The application of neutron scattering to molecular biology has been pioneered by B. Schoenborn at the Brookhaven National Laboratory, who has used the method to show up the positions of hydrogen atoms in crystalline myoglobin. Because of their low atomic number hydrogen atoms are virtually invisible to X-rays, but they scatter neutrons strongly and negatively. The method has been extended by Caspar and Krishner so that it can be used to define the location of water in myelin sheath. This involves the exchange of D_2O for H_2O and makes use of the fact that the scattering lengths of D and H are very different.

Engleman and Moore once more make use of this scattering difference between D and H. Ribosomes are complex aggregates of a number of protein molecules and their subunits are themselves macromolecular aggregates and can be reconstituted from their components. Now if a subunit could be reconstituted with two of the components rich in H while the rest of the subunit was heavily deuterated, then it can be shown that the vector relating the two components rich in H would be easy to determine. The authors then point out that if the relative positions of the components rich in H could be varied in a controlled fashion by the reconstitution process, then vectors between all possible pairs of component could be highlighted successively; the amount of information is then more than sufficient to solve the quaternary structure and this can be done by a triangulation method. Engleman and Moore present calculations to illustrate the feasibility of the method, and they reveal that it yields a contrast equivalent to an X-ray experiment with a uranium atom for every three amino-acids.

SEMICONDUCTORS

Acoustic Waves

from a Correspondent

THE annual meeting on semiconductor devices sponsored by the Institute of Physics was this year incorporated in the second European Solid State Devices Research Conference, and was held at the University of Lancaster from September 12 to 15. Elevation to the status of a European conference was reflected in the increased attendance and number of papers submitted.

Of the invited speakers reading review papers, undoubtedly the greatest interest for many of the delegates was the paper by Professor W. Shockley (Stanford University, California) who described his work at Bell Telephone Laboratories in the late 1940s. This work led to the development of the transistor and constituted one of the principal landmarks

in the history of electronics. Although rather historical in content, Professor Shockley's lecture gave an insight into the problems and obstacles encountered on the road to an important discovery.

Returning to more recent events, the conference papers as a whole echoed the ever-changing emphasis in the field of semiconductor devices. The increasing interest in surface acoustic waves during the past few years was reflected in the devotion of a full session to the topic. After an introductory review by Dr E. G. S. Paige (Royal Radar Establishment, Malvern), a succession of papers described several electro-acoustic devices. Piezoelectric ceramic materials seem to be finding increasing applications in this field, for example in surface wave delay lines in which the delay time can be varied. Dr F. G. Marshall (Royal Radar Establishment) described a new multistrip device which couples two independent surface waves. This device allows the vector sum or difference of the two signals to be obtained, and may be used to halve the width of a beam or to double the effective intensity.

Transferred electron devices, Gunn and Impatt diodes, occupied much of the proceedings. The theoretical models describing the Gunn effect in certain materials are the subject of some controversy, and this was evident in the papers presented. Support for the so-called three-level model was provided by Mr B. A. Prew (Royal Radar Establishment) who reported experimental measurements of the electric field distribution of dipole domains propagating in indium phosphide. Some interest was also apparent in contact effects in Gunn devices.

Dr H. C. Card (University of Manchester Institute of Science and Technology) described his work on the determination of the population of interface states in devices that involve the tunnelling of electrons through thin insulating layers. Such devices include electroluminescent metal-insulator-semiconductor tunnel junctions, and the subject of luminescence was the basis of a number of papers. The Royal Radar Establishment is again in the forefront in this field and a paper by Mr A. L. Mears and his colleagues described the high brightness which can be obtained with zinc sulphide electroluminescent panels. The problems associated with many-character alphanumeric displays were discussed, and it was shown that long display lifetimes may be obtained by the use of pulse techniques.

An alternative display medium is afforded by using liquid crystals. Mr R. C. Bottomley (SERL, Baldock) discussed an attempt to overcome the resolution problems normally encountered in liquid crystal displays when addressing methods using electron beams are

employed. By using a "write gun" selected areas of the target can be activated by secondary electrons, the resulting storage display giving both high resolution and high illumination levels.

A notable advance in the operation of GaAs lasers was described by Dr G. H. B. Thompson (STL, Harlow). He showed that by narrowing the carrier confinement region in a double heterostructure laser to a width of $0.18 \mu m$ a threshold current density of only $820 A cm^{-2}$ could be obtained. The multilayer structure of these lasers poses a number of fabrication problems, but once overcome threshold current densities for lasing action of as low as $300 A cm^{-2}$ are predicted.

RELATIVITY

Apollo Clock Corrections

by our Cosmology Correspondent

ALTHOUGH widespread interest in the relativistic time shift suffered by a spacecraft has grown up as a result of the Apollo missions to the Moon, until recently calculations of the magnitude of such an effect were entirely hypothetical. Now, however, John Lavery, of the Goddard Space Flight Center, has published the results of precise calculations using actual tracking data for the Apollo 12 and 13 missions (NASA Technical Note, D-6681, NASA, Washington, 1972). These calculations confirm that it is within the state of the art today to measure these effects.

The principal factor causing the difference in time elapsed as recorded on a clock carried around the Moon compared with one which remains on Earth is that the moving clock is carried through a part of the Earth's gravitational field in which there is a steep gradient. The problem is not, except incidentally, concerned with the time dilation due to motion of Special Relativity, but with the gravitational time shift of General Relativity. It is the influence of the Earth's gravitational field which predominates, because in the region of the Earth-Moon system the Sun's gravitational field is roughly constant and, of course, the Moon itself only has a very small influence compared with the Earth, because of its much smaller mass.

According to Lavery's calculations, the total time advance of a hypothetical standard clock on Apollo 12 would have been $570.3 \pm 0.3 \mu s$ and for a similar clock on Apollo 13 the advance would have been $327.6 \pm 0.2 \mu s$. These effects are certainly measurable using modern caesium or rubidium clocks but, unfortunately, it seems unlikely that an appropriate experiment can be accommodated on the sole remaining Apollo mission.