



TWENTY YEARS OF PHYSICS

ACOUSTICS

By R. BRUCE LINDSAY

THE SCIENCE OF ACOUSTICS touches on practically every aspect of human experience; hence it advances on broad fronts ranging all the way from basic physics and chemistry through most branches of engineering to the life sciences. The extent of its development during the past two decades may in some measure be gauged by the growth in membership of the Acoustical Society of America from 1300 in 1947 to 4150 in 1967. During the same period the number of pages published per year in the Society's Journal grew from less than 1000 in 1947 to 4150 in 1967. This is typical of the world progress in acoustics.

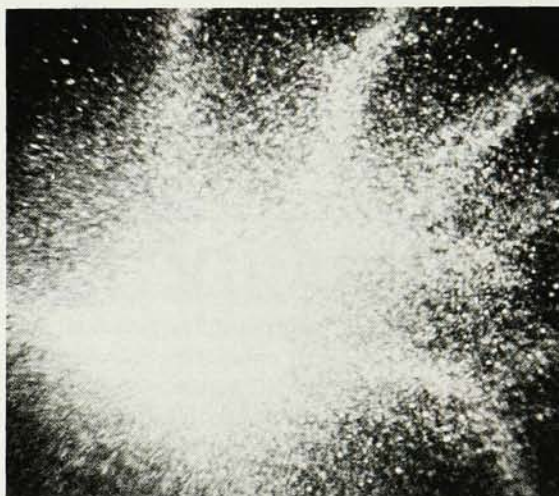
Acoustics comes from the Greek meaning "hearing." Steady progress in our understanding of the basic mechanics of sound transmission in the ear culminated in the award of the Nobel prize in physiology or medicine to Georg von Bekesy in 1961. Advances have been conspicuous in such aspects of the psychology of hearing as binaural localization, loudness, auditory fatigue, pitch and the auditory perception of signals. To consider another aspect of bio-acoustics much has been learned about the action of sound radiation (especially high frequency) on living tissue, as well as the genera-

tion and detection of sound by the lower animals, particularly marine creatures. Ultrasonic radiation has come of age as a diagnostic tool in medicine, and good progress is being made in its application to therapy.

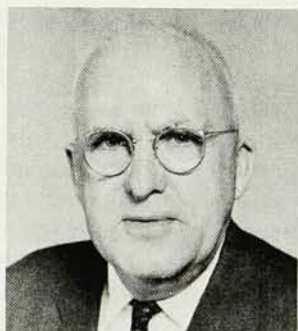
Progress in physical acoustics has been reflected in the use of ultrasonic attenuation to study relaxation phe-

had to introduce a new index classification category covering aeroacoustics and macrosonics to take care of increased activity in the domain of sound production resulting from fluid turbulence and nonlinear problems in general, including shock waves.

Every aspect of acoustic research leads quickly to applications. We can



ACOUSTIC cavitation may be generated by an intense sound field in a liquid. Very small bubbles expand and then collapse with great violence. This phenomenon produces drastic effects such as erosion of solids, chemical reactions and the emission of light.



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nomena in solids, liquids and gases, shedding much light on the nature of these states. Thus at very low temperatures acoustics has contributed notably to our understanding of superconductivity and the structure of metals. The practical production of ultrasonic radiation has been pushed up in frequency to approximately 70 000 MHz. Even higher frequencies are involved in the hypersonic (or shall we call it pretersonic, as some would have it?) domain of Brillouin scattering. Not without interest is the award of a 1967 Nobel prize in chemistry to Manfred Eigen of the Max Planck Institute of Physical Chemistry in Göttingen. He has applied ultrasonic techniques extensively in studying fast chemical reactions. The laser promises to become a useful source of very high-frequency sound. The *Journal of the Acoustical Society* has

mention but few. Better knowledge of hearing and closer attention to transducer design have led to more effective hearing aids for the deaf. The audio experts have brought stereophonic music to a high peak of excellence. Intensive studies of speech coupled with clever electronics have made the phonetic typewriter a reality. Improved transducers and methods of signal processing have increased greatly the efficiency of sound transmission in the sea, and this connection between acoustics and oceanography promises to be fruitful for years to come.

Of course there remain practical problems to be solved. We know a great deal about noise and its control, but we have not made a very big dent in the removal of the noise pollution in our environment. Here indeed is a challenge to acoustics! □



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THE SOLAR SYSTEM

By A. G. W. CAMERON

BOUNCING RADAR SIGNALS off the moon was considered quite a feat 20 years ago. Today they are being bounced off planets on the other side of the sun. This accomplishment is symbolic of the enormous expansion in our knowledge of the solar system that has taken place in the last two decades. The expansion has resulted jointly from the development of new technology and from the large investment in the space program and in geophysical and astrophysical research.

The existence of the space program has in itself given an enormous stimulus to ground-based research, largely because a few observations made in space and in the vicinity of other planets render ground-based measurements more meaningful. There is also a psychological factor involved: People are more likely to do solar-system research when it appears probable that the more important problems can be solved in a few years.

Geophysics

In recent years there has been wide study of the earth's interior and of the atmosphere that surrounds us.

Geodesy. Artificial satellites have allowed determination of much-improved spherical-harmonic coefficients for mass distribution in both the earth and moon. Although there are interesting correlations with anomalies in terrestrial heat-flow data, conclusions regarding the static strength of the lunar and terrestrial interiors and the possibility of convection in the earth's mantle are still in dispute.

Seismology. Modern computing methods applied to seismic travel times have allowed a great improvement in knowledge of the structure of the earth's interior. Observation of oscillations of the earth as a whole with new long-period seismographs give important information about the earth's core but are not quite consistent with the travel-time analyses. Experimental and theoretical studies

of the properties of matter at high density have greatly strengthened inferences about the predominant iron composition of the core.

Geomagnetism. The main geomagnetic field probably arises from some little-understood "dynamo" process involving the interaction of seed magnetic fields with fluid motions in the earth's core. A highlight of the last two decades is the discovery that the main field irregularly and abruptly changes sign every few million years or so.

Geophysical fluid dynamics. Nothing very new in the way of fundamental principles has been added to the classical understanding of this subject. The modern computer, however, has greatly facilitated construction of fluid-dynamic models of geophysical fluid situations. Oceanographers, studying internal and surface wave motions on a wide range of scales, have made some progress in understanding oceanic circulation.

Meteorologists have made great progress in understanding the structure of atmospheric turbulence and have studied internal gravity waves in the atmosphere in some detail. Owing to the advances in construction of global models of atmospheric circulation and numerical weather prediction, we can, in the near future, expect fairly reliable forecasts as far as two weeks ahead. There are, however, fundamental limitations that will prevent longer range forecasts: One of the major, current problems is lack of knowledge of the physical properties of the air-sea interface.

Earth's envelope

From rocket, satellite and radar investigations we have gained new insights concerning the nature of the ionosphere and magnetosphere, and especially the effects of solar activity on these regions.

Upper atmosphere and ionosphere. Knowledge of the uppermost regions

of the atmosphere has increased enormously in two decades, owing to sounding rockets, satellites and powerful radar systems (which now detect Thomson backscatter from the ionosphere). The upper atmosphere is subject to diffusive separation of gases; the gases in uppermost layers, composed of helium and hydrogen, are ionized by solar ultraviolet radiation. Both satellite-drag measurements and ionospheric measurements show that the upper atmospheric densities undergo diurnal, semiannual and annual variations. Many of these are correlated with solar activity and consequent variations of solar-ultraviolet heating, but there also appear to be density variations correlated with fluctuations in the solar wind. The mechanism of solar-wind heating of the upper atmosphere may involve hydrodynamic waves, but the details are not understood. Rocket measurements have also detected upper-atmosphere currents responsible for significant and variable contributions to the outer geomagnetic field.

The magnetosphere. One of the most significant discoveries of the last 20 years is the region of trapped ra-



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