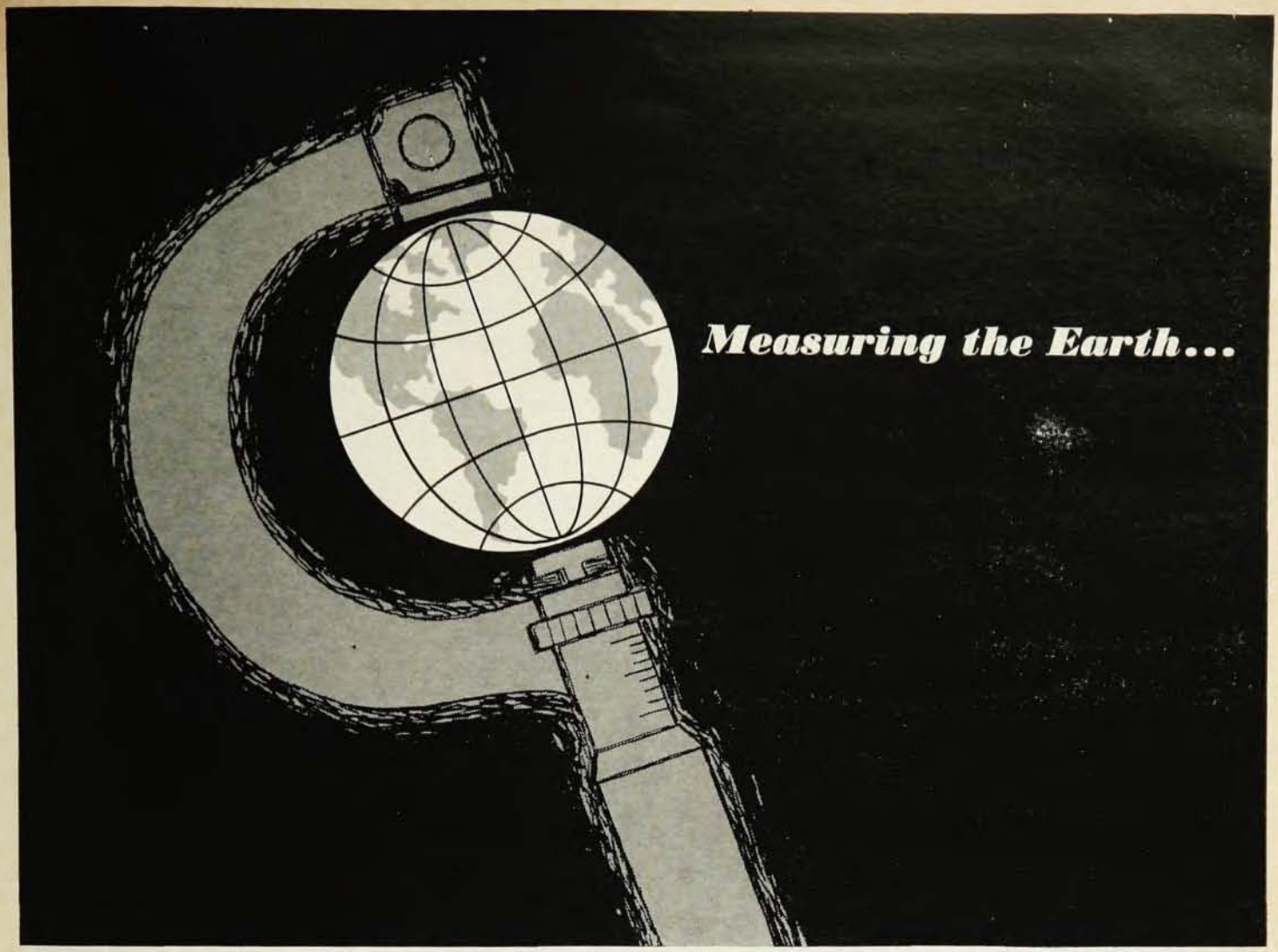
Rapidly growing research, applications and future possibilities made an impressive picture at the annual ultrasonics symposium sponsored by the Institute of Electrical and Electronics Engineers. Leading subjects were nonlinear effects, acoustic-electric energy exchange, transducers, amplifiers, delay lines and biomedical applications.

Nonlinear effects. Robert N. Thurston (Bell Labs), discussing third-order elastic constants and their relation to nonlinear processes, provided an introduction to a number of papers dealing with nonlinear elastic effects in acoustic-wave propagation. Since nonlinear elastic moduli provide the means for interchanging acoustic energy with thermal phonons, one must know their values to determine thermal-acoustic losses. When angular frequency ω times thermal relaxation time τ is greater than unity, the direct exchange can be followed, and Paul G. Klemens (Westinghouse) showed that for shear waves loss is proportional to frequency and to the fourth power of absolute temperature. He presented evidence that for longitudinal waves and lowest temperatures the increase should be proportional to the ninth power of temperature; dependence changes to fourth power at higher temperatures. Experimental results by John de Klerk (Westinghouse) indicate agreement with this result in silicon dioxide, lithium fluoride and calcium fluoride.

When $\omega\tau < 1$, individual modes cannot be followed and the interaction is in the nature of a phonon viscosity. With recently measured third-order moduli for sodium chloride, potassium chloride and yttrium-iron garnet—presented by D. E. Eastman—a formula derived by W. P. Mason found good agreement with measured ultrasonic losses.

Sonic-electric exchange. Electrons can damp acoustic waves by interchange of acoustic energy with electron energy, and dislocations dragged through the crystal are also damped by the "effective" viscosity of these electrons. This effect is the origin of a nonlinear attenuation, which, as discussed by R. W. Shaw and W. P. Mason, is different in normal and superconducting states.

A major effort is generation of higher-frequency acoustic waves. The highest frequencies discussed at the December symposium in Boston were about 70 gigacycles/sec (70×10^9) reported by P. E. Tannenwald and J. B. Thaxter, who use surface-wave excitation in quartz. Cadmium-sulfide and zinc-oxide thin-film transducers, discussed in a number of papers, can be



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- Acoustic properties of the ocean
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- Building on the ocean floor
- Digital control system techniques
- Miniaturized telemetry development
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- Computerizing recruit assignments
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- Supersonic water entry shock environment
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- Computerizing information storage/retrieval

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applied in layers having half-wavelength frequencies in the high gigacycle range. An alternative method for reaching these high frequencies is Brillouin scattering of laser beams. This technique was reviewed by G. B. Benedek. Lasers have been used by Benjamin Tell, T. C. Damen and S. P. S. Porto (Bell Labs) to investigate Raman active modes in zinc oxide and cadmium sulfide. Brillouin scattering is also employed by Martin G. Cohen and Eugene I. Gordon (Bell Labs) to investigate the properties of externally generated sound. Study of thermal phonons in the transmission of heat pulses was described by Arthur H. Nethercot Jr., R. J. von Gutfeld (IBM Watson Labs), J. M. Andrews and M. W. P. Strandberg (MIT).

Conventional transducers. Don Berlincourt (Clevite) described ferro electric-antiferroelectric transition transducers, and several speakers discussed gallium-arsenide and $LiNbO_3$ piezoelectric transducers. The latter material has very high Q (above 10^5 at 10^9 cycles/sec) and has a strong electro-öptic effect described by Edward G. Spencer (Bell Labs). An ingenious technique for measuring piezoelectric constants having a high electrical conductivity is the piezoëlectric Hall effect devised by G. Arlt.

Acoustic wave amplifiers discussed included acoustic masers discussed by Norman S. Shiren (IBM Watson Labs) several forms of cadmium sulfide amplifiers with high electronic drift velocity and parametric amplification of magnetoëlastic waves discussed by R. G. Damon. A group of papers dealt with the effect of acoustic gain on electrical impedance and resonant vibrational modes of cadmium-sulfide plates. Andrew R. Hutson (Bell Labs) predicted an active crystal resonator based on these effects, and Donald L. White and Wen Chung Wang (Bell Labs) reported experimental observation of stable single-mode UHF oscillations in cadmium-sulfide plates.

Warren P. Mason
Columbia University

Strong interaction theory

Last year's summer school at the University of Hawaii concentrated on theoretical aspects of strong interactions.