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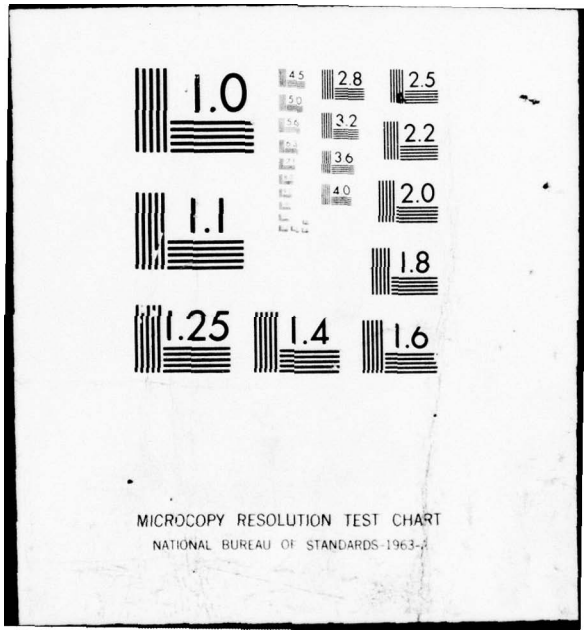
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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL, with certain articles prepared by, or in cooperation with, members of the scientific

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BIOLOGICAL SCIENCES

MICROWAVES FOR BIOLOGISTS

An outstanding physicist interested in the biological effects of microwaves complained to me of his difficulties in getting either support for his work or the cooperation of biologists. The physicists told him that biology has no place in a solid-state laboratory. The biologists said that microwaves are of no importance because they had played no part in evolution.

These attitudes seem to me to be profoundly mistaken. In this and the succeeding article I shall refer to some European work that would seem to justify a deeper interest on the part of both of these types of scientist and their several hybrids. I shall not introduce the military and diplomatic considerations that will occur to the reader who knows about the use of microwaves for overt and covert communication and has read the newspapers.

All electromagnetic radiation (emr) is biologically active, if only because temperature, undeniably a biologically significant determinant of state, is defined by the distribution of emr with which a body is in equilibrium. In nonequilibrium conditions the eventual conversion of absorbed emr to heat may be postponed by the intervention of processes set in train by local excitation. These are far-reaching and fundamental: think of the act of seeing, the greenery thriving on sunlight, or the production of cancer by x-rays.

X-ray frequencies are around 3×10^{18} Hz. Those of visible light are about 6×10^{14} Hz. Nobody doubts the existence of biological phenomena initiated by the primary act of absorption of such radiation: the evidence is overwhelming. This is no longer quite so obvious if one drops the frequency by a factor of ten thousand or more, to the microwave region below 3×10^{11} Hz (or 300 GHz) and on down through the radiofrequencies approaching ordinary ac. Over this range the most noticeable effects of emr are sensations of heat in creatures capable of describing their experiences and other evidence of thermal change in those who are not.

Orthodox physicists have tended to attribute any peculiarities of biological response to local heat production—compare cooking by microwaves with cooking in an ordinary oven—because they were at a loss for any mechanisms that would compete with the thermal noise in the system. Nevertheless, among those who have studied the biological effects of emr there have always been some, more usually perhaps in medical circles, who thought that radiowaves could produce specific effects which did not originate from thermal degradation of the absorbed energy. It was generally acknowledged that the beneficial effects of diathermy, originally applied with emr currents at about 100 kHz, were primarily the result of heat, but a lot of information and discussion was built up around the subject of nonthermal change in colloids, cells, tissues, and sick people placed in the "condenser field" generated by "short waves" and "ultrashort waves" of 100 to 500 MHz.

While these contentions have not been generally accepted, they derive a certain plausibility from the fact that emr in this frequency range is differentially absorbed, with respect to ordinary water, by water associated with macromolecules. Local "heating" of macromolecules by changes in the ambient "bound" water might be quite specific and might not be attended by any rise of temperature, as ordinarily measured, in the irradiated sample. To this extent the distinction between thermal and nonthermal effects is semantic, as E. Schliephake and other early investigators realized when they discussed the concept of "Punktwärme." The possible importance of selective absorption by bound water has been discussed recently by Professor E. Grant (Queen Elizabeth College, Univ. London) and Dr. A.J. Berteaud [Centre National de la Recherche Scientifique (CNRS) Research Group on Molecular and Macromolecular Organization, Thiais, France].

As technology broadened the range of frequencies available so as to encompass the microwave region (roughly 500 MHz to 300 GHz), with ever greater occasion for the deliberate, incidental or accidental exposure of people, interest in the physiological consequences was no longer confined to the hospitals and physiotherapy clinics. Some interesting data on the world-wide energy output of microwave communication towers were presented, for instance,

in an article by J.H. Schulman on the hazards of nonionizing radiation (*ESN* 29-12:546). Once again the question of possible nonthermal effects became a topic of study and discussion, with joyous flogging of horses previously believed dead. A new factor entered, with apparent polarization of opinion along national lines, typified by wide divergences among the maximum levels of exposure deemed safe for man: 10 mW/cm^2 in the USA, on the basis of an acceptable transient thermal burden, and 0.01 mW/cm^2 in the Soviet Union, on the basis of supposed nonthermal effects.

There are now experimental and theoretical grounds for taking nonthermal microwave effects rather more seriously than was the case when short and ultrashort waves were therapeutically popular. Typical of the experimental evidence is the series of abstracts in *Uspekhi Fizicheskikh Nauk* 110, Nos. 3 and 4 (1973). These experiments are of immediate relevance to a novel approach sketched by the theoretical physicist H. Fröhlich (Univ. Liverpool and Univ. Salford) in several papers dating from 1968 to 1977.

Fröhlich's ideas force our attention upon the microwave region for the following quite primitive reason. Distances of the order of magnitude 10 nm are of special biological significance. This is, for instance, the thickness of many membranes surrounding cells or structures within cells. If such a membrane is electrically polarized, as is probable, it will contain on its opposing surfaces opposite charges, separated by 10 nm, which may be mechanically linked so as to be capable of longitudinal elastic vibrations. The frequency will be determined by the velocity of sound, say 10^5 cm/sec, and will therefore be of the order of $10^5/10^{-6}$ or 10^{11} Hz. This too will be the frequency of the emr generated by the oscillating dipole.

So far nothing remarkable, for the vibrations will be randomly distributed and lost in thermal noise. Fröhlich, however, examines the properties of a model in which long-range Coulombic interactions of the individual quantized oscillators are considered. He shows that energy supplied, perhaps by local chemical reactions or by external sources, is shared among the various oscillators. Furthermore, "if the rate of energy supply is sufficiently large," he writes, "the energy gets channeled into a single mode which then presents a strongly excited coherent longitudinal electric vibration" [*Internat. J. Quantum Chem.* 11, 641-649 (1968)]. As a result, metabolizing cells in which the threshold energy-production rate is exceeded would be expected to emit emr, of specific frequency and narrow band-width, in addition to the black-body emission given by the Planck equation. Similarly, incident coherent emr would be absorbed selectively at the resonant frequency to generate a store of nonthermal or high-grade energy confined to a single mode and its harmonics and subject to long-range correlations. This stored energy may well be available for cellular activities such as mitosis or enzymic catalysis. Indeed, the need for cooperative or cumulative effects in biology has been recognized, and in the case of enzyme action an alternative mechanism based upon large electrostatic fluctuations in the vicinity of the active site has been proposed by Careri (*ESN* 30-9:395, 1976).

This account does scant justice to Fröhlich, who presents other major considerations and additional details. It suffices, though, to lend special interest to the papers from the USSR mentioned earlier. The systematic investigation of frequency-dependent biological effects, which was said to have been started in 1965, became possible as a result of the development of tunable millimeter- and submillimeter-wave generators. In the paper by N.D. Devyatkov it is emphasized that "for almost all of the biological objects studied..." the effects are strongly frequency-dependent but only slightly dependent upon the "power" over several orders of magnitude. These features are precisely those predicted by Fröhlich. In the case of the yeast *Rhodotorula rubra* the data shown graphically, with wavelength (in air?) as abscissa, indicate a very sharp resonance band of cell division stimulation at 41.783 GHz (wavelength 7.18 mm) flanked by inhibition at 41.841 and 41.725 GHz, the band width thus being about 100 MHz.

Apparent resonance effects are reported in other systems, including a remarkable series of four closely spaced ones at about 46.15, 45.94, 45.77, and 45.52 GHz, for the stimulation of colicin synthesis in a colicinogenic strain of *Escherichia coli*.

Again, there was a pronounced threshold intensity (around 0.01 mW/cm^2) above which the effect was independent of intensity (A.Z. Smolyanskayaa and R.L. Vilenskaya). There is no space to review all of the remarkable effects described in the Russian papers, but I ought to mention the note by D.S. Chernavskii who refers to Russian work in which apparently the electric oscillations of protein molecules with frequencies around 100 GHz are discussed in relation to mechanisms to enzymic catalysis.

Unhappily, like so much other work on nonionizing radiation, most of these researches are reported in insufficient detail for critical appraisal to be possible. A degree of confirmation of the existence of resonance effects in microorganisms can be seen in published work on *E. coli*. Papers by S.W. Webb and A.D. Booth (1969) and A.J. Berteaud, M. Dardahlon, N. Reybeyrotte and D. Averbeck (1975) contain reports of inhibition of cell division at about 71 and 73 GHz. S.J. Webb and M.E. Stoneham (1977) claim to have detected several resonances in metabolizing *Bacillus megaterium* and *E. coli* cells in the laser Raman spectra between 70 and 5000 GHz but, again, necessary details are lacking. Some more recent attempts to resolve the question of microwave selectivity are reviewed in the article which follows. (J.B. Bateman)

MICROWAVES UPDATED

The preceding article dealt with the alleged existence of nonthermal biological effects of microwaves. Such effects have been thought to arise at field strengths too low for significant gross changes of temperature to be produced, and are said to be characterized by sharp spectral selectivity.

Aware of the scepticism aroused by the accounts of this work, I was interested to learn from Professor H. Fröhlich (Univ. Liverpool and Univ. Salford, UK) of two laboratories in Germany where efforts are being made to arrive at definitive answers.

I visited those laboratories, but first let me mention a call on Dr. Dietrich Averbeck at the Fondation Curie—Institut du Radium in Paris. There I also met Dr. A.J. Berteaud who was largely responsible for the physical adequacy of their joint experiments, referred to in the preceding article. I accompanied Berteaud to his CNRS laboratory in Thiais, where biology forms only a small part of the research program. Berteaud has a strong personal interest in the properties of water in polymeric systems as studied by dielectric measurements, differential thermal analysis and other techniques. Averbeck, for his part, has not extended the published data on cell-growth inhibition by microwaves already referred to, but is examining more closely his conclusion that the observed effects do not involve any change in mutation rate and thus are not brought about at the level of DNA. A more sensitive test for possible changes in rate of reversion of tryptophane-dependent strains of *E. coli* is being used. The fluctuation method of Delbrück, Bridges, and Green should be capable of detecting deviations of 1.5% from the spontaneous mutation rate.

Aside from this, Averbeck has shifted his interest to the lethal effects of simultaneous or sequential irradiation of bacteria with x-rays and microwaves, a study which is readily assimilable at the Fondation Curie where major effort is being put into an attempt to express the effects of chemical agents in terms of a "rad equivalent" or comparable dose of ionizing radiation. The experiments to date show clearly that the strictly exponential course of decay found under the influence of x-rays alone is distorted by microwaves given before, after, or during x-irradiation. The effects are not frequency-dependent between 17 and 73 GHz and may be positive (sensitization) or negative (protective) even within a given series of experiments at a particular frequency. Shortage of funds makes it expedient at this stage to work at 9 GHz. This will no doubt cause some delay, if nothing worse.

At Neuherberg, near Munich, microwave experiments on yeast are being done in one of the 33 Institutes and Divisions of the Gesellschaft für Strahlen- und Umweltforschung mbH München (GSF), an organization controlled by the Federal Ministry of Research and Technology. The investigator is a young physicist, Dipl.-Phys. W. Grundler, whose main responsibility

is establishing correct conditions for irradiation experiments in the Neuherberg research reactor within the Physikalisch-Technische Abteilung. The Chief of the Abteilung, Dipl.-Phys. W. Westphal, made it clear that the microwave work is a sideline, though of sufficient importance to justify its inclusion in his program. In a detailed briefing I was much impressed by Grundler's critical approach and his keen appreciation of the pitfalls of biological experimentation. This feeling for biology was inherited, Grundler says, from B. Rajewsky, his scientific "grandfather." Close cooperation is maintained with Rajewsky's former laboratories in Frankfurt/Main, now the GSF's Abteilung für Biophysikalische Strahlenforschung under Professor W. Pohlit.

Grundler's plan, still in its early stages, is first to repeat the Russian experiments on yeast, referred to in the preceeding article, using increase of optical absorbance as the quantitative criterion. Then, recognizing that this method, in common with counts of visible colonies generated from surviving cells, fails to tell us anything about the number of cell divisions that have taken place before the "death" of those cells that cannot produce colonies, he proposes to examine the kinetics of the first few generations.

Any real success in observing the sharp resonances reported by Devyatkov would require elaborate frequency control measures. This is done at Nueherberg by tapping off 0.1% of the oscillator output through a resonator and processing it to give a rectified signal roughly proportional to the derivative of the output with respect to frequency, which must be zero in the resonant condition. The feedback circuit controls the oscillator so as to minimize this signal. Constancy of frequency to within 1 MHz at 40 GHz is claimed. Corrections for the effects of small temperature changes in generation time of the synchronized and fractionated yeast cultures can be made by determining families of growth curves at different temperatures and calculating $d(\log A)/dt$ in the linear region, where A is absorbance and t is time. The growth of the stock culture is also monitored during each experiment so as to detect any aberration that might otherwise be attributed to the electromagnetic field. Growth of the irradiated cells is followed in a double-beam spectrophotometer with a buffer solution in the control cuvette.

It would perhaps be more satisfactory to use the apparatus differentially, with an unirradiated suspension on the control side. The actual irradiation is done *in situ* by means of a two-pronged Teflon probe immersed in the contents of the cuvette and connected to the metal waveguide, the latter being about a wavelength (7 mm) thick. This design ensures a large area of contact that is enhanced by a plunger agitating the cells. Loss of field intensity along the probe amounts to about 50%. The temperature of the cuvette's contents is measured continuously with a bimetallic spring that serves also to position the cuvette. The temperature is also measured at the end of the experiment with a crystal detector placed in the cell suspension.

At the date of my visit (April 1977) Grundler had found a rather unconvincing tendency for lag time to be slightly shortened and growth to be slightly inhibited at certain frequencies. In the meantime a significant spectral fine structure of growth rate seems to have been established in some 67 experiments, and a manuscript has been submitted for publication in *Physics Letters*. Peaks of stimulation and inhibition alternate over the range 41.62 to 41.82 GHz with a bandwidth of the order of 10 MHz. The amplitude of the effect, between peak and trough, is around 20%, though variable: less, therefore, than the 80% shown between maximum and minimum in the data of Devyatkov cited in the previous article. Nevertheless, the effect is considerably larger than the random variability of about ±3%, and these experiments go much further than those of Devyatkov in plotting the detailed course of events, with a series of six maxima and six minima as against Devyatkov's single ripple. Whereas Devyatkov reported results at only four frequencies in steps of 58 MHz, Grundler's measurements are spaced at irregular intervals often as small as 10 MHz. It is notable also that Grundler found a range of frequencies, roughly 41.80 to 41.90 GHz, over which the growth of yeast was unaffected by the microwave field. Perhaps it would be unwise at this stage to attach too much

importance to discrepancies that one notes when making a more detailed comparison. It is preferable to accept Grundler's work as broadly confirmatory of earlier claims, while leaving several questions unresolved.

In his search for mechanisms of these strange effects, Grundler plans to use instrumentation already available from cancer research and radiation biology to follow the growth of single yeast cells on an agar surface by applying correlation analysis to growth data processed by computer. Kohler illumination gives sharp-edged images that can be scanned to give a numerical plot of cell profile. This can be programmed to read out the numbers of one-, two-, and four-cell groups and to detect buds. The changes in distribution after x-irradiation have already been determined elsewhere in considerable detail.

The second German laboratory mentioned by Fröhlich is the Max-Planck-Institut für Festkörperforschung (Institute for Solid-State Research) at Vaihingen near Stuttgart. There the microwave program is in the hands of Professor Dr. Ludwig Genzel, a noted physicist whose laboratories for semiconductor research encompass an impressive range of spectroscopic instrumentation: frequency-doubling tunable lasers, microwave generators, Raman and resonance Raman spectroscopy, Brillouin scattering, and far infrared. Genzel's plans for research in microwave biology have received a setback from the unavoidable cancellation of collaboration with an Australian biologist. Nevertheless, the necessary instrumentation has been developed and is undergoing tests. It will have other uses if the biological venture comes to naught.

The microwave setup is being treated as an optical system in order to avoid the standing wave artifacts which may well vitiate the results obtained with waveguides and resonant cavities. Two coherent beams from the same oscillator are processed so as to give an interferogram and an anti-interferogram. These modulations cancel as long as the losses from both beams are identical. When an absorber is placed in one beam, a signal is obtained, the Fourier transform of which gives the absorption spectrum. Several modifications are being studied. The assembly that was working during my visit made use as far as possible of large plane reflectors and beam splitters, but the final convergence upon the sample cuvettes had to be done with polythene lenses because computation and construction of concave reflectors is too expensive. The lenses gave some trouble, being optically nonuniform. The sample cuvettes were designed to contain water films of an adjustable thickness about 1 mm.

The power output of the "Rückwärtswellenoscillator" (Siemens) or "carcinotron" (French version) is sharply and irregularly frequency-dependent so that adjustment of the double-beam system has to be extremely precise, and elaborate frequency stabilization is essential. When I was there Mr. Chandrasekar, a guest, was very happy to have obtained an absorption curve for water between 60 and 90 GHz free of ripples. So the system is promising, and from a physical point of view they could proceed with biological experiments if a suitable coworker were available. The experiments planned include measurement of the microwave spectra of dissolved and crystalline proteins as well as detection of possible biological disturbances.

The Genzel laboratory would be an admirable place for other work bearing on the Fröhlich theories, such as closer examination of the laser Raman spectra of bacteria, attributed by Webb to resonances but possibly due in part—if not to experimental artifacts—to fluorescence. This could be tested by looking for the corresponding anti-Stokes lines. It will be unfortunate if lack of support from the Max-Planck-Gesellschaft or other sources should enforce cancellation of these plans. The Institutes generally are suffering from a waning of official interest, and the splendidly equipped buildings are not always being effectively used. For this very reason, guests from abroad are doubly welcome. The reputation of the Solid State Institute seems to guarantee it a healthy flow of visitors: 63 from 22 countries in 1976. A physically inclined biologist could not do better than to spend a year or so with Genzel investigating microwave resonances in cells and tissues.

My excursion into microwave biology was rounded off by a visit to Toulouse where current French work formed the subject of a symposium at the Centre

d'Etudes et de Recherches de Toulouse (CERT), a government research organization responsible for training research engineers who wish to acquire proficiency in advanced techniques needed in the aerospace industry. A separate report (ONRL C-14-77) deals with the sponsorship, terms of reference, and technical coverage of the symposium.

Some of the work done at CERT showed frequency-dependent effects which were taken to be of nonthermal origin. B. Thourel exposed yeast cells (identified only as "beer yeast"), harvested during exponential growth and washed with water, to microwaves at intervals of 0.1 GHz between 2.0 and 12.4 GHz. Heating occurred. Cultures similarly heated in a waterbath served as controls. Irradiated and heated suspensions were diluted and plated for colony counting. The scatter between experiments was large—greater at certain frequencies than at others—but Thourel claims to have shown that growth was stimulated at 6.4, 8.6, 9.1, and 11.0 GHz, and inhibited at 2.1, 3.4, 5.0, 6.9, and 10.0 GHz.

Effects reported for individual experiments were considerable: 80% inhibition, for example, after 30 sec at 2.1 GHz. The effect then leveled off until the chosen "cut-off" temperature of 31°C was reached after 4 minutes exposure. Although I have chatted with Thourel and have seen a manuscript describing the experiments in some detail, I find important loopholes and a failure to perform (or perhaps merely to record) controls of several kinds, the most serious being the lack of evidence on the intensity-dependence of the effects recorded. There is in fact some reason to think, from measurements in the Coulter Counter and observations in the scanning electron microscope, that the radiation may merely produce cell aggregates that invalidate the results of colony counting.

Other work at CERT under the direction of Professor Dumas appeared to show that there are frequency-selective effects of microwaves on the coagulation of blood plasma *in vitro* and on the lipid metabolism of mice *in vivo*. In the former case the coagulation time, in presence of a cephalin-kaolin reagent and added calcium, was normal at 8 and 10 GHz and elevated at 9.8 GHz. In the *in vivo* experiments serum triglyceride levels were found to be normal at 2.3 and 2.5 GHz and elevated at 2.4 GHz.

These experiments, too, invite scepticism. There are no dose-response curves, and the properties of the microwave field within the waveguides in presence of the test objects seem to have been incompletely characterized. One can conclude only that the data of Thourel and Dumas are not inconsistent with the Fröhlich prediction of sharp resonances. From the diagram in Thourel's manuscript one can estimate that the bandwidths for inhibition and for stimulation of the growth of yeast, at the frequencies where Thourel claims to see distinct effects, are around 200 MHz; so too are those implied by Dumas' results cited above.

I do not propose to discuss the vexed question of specific effects of low-intensity microwave fields upon the central nervous system. The subject is being investigated with very modest resources by B. Servantie (Centre d'Etudes et de Recherches de Biophysiologie Appliquée à la Marine, Toulon) to whom we owe the salutary, if rather obvious, observation that nonthermal effects tend to be masked by heat production in "acute" exposures to high field intensities. They are more likely to be seen after prolonged exposure to very weak fields. The Fröhlich effect, on the other hand, postulates a threshold rate of energy input below which coherent vibrations are not generated. The absorbed energy can, however, be accumulated, so that prolonged exposure to weak fields may be equivalent to proportionately briefer exposure to proportionately stronger fields. Obviously there are limits to the validity of this idea, and it would be unprofitable now to try to bring Servantie's data on the results of chronic exposure for hours, weeks, and months, into the Fröhlich framework.

So there are many questions still to be answered. This can hardly be done without the cooperation of biologists as competent and imaginative as the best of their colleagues in physics and engineering. And they ought to challenge the assertion, reported in the preceding article, that microwaves can have nothing to do with evolution or genetics. The microwave component in our surroundings is now quite significant, thanks to contemporary communications technology.

It has never been totally absent. Fröhlich makes the interesting remark that life has developed by exploiting all the possibilities inherent in the properties of matter. It is reasonable to expect that protoplasm has anticipated, and perhaps improved upon, the latest findings of quantum mechanics, solid state physics and cryogenics. For instance, Fröhlich goes so far as to suggest that local superconducting regions may exist at ordinary temperatures in biological materials. This idea, initially supported by the report of a Meissner effect in lysozyme, has suffered from the publication of incontrovertible evidence that the diamagnetic susceptibility of lysozyme does not change over the relevant range of field intensities. The set-back may be only temporary. In any event, the importance of these matters for biology is such that biologists ought to become whole-heartedly involved. (J.B. Bateman)

FUNCTIONS OF MICROBIAL MEMBRANES

The symposium on functions of microbial membranes, which was held at the University of Tübingen on the occasion of its 500 year's anniversary, was sponsored by the University and the Deutsche Forschungsgemeinschaft. Tübingen is a charming old city of 80,000 inhabitants located approximately 20 miles south of Stuttgart. The University has 17,000 students and is now spread throughout the city. Most of Tübingen and its University was spared during WWII, and many of the buildings have been standing for half a millennium. The symposium, which was superbly organized by Dr. V. Braun, was held on 5-7 September 1977 at the Naturwissenschaftliche Institute, which is a modern complex of buildings overlooking the city. The facilities and hospitality provided by the hosts were outstanding and included a reception and dinner at beautiful Kloster Bebenhausen.

It was most appropriate that such scientific discussions should be held at Tübingen since it was there that serious investigations on membranes began 25 years ago by Weidel, who studied phage absorption and membrane changes. Also, a great deal of the significant work currently being conducted on membranes is being done in that city; of the twenty-four 40-minute presentations made during the 3-day program (there were also 48 poster presentations), six were by investigators from the University of Tübingen and the Max-Planck Institut für Biologie in Tübingen. Other contributions were from other German cities, the United States, Japan, Great Britain, France, and Australia. The 124 biologists who attended the meeting were from 11 nations, which besides the above, were the Netherlands, Sweden, Switzerland, Belgium, and Finland.

The cell envelopes of Gram-negative bacteria consist of a cytoplasmic membrane and a cell wall. The cytoplasmic membrane is a lipoprotein structure that produces trilamellar images on electron micrographs. The wall is composed of a rigid peptidoglycan layer and an outer membrane which is structurally similar to the cytoplasmic membrane. Periplasmic spaces containing envelope enzymes are located between the cytoplasmic and outer membranes. Although the concentrations of lipid and protein in the cytoplasmic membrane are similar to those in the outer membrane, they are qualitatively distinct. The structure and function of the proteins in these membranes were the principal subjects addressed at the symposium. Their arrangement and properties were outlined in the introductory presentation of Dr. U. Hemming (Max-Planck Institute, Tübingen). Hemming's remarks concentrated on two of the major *E. coli* outer-membrane proteins, I and II*, their capacity to serve as phage receptors, and the apparent requirement for the presence of lipopolysaccharide for this function.

There are at least three different species of outer-membrane protein I. J. Mizushima (Nagoya Univ., Japan) found that these can be purified without heating in sodium dodecylsulphate (SDS) solution. Unlike cytoplasmic membrane proteins, the tertiary structure of protein-I species was stable in SDS solution at physiologic temperatures, making it possible to study the interactions between these proteins and peptidoglycan, or these proteins and lipopolysaccharide. Two of the protein-I species were shown to interact with the peptidoglycan layer. Although these proteins are distinct, they are structurally similar and most

likely interact with the same site of the peptidoglycan layer.

Dr. M.E. Bayer (Institute for Cancer Research, Philadelphia) presented evidence that there is a junction between the inner and outer membranes, that these are receptor sites for phages, and that they comprise 5% of the total surface area. He showed fascinating electron micrographs of plasmolized cells showing points of adhesion. His hypothesis was supported by Carl Schnaitmen (Univ. of Virginia, Charlottesville) who transmitted susceptibility to colicin from cells requiring arginine to cells that grew in arginine-free medium. At various times after mating and during subsequent growth, recombinants were treated with colicin and the percent of survivors determined. The results of these experiments suggest that only new colicin receptors can function in colicin killing (although old proteins can still bind colicin). This indicates that the colicin receptor sits on a "sensitive" site (possibly a "fusion site" between outer and inner membranes) in order to mediate killing. M.J. Osborn (Univ. of Connecticut Health Center, Farmington) suggested that lipopolysaccharides and phospholipids are synthesized in the cytoplasmic membrane and translocated to the outer membrane and that this occurs at specialized areas of contact between the two membranes.

H. Nikaido (Univ. of California, Berkeley) discussed the structural basis of the selection permeability properties of the outer membrane. He found that the outer membrane is permeable to hydrophilic molecules smaller than 600 daltons suggesting the presence of nonspecific diffusion pores. T. Nakae (Tokai Univ. School of Medicine, Japan) reproduced this permeability property *in vitro* in vesicle membranes reconstituted from isolated phospholipids, lipopolysaccharides, and outer-membrane proteins. The constituent that could confer this permeability property to the reconstituted vesicles was identified as the outer membrane protein with molecular weight around 35,000 daltons ("porins").

Various methods by which antimicrobial agents penetrate cell envelopes were presented by T.J. Franklin and G.A. Snow (Imperial Chemical Industries, Ltd., Cheshire, UK). Some relatively nonpermeant molecules such as phosphoromycin, cycloserine, and the sideromycins make use of facilitated transport systems localized in the cytoplasmic membrane. There is, in some cases, clear structural resemblance between the transported drug and the physiological nutrient. These investigators studied the oligopeptide permease systems as means of facilitating the uptake of drugs. They found, for example, that sulfuric acid penetrates when coupled with phe-gly.

A murine-hydrolase system responsible for morphological alterations in the peptidoglycan layer, thereby allowing modifications of bacterial shape during cell enlargement, was described by U. Schwarz (Tübingen), and studies on the biosynthesis of cell-wall peptidoglycan were presented by M. Matsuhashi (Univ. of Tokyo, Japan). M. Sumper (Univ. of Würzburg) discussed purple membranes of holobacteria as a model for studying membrane biosynthesis. Iron transport in bacteria was described in four presentations: H. Hankte (Tübingen), R. Negrin (Berkeley), H. Rosenberg (Australian National Univ., Canberra), G. Winkelmann (Tübingen).

M. Schwartz (Institute Pasteur, Paris) fused the gene for maltose transport with that for β-glactosidase and a resultant strain had the enzyme, which is normally cytoplasmic, in the outer membrane. The results of his experiments suggest that the information that directs the maltose-transport protein to the outer membrane lies with the transport gene itself. R. Teather (Tübingen) produced a plasmid that produces high levels of lactose permease and has shown this protein to be a true cytoplasmic-membrane carrier and not a "porin." W. Boos (Universität Konstanz) described a soluble protein contained in osmotic shock fluids and is therefore a periplasmic component. In contrast to transport-related periplasmic substrate-binding proteins, this protein does not bind its supposed substrate. The author suggests that it plays a role in specifically overcoming the diffusion barrier of the outer membrane.

The cell-cell interactions in bacterial conjugation were discussed by M. Achtman (Max-Planck Institut, Berlin). Although the initial interactions involve F pili, once stable, wall-to-wall contacts are formed, pili are no longer involved. The major outer membrane II* has been shown to be involved in the stabilization of

the wall-to-wall contact. Cells in a mating mixture are found in aggregates of up to 50 cells. These often exhibit more than one conjugation specific contact with other cells in the mating aggregate.

In the symposium's only evening lecture, F.M. Harold (National Jewish Hospital, Denver) discussed the role of ATP in potassium and calcium transport. Although ATP appears to provide the energy for accumulation of these ions, other factors, particularly electrical potential or pH, seem to regulate the process.

Posters were presented under four categories: (1) 13 were on translocation of substrates across membranes, most of which pertained to the role of outer-membrane protein in transport and transport of antibiotics, (2) 9 were on receptor interactions and primarily involved cell interactions with phages and colicins, (3) 8 were on biosynthesis and assembly, and (4) 18 were on structural organization. Several of the posters in this last group were on lipid composition of membranes and two were on enterobacterial common antigen.

The presentations were always well received and followed with lively comment and discussion. The poster sessions were also well attended. Considering the caliber and amount of material presented and the charm of Tübingen and its University, the only criticism I make is that it should have been extended to five days. It might then have included some papers on the immunological properties of membrane components. (LCDR John E. Sippel, MSC, USN, Naval Medical Research Institute, Bethesda, MD)

ONRL REPORTS

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EARTH SCIENCES

GEOPHYSICAL FLUID DYNAMICS IN MUNICH

The Fourth European Geophysical Society (EGS) Meeting was held at the University of Munich at the beginning of September, when Germany was rocked by another wave of terrorism resulting from the kidnapping of the industrialist H.M. Schleyer by the Baader-Meinhoff terrorists.

Through its annual meetings, the EGS seeks to provide a forum where Earth scientists can discuss and exchange new ideas. These meetings, while being primarily devised for European scientists, are open to those from other continents. One of the primary aims of the EGS is to provide, through such annual meetings, an opportunity for the younger scientists and research students in the geophysical disciplines to talk about their research and meet with established and senior scientists. To that effect the Society has instituted a Young Scientists' Travel Award Scheme (age limit: 27 years) to make it easier for graduate students to attend such meetings. The next EGS meeting is to be held in September 1978 in Strasbourg, France, at which the Geophysical Fluid Dynamics Symposium will be convened by Prof. B. Gjevik of Oslo University, Norway, and Dr. P. Davies of the University of Newcastle upon Tyne, UK.

In this recent meeting, the Geophysical Fluid Dynamics Symposium was of special interest to me, for it dealt with basic hydrodynamical processes in the oceans and atmospheres of the Earth and other planets. It was rewarding to see among the fifty or more participants several well-known scientists, from both the US and Europe. The three invited papers were each of 30 minutes' duration, while the contributed ones were allowed 20 minutes. The topics discussed could be broadly divided into the following areas: atmospheric and oceanic turbulence and turbulent flows, dynamics of fronts, effects of mountains on large-scale atmospheric flows or their experimental analogs, and ocean and ocean-atmosphere dynamics. Rather than discuss each presentation, I will briefly describe the highlights and

refer the interested reader to the EGS compilation of abstracts of the various talks. These may be obtained by writing to Dr. P. Davies at Newcastle upon Tyne.

Turbulence is a central problem in many areas dealing with fluid flows. It is especially important in geophysical applications in which characteristic dimensions are often large compared to other fluid-flow problems, so that the characteristic nondimensional numbers that describe these geophysical situations are for the most part such that these flows are turbulent. Prof. J.D. Wood (Univ. of Kiel, FRG), presenting the invited paper on geophysical turbulence, stressed the enormous range of scales involved—this is made evident if one considers the spectrum of averaged kinetic energy which spans a very wide range of wave numbers. Observations of these turbulent flows cannot be made on spectral ranges that exceed two orders of magnitude. Yet, the effects that represent the cascade of energy to the various scales of motions must be accounted for in atmospheric and oceanic models. The rotation of the Earth, its spherical shape, and the presence of both the gravitational field and topography confer to geophysical turbulence its special character. Woods discussed and compared kinetic-energy spectra for the ocean and atmosphere and discussed the various sources and sinks of energy, pointing out similarities and differences between these two spectra. He concluded that approximations used in two-dimensional turbulence theory appear to be more applicable to the ocean than to the atmosphere. Woods also discussed the role played by oceanic fronts in the cascade of energy to smaller scales: ocean eddies having a three-dimensional character become stretched and elongated and in the process develop into ocean fronts in which shear instabilities develop, resulting in the break-up of these sharp velocity and temperature interfaces. Other papers dealing with turbulent growth of atmospheric-mixed layers, growth of turbulent billows, and the experimental development and nonlinear break-up of internal gravity waves in a stratified shearing layer contributed to this theme on turbulent flows.

The role of topography in geophysical fluid-dynamical problems is not yet quite understood, and Dr. R. Hide (UK Meteorological Office, Bracknell, Bucks., UK) presented in his invited talk the reasons why such an understanding is important. The presence of rotation can be felt in gyroscopic-like effects that inhibit three-dimensional fluid motions and tend to render the flows two-dimensional. When the effects of rotation are strong compared to those of inertia, so-called Taylor columns develop above bumps or depressions. The remaining fluid attempts to move around these fluid columns which remain over the obstacles or the depressions as if they were solid. It appears that when the height of the obstacle divided by the total depth of the fluid reaches a certain fraction of a nondimensional parameter that measures the importance of the inertial versus Coriolis forces, the flow changes from one having a two-dimensional character to one having a three-dimensional one. Topography might play a part not only in the understanding of atmospheric large-scale circulations but also in circulations in the Earth's liquid core where the main geomagnetic field originates; it might also be important in a wide range of planetary and astrophysical investigations. Other papers contributing to this theme discussed synoptic situations leading to cyclogenesis in the lee of the Alps, numerical models of time-dependent flows over air obstacle, experimental investigations in which the flow moving over some obstacle exhibits a horizontal shear, as well as the three-dimensional lee-wave patterns which develop behind a small obstacle.

Dr. G. Walin (Institute of Oceanography, Gothenburg, Sweden) presented an invited talk on the hydrodynamics of the Baltic. This body of water is dominated by the competition between water masses of very different salinities that meet in the shallow entrances of the basin; these shallow and narrow regions exert hydraulic control on the remainder of the basin dynamics. Walin introduced a somewhat different description that relies on using the salinity rather than depth as an independent variable (see *ESN* 31-9:278) Experimental evidence of complicated and sometimes unstable gyres in various basin configurations with either a homogeneous or a two-layer model was presented; Professor J. Charney (MIT) discussed a simple coupled ocean-atmosphere model that would explain the presence of the Inter Tropical

Convergence Zone (ITCZ) away from the equator. The ITCZ is a cloud belt found, on average, at some 10 degrees of latitude on each side of the equator. Simple arguments show that if the ITCZ were at the equator and if it were displaced, a sequence of events would lead to upwelling of cold waters at the equator and a shifting of the warmer waters at latitudes a few degrees away from it.

In conclusion, the Geophysical Fluid Dynamics session at the Fourth European Geophysical Society Meeting proved to be a most worthwhile one, well serving the objectives of the EGS meetings. (A. Barcilon)

GLORIA II IOS

Under the heading GLORIA, J.E. Bennett in July '66 briefly reported in these pages on the development at the National Institute of Oceanography [since June 1973, the Institute of Oceanographic Sciences (IOS)], Wormley, Surrey, UK, of a 7-kHz long-range sideways-looking sonar intended for geophysical investigations in deep water (*ESN* 20-7:105). R.O. Rowlands, later reporting in some detail on this system. noted its successful use in the Mediterranean and Atlantic, and that development work was continuing particularly in the signal-processing area (ONRL R-26-71, A British Long Range Side-Scan Sonar).

Basically a side-scan sonar transmits echo-ranging underwater acoustic pulses in a narrow sideways-looking beam which illuminates the bottom. As the sonar advances, the beam sweeps out a rectangular area defined by the effective range of the sonar and the distance covered.

GLORIA was, in fact, successfully deployed in 1969 and was the first side-scan sonar reported to have given ranges in the excess of 20 km. The development was the result of experience at IOS with substantially higher-frequency short-range side-scan sonars dating back to the late 1950s. This has also served in part as the base for continued exploitation of this technique in research on the seabed led by Prof. W.D. Chesterman at the University of Bath (*ESN* 31-6:254).

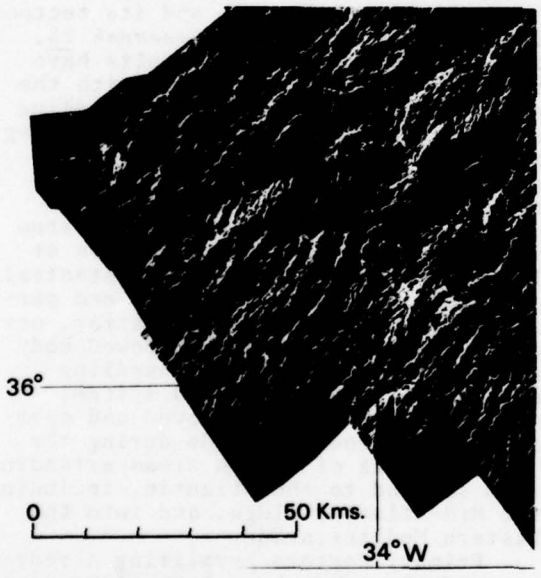
GLORIA is an ancronym for Geological Long-Range Inclined Asdic. The GLORIA system is, however, much more than an asdic or sonar. For useful and efficient operation the central component, a large transducer, must be deployed so as to be suitably stable for receipt of the returning echo, and suitably placed to avoid the adverse effects of vehicle noise, possible cavitation on transmission, and propagation variabilities of the medium, and yet be able to take advantage of forward motion for scanning purposes. This was achieved with the 5 × 1.3 m GLORIA transducer array by installing it in a heavy towed body, 10 m long and 2 m in diameter, and isolating it from unwanted ship motions by towing it via a faired cable from a submerged buoy towed in its turn by the ship.

The highly successful results obtained with this system with their mosaics of sonographs of the ocean bottom (Fig. 1) have been well reported in the literature and have added much to our knowledge of bottom topography and of the nature, structure, history, and indeed, dynamics of the ocean bottom [for example, see R.B. Whitmarsh and A.S. Laughton, "A long-range sonar study of the Mid-Atlantic Ridge crest near 37°N (FAMOUS area) and its tectonic implications," *Deep-Sea Research* 23, *1005-23 (1976)*]. These results have been obtained, however, only with the accompanying difficulties of handling a complex towing arrangement including a large heavy "fish," and requiring a large team to handle launch and recovery.

Experience with the GLORIA system and continuing R&D over the years at IOS have now resulted in a substantially different design of the sonar and particularly of the transducer array, permitting a smaller-diameter towed body adaptable to much simpler handling procedures. This improved system, GLORIA II, has been deployed and operated for extended periods during the summer months of '77 in areas extending from Iceland to the Atlantic, including the Mid-Atlantic Ridge, and into the Eastern Mediterranean.

Primary factors permitting a redesign of the sonar have been (1) successful outcome of the signal-processing research which resulted in a linear-correlation signal processor being added to the GLORIA I system in the early 1970s, giving an improvement

of some 20 dB in signal to noise, and (2) demonstration that the 10° vertical beam width of the GLORIA I, which determined its 1.3-m dimension and which had been based on experience with higher-frequency short-range shallow-water systems, was too narrow, and that a wider angle of up to 30° was acceptable. Redesign of the transducer array into two arrays looking 20° down to opposite sides, has been accomplished using the Tonpilz elements built for GLORIA I. One array is operated at 6.2 kHz and the other at 6.8 kHz. The elements (120 in all) are now disposed in two rows of 30 elements each in each array. They are housed in 30 machined Nylatron blocks each accommodating four elements, comprising a vertical pair from each of the two opposite arrays. The 30 blocks, bolted together at the corners, are tied together by a central tie bar, prestressed to 6 tons, that runs through them. With the additional fairings, etc., and top buoyancy to prevent roll, the transducer array vehicle is now about 7.7 m long with a section 66 cm in diameter having a top protruberance of about 15 cm to accommodate the buoyancy float.



Partial Mosaic of GLORIA Sonographs over Mid-Atlantic Ridge (after Whitmarsh & Laughton cited)

The neutrally buoyant GLORIA II body is towed from its nose by a heavy cable without fairing, considerably simplifying the launching, recovery, and winching operations, which can now be achieved with a team of 2 rather than the 8 required for GLORIA I. The depth of the body is controlled by the towing speed and cable scope. Launch and recovery are made from and to a hydraulically controlled tiltable ramp of unique design, carried at the stern of the surveying ship and having 1000-m cable drum storage. The ramp, which is designed for easy installation and removal, can be installed on any vessel with adequate deck space. Additional space is required for a portable hut containing the transmitters and batteries, and a hydraulic power supply also requires deck space near the ramp. Laboratory and darkroom space is required for the receiving and processing equipment.

Substantial detail on the GLORIA II development and a brief of the system's first summer's operation will be covered in a paper "GLORIA II—An Improved Long-Range Side-scan Sonar" by M.L. Somers, R.M. Carsons and others to be presented at "Oceanology International" to be held at Brighton, UK, 5-10 March 1978, and which will appear in the Proceedings.

Initial sonographs taken during the summer of '77 over the Mid-Atlantic Ridge demonstrate an effective range from each array of 16 nautical miles (30 km) with little if any noise background. There can be no doubt that GLORIA II is a much improved system over GLORIA I both in terms of performance and ease of handling and that it will contribute much to our knowledge of the ocean bottom. Kudos to IOS! (A.W. Pryce and J.D. McKendrick)

ONRL REPORTS

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ENGINEERING

WHY IS COLOR TV SO MUCH BETTER OVER HERE?

American visitors are often struck by the excellence of British and European color-TV reception. To understand the American inferiority in this field we must remember that the Federal Communications Commission (FCC) accepted the recommendations for color TV of the National Television System Committee (NTSC) in 1953, thirteen years before color-TV standards were adopted in Europe. The first regular monochrome TV broadcasting began, however, in Britain in 1936. The 405-line system introduced at that time is still in use for the VHF broadcasting of the BBC-1 and commercial networks, though no one knows whether any significant number of receivers remain for this antiquated standard.

In 1941 the FCC adopted a superior (black-and-white) TV standard involving 525 (horizontal) lines per frame and 30 frames per second, each consisting of two interlaced "fields" containing alternate lines of the frame in order to reduce flicker. Thus, there are 60 fields per second in the US, whose standard has been adopted throughout most of North, Central, and South America as well as in Japan, Korea, Thailand, and Cambodia. Other countries delayed their decisions and ultimately selected 625 lines per frame, with 25 frames per second, as their standard, again with two interlaced fields per frame. Aiming for even sharper pictures, France chose 819 lines per frame but is now phasing it out in favor of 625 lines.

Britain joined in the selection 625 lines, which is in use now for UHF TV broadcasting while the 405-line monochrome broadcasts of the same programs (except BBC-2) continue on VHF for the present. Despite the widespread agreement on 625 lines per frame, however, some of the other system characteristics differ from country to country, such as the separation between the vision and sound carrier frequencies. The sound signal may also be AM or FM, and the vision modulation may be positive or negative, i.e., the luminance may increase or decrease with increasing signal amplitude. However, FM sound and negative vision modulation are most widely used, as in the US, though not in France.

In regard to color, the early American experience with the NTSC system and subsequent advances in available components led to the development of the PAL and SECAM systems in West Germany and France, respectively. PAL (Phase Alternation by Line) was developed by a team under Dr. Walter Bruch at the Telefunken Laboratories in Hanover and was accepted as a standard by the European Broadcasting Union in 1966. SECAM (SEquential Color with Memory) based on the work of Henri de France was introduced in France in 1967. East Germany, the USSR, Hungary, Lebanon, Libya, Tunisia, and Morocco are among those that adopted the French system, while PAL is used in Britain, much of the rest of Europe, and other parts of the world.

In order to appreciate the improvement afforded by PAL and SECAM, it is necessary to understand the NTSC system on which they are based. Each resolvable spot of a color picture needs three numbers to describe how much red, green, and blue it requires. Instead of these three, however, the NTSC system transmits three linear combinations of them. One of these represents the total luminance of the spot, and it is the only part of the signal to which monochrome sets respond, referred to earlier as the vision signal.

The other two linear combinations of the red, green, and blue voltages together indicate the hue and saturation of each spot, both combinations being zero when the spot is to be gray or white. In the NTSC system, this color information is transmitted by the chrominance carrier, which in the US is 3.579545 MHz higher in frequency than the luminance carrier. (This value minimizes interference between luminance and chrominance sidebands.) The amplitude of the chrominance carrier indicates the saturation, and its phase angle relative to a reference pulse (the "color burst" transmitted once per line just after the horizontal synchronizing pulse) indicates the hue. More precisely, the saturation and hue are determined by the polar coordinates of the chrominance phasor, whose rectangular coordinates I and Q are suitable linear

combinations of the red, green, and blue voltages *R*, *G*, and *B*. At the transmitter *I* and *Q* amplitude modulate two equal-frequency color carriers that are 90° out of phase with one another, and at the receiver two color-reference waveforms 90° apart in phase are generated which are used to recover *I* and *Q* by means of coherent demodulation (product detection). From *I*, *Q*, and the luminance, the receiver is able to determine *R*, *G*, and *B*, which are used to control the beam currents from the three electron guns in the picture tube.

The principal problem arising with the NTSC system results from phase distortion, which alters the phase relationship between the color signal and the color reference waveforms. To the extent that this phase shift is constant, it can be corrected by adjustment of the hue ("tint") control on the receiver. However, phase distortion has many sources, and it generally varies with both time and position on the screen. Phase distortions as small as 5°, corresponding to delays of the order of 4 nsec (4×10^{-9} sec) at 3.58 MHz, produce noticeable changes in hue, but would be of no consequence for monochrome television. Among the causes of phase distortion are the nonlinearities of transistor circuits, which can permit the luminance signal to produce a varying phase shift; slight mechanical imperfections in video tape recorders, which can introduce varying delays; switching between cameras that are not quite identical; and unsymmetric filter response curves, especially the frequency responses of long-distance transmission channels over which TV programs are sent by means of frequency modulation.

To overcome the effects of phase distortion, the PAL and SECAM systems use different approaches, but both permit the receiver to dispense with the tint control and allow the viewer to turn up the saturation ("color") without revealing serious flaws in the hue. The result is a very pretty picture, also enhanced by the greater number of lines per frame than in the US, which can be a pleasure just to look at.

In the PAL system freedom from hue errors due to phase distortion is achieved, in effect, by using phase modulation of the chrominance carrier in opposite senses on successive lines. This reversal of sense is accomplished by reversing one of the rectangular coordinates of the chrominance phasor. Since the reversal is introduced at the transmitter and removed by means of electronic switching in the receiver, the effects of phase distortions in between are opposite on successive lines. In the original, simple form of PAL receiver, it was left to the eye to perform the averaging, which, when the distortion is not too large, gives the proper hue to every group of four successive lines in the frame (one adjacent pair from each of two successive, interlaced fields). In the advanced form of PAL receiver, a 64-μsec delay line is incorporated which stores an entire line of chrominance information and thus enables the receiver to average electronically the information from the present line and the preceding one. Although phase distortion causes a slight reduction in saturation, this delay-line form of averaging yields the proper hue for every spot on every line. A further advantage of the use of a delay line is that it permits the recovery of the two rectangular components of the chrominance phasor by simply adding and subtracting the delayed and undelayed signals, and there is no need to generate local reference waveforms in the receiver.

In the case of SECAM, only one rectangular chrominance component is transmitted for each line, conveyed by means of frequency modulation of the color carrier, and a delay line is again used for combining the information on one component from the preceding line with that on the other component from the present line. While this approach results in some loss of vertical color resolution, it is not necessary to have chrominance resolution as fine as that of the luminance and, in fact, a smaller bandwidth is used for the chrominance signal, thus giving a coarser horizontal resolution for it, too. The SECAM system is immune to the effects of phase distortion because it does not use phase to carry color information. For the same reason, it does not require a local reference oscillator locked to the phase of the color burst, and so the design of the receiver is somewhat simplified, just as in the case of the advanced PAL receiver.

The use of frequency modulation provides immunity to variations in amplitude, and the separate transmission

of the two color components avoids undesirable interactions between the two. Flicker does arise, however, at horizontal edges between different hues as a result of the system's switching between color components from line to line, and the FM chrominance signals, which are present even in white areas, produce some degradation of monochrome images. To overcome some of these problems a modification, "SECAM-IV," has been proposed which is like PAL except that, instead of using reversed phase modulation of the chrominance signal on alternate lines, its phase is held fixed.

Thus, we see that the US is paying a penalty for having been the first country to introduce color television, but the improved systems also have disadvantages, including some 12.5-Hz flicker due to the odd number of lines per frame and distracting moiré interference patterns occasionally resulting from the interaction of stripes in the scene with the chrominance-switching pattern. In addition, PAL and SECAM require acoustic delay lines of very precisely controlled length, particularly for PAL, and these add to the cost of the receiver, but the result is worth it. (Nelson M. Blachman)

POSTAL AUTOMATION IN LONDON

Since *ESN* was not around to record the inauguration of London's automated underground postal railway in December 1927, its golden anniversary affords an occasion on which to describe this still unique means for conveying mail between sorting offices and (British Rail) train stations. Having tried pneumatically driven unmanned cars running on rails in a 30-inch tube 9 ft below ground level from 1863 to 1866 and a larger system 2.5 miles long with a tunnel 49 inches high and 54 inches wide from 1873 to 1874, the Post Office gave up this approach on account of difficulty in maintaining the working vacuum. (The telegraph offices throughout France, on the other hand, are interconnected by a system of pneumatic tubes that are still in use today for the transmission of telegrams.) The present electric railway, carrying up to 50,000 bags of mail each day, is the outcome of a 1911 investigation into the problems of moving mail within the capital, which accurately foresaw that, "even with the introduction of motorised vans, the average speed for cross-London traffic will not rise above 8 mph."

Work on the electric railway started in 1913 but was interrupted by WWI and the financial difficulties that followed it. In 1926 the excavation of the 6.5-mile tunnel connecting 7 stations along a curving line from Whitechapel to Paddington was completed, and the English Electric Company then fitted them with 2-ft-gauge rails, a fleet of cars, and the necessary power supply and control equipment. The 440-V dc power is supplied on a third, center rail, while a low voltage on one of the running rails is used for detecting the presence of a car on any section of track. When this low voltage is connected through the car's wheels to the other running rail, the current that flows is used to disconnect the high voltage from the preceding section of track, and the brake solenoids on any car in that section thus become de-energized, bringing it to a stop.

The present tunnels, with an average depth of 70 ft, are mainly 9 ft in diameter to accommodate two tracks, one westbound and the other eastbound; near stations these divide into separate 7-ft tunnels to allow access from a center platform, and the voltage on the center rail is reduced to 150 V to cut the speed from 33 down to 7 mph. In addition, there is a several-hundred-foot-long 1:20 upward grade toward the stations for deceleration, convenience to the surface, and acceleration. (A 33-mph velocity can lift the car up to 36 ft.)

Several stations are equipped with transformers and mercury-arc rectifiers to convert 11,000-V ac power from the national electric grid to the required levels of dc. Each station has controls for starting, stopping, and switching cars as well as for routing them to sidings or reversing loops in some cases, but the unmanned cars run automatically between (and sometimes through) stations, keeping to regular schedules 22 hours a day Monday to Friday and 12 hours on Saturdays, with a train each way every 4 minutes during peaks. Maintenance is carried

out from 0800 to 1000 daily, with routine service every 2,500 miles, and complete overhaul every 80,000 miles for each car.

Nearly the entire fleet of 60 cars dates from 1930-1931, and each has run a total of 1.4 million miles. The cars are 27 ft long, weigh 7.5 tons, and carry 4 mail containers, each holding 1.8 tons of mail—60 bags of letters or 24 of parcels. The containers are on casters and are easily rolled onto and off of the cars by means of metal ramps which, when raised, form part of the side of the car and keep the containers aboard in place. Traction is provided by a 22-hp series motor on each car, and pairs of cars are sometimes run together. There are also manned battery-powered locomotives for use in case of breakdowns and for pulling maintenance cars through the tunnels, but breakdowns seem to be rare.

Although the English Electric Company developed an improved car for this railway in 1963, only 2 have so far been procured for use. More will eventually be bought to replace the older vehicles, but there are no plans for other alterations in this system, which includes well-designed devices for handling containers and moving mailbags between platform and surface. Despite its being 50 years old, it continues to be very effective in its mission of speeding up the mail, evening out the flow of work in the sorting offices, and making a contribution to the relief of traffic congestion in London. Meanwhile modernization is proceeding slowly in regard to the automatic sorting of letters (*FSN* 31-2:45). (Nelson M. Blachman)

SUSPENSION IN THE TRANSPORT INDUSTRY

Today, the great majority of rapid-transit systems existing and being introduced are steel wheel on steel rail, although a few hybrid systems have been employed recently using rubber-tired wheels on concrete tracks. Conservatively, most of these rubber-tired systems employ steel wheels in steel track as a back-up! Only very recently have rubber-tired systems been introduced without this expensive back-up so that the systems are finally benefiting from the resulting lighter-weight vehicles and reduced noise and vibration. Tracked air-suspension vehicles developed from proven Hovercraft cushion-seal, or skirt, technology would continue this trend to still lighter-weight vehicles that would run more quietly on maintenance-free tracks.

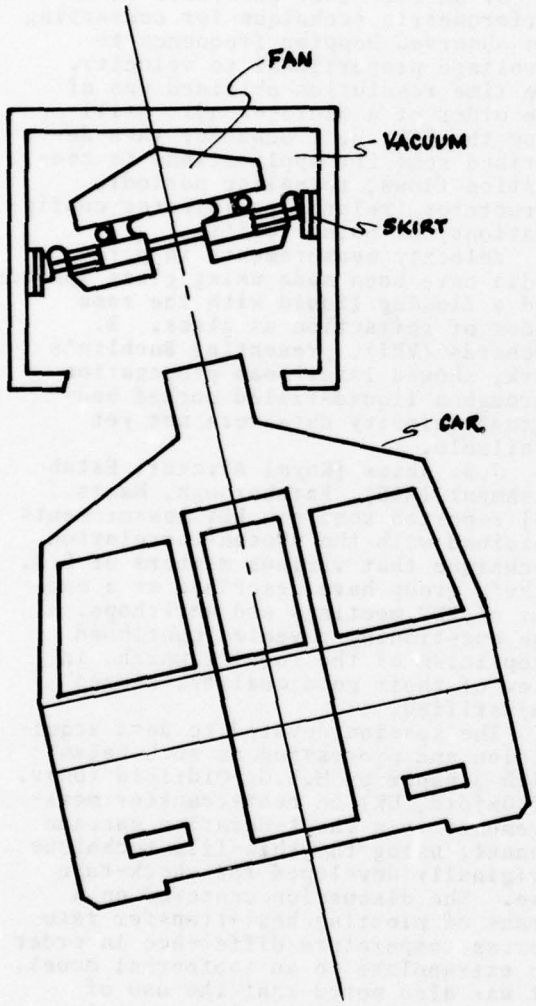
There has been some full-scale prototype testing of tracked base-supported air-cushion vehicles. However, Mr. Denys Bliss (Bliss-Pendair, Ltd., London), the inventor of the universally adopted segmented type of Hovercraft skirt, is convinced that his recent design for a vehicle suspended like a pendulum from an overhead track and using suction suspension will overcome drawbacks of base-supported cushion vehicles. In addition, it will yield several advantages over conventional tracked systems and the more sophisticated monorail systems being developed.

His configuration was chosen mainly: (1) to allow use of a simple monobeam track requiring minimum maintenance; (2) to help contain propulsion and suspension noise; (3) to protect track running surfaces from snow, ice, and obstacles resulting from vandalism; (4) to reduce vehicle and ground vibration; and (5) to facilitate lightweight vehicle construction.

Bliss-Pendair vehicles use an overhead track of prefabricated hollow concrete girder of inverted channel section. Each car is suspended beneath the channel-section girder by a T-shaped lift platform connected to the car at a number of points along its length. Edge sections of the platform are made of heavy rubber to form a seal (skirt) with the vertical sides of the "track," and suspension is achieved by an electric fan producing a partial vacuum between the platform and the roof of the track. Vertically mounted, sprung guidance wheels mounted at each end of the car contact the roof of the track and operate air-entry valves for pitch and elevation control of the support platform within the channeled track. Horizontally mounted wheels ride against the vertical track walls and provide lateral guidance and propulsion via conventional rotary electric motors deriving power from a third rail attached to the outside of the track beam.

This type of suspension distributes the load over a large area under low bearing pressure without contact (except

for the rubber skirts). It results in a virtually maintenance-free track of relatively light weight able to carry heavily loaded vehicles. The pendulum suspension allows vehicles to negotiate curves more rapidly than existing rail vehicles, although the track is not banked (see the figure). Accordingly, there is no danger of derailment. Thus track curvatures much greater than in current use are feasible. The suspension seal has been proven in principle by the French transport engineer Bertin, who has operated a tracked cushion vehicle at speeds over 400 km/h and has experienced skirt-wear lifetimes of 50,000 miles.



Bliss, with the backing of the large civil-engineering firm, Sir Robert McAlpine and Company, has progressed with research to the stage where a prototype can be built. He claims that designs can be produced in a few months, because most of the proposed engineering components are orthodox ones already being manufactured for other purposes. Vehicles can be sized to meet requirements, but a typical design might be 15 m long by 2.5 m wide and would carry 160 passengers.

Ironically, while the Bliss-Pendair approach using established technology awaits a sponsor able to appreciate the economics and simplicity of the system, three German firms (AEG-Telefunken, BBC, and Siemens) are being funded to build a large test track at Donauried near Augsburg to test their magnetic-suspension train. This German system combines several high-risk technologies such as linear motors and superconducting magnets for the magnetic levitation of the train. The progress in this highly advanced technology is impressive and long awaited, but even its strongest supporters would agree there is still a lot of technical risk to overcome before economically viable commercial systems are possible. The McAlpine engineering calculations indicate that the technical risk for a Pendair system is quite low, that construction costs would be competitive with conventional steel-rail systems, and that operation would be significantly less expensive. Although an overhead-monorail configuration would be the most economical, surface level and underground installations are also technically and economically feasible.

With the advantages of a pendulum air-suspension system fairly obvious and the technical risks low, where are the bold innovators in the transport industry to carry this system into operation? (CAPT L. Roy Patterson)

ONRL REPORTS

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SEVENTH INTERNATIONAL CONGRESS ON INSTRUMENTATION IN AEROSPACE SIMULATION FACILITIES

About 65 people from the United Kingdom, the United States, and a number of European countries attended the Seventh International Congress on Instrumentation in Aerospace Simulation Facilities during its three-day meeting held 6-8 September 1977. This Congress, sponsored by the Institute of Electrical and Electronic Engineers is a biannual affair held more or less alternately in Europe and North America. This Congress was the first one held in the UK.

The site was the Royal Military College of Science (RMCS) at Shrivenham in Wiltshire, not far from the prehistoric stone circles at Stonehenge and Avebury. The College at Shrivenham is the post-war successor to the RMCS at Woolwich (London), where formal courses in artillery had been taught since 1864. Degree courses in engineering and applied science are offered to both military and civilian students. Short courses on topics ranging from procurement science to bomb disposal are also given and are attended by students from a large number of foreign countries, including the US. The laboratories appear to be very well equipped for teaching and the overall layout is that of a small college campus.

Twenty-six papers from seven different countries were presented. Of these, the largest number, eight, came from the US. Six additional papers, all from the US, were withdrawn after the program had been printed.

The first session was on laser-Doppler velocimetry (LDV), starting with a summary paper by Alain Boutier and others from ONERA (Office National d'Etudes et de Recherches Aérospatiales, Châtillon-sous-Bagneux, France). After a review of the basic concepts, he described some recent applications to mixing regions, shock-wave-boundary-layer interactions, flames, compressor rotors, and a recirculation zone with velocity reversal. The next paper, by König and Pfeifer [Institut Franco-Allemand de Recherche de Saint-Louis (ISL), Saint-Louis, France], described a novel counter technique for data acquisition. Here the ±1 count ambiguity in signal cycles is eliminated by counting an integral number of cycles in a time $T + t$. T is a prechosen fixed time at the end of which a fractional cycle remains, and t is an interpolated time required to complete the cycle. A minicomputer is required to perform the calculation, and a unique combination of high data-rate and accuracy is achieved.

M. Timmerman [von Karman Institute (VKI), Belgium] was concerned with preprocessing the Doppler signal to improve the signal-to-noise ratio. He accomplished this with a bank of band-pass filters and some decision circuits to select the optimum filter automatically. Six different filters were used to cover the range from 10 kHz to 20 MHz.

G. Smeets (ISL) described an interferometric technique for converting the observed Doppler frequency to a voltage proportional to velocity. The time resolution obtained was of the order of a microsecond. Still from the ISL, H.J. Schaefer then described some LDV applications to combustion flows, revealing periodic structures (related to injector configurations) at burner exits.

Velocity measurements in porous media have been made using glass spheres and a flowing liquid with the same index of refraction as glass. B. Richards (VKI), presenting Buchlin's work, showed laser-beam propagation through a liquid-filled packed bed—actual velocity data were not yet available.

J.B. Abiss [Royal Aircraft Establishment (RAE), Farnborough, Hants., UK] reported some new LDV measurements obtained with the photon-correlation technique that various members of E.R. Pike's group have described at a number of LDV meetings and workshops. The questioning revealed continued skepticism of the results which, in view of their good quality, seemed unjustified.

The session devoted to data acquisition and processing as such began with a paper by M.L.G. Oldfield (Univ. of Oxford, UK) on heat-transfer measurements in a short-duration cascade tunnel, using the thin-film technique originally developed for shock-tube use. The discussion centered on a means of plotting heat-transfer rate versus temperature difference in order to extrapolate to an isothermal model. It was also noted that the use of MACOR(TM), Corning's glass ceramic

which machines like brass, has made model construction much easier than with the formerly used PYREX(TM).

To substitute for a cancelled US paper on holographic interferometry, R.J. North (RAE) next described the computerized data-acquisition system for their new 5-m tunnel. Although planned several years ago, this system features the currently fashionable distributed processing by a number of small computers. The last paper, by P.H. Fuijkshot (National Aerospace Laboratory, Amsterdam), described a computer-controlled system for determining the transfer functions associated with the pressure distributions on oscillating airfoils.

A session organized under the title of Flow Diagnostics occupied the entire second day of the Conference. It began with a proposal for the development of an infrared-streak camera, presented by J.H.L. Ranson (Pilkington Ltd., UK). In essence, a detector array would be directly coupled to a light-emitting-diode (LED) array which in turn would be viewed by a streaking-image tube such as the one incorporated in Hadland Photonics "Imacon" camera. It is reminiscent of the forward-looking infrared (FLIR) systems developed in the US by Texas Instruments and others. It was not made clear whether Pilkington intends to proceed beyond the few experiments, using visible light, reported here.

W.J. Miller (Max-Planck Institute for Fluid Dynamics, Göttingen, FRG) reported on a flow-visualization technique using laser-induced fluorescence of gas molecules. The flow is seeded with iodine which responds to the 5145-Å line of an argon laser. Shock waves and mixing layers were clearly visible in the photographs shown of low-density jets. A much older means of flow visualization, smoke, is still being used in very low-speed wind tunnels at the Illinois Institute of Technology (IIT), as reported by J.L. Way. They produce very clear, closely spaced streak-lines by pulse heating a wire coated with mineral oil and mounted in the flow upstream of the test section.

There were two papers on heat-transfer measurements in short-duration facilities. B.F. Richards (VKI) described a parametric curve-fit technique for analyzing data from time-dependent flows. He also described a calibration technique for thin-film gauges using impingement heating from an array of 24 small nozzles. C. Witliff (Calspan) reported on shock-tunnel measurements of heat transfer on the leading edges of the Space Shuttle. Thin-film gauges mounted on pyrex were used, and the main part of the paper described the very complex manufacturing technique used to obtain contours smooth to 0.0005 in. In the subsequent discussion it was suggested that it would have been much simpler to use the machineable ceramic MACOR(TM), whose use had been described in an earlier paper. However, the thermophysical properties of MACOR(TM) are not yet as well defined as those of PYREX(TM).

There were papers on temperature measurements at both low and high temperatures. J.C. Way (IIT) was concerned with tracking eddies in very low-speed turbulent flows, using temperature differentials as small as 0.001°C. He discussed 24 variations of the Wheatstone bridge and evaluated them in terms of sensitivity and common-mode rejection. The winner was the constant-current broken bridge. VKI has a free-piston hypersonic tunnel producing high Reynolds-number flows with a very short (about 10 msec) duration. E. Backx described fine-wire probes used in work performed at VKI to measure boundary-layer profiles, both on the nozzle walls and on flat-plate models. Quite accurate measurements of temperature can be obtained, but the probes are fragile and require frequent replacement.

The newest high-Reynolds-number hypervelocity facility is at the White Oak Laboratory of the Naval Surface Weapons Center (NSWC/WOL). It has been operating for about a year at Mach 14 and a Reynolds number of 4×10^6/ft. The run time is about 1 sec, with 0.5-0.7 sec available for data recording. In that short time, models are pitched at rates up to 100 deg/sec and data are obtained for a 30° range at angles-of-attack. J.A.F. Hill described how digital filters are used to eliminate model oscillations from the force data. Pressure measurements can also be obtained during these rapid-pitch sweeps, using pneumatic tuning of the pressure tubing.

Concluding the session of Flow Diagnostics, E.S. Hanff described the continuing effort at the National Research Council (NRC) in Canada on the measurement of aerodynamic cross

derivatives (e.g., rolling moment due to yaw). Their most recent development is a calibrating device in which such moments can be simulated outside the wind tunnel, using electromagnetic torques. It was used to check the special balances built to measure cross derivatives and showed that they work very well.

The final session was devoted to ballistics. This was the first time such a session had been included in an ICI-ASF conference. The first paper, by R.E. Hendrix [Arnold Engineering Development Center (AEDC)] described the instrumentation used in a high-speed range equipped with a track. This facility, as well as a newer and larger similar facility, has been developed so that re-entry-vehicle nose tips can be exposed to various erosive environments and subsequently recovered. The instrumentation includes laser photography; x-ray shadowgraphs; stereophotography; photographs of the rain, snow, or dust fields; and a five-frame laser sequential system with a framing rate of up to 10^7/sec.

Ballistic research at the Cavendish Laboratory at Cambridge includes impact research (both liquid and solid), fracture mechanics, and work on stress-wave propagation. The paper presented by J.E. Field described instrumentation for high-speed photography, again up to 10^7 frames/sec and various methods for measuring the velocity of propagation of cracks.

At the Harry Diamond Laboratory (Silver Spring, MD) there is considerable interest in determining the effect of launch accelerations, called setback, on fuzes for various kinds of ordnance. I. Pollin described a facility for duplicating this acceleration pulse by launching test articles, called birds, to impact on crushable targets constructed of aluminum honeycomb. The fuze to be tested is, of course, mounted backwards. It was shown that very faithful simulations of a wide variety of pulse shapes can be obtained.

E. Schneider (Ernst Mach Institute, Freiburg, FRG) described some experiments in which they measured the temperature rise in steel targets impacted by hypervelocity projectiles. Constantan wires were installed inside the target and formed thermocouples in conjunction with the steel. Analysis of the temperature data showed that about 60%-70% of the projectile energy is dissipated as heat in the target.

Rotating or rifling bands are used to transmit rifling torque to spin-stabilized projectiles. J.P. Barber (Univ. of Dayton Research Institute, Dayton, OH) described a device for launching a barrel over a stationary projectile, thus saving the rotating band for examination and analysis.

While some ballistic ranges are being closed, such as those at the Naval Surface Weapons Center, others are just going into operation. One of the latter is at Eglin Air Force Base, and its shadowgraph system was described by C. Babham. Multiple sparks are used to obtain closely spaced shadowgrams for accurate determination of angular motion.

P.W.W. Fuller, the Conference chairman from RARDE (the Royal Armament Research & Development Establishment, Fort Halstead, UK), gave the last paper. His problem was to select from a list of ten candidate methods the best one for determining the shot-exit time from a gun barrel. His standard was a flash-x-ray system. The best performers were a wipe switch and a pair of strain gauges mounted directly on the barrel. The latter would be the first choice when the barrel cannot be drilled.

The size of the group attending and the quality of the papers presented combined to make this Congress a very sucessful meeting of specialists in wind-tunnel and ballistic-range instrumentation. The audience was well enough informed that most of the papers were followed by meaningful discussions. The excellent living and dining facilities at the RMCS provided opportunities for many informal exchanges among the participants at the Congress.
(J.A.F. Hill, Naval Surface Weapons Center, White Oak, Silver Spring, MD)

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GENERAL

15TH INTERNATIONAL CONGRESS OF THE HISTORY OF SCIENCE

As they have every few years since 1929, historians of science gathered this summer for papers, discussions, tours, and the other modes of scholarly fellowship. Their meeting place in 1977 was Edinburgh, Scotland, for ten days preceding the Edinburgh Festival. Part of the charm of "the Athens of the North" is that it is, like Vienna, a capital without a country. Thus one of its principal activities is entertaining visitors, and in recent years Ediburgh has developed the scholarly side of tourism, playing host to a number of bodies, affiliated with the International Council of Scientific Unions.

The 1977 Congress was the first to meet in the United Kingdom since the famous 2nd Congress of 1931. There the Soviet delegation, led by N.I. Bukharin, caused a great stir among historians of science by their Marxist claim that the kinds of science done in a society reflected the political economy of that society. The most famous of the Soviet papers of 1931 was the physicist Boris Hessen's "Social and Economic Roots of Newton's *Principia*," which claimed that Newtonian mechanics served the need of 17th-century English *bourgeois* society for improvements in ballistics and marine transportation. Hessen's paper, crude but pathbreaking, stimulated a substantial response from English scholars. A.R. Hall (now Professor of the History of Science & Technology at Imperial College of Science and Technology, London) wrote a dissertation at Cambridge (published in 1952 as *Ballistics in the Seventeenth Century*) which showed that contemporary ballistics were too crude to profit from Newton's theories. Hall thus demolished the weaker half of Hessen's argument, that Newtonian science helped solve the technical problems of the "rising *bourgeoisie*." But Hall left intact the stronger half, that science finds its problems in the technical needs of society, and most historians of science today would probably find this a commonplace.

With the sociological study of science that Hessen began in 1931 now very much in vogue, Joseph Needham (Cambridge Univ., UK), the historian of Chinese science, opened the 1977 Congress with a Presidential Address that harked back to the earlier meeting in Britain, and others referred to it as the Congress progressed. But the Soviet delegation, which might have looked with pride back to its predecessors of 1931, could say little. Both Hessen and Bukharin perished in the purges of the 1930s along with other members of the delegation. In Soviet physics, unlike genetics, it was the ideologues rather than the scientific leaders who fell victim to Stalin.

Nothing so stirring as the 1931 papers took place in 1977. The history of science is too well established now for that. About 700 persons attended the 11 symposia of invited papers and the 50-plus sessions of contributed papers. The program committee (chaired by Professor Hall and served as secretary by Dr. E.G. Forbes of the University of Edinburgh, whose kilted recital of Burns' "Ode to the Haggis" was the high point of the Scottish Evening) discouraged contributed papers and organized many more symposia than have been customary at History of Science Congresses. The result was a higher level of scholarship and delivery than has been usual at these meetings. Again breaking with custom, only the symposia papers will be published in the *Proceedings* of the Congress.

Two symposia will be of particular interest to the readers of *ESN*. The first, International Cooperation and Diffusion in Science, was organized by Professor M.P. Crosland (Univ. of Kent, UK). Discussing international cooperation between 1900 and 1945, Brigitte Schroeder-Gudehus (Université de Montréal) pointed out that, contrary to the internationalist ideology that they professed, the scientists who took part in international "umbrella organizations" expressed in their actions national, personal, and disciplinary rivalries. Nathan Reingold (Smithsonian Institution, Washington, DC), seeking in the United States from 1850 to 1900 for an "American style" of science, pointed out that earlier historians of science had looked at the content of science rather than at the behavior of scientists for their clues. Comparing government support for science in Germany, the United

Kingdom, and the United States, he noted that by 1900 the United States was beginning to pull ahead. But the areas of science supported differed considerably from one country to another. The United States, with its vast land area, spent much more on earth sciences (related to inventorying resources) and agricultural sciences (related to the export of farm products).

In the symposium on Problems of Source Materials in the History of Science, Charles Weiner (MIT) reviewed the past two decades of collecting irreplaceable source material before it is destroyed and the associated recording of oral history interviews with prominent scientists. With the end of the twentieth century now in sight, he asked whether there might not be a need to broaden this collecting beyond materials useful for internal and institutional history of science. Historians of science and technology may not be the principal users of these archives, he suggested, since the interface between science and society in such issues as nuclear power and recombinant DNA research may be explored in future years by social historians, political scientists, and sociologists.

In spite of the efforts of the American delegation on behalf of Berkeley, the Assembly of the International Union of the History and Philosophy of Science voted to convene the 16th Congress (1981) in Bucharest, Rumania. (Harold L. Burstyn, US Geological Survey, Reston, VA)

MATERIAL SCIENCES

RARE EARTHS AND ACTINIDES: RESEARCH AND APPLICATIONS

A sprinkling of Americans celebrated the 201st Fourth of July in Durham, England, by attending an International Conference on Rare Earths and Actinides. This was the second conference on this topic to be held at the University of Durham in what promises to become a regular series. The six-year interval between these meetings does not imply neglect of the field but rather that its progress is usually reported elsewhere, for instance at the larger and more frequent Conferences on Magnetism.

This year's Conference had approximately 120 participants with a total of 71 papers. By interspersing oral with poster sessions, the organizers managed to accommodate the relatively large number of papers without losing either the informal character of the Conference or the opportunity for a reasonable discussion of each paper. Most of the participants seemed to react favorably to this mix, citing the ample opportunity for discussion that it allowed. The major task of organizing the Conference fell to Drs. W.D. Corner and B.K. Tanner of the Physics Department, University of Durham.

The meeting was opened with an invited address by Prof. K.A. Gschneidner, Jr. (Ames Laboratory and Iowa State Univ.) who described the evolution of rare-earth research during the twenty-five years which have elapsed since the first significant quantities of pure rare-earth metals and salts began to become available. He pointed out the major impact that technological innovations, such as use of rare-earth phosphors for color TV, have had on the development of the field, and predicted that the discovery of rare-earth permanent magnets and the development of magnetic-bubble devices for computer memories will have an even greater effect in the future. We shall return to these applications later in this review.

In another invited address Dr. D.W. Jones (Univ. of Birmingham) reviewed the state-of-the-art in a field dear to the heart of every rare-earth experimentalist: specimen preparation. Particular emphasis was given to the preparation of relatively high-purity single crystals of rare-earth metals by solid-state electrotransport techniques. In this method a rod of rare-earth metal is held in a high vacuum (10^{-10} to 10^{-12} Torr) and heated for a day or more by the passage of a large current. These extraordinary measures result in substantial purification—typically from starting impurity concentrations of 1000 ppm to final values of 30 ppm. The high vacuum is necessary to prevent the very reactive materials from degrading by combining with ambient gases in the vacuum system. Purity is an even greater problem for those who work

with metal alloys or with rare-earth compounds.

Gschneidner's estimate that only 10% of the current research uses single crystals points out the often crucial nature of specimen preparation in this field. Only recently have single crystals of rare-earth metals been produced with sufficiently high purity for the use of such powerful methods as the de Haas-van Alphen effect for the study of the electronic band structure. The availability of high-purity crystals and the data obtained from them have been a very important recent link in the attempt to develop more refined band-structure calculations for both the rare earths and actinides—a subject that was reviewed in detail by Professor A.J. Freeman (Northwestern Univ.) in an invited paper.

One of the most significant methods for studying the microscopic magnetic properties of rare-earth metals and compounds has been neutron inelastic-scattering measurements of magnetic-excitation energies. The crystalline electric fields in rare-earth metals and compounds are frequently as strong or stronger than the exchange interactions, leading to complex excitation spectra. Dr. P.-A. Lindgård (Research Establishment, Risø, Denmark) reviewed the current theoretical situation, including the standard basis operator technique as well as a discussion of how single-ion anisotropy terms in the Hamiltonian can give rise to apparent two-ion terms. On the experimental side, Prof. A.R. MacIntosh *et al* (H.C. Ørsted Institute, Univ. of Copenhagen) discussed the effect of Nd impurities in Pr on the excitation energies, while Dr. N.C. Koon (Naval Research Lab, Washington, DC) and Dr. J.J. Rhyne (National Bureau of Standards, Washington, DC) presented an interpretation of crystal-field effects in cubic rare-earth-iron Laves-phase compounds.

Lindgård and B. Spuznar (Inst. of Metallurgy, Crakow) presented an interesting analysis of the magnetic moments and transition temperatures of a series of rare-earth/transition-metal alloys assuming an RKKY interaction between the rare-earth moments and the transition-metal pseudospins. An effective alloy medium mediating the interaction was calculated using the coherent-phase-approximation theory and elliptic densities of states. Agreement between theory and experiment was impressive.

There was considerable interest at the Conference in anisotropy and magnetoelastic effects, especially in the cubic RFe_2 Laves-phase compounds that exhibit large magnetostriction at room temperature. Dr. H.T. Savage *et al* (Naval Surface Weapons Center, Washington, DC) reported on magnetomechanical coupling-factor measurements in both positive and negative magnetostriction RFe_2 materials, while Dr. J. Cullen *et al* (Naval Surface Weapons Center, Washington, DC) found changes of the C_{44} elastic constant in low anisotropy $Tb_{.3}Dy_{.7}Fe_2$ as great as 50% with different field orientations. Dr. C.M. Williams *et al* (Naval Research Lab, Washington, DC) presented a detailed study of anisotropy and spin reorientations with temperature in a series of $Ho_xTb_{1-x}Fe_2$ single crystals. Good agreements with single-ion crystal-field theory were obtained when magnetoelastic contributions to the anisotropy were taken into account. Dr. S.B. Palmer *et al* (Univ. of Hull, UK) investigated magnetoelastic effects in pure Pr and found that the acoustic mode associated with C_{66} does indeed soften at low temperatures in accordance with a theory by Dr. J. Jensen. Previously reported negative results had been due to transducer-bonding problems.

The cubic RCo_2 Laves-phase compounds are still the subject of active research because the cobalt moment is so close to instability. Dr. W. Steiner *et al* (Technical Univ. of Vienna, Austria) studied the nature of the magnetic-phase transition in $Ho_xY_{1-x}Co_2$. With increasing Y content they found the transition to go from first to second order. Dr. D. Gignoux *et al* (CNRS, Grenoble, France) studied the effects of nonmagnetic impurities on the ordering temperatures of RCo_2 compounds, while Dr. A. Tari *et al* (Manchester Univ., UK) reported on the effect of nickel substitution for Co in $HoCo_2$ and $Ho_{.01}Gd_{.99}Co_2$.

The amount of work reported on the actinides was notably less than that for the rare earths. There are several possible reasons for this. Work on actinides that is related to nuclear energy is probably reported elsewhere. Another reason is that the extraordinary health hazard of even very minute

amounts of some of these materials makes them unattractive for university research.

Dr. G.H. Lander (Centre d'Etudes Nucléaire, Grenoble, France and Argonne National Lab) introduced the actinide portion of the Conference with a review talk on their magnetic properties. He pointed out that early expectations of complex magnetic and nearly-magnetic behavior caused by the close proximity of the 5f band to the Fermi level have been fulfilled, but that generally more precise experimental data are needed before microscopic theories can be taken seriously.

In a separate talk, Lander *et al* presented measurements of induced magnetization in paramagnetic URh_3 deduced from polarized neutron data on a single crystal. They found that an induced moment exists at both the uranium and the rhodium sites, suggesting a partial filling of the rhodium 4d band due to hybridization.

A welcome change of pace for the Conference came in a novel evening session with discussions of the status of some of the rare-earth applications from the point of view of interested industries. Dr. H. Zijlstra (Philips Research Laboratory, Eindhoven, the Netherlands) talked about rare-earth permanent magnets of the $SmCo_5$ type. He pointed out that these high-energy density magnets are very attractive, except for their relatively high cost. Since commercial users will almost always employ the cheapest product that will do the job, he predicted that production of rare-earth permanent magnets will continue to be a relatively small-scale industry geared to applications in which high energy-density or high coercivity are critical and for which the customer is willing to pay the price. Furthermore, the production of rare earths is so limited that they can at best account for no more than 2% of the total volume of permanent magnets. Applications of rare-earth magnets may be in traveling-wave tubes and servomotors that need to reverse in minimal time.

R.J. Fairholme (Plessey Memories, Towcester, UK) showed a lot of clever hardware development of magnetic-bubble memories. However, the future of bubble memories is not clear. They are faster than magnetic discs but have less storage. They are slower than semiconductor circuits but have more storage. A new competitor is emerging in charge-coupled devices. Plessey is making 16-K bit chips of permalloy on YIG (yttrium iron garnet). They are working on 64-K bit devices, and 10^6-bit experimental units have been reported in the industry. The best potential of these memories seems to be in moderate applications—many of them probably commercial—where both moderate speed and storage are useful.

Gschneidner informally suggested an interesting use for rare-earth oxides. The very high stability of these materials may make them useful as coatings for surfaces exposed to reactive atmospheres and high temperatures. Little or no work seems to have been done in this direction as yet. Perhaps this will be one of the new applications for rare earths that might be discussed at the next Durham meeting. The Proceedings of the Conference will be published by the Institute of Physics. [Norman C. Koon, Conrad M. Williams (Naval Research Laboratory, Washington, DC), and Clifford C. Klick]

NEW DIRECTIONS FOR TRINITY

In the Republic of Ireland there are primarily three centers for academic physics research: Trinity College in Dublin, University College in Dublin, and University College in Galway. There have been new appointments to head important physics groups at two of these institutions in recent years. Prof. G.F. Imbush is now head of experimental physics at Galway; and Prof. Brian Henderson is head of physics at Trinity College. Both of these men are from the solid state community, and it seems certain that an increasing emphasis will be placed on solids in Ireland.

On a recent visit to Dublin I had the opportunity to visit with Henderson and some of his colleagues at Trinity College. It seems clear that the new directions for physics research at Trinity have been charted and the voyage is well underway. Henderson views the work of the dozen staff members as falling into three areas:

Solid State Spectroscopy, Nuclear Instrumentation, and Surface Physics.

The surface physics group is the newest and is in the process of adding men and machines. Low-energy electron diffraction (LEED) and Auger apparatus exist, and there is an on-going program in the photoenhancement of surface-electron emission.

Nuclear Instrumentation includes some of the work in the Department that is a continuation from earlier times. Dr. E.C. Finch is concerned with the pulse-height response of semiconductor detectors to heavy ions and has made extensive measurements using the fission-fragment mass separator "Lohengrin" at the Institut Laue-Langevin in Grenoble.

Solid State Spectroscopy is Henderson's own interest, and the collection of Dewars, magnets, microwave gear, optical benches, and lasers is growing steadily. Dr. V.J. McBrierty heads a group concerned with polymers. The tools at their disposal include esr, nmr, positron annihilation, electrical conductivity, and x-ray analysis. They have set out to study a somewhat unusual problem: how does carbon-black interact with elastomers to enhance their physical properties? The group works with a local commercial company that supplies samples and with the Chemistry Department. Their most recent studies using nmr are consistent with the existence of a tightly bound layer of elastomer in the immediate vicinity of the carbon-black particle in addition to a loosely bound component.

Henderson is continuing his long-term involvement with the study of defects in MgO and other alkaline earth impurities. One of these studies is to examine the photo-excited states of the F_A center in MgO. Other recent work is concerned with hole traps and luminescence phenomena in alkaline earth oxides. A new area of interest is the study of excitons in GaSe and CdTe. Another is the study of CdF_2 doped with rare earths, with emphasis on the optically excited states.

A recently completed study at Trinity involves the analysis of Mn^{2+} in sodium β-alumina. The high conductivity of this material, caused by migration of the sodium ions, can be altered by adding impurities. As a result, the specific locations of impurities and their role in the conduction process is of considerable importance. In the case of Mn^{2+} the magnetic-resonance spectra are quite different depending on how the Mn^{2+} is added. If it is added by diffusion after the crystal is grown, the Mn^{2+} enters the β-alumina through the relatively open mirror planes and is prevented from diffusing further by the close-packed oxygen ions. On the other hand, Mn^{2+} that is present during the β-alumina synthesis will occupy all the Al^{3+} sites, not only those near the open conduction planes, thus leading to a much more complex spectrum.

Trinity College has an ancient tradition as one of the most senior institutions in English-speaking academia. Its old brick and lovely stone buildings, the cobblestoned walks, and the lush playing fields are being accentuated by the addition of a new library and an Arts building. It is in this setting that current practioners of Quantum Mechanics ply their art as the past heroes of Trinity—like Hamilton, the developer of an earlier mechanics—look fondly down. (Clifford C. Klick)

THERMOMECHANICS OF MAGNETIC FLUIDS

An advanced course and workshop entitled "Thermomechanics of Magnetic Fluids" was held from 3-7 October at the International Centre for Mechanical Sciences, Udine, Italy. The program, sponsored by UNESCO, was directed by Prof. B. Berkovsky, Head of Mechanics, Science Sector, UNESCO, Paris, on leave from the Luikov Institute for Heat and Mass Transfer, Minsk, USSR. The "course" was attended by some 30 participants who, for the most part, were active contributors to various aspects of the field.

A magnetic fluid is a fluid that has a high magnetic permeability; such a fluid is achieved, in practice, by suspending magnetic particles in a liquid. The particles often used are magnetite, cobalt, and Fe_2O_3 and are so small ($\sim$100 Å) that they are of monomagnetic domain. In the paramagnetic temperature range (well below the Curie temperature) the grains are saturated magnetically. Besides the liquid in which the particles are suspended, it is necessary to have a surfactant consisting of long-chain molecules which coats the particles and

keeps them separated. Due to the Brownian motions of the suspended particles, the properties of the fluid suspension are isotropic in the absence of a magnetic field. However, when a magnetic field is applied to the fluid, the particles line up so that the preferred direction of their magnetic domains coincides with the applied field. If the direction of the applied field varies, the particles rotate to accommodate the changes. However, if the temperature is sufficiently high, the particles become superparamagnetic (the domains do not show a preferred orientation) and they need no longer rotate to accommodate the changing direction of the applied field.

The action of a directionally varying applied magnetic field upon a magnetic fluid with paramagnetic particles causes body moments in the fluid because of the oriented rotation of the particles, and therefore the resulting magnetic stress tensor (caused by particle interaction) is asymmetric.

There are two methods of preparing magnetic materials for use in magnetic fluids: the first consists of grinding magnetic material into fine particles; the other of chemically synthesizing the particles. The usual method of chemical synthesis is to precipitate magnetite from a ferrous chloride-ferric chloride solution using sodium hydroxide. Magnetic particles can also be electrolytically deposited on a mercury cathode that, if agitated, keeps the particles small.

The solvent (fluid carrier) of a magnetic fluid (also called ferrofluid) may be water, hydrocarbon, Freon, or even a liquid metal such as mercury. Generally, the ferrofluid has very low electrical conductivity, although in the case of a liquid metal carrier, the electrical conductivity is high. The suspension of magnetic particles in a nematic liquid-crystal carrier fluid is being pursued and if accomplished, would raise a number of interesting application possibilities.

When a nonmagnetic body is immersed in a magnetic fluid with an applied magnetic field, it will gravitate to a region where the magnetic field is lowest. If the field is caused by two pole pieces of similar polarity opposing each other across the fluid, the nonmagnetic body will be levitated at a point midway between the pole pieces. The reason is that since the ferrofluid has a higher permeability than the body, the energy stored by the field is minimal when the body is in the location of the smallest field. Similar reasoning indicates how a magnetic body can be self-levitating in a ferrofluid with at least one (though free!) boundary.

The workshop consisted of lectures on the colloid chemistry, preparation, static conformation, dynamic magnetization, reversible field-induced agglomeration, properties, small-angle x-ray scattering, theoretical modeling, and applications of ferrofluids, as well as round-table discussions. The applications discussed by the lecturers all depended on the static aspects of ferrofluidics and included such devices as ferrofluid bearings and seals. Since a ferrofluid with applied magnetic field will statically support a bearing journal, the bearing will function equally in rotation as well as in axial translation. The ferrofluid, held in place by the applied magnetic field, also serves as a seal. Another current application of ferrofluidics is the elimination of a spider to locate the voice coil of a loudspeaker within the field magnet. The ferrofluid is used to center the voice coil, and since the stiffness of the eliminated spider is absent, the fundamental loudspeaker resonant frequency is lower and the loudspeaker response is closer to linear. The ferrofluid bearing finds further application in inertial-guidance navigation devices and is of particular interest in gravity-free environments.

At the present state-of-the-art, bearing loads of 0.15 psi and pressure seals (for 8 stages) of 4 psi are practical; the future projected relevant figures are 120 psi for the bearing load and 960 psi for the seal. At low speed, the bearings and seals are virtually frictionless. At high speed, hydrodynamic forces enter the picture, and the suspended particles cause erosion and wear. The seals are leakproof. If used in high-speed applications, the ferrofluid seal and bearing will probably be subject to hydrodynamic instabilities that will further increase the friction losses over and above that corresponding to laminar Couette flow (flow between differentially-rotating coaxial cylinders).

The only modeling of ferrofluid dynamics presented at the meeting was

by Berkovsky and Prof. J. Buckmaster (Univ. of Illinois). Berkovsky lectured on "Physical, Mechanical, and Mathematical Models of Magnetic Fluids" whereas Buckmaster spoke on "Ferrodynamic Boundary Layers." All present, however, realized that a lot more ferrofluid will have to be available before applications involving large-scale flow fields can be seriously considered. The other speakers and their topics were Dr. R.E. Rosensweig (Exxon Research Labs., Linden, NJ) who with J.L. Neuringer wrote the pioneering paper in the field; Dr. P.C. Scholter (Phillips Research Labs, Eindhoven, Netherlands), Colloid Chemistry; Dr. E.H. Bogardus (IBM Research Labs., Yorktown Heights, NY) Dynamic Magnetization; Prof. P. Pincus (UCLA, CA), Static Conformation and Dynamics of Isolated Grains; Dr. A. Martinet (Lab. of Phys. of Solids, Univ. of Paris, Orsay, France), Experimental Evidence of Static and Dynamic Anisotropics; Dr. C. Petipas (Univ. of Rouen, France), Small-Angle X-ray Scattering; and Prof. T.B. Jones (Colorado State Univ., Fort Collins, CO) who spoke on Ferrofluid Seals.

The meeting brought out the wide interest in the general area and applications of ferrofluidics of many academic and industrial laboratories, in various countries. As better ferrofluids are developed, there will certainly be an accompanying increase in devices and applications to utilize them; I fully expect this before much more ferrofluid flows over the dam. (Martin Lessen)

ONRL REPORTS

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MATHEMATICAL SCIENCES

COMPUTER-AIDED SHIP HULL DEFINITION AT THE HAMBURG SHIP MODEL BASIN

The Hamburg Ship Model Basin (Hamburgische Schiffbau Versuchsanstalt—HSVA) was first established in 1913 at the initiative of German shipbuilders and shipowners. With the exception of the post-war years 1945-53, it has operated as a self-supporting nonprofit company providing a host of experimental facilities and services to dozens of shipyards and shipowners as well as navies and ship certification authorities. More recently, it has undertaken experimental investigations and simulations of the behavior of offshore structures. The experimental facilities at HSVA include two towing tanks of 300 m and 80 m in length, each equipped with wave makers, an 80-m shallow-water flow channel, three cavitation tunnels, a computerized towing and data-acquisition carriage for the study of planar-motion maneuvering and a 37-m Ice Model Basin for the testing of ice-going ships. For a more complete description of the experimental facilities at HSVA, see the article by M. Lessen in *ESN* 31-6:248-250.

My own principal interest in visiting HSVA was to discuss the computer-aided shape-definition techniques used for the automatic numerically controlled production of the scaled ship models used for towing-tank experimentation. Dr.-Ing. Günter Collatz, Head of Model Manufacturing, was my host for a tour of the experimental facilities, after which we were joined by his assistants, Ings. Walter Alef and Eckhart Seiffert. The research and development of the present computerized system for hull-shape definition was due principally to Collatz and Alef. However, the prime responsibility for the further development of the system now seems to rest with Seiffert who has only fairly recently joined the staff.

Some of the considerations which must be taken into account in designing a ship hull are the commercial and economic requirements, the hydrodynamic and structural characteristics, and the empirical knowledge gained from

experience and experimentation. Since not all of these factors can be optimized simultaneously, the actual hull shape represents a compromise which satisfies all of the practical constraints but, in general, optimizes none of them.

As a rule, HSVA does not have the responsibility for the design of ship hulls. The designs are provided in the form of a small-scale "lines plan" drawing by clients who wish to have tow-tank models produced and tested. The job of HSVA is to enlarge the lines plan to an appropriate size for the model which is to be made and tested. The lines plans provided by clients are surprisingly crude and usually contain only the minimum number of key design curves (e.g., water-lines and vertical section profiles) needed to define the 3-D hull surface. The gross imperfections in the blueprints together with the necessity of enlarging the lines-plan curves by a factor of 10 or perhaps 100 leads to the mathematical problem of "lines-fairing," i.e., the process of making all curves smooth, of removing any local humps or hollows, and of making sure that all intended intersections of curves are actually achieved.

As a service organization, HSVA is always under time pressure from clients who are impatient for test-tank results. Thus, in addition to reducing the labor content of model making, there is a strong competitive incentive to reduce the lead-time from receipt of the lines plan to the completion of the test model. Since it is difficult, if not impossible, to quantify the subjective notion of fairness, the HSVA system of lines-fairing adopts the pragmatic approach of automating those facets of lines-fairing that are most laborious and time-consuming while leaving all decisions regarding aesthetic acceptability and fairness to the discriminating eye of an experienced draftsman. In other words, the lines-fairing and hull-surface definition system is based on the philosophy of interactive work-sharing between the draftsman and the computer.

There are three basic steps in the lines-fairing procedure: (1) fitting data points ("offsets") measured from the design blueprint with a mathematically defined curve, (2) calculating the ship's displacement and position of bouyancy, and (3) modifying the key design lines to meet the specified displacement and center of bouyancy requirements as well as hydrodynamic and aesthetic criteria.

From the point of view of the mathematical techniques employed, it is the first of these three steps that is of greatest interest. In general, this first step is termed "splining," in deference to the traditional drafting technique in which a thin elastic beam (a spline) is forced, by means of heavy weights (ducks) strategically positioned along its length, to smoothly approximate a set of measured curve offsets. The thin-beam (mechanical) splines used by draftsmen have the desirable property of minimizing the strain energy of the curve which approximates the offsets. Since the minimization of strain energy is found empirically to be closely related to the intuitive concept of smoothness or fairness, many systems for the computer-aided design of free-form curves are based upon mathematical functions that emulate the curvature properties of thin-beam splines.

The specific fairing techniques in use at HSVA are: (1) Bernstein-Bézier polynomials and (2) Cornu spirals. The first of these techniques was developed a decade or so ago by Prof. P. Bézier of Régie Renault for the computer-aided design of automobile exterior curves and surfaces. The method is based upon classical Bernstein approximation of functions and, although it requires a high degree of draftsman interaction and iteration in order to accurately fit prescribed offset data, it has met with considerable success and is used extensively in the French automobile industry.

In order to exercise maximum control over curve shape, HSVA uses only cubic Bézier curves. While satisfactory for a large number of curve types, they do not have sufficient flexibility to handle all ship lines. Consequently, they have developed a method of lines-fairing based on Cornu spirals which seems very similar to the method developed by Dr. Even Mehlum (Central Institute for Industrial Research, Oslo, Norway) for use in the AUTOKON system for ship hull design. The basic notion here is that a Cornu spiral is defined "intrinsically" (i.e., without reference to any particular coordinate system) as a curve whose curvature κ varies linearly as a function of the arclength

s along the curve, i.e., $\kappa = as + b$ for some constants a and b. The nonlinear mathematical problem which arises with the use of Cornu spirals for curve smoothing is that of integrating the nonlinear differential equations which define the spiral subject to the constraint that the resulting curve deviate minimally from the prescribed offset data. The group at HSVA has developed mathematical software to solve this nontrivial problem and report that, except for some difficulty in specifying curve tangents at end-points, the method produces very acceptable results in most cases.

The fairing of individual lines (curves) leads eventually to a collection of curves, each of which is acceptable in its own right. However, if one views this set of curves as an ordered sequence of, for example, water-lines at different heights, then it is natural to require that adjacent curves have similar curvature or aesthetic features. In other words, the "character" of the curves should change smoothly and gradually from one curve to another. Again, as with the term "fairness," the concept of the "character" of a curve is not easy to quantify, although it is an intuitively meaningful notion to an experienced draftsman.

What is done, therefore, to take into account the interrelationship between curves of the same family is to locate the critical points on each curve at which its curvature is a maximum, minimum, or zero (an inflection point). One then connects the critical points of corresponding type (e.g., location of inflection points) by a curve which cuts more or less orthogonally across the family of faired curves. In general, the curves connecting corresponding critical points will not be fair, and the procedure is then to smooth these new lines to obtain a fair curve which most closely fits the loci of critical points. The faired curves obtained are termed "charming lines" and are really only auxiliary curves which the draftsman will then use to modify the initially faired design curves of the lines plan. The final set of lines which are used to define the model's hull surface will only emerge after several iterations of the fairing and charming procedures.

It is interesting to note that the HSVA techniques do not lead to a mathematical definition of the entire hull surface. Rather, the final result is a fairly dense collection of cross-section lines (e.g., water-lines) which are digitized and used to drive a 3-axis mill which cuts the actual model. The grooves left by the milling machine are removed by hand-finishing to obtain the smooth hull model that will be used for experimental testing.

Depending upon the type of experiments to be performed, the models are made of wood, wax, glass-fiber reinforced plastics or epoxy resin with a filler. The latter material is also used for alterations of models when tests indicate a potential for improvement in the ship's form.

The hardware used for geometric design at HSVA consists of a Hewlett-Packard 21-MX computer, a Haromat digitizer for the initial digitization of offsets from the small lines plan, and an electronic drawing table for the production of drawings. An interactive graphics terminal will soon be added to make the system more efficient by decreasing the waiting times between user commands and visual output. The drawing table will then be used only for the generation of final drawings. (William J. Gordon)

PHYSICAL SCIENCES

LATTICE DYNAMICS—1977

An International Conference on Lattice Dynamics was held in September at the Université Pierre et Marie Curie in Paris. The following report is an attempt to describe the present state of the field and its principal areas of activity as revealed by this extensive Conference.

Lattice dynamics is the study of the motion of atoms (or ions) in a solid, and as such constitutes one of the two basic disciplines of solid-state physics. The second discipline, which deals with the motion of the electrons, is the one that has traditionally drawn the interest of more scientists as well as the public at large. For example, the Nobel prize for the invention of the transistor came as early as 1956,

when the word "solid-state electronics"—as applied to radios and hi-fi equipment—was already part of the vernacular. These applications deal largely with electronic phenomena. Lattice dynamics experienced its explosive growth later, mostly in the late 1950s, and it was not until 1963 that the first large international conference took place (in Copenhagen; the proceedings appear in *Lattice Dynamics*, R.F. Wallis, ed., Pergamon, 1965). This year's conference, the second, showed great changes in emphasis.

The reader may wonder whether separation of phenomena in a solid into those caused by electronic and those caused by atomic motion is at all logical or justifiable. Lattice dynamics began with the simple assumption that atomic displacements must be small compared to the distances between atoms (Born and von Karman, 1913). Today we can view this as little more than a definition of a solid (if atomic displacements are large, we're talking about a liquid or a gas). Nonetheless, a rigorous justification of the assumption could not be provided until the invention of quantum mechanics, which is now believed to provide the correct foundation of all phenomena on the atomic level (Born and Oppenheimer, 1927). The separation remains a curious one: it is, after all, precisely the action of the electrons (which the lattice dynamicist ignores) that provides him with the basically stable equilibrium of the atoms and their small excursions about that equilibrium that he studies. By 1960, van Hove had established the analytical structure of the distribution of normal frequencies, computers existed to provide these rapidly for individual models, and experimental measurements were possible by the scattering of cold neutrons, a scientific by-product of wartime nuclear reactors; those were the main topics of the 1963 conference. The major concern was phenomenological models within the harmonic approximation for fitting the experimental data without much concern with their quantum mechanical origins (these included "shell" and "deformation-dipole" models to take account of charge distortion). A noteworthy exception to this unconcern was the paper by Harrison on the pseudopotential approach to calculating phonons in nearly free electron metals. Also, some important work was being done on defects and anharmonic effects.

This year, the basic separation—to look only at lattice vibrations or "phonons" and ignore electrons—was much harder to detect. With large computers one can now apply the old phenomenological models to rather complicated systems. There were papers on surfaces, point defects, dislocations, amorphous materials, and numerous perfect crystals with complex structures, e.g., crystalline DNA pyrimidines. There were two sessions on "weak anharmonicity" (anharmonicity asserts the failure of the essential lattice-dynamical assumption of small atomic displacements; the adjective "weak" therefore conveys that the failure may be less than catastrophic). Beyond these, the failure of the separation of atomic and electronic motion was usually of the essence: phase transitions, which clearly involve large motions—including even melting; solitons—special propagating wave packets that can be found by solving highly anharmonic problems. There were also many attempts to understand "superionic conductivity"—experimentally not a new phenomenon—in terms of the interaction between a moving particle and lattice vibrations.

The lattice dynamicist became interested in phase transitions when Cochran (1960) pointed out the connection between soft modes and structural-phase transitions. The standard picture involves a "soft mode" in the high-temperature phase that drives the lattice unstable as the frequency approaches zero. This mode is commensurate with the low-temperature structure; i.e., its wave vector is a simple fraction of a reciprocal lattice vector (normally at the zone center or zone boundary). The macroscopic properties of the material in the very anharmonic regime near the transition temperature are expressible in terms of an order parameter, essentially the amplitude of the soft mode. However, two new phenomena, incommensurate phase transitions and central peaks, discovered by neutron-scattering measurements, have shown that the old soft-mode picture is not entirely adequate. Most of the present interest in phase transitions deals with these two effects, but neither seems to be clearly understood yet. The instability in incommensurate transition is apparently often caused by a large coupling of the phonons to the electronic structure. Since the discovery (1972) of a very intense and narrow central peak

in neutron-scattering measurements on $SrTiO_3$ (later also in other compounds and in light-scattering measurements) many explanations have been offered, involving concepts ranging from coupling of soft phonons to defects to domain formation. After the Paris Conference it is still not clear if the central peak is of a static or dynamic origin or even both.

Of particular interest seem the attempts to calculate atomic motion from "first principles." Past practice—so-called "model calculations"—had been to assume interatomic forces as given and calculate the lattice dynamics from them according to the old-honored recipe of Born and von Karman; with a big enough computer, assumed forces can be varied as often as necessary until a fit is obtained. This process is neither conducive to physical understanding nor even mathematically unique. At present, several groups are therefore trying to calculate, rather than assume, the force constants that go into the calculations; and to do so by using existing information about the electronic structure of the solid. Take the example of a phase transition again: one may be able to describe the essential features of the highly anharmonic system near a structural transition in terms of a mode that softens with temperature, but to understand why the mode softens at all requires an accurate microscopic theory of interatomic forces in the harmonic lattice. The latter is, of course, a difficult task indeed, but one that may be ripe for a breakthrough. Accurate first-principles calculations of electronic band structures and crystal-charge densities are becoming commonplace. Further, it has been shown that the ground-state energy of a solid is a unique function of the charge density; thus all the information needed for a phonon calculation is in the electronic structure just waiting for an effective way to be extracted. It was evident at the Paris meeting that some progress has been made.

The easiest systems to treat are those where the outer electrons are either tightly bound, as in ionic solids, or nearly free, as in simple metals. For ionic solids one can do pretty well by simply rigidly overlapping the charge densities of the free ions (see Born and Huang, 1954, and references therein). Models for the charge distortions that arise when the ions move (shell- and deformation-dipole models) existed even before 1963. Recently, a variational theory for calculating phonon dispersion in nonmetals (R. Zeyher, Max-Planck Institute, Stuttgart, FRG), discussed at the Paris meeting, has been used to explain the various terms of these models on a microscopic level (S.S. Jaswal, Univ. of Nebraska). In a first-principles calculation applied to the simplest ionic compound LiD, it gave an accuracy of 20% in the phonon frequencies.

For simple metals, on the other hand, the electronic structure can be determined by treating departures from free-electron behavior as a perturbation. This was worked out in the early 1960s and given the name pseudopotential theory. In this approach the dependence of the energy of the system on the configuration of the atoms takes a relatively simple form that can in turn be used to calculate the phonon spectrum. However, for nonsimple metals experimental information of some sort must be used to determine the pseudopotential.

Density-response theory should in principle be applicable to any material. It gives the dynamical matrix as a sum of a bare interaction minus a second term involving the density-response function, $\chi(q)$, that accounts for the response of the electrons to the moving ions. No complete calculation without adjustable parameters has yet been done, but it has helped to understand anomalous phonon spectra in transition metals and their compounds. These materials are particularly interesting because many of them are high-temperature superconductors. For some materials (e.g., NbC and TaC) the anomalous features in the phonon dispersion can be understood qualitatively from the geometry of the Fermi surface or from calculations of $\chi(q)$ in the constant matrix-element approximation. However, a more sophisticated treatment is required to explain the large anomalies in Nb. A paper was presented by S.K. Sinha (Argonne National Laboratory, Argonne) in which a tight-binding picture for the band structure was used along with parametrized short-range forces to obtain very good results for Nb, including all the anomalous features. However, his explanation of the anomalous behavior conflicts with earlier work by C.M. Varma and W. Weber (Bell

Laboratories, Murray Hill) that explains the anomalies as a screening effect.

In sum, it seems that the basic separation of solid-state theory into electronic and lattice-dynamical problems will be with us for a long time to come. We saw no attempt at a rigorous solution of both problems together, but ever more work combining the results of both theories. Those who find these achievements logically unsatisfying, however successful they may be in describing reality, can take some comfort in the somewhat higher level of internal consistency of the "first-principle calculations" of phonon spectra from electronic-band theory. (L.L. Boyer and Herbert B. Rosenstock, Naval Research Laboratory, Washington, DC)

BETTER CLOCKS IN FRANCE

The desire to measure time with great precision has had a long history. In earlier ages astronomical observations and mechanical clocks served man's needs. With the advent of vacuum tubes, the quartz crystal-controlled oscillator became a widely used standard. The past several decades have seen a remarkable development of various other ways of telling time grouped under the general title of "atomic clocks." These include alkali-vapor clocks such as rubidium and cesium; sharp laser lines which are sometimes used for the complementary problem of length measurement; and there has been a steady development of the hydrogen maser as a frequency standard because of its remarkable stability and good accuracy. Not all high-precision clocks are atomic, however. The use of a low-loss superconducting microwave cavity has also been proposed and developed as a very stable frequency standard.

Development of these high-precision clocks has made possible applications such as very long-base radio astronomy, verification of the general theory of relativity, precision navigation and spacecraft tracking. An ambitious project currently being pursued is an Air Force-Navy effort called the Global Positioning System (GPS). Its goal is to disperse around the earth a large number of satellites, each of which has a stable clock-controlled radio oscillator. From any point on earth several of these satellites will be visible at the same time. Comparison of the signals from these satellites allows the ground point to determine its position with great accuracy. In the GPS program several test satellites with rubidium and cesium vapor clocks have been flown. It is planned that a hydrogen-maser clock will be part of the next satellite launch, and intensive effort is being spent to develop a small, reliable, and lightweight maser that will operate successfully in a space environment.

In France the Centre National de la Recherche Scientifique has concentrated its support of efforts to develop advanced frequency standards at the Laboratoire de l'Horloge Atomique which is on the campus of the Université Paris-Sud in Orsay near Paris. Dr. C. Audoin is director of the laboratory. Its staff consists of six scientists and an equal number of graduate students with a few supporting engineers and technicians. The group is working actively on hydrogen masers, helium-neon lasers with an iodine absorption cell, methane as an infrared laser standard, continuous-wave dye lasers, and long-lived excited ions trapped in a magnetic field as sources of very sharp microwave lines.

The largest effort has been in the hydrogen-maser development. There are four hydrogen masers in operation. Two are high precision standards which are nearly alike and are housed in the same room but are completely separate, even to the use of separate vacuum pumps. Another hydrogen maser is designed to operate over a temperature range from 77 K to 373 K; a unique development of the laboratory. The fourth hydrogen-maser is used for atomic-physics experiments not involving temperature variation.

All of the apparatus has been developed with great skill and care. A high vacuum of 10^{-7} mm Hg is maintained in the bulb containing the excited hydrogen atoms. Magnetic shields are used to isolate the hydrogen atoms from varying ambient magnetic fields. Inside the shields all the vacuum apparatus is made of copper to avoid the possibility that stainless steel might not be entirely nonmagnetic. The microwave cavity, which surrounds the bulb containing the hydrogen, is made of

metallized quartz tubing with metal end plates. The cavity temperature is regulated to 10^{-3} K. A quartz bulb coated with Teflon and then baked is used to contain the excited hydrogen atoms; the Teflon reduces the tendency of the excited hydrogen atoms to relax to their ground state at the walls. Similar care is lavished on the electronics to reduce noise, isolate the oscillator from the load, and make amplifiers that have a phase shift independent of signal level. The result of all of this is that the two standard masers have a fractional frequency stability with respect to each other of 3×10^{-15} for time intervals of 1000 sec and 10^{-14} for 5-day periods.

Although the frequency stability of a hydrogen-maser clock is impressive and is better than any other clock now used in practical applications, one can inquire about the source of the present limitations. In a recent paper M. Desaintfuscien, J. Viennet, and C. Audoin, *Metrologia* 13, 125 (1977), looked at some of these limitations for hydrogen masers as a function of temperature. Stability is related to $(\nu/\Delta\nu)$ where ν is the average frequency of the maser and $\Delta\nu$ is the width of the frequency distribution. It is obvious that one would like to reduce $\Delta\nu$ as much as possible. There are two primary problems. One is that the excited hydrogen atoms react at the walls of the bulb that contain them. The other is that the atoms collide with each other. At the walls there is a finite probability that excited atoms will not be simply reflected but will interact with the wall in some way to make a transition to the ground state thus reducing the lifetime of the excited state and broadening the line. Even if the atom is reflected from the wall, a phase shift may occur on reflection that also tends to change the frequency slightly and broaden the line. For atoms that collide in the bulb there is a frequency shift caused by spin exchange between the atoms. There is also an effect related to the interruption of the oscillating magnetic moments of the atoms during the collision. Finally, there is some loss as the ions relax to the ground state.

The French group find that the effects of the Teflon wall appear to have three temperature regions. Below 202 K there is a simple physical adsorption of hydrogen atoms on the walls with an activation of about 2×10^{-2} eV which gives rise to some phase shift. Wall losses are very small. There are changes in wall interactions at 202 and 296 K that are probably connected with the motion of some parts of the Teflon macromolecules. The wall material tends to be more liquid in character than at lower temperatures, and the hydrogen atoms may be able to penetrate to the quartz substrate that is much more interactive than the Teflon. New losses and phase shifts appear at each of these higher temperatures.

The measured values of the cross section for excited hydrogen atoms to interact with each other and relax to the ground state is nearly independent of temperature above 100 K and agrees with the theory. Collisions between atoms also give rise to frequency shifts, and these have also been measured as a function of temperature. Again agreement with theory is good.

It appears therefore that the one area in which appreciable improvement could be made in hydrogen masers is the wall coating. It would be helpful to have some material that is as inert at 300 K as Teflon is below 200 K.

There are several other activities of Audoin's group that are of special interest. One is their development of a very sharp laser-source by the use of a helium-neon laser combined with a saturated iodine vapor cell. Audoin says that this eliminates the first-order Doppler effect in the laser line and leads to a source that is 100 times better than the krypton line widely used as a standard for length measurements. The French standards organization (the Bureau National de Métrologie) is now actively looking into this as an improved tool. Audoin's group is looking for other dyes that might make similar improvements for specific laser lines in other portions of the spectrum.

A novel idea, in the early stages of development at this and other laboratories, consists of the magnetic storage of ions. In the work in progress at Audoin's laboratory, barium ions are injected into an evacuated bulb with magnetic fields around it such that the ions are deflected away as they approach the wall. Lifetimes of a second have been achieved for these ions. The ions are excited by pulsing with a dye laser in the blue. Under these conditions the ions have a

microwave transition at 8 GHz that has been seen on occasion with a width of 10 Hz. By comparison, the hydrogen maser has a width of about 1 Hz at 1.4 GHz so that $(\nu/\Delta\nu)$ is nearly the same for these systems at present. The stored-ion system has potential advantages in that wall effects are reduced and the geometry can be arranged so that Doppler broadening is eliminated. It would seem possible that with continued development the stored-ion technique could become another important frequency standard.

The hydrogen-maser clock was first proposed fifteen years ago by Professor Ramsey of Harvard University and his associates. The progress that has been made since then in the clock's operation, in the understanding of its limitations, and in its application to major practical endeavors is an illustration of the rapid transition of basic research to engineering characteristic of our time. (Clifford C. Klick)

PSYCHOLOGICAL SCIENCES

THE EYES, THE HANDS, AND THE COCKPIT

L. Nordström, Head, Man-Machine Systems, Airplane Division, SAAB-SCANIA AB, Linköping, Sweden, is a corner of a triangle whose other corners are the Airborne Electronics Division (I. Carlsson, Head), Defense Materiel Administration, Air Materiel Department, Stockholm, and the Forsknings Simulator (FOSIM, or research simulator) Research Facility (O. Hällén, Head), Department of Aeronautics, Royal Institute of Technology, Stockholm. Standing in the center of the triangle is aircraft cockpit design. The Airborne Electronics Division, as a central government agency, provides the money as well as offering design and research ideas, the FOSIM provides research support, and the SAAB-SCANIA plant is where the aircraft are developed. They have mostly attack and fighter-interceptor aircraft on their minds, and they give considerable attention to low-level, high-speed attack. This kind of attack, in which the earth goes by with incredible swiftness and fractions of a second make a difference, certainly must be one of the most demanding of flying assignments, and so there is an understandable concern with the human factors of the cockpit. With his human factors research program on site at the aircraft plant, Nordström is the focal point of the concern. Test pilots and test aircraft are nearby, so he is in a good position to try out new design ideas and get the worthy ones adopted.

One of the impressions distilled from discussions with Nordström and his colleagues is a preoccupation with eye movements. Low-level, high-speed flying involves attention to events both in and outside the cockpit, and eye movements not only take time but the highly directional eyes can be in the wrong place at any particular moment and miss a vital event when it occurs. Apparently this preoccupation has been with the SAAB-SCANIA human-factors staff for some time. The head-up display, where symbology is projected on the windscreen so that instrument values and the outside world can be processed without appreciable eye movements, is in the Swedish AJ37 attack fighter.

On the day of my visit to the SAAB-SCANIA plant, Nordström was concerned with finding panel space to move a cathode-ray tube near the head-up display so that the visual processing of the two would be easier. Nordström also has an interesting basic research idea that bears on eye movements and which, if supported, could have implications for cockpit design. He has the hypothesis that the eye does not need to move to receive two spatially separated items of information. He believes that the fovea and the periphery of the eye are two channels that can operate simultaneously, and that we can centrally select and attend to either one we wish.

The cockpit of an advanced, modern military aircraft is a mix of conventional electromechanical instruments and one or more cathode-ray tubes for radar and computer-generated information. If the present trend toward computer-generated information in the cockpit continues, and there is every indication that it will, the day probably will come when the cockpit panel is nothing but cathode-ray tubes and computer-derived information. On that day the cockpit designer will have a new power because he will be able to

place any item of information at any place on the panel, at any time, in any reasonable size, and in symbolic or pictorial form. There are many ramifications of the new power, and one of them is for eye movements. How are designers going to array the panel information so that eye movements are minimized? Are they going to spread it all in front of the pilot and imitate the electromechanical instrument arrays of the past, thus committing the eye-movement sins of the past? Will only a subset of the items be displayed at a time, thus keeping the set to be scanned small so that eye-movement requirements are minimal? The particular subset showing at any moment could be the pilot's choice. Or should eye movements be eliminated almost entirely by displaying one item at a time? Instead of moving the eyes to the item, move the item to the eyes. Items of a single category, such as basic flight parameters, could be cycled to appear successively at the same place on the panel; other categories of information could be displayed at the pilot's discretion. It will be interesting to see if our ideas of eye movements are defined well enough, and our knowledge about eye movements strong enough, to decide on one of the new options for presenting cockpit information that will be open to us.

If the cockpit of the future will be dominated by computer-generated information, the pilot must have an input device for interacting with the computers. The input device is typically a keyboard, and Nordström expressed concern about the growing number of keyboards in the cockpit. If the cockpit panel is a spread-out array of instruments that places heavy demands on the visual system, the controls can be said to make analogous demands on the motor system. Nordström believes that the answer may lie with a voice-recognition system as the input device. Instead of punching a keyboard the pilot could quite literally talk to a computer and give it instructions, with a voice-recognition system identifying the complex of sounds in the pilot's voice and being the basis of the input to the computer. An experiment in the FOSIM was conducted along these lines under Hållén's supervision. A digit-reading task was required while flying a standard maneuver, and voice recognition and push buttons were compared as methods of pilot input to the system. Experienced pilots were the subjects. The result of the experiment was that voice recognition had slightly less error than push buttons. The pilots were delighted to have their hands free of button pressing, and they were enthusiastic about the possibilities of voice recognition in the cockpit.

Will the day come when we can fly an airplane by talking to it? If the system can receive the vocal input of digits in Hållén's experiment, and so would be able to receive, say, navigation coordinates, then a system could be expected in the future whereby the pilot would instruct his aircraft to make a standard rate turn to heading 180. (Jack A. Adams)

THE SPIRIT OF NEGOTIATION RUNS HIGH IN DENMARK

Not belonging to a trade union in Denmark must produce a feeling of being alone because almost everybody belongs to one. Even the armed forces are organized, and have been organized for much longer than most would believe. The concern about trade unions in the US Armed Forces is recent, but Danish military have had the right of negotiation since 1919, and have had an official union since 1921 (the Chief of Defence, Denmark's highest military man, is a member of the officers' union). With the exception of conscripts (Denmark has retained the draft), enlisted personnel have had the right of negotiation since 1953. The conscripts have not been forgotten, however. In 1967 the Danish Parliament passed the Co-operation Act which required command personnel to establish negotiation and grievance procedures for conscripts. A visit to the Social Psychology Division of the Military Psychology Institute, Copenhagen, finds one hearing that all of this is a good thing, that it is ingrained in Danish life, that the Danish people want and expect it, and that it reduces group tension and conflict. The Military Psychology Institute houses all of the psychologists in the Danish Armed Forces. In addition to Social Psychology, it has divisions concerned with personnel selection and classification,

and statistics. Major P.E.O. Sucksdorff heads the Social Psychology Division.

An attitude questionnaire ordinarily asks what one thinks about a topic, with nothing to do with negotiation, but not so in Denmark. Each year the Social Psychology Division administers an attitude questionnaire throughout the armed forces. Last year they gave it to 20,000 personnel in 400 units, which is about 50% of the units in the armed forces. The main part of the questionnaire has items that fall into four main categories: attitude toward the job, relations with the members in your working group, relationship to superiors, and management and control. The results of the survey provide useful information about personnel opinions, and this is where the usual attitude survey ends. In Denmark, however, the survey results are fed back to unit commanders who are strongly urged to discuss them with the personnel of their command. In the discussion a commander hears negative attitudes and the conditions that cause them, and certainly he is urged to do something about them. Of course, there are problems that a unit commander can do nothing about, like salary, but there are local problems that can be brought to his attention about which he can do something. An attitude questionnaire measures opinion in its usual applications, but here it is used to change attitude as well. It is as if a thermometer could both measure temperature and change it.

As one of his specialties, S. Borup-Nielson, a colleague of Sucksdorff, deals with the subject of trade unions in the armed forces, and he strongly endorses them as a mechanism of negotiation. The strongest recurrent theme in the contemporary debate over trade unions in the US Armed Forces is that unions may use their power of strike in wartime, interfere with discipline and command decision, and generally undermine unit effectiveness. Borup-Nielsen does not take this criticism seriously. He believes that firm discipline in training may transfer very little to actual combat. Military units can become informal under combat conditions in which individual and group survival are involved, with little semblance of garrison discipline, and yet can fight very well. The enormous pressures of survival can drive a unit to fight very effectively, he believes. Put another way, survival pressures guarantee the discipline. Borup-Nielsen also pointed out that we have unionized forces in society where superiors are required to order their subordinates into very dangerous situations, and yet there is no breakdown of discipline, no failure of mission. These forces are called police and firemen.

The debate about unions in the armed forces has generated more argument than research, although there has been some assessment of the attitudes of military personnel toward trade unions. The thrust of the discussion with Borup-Nielsen was that we need more incisive research. It would be useful to study the behavior of unionized police and firemen under stress. We could ask how a unit fights. What are the attitudes during combat when individual and unit survival are at stake? Would union action enter anyone's mind? A search could be made of military history for incidents in which personnel resisted commands of their superiors under combat conditions. What were the causes of such incidents? How would the presence of a trade union have affected them? Research topics like these are different from the conventional attitude survey, and potentially more fruitful, it would seem.
(Jack A. Adams)

OUR BABEL OF TONGUES

The NATO Conference on Language and Communication, held in Venice 26 September to 1 October 1977 under the stewardship of H.W. Sinaiko (The Smithsonian Institution, Washington, DC) and D. Gerver (Univ. of Stirling, UK), could have been about many things, given the conference title, but actually it was about simultaneous conference interpretation. The conferees were mostly conference interpreters and research psychologists, with a sprinkling of linguists and sociologists.

We are all familiar with simultaneous interpretation from listening to sessions of the United Nations, which is transposition from one language to another at the moment of speaking. Simultaneous interpretation is distinguished from consecutive interpretation where an interpretation of the speech is given after the speech is completed,

and from translation where the transposition is from a written text in one language to a written version in another. The origins of interpretation lie in antiquity. Christopher Columbus brought American Indians back to Spain so that they could learn Spanish and serve as interpreters. As recently as World War I all international conferences in the West were held in French, but the British and the Americans were weak in the language and so the profession of conference interpreting was begun. Today the profession is organized into the International Associaton of Conference Interpreters, headquartered in Geneva, with 1500 members. The Association has a trade union quality, setting as it does the standards for its members, working conditions, and wage rates. The Association members refer to their skills as A Language, B Language, and C Language (no reference was made to language competence beyond C). The A language is as with the mother tongue, and it is rare to have two A languages. The B language is very good and will serve professional ends, and the C language will do in a pinch.

Originally, skilled interpreters were usually born, not made, as a diplomat's child raised in two linguistic communities, but now it is common for interpreters to have attended an interpreters' school. Some schools are institutes that train only in interpretation, but a few universities have an interpretation curriculum that, along with the usual general education requirements, leads to a university degree. The interpreters at the Conference emphasized the importance of general education, not only about the culture of a language which helps in grasping the nuances of expression, but in technical topics like politics, economics, and the physical sciences which are so often the topics of international conferences. An unavoidable impression of this meeting was the enormously high language skills of professional interpreters. Most language majors of universities in the US and the UK, and who hold degrees, cannot qualify for entry into interpretation schools. Because the skill demands are so high, the International Association of Conference Interpreters is an exclusive club whose members are good and know that they are good, like a society of Olympic gold-medal winners would be.

On examining the program and the credentials of the conferees, a naive outsider might decide that the interpreters had problems with their skills and had gotten together with psychologists whose research on language might help them. Not so. Interpreters are a self-confident lot who do not readily admit to problems, and so they were not the motivators of the Conference. What appears to have happened is that Sinaiko and Gerver, on the basis of their knowledge of interpretation and research on it, saw that problems do indeed exist, and that the application of psychological knowledge and research methods could ease the problems and smooth our passage through this babeling world. The research psychologists who were brought in were a solid but mixed group. All had an interest in language and most had done research on it, but interest and research on language is not the same as interest in simultaneous interpretation and research on it (research on simultaneous interpretation is a very small proportion of all research on language). The interpreters and the psychologists could hardly have differed more, but within a few hours they were communicating, and within a few sessions some of the interpreters had admitted to problems, particularly in the areas of workload and stress, and the psychologists had learned a great deal about simultaneous interpretation. By the end of the Conference there was some agreement that a mutually beneficial meeting had taken place, and that the foundation for future meetings, collaboration, and research had been laid.

H.M. Parsons (Institute for Behavioral Research, Silver Spring, MD), who is an engineering psychologist of wide experience, observed that the Conference was similar to the initial meetings in the late 1940s and early 1950s between engineers and engineering psychologists on problems of human factors in cockpit design. The engineers, as experts on machines, were only dimly aware of human factors, and they had little idea of what psychologists could contribute. Similarly, psychologists were only slightly aware of engineering problems. Progress began when skilled organizers, with better perception than either group had, brought the two sides together and started them talking to each other. Today our cockpits are showing the benefits of those negotiations.

It was evident from the Conference papers that psychological research

has little to offer interpreters at this moment in history, primarily because the behavioral complexities of simultaneous interpreting are in a region where few psychologists have dared to go (Gerver is one of the few exceptions). Psychological research on language has been motivated by interests in learning, memory, and perception, and it has built up our knowledge of these processes with investigations on syllables and words, and more recently on sentences and paragraphs. For whatever research progress that psychologists have made, their experiments in relatively simple laboratory situations have little power of inductive generalization to the complex behavior that is simultaneous interpretation. Even psychological research on bilingualism, which seems relevant, is only marginally pertinent because the subjects are usually several orders of language skill below that of professional interpreters. In addition to very high skill, an interpreter's professional behavior is characterized by the extraction of meaning in transposing from one language into another, not rote transposition (the correct translation of "*Ich habe das buch gelesen*" is not "I have the book read"), the anticipation of what will be said on the basis of what has been said and on the general intent of the speaker, and performance under heavy workload and time-stress in a situation that is intolerant of error. Psychological research on language has little to say about such matters.

What is the strategy that research psychologists should follow if they are to bear on the problems of simultaneous interpreting? They could urge patience and say that relevant knowledge will appear in the decades to come, which is true, but this is an impatient world in which we live, and in the future we will all be dead. Is there anything that psychologists can do to provide help soon? An affirmative answer lies in the human factors research reported by Parsons; it was an applied psychological research study indicative of a valuable direction to go. He examined the equipment and working conditions of simultaneous interpreters at the United Nations Headquarters, and he interviewed them and had them fill out questionnaires about their work and their problems. In a short time he came up with a number of recommendations, some of which are being implemented. The philosophy of Parson's research is to examine variables and study problems at the level of the complex phenomenon itself rather than study basic constituent processes as laboratory scientists do (but, of course, taking cognizance of basic knowledge as it is uncovered).

Simulation can be a sophisticated form of applied science, and Parsons hopes to simulate the interpreter's work situation. Realistic simulation would be easy, relying as it would on interpreters' booths, tapes of speakers, and equipment for recording the performances of interpreters. As for basic psychological research, it might well take a greater interest in the behavioral characteristics of interpreters that were mentioned above. And, it might profitably shift away from emphasis on oral language and work toward an understanding how we go from one code to another, whatever the code may be. The interpreter goes from one code to another as he goes from one language to another, as does the telegrapher when he goes from printed text to finger movement, the musician when he goes from musical notes to the intricate movements that is his performance, and the deaf person who uses sign language. Fascinating presentations on sign language and interpreting for the deaf by H.L. Lane (Northeastern Univ., Boston, MA), R.L. Dominque (Gallaudet College, Washington, DC), R.D. Tweney (Bowling Green State Univ., Bowling Green, VA), R.L. Ingram (Brown Univ., Providence, RI), and L. Ingram (New York Univ.), underscored that the earmouth route may be a common human communication channel but hardly the only one. (Jack A. Adams)

ONRL REPORTS

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SPACE TECHNOLOGY

USING SPACE—TODAY AND TOMORROW

XXVIIIth Congress of the International Astronautical Federation

The International Astronautical Federation (IAF) is a nongovernmental association of national societies and institutions with the aims of fostering the development of astronautics for peaceful purposes, encouraging the widespread dissemination of technical information, stimulating public interest in space flight through the major media of mass communication, encouraging astronautical research, and conducting congresses and scientific meetings with other organizations in all aspects of natural, engineering, and social sciences related to astronautics and the peaceful uses of outer space. It is these goals which make the IAF a truly international organization of societies representing 35 nations of both the Western and Eastern world.

The Federation organizes an International Astronautical Congress every year in a different country with the XXVIIIth Congress being held in Prague, Czechoslovakia from 24 September through 1 October 1977. The main theme selected for the Congress this year was "The Utilization of Space—Today and Tomorrow." This was approached from three main angles: scientific, technological, and biological. In addition to the main theme more classical subjects were treated including application satellites, astrodynamics, space medicine, and communication with "extraterrestrial intelligence." Several papers of interest to the general public on an international basis concerning the INTELSAT (International Telecommunications Satellite Consortium) system, the INTERSPUTNIK system, and Spacelab were presented plus a paper by an American astronaut and one by a Russian cosmonaut on their space flight experiences.

The Czechoslovak Academy of Sciences and its Commission on Astronautics were the hosts for the Congress. As is customary, the opening session was addressed by the head of the host country's government, in this case his representative the Deputy Prime Minister of Czechoslovakia. This was followed by addresses by the President of the Czechoslovakia Academy of Sciences and the Chief of the Outer Space Affairs Division of the United Nations. These addresses pointed out two significant facts: one that the Congress was held during the period of the 20th anniversary of the launching of the first earth satellite, Sputnik I; and second, that in attendance was the famous British scientific writer A.C. Clarke who, as early as 1945, first proposed the concept of the geostationary communications satellite system which today is probably the most universally successful application of outer space.

Before delving into some of the more poignant details of the Congress it seems significant to mention some of the scientific endeavors of Czechoslovakia in the area of space science. The development of astronomy has a history of over 600 years in Czechoslovakia and many non-Czech scientists such as Kepler, Doppler, and Einstein carried out research here. The detailed history of Czech astronomy over this period is beyond the scope of this article, but the evidence of its current status is exemplified by the work of the Astronomical Institute of the Czechoslovak Academy of Sciences and its Ondrejov observatory located 40 km southeast of Prague. The ongoing research at the Astronomical Institute includes: solar-system dynamics research, research of interplanetary matter, solar research, space research and stellar astronomy, and astrophysics. The director of the Institute is Vaclav Bumba.

The solar-system dynamics research is directed mainly toward the investigation of the dynamics of the Sun-Earth-Moon system, motions of artificial earth satellites, and determination of the earth's polar motion. Research of interplanetary matter is concentrated on meteor, meteorites, and micrometeorites. Photographic cameras in the Ondrejov and Prcice centers are used to study meteors and much original research has been carried out in this field. In the area of solar research, focus is placed on studying both the physical substance of all processes on the sun and solar effects on the earth and the upper atmosphere. Studies of the interaction of active zones of the sun and their magnetic fields are of particular interest with efforts concentrated on forecasting solar

activity. A wide range of sophisticated equipment is employed to this end. In the general area of space research, the Astronomical Institute has provided instrumentation on many Interkosmos satellites. These instruments have been designed to measure solar x-rays, cosmic rays, charged particles, and aerosol layers in the upper atmosphere. In the stellar astronomy and astrophysics area, close binaries, stellar atmospheres, star clusters, planetary nebulae and galactic structure, and dynamics are studied. The main instrument of the Stellar Department is a parabolic reflector telescope with a 2-m prime mirror, incorporating Cassegrain and coudé foci, each of which is attached to a spectrograph.

The Czech scientific community and government are justly proud of the advanced degree of space science being carried out in Czechoslovakia with scientists and engineers actively participating in the International Astronomical Union, the Commission on Space Research (COSPAR), the IAF, and Interkosmos. The trend in space science appears to favor a permanent organization which will continue to enjoy a high level of government support.

The Congress was opened in the Old Congress Hall which by no means gave any credence to the term "old" as the facilities were definitely modern with respect to facilities' decor, size, and comfort. The multiple sessions were held at the Congress hotel in some six different rooms. Over 300 papers were presented and the attendees numbered over 800. The Czech people are of an extremely friendly nature, particularly to visitors, and are very proud of their culture and heritage. The willingness of the hotel and Congress staffs to accommodate the participants' needs made the Congress an administrative success. The Congress was also a technical success in every way as evidenced by the large participation of attendees from 35 nations and six continents. The technical quality of the papers was exceptionally high and many opportunities were available for private conversations among participants, particularly at the receptions given by the Czechoslovakian Government via the Academy of Sciences and the various embassies.

Certainly among the best-attended sessions were those on communications satellites. In the initial session on this subject papers were presented on the INTELSAT System by S. Astrain, Director General of INTELSAT, the European Communications Satellite System by R. Gibson, Director General of ESA (European Space Agency) and the INTERSPUTNIK System by J. Krupin, its Director General. INTELSAT is the International Telecommunications Consortium consisting of 99 member nations which through a Board of Governors and a Director General is responsible for the implementation and operation of the space segment of an international satellite-communications system. INTERSPUTNIK is the International Organization of Space Communications consisting of 9 member nations which, as will be described later, is responsible for the implementation and operation of a different international satellite-communications system. This organization was initiated by the Soviet Union whereas INTELSAT was initiated by the United States.

The INTELSAT System had its operational beginning in 1965 with the launch of Early Bird (INTELSAT I). This geostationary satellite had an on-orbit mass of 38 kg, a primary power system of 40 W, a capacity to carry 240 telephone circuits, a design lifetime of 1.5 years, and a cost per telephone circuit of $32,500 per year. The fourth-generation INTELSAT satellite became operational in 1971 with the launch of INTELSAT IV. This spacecraft (geostationary, as are all INTELSAT satellites) has an on-orbit mass of 700 kg, a primary power system of 400 W, a capacity to carry 4000 telephone circuits, a design lifetime of 7 years, and a cost per circuit of $1200 per year. The INTELSAT earth terminals have until recently been large and expensive, utilizing 30-m diam. antennas and costing over $5.0 million. Three satellites provide global coverage with the cost of the satellites and their spares being borne by the 99-member INTELSAT Consortium (which now includes the People's Republic of China). The cost of the 140 earth terminals is borne by either the nations on whose territory they reside or the group of nations that share a common terminal. The system has proved to be an efficient means of providing economical worldwide telephone, television, and data services. The current system has an end-to-end reliability of over 99.9%.

The philosophy behind the utilization of large earth stations by the

INTELSAT System was to obtain the most beneficial utilization of the limited power and bandwidth of early satellites. With the introduction of the INTELSAT V satellite, smaller earth stations of the 10-m diam. antenna variety will be introduced into the system resulting in a considerable savings in individual earth-station cost. This will be possible due to the utilization of higher microwave-frequency bands, permitting a tripling of the prime power of the satellite. The cost per telephone circuit per year is expected to be reduced to about $800.

The paper presented on INTERSPUTNIK is probably one of the most comprehensive summaries available to date on this Soviet-instituted system. Although much technical detail was lacking, there was a wealth of information on the operational philosophy of the system, the INTERSPUTNIK Organization and the methods by which the Soviets are attempting to improve the system. In addition to the formal paper, a very attractive public-relations brochure was also provided to those interested. The brochure is written in both Russian and English, and pictures of earth terminals and satellites are vividly depicted. A later paper by a member of the Czechoslovakian delegation provided an insight on obtaining cooperation between different satellite communications. The classic example of such a situation is, of course, the Washington-Moscow "hotline," which incorporates both the INTELSAT and INTERSPUTNIK satellites and earth terminals.

INTERSPUTNIK was officially instituted and registered with the United Nations in June 1972 on the initiative of the Soviet Union with the expressed purpose of "strengthening and developing the economic, cultural and other relations of the socialist countries of Bulgaria, Hungary, the German Democratic Republic, Cuba, Mongolia, Poland, Rumania, Czechoslovakia, and the Soviet Union via artificial satellite communications." As with the INTELSAT organization, any nation which conforms to its rules and regulations may join INTERSPUTNIK. Inasmuch as INTERSPUTNIK coordinates its activities with the International Telecommunications Union (ITU) and actively cooperates with other international organizations (the Soviet Union utilizes the INTELSAT system on occasion for purposes other than the "hotline") whose activities are related to communications satellites, INTERSPUTNIK "can be available to users other than the aforementioned countries." INTERSPUTNIK is governed by a Council composed of representatives of the socialist countries with each country having one vote. The Council elects a Director General and approves the structure and staff of the Director General. The Office of the Director General is responsible for implementing the decisions taken by the Council. The Council considers such matters as specifications for earth stations, allocation of frequency channels, adoption of plans for the use of the space segment, and fixation of rates to be charged for various services. There are many similarities among the INTERSPUTNIK Council and the INTELSAT Board of Governors, the notable exception being the "one-country-one-vote" policy that is not followed by INTELSAT. INTELSAT basically follows the policy of voting power based upon usage of, and therefore contribution to, the financial support of the space segment. As with the staff of the INTELSAT Director General, the INTERSPUTNIK Director General's staff is selected from member nations with due regard to their techical qualifications and equitable geographical representation.

The INTERSPUTNIK system comprises a space segment which is owned by the organization (or in some cases leased by it) and an earth segment in which the earth stations are the property of the countries building them. The stations are brought on the air after they have been proven to meet the technical specifications of the Council. The INTERSPUTNIK system employs high-power satellites which permit the earth stations to operate with relatively small 12-m antennas. This of course results in reduced costs for the ground segment and higher costs for the space segment. The stated intention for such a policy is to allow the Soviets to bear the initial high start-up costs of the space segment while permitting the less affluent member countries to invest in the earth terminals that they are better able to afford. The Soviets will recoupe some (and they hope all) of their space-segment investment through the tariffs they levy for its use. It is hoped that eventually the economics will become more equitable for all members, particularly if the INTELSAT and INTERSPUTNIK systems

operate together in some fashion. The current tariff for a one-way telephone channel is 1250 gold francs per month. (Using the gold franc referred to, this is equivalent to about $1000/channel/month at the current market price of gold.)

The current space segment consists of the "Molniya 3"-type satellites in highly elliptical orbits and the "Statsionar" geostationary satellites over the Atlantic and Indian Ocean regions. This permits global coverage, especially of the high latitudes needed for the northern regions of the Soviet Union. However, the elliptical satellites impose the requirements of tracking and handover of traffic, a condition which has intentionally not been required for the INTELSAT earth stations.

The Russian paper also outlined R&D efforts currently underway to increase the capacity of the system through the implementation of low-noise temperature receivers in the earth stations; the development of wideband low-noise amplifiers; the improvement of antenna and waveguide systems, transmitters and receivers; and channelization of equipment. Higher-power and wider-bandwidth transponders on the satellites are also under development.

The Russian paper is summarized with the observation that "the satellite communications which in recent times have played an auxiliary role in spacecraft flights, is presently an independent operation in the Soviet Union and holds an important place in the ever-increasing exchange of information between the peoples of the world." This is evident in the Soviet's determination to maximize the use of the INTERSPUTNIK system to provide complete and comprehensive coverage of the 1980 Olympic games.

In his paper on the European communications-satellite system the Director General of ESA outlined the progress on the OTS, CTS, ECS, MAROTS, and AEROSAT programs. The OTS (Orbital Test Satellite) was developed by ESA to test the concept of a European designed and built platform and payload for general communications of telephony, television, and data via a geostationary satellite. Unfortunately, the launch of the first OTS had to be aborted when the Delta launch vehicle malfunctioned. A second launch is scheduled for 1978. The CTS (Canadian Communications Technology Satellite) was designed to test the concept of utilizing a very high-power communications satellite with small earth terminals. ESA provided equipment in the communications package and for the solar arrays for this satellite which was successfully launched in January 1976. ECS (European Communications Satellite) is still in the study phase and would result in the development of a European "domestic" communications-satellite system in the 1980s. MAROTS is being designed and built to test the concept of a European maritime communications satellite for possible incorporation into the international satellite-communications system (INMARSAT). The decision was taken at the time of the Congress by ESA in Paris to utilize the 6/4-GHz frequency bands for the communications system. With regard to the AEROSAT program, which was a joint US-ESA-Canadian program for aeronautical communications, very little could be reported as the program is either dead or in a state of permanent suspended animation depending upon with whom you talk.

Mr. R. Gibson (Director General of ESA) very benevolently concluded his talk by forgiving the Americans for delaying their communications-satellite program by aborting the OTS launch and promised to continue the program with vigor.

A final paper worth mentioning was presented during one of the sessions on Rescue and Safety. I am partial to it for two reasons: First, it is a demonstration of one of the humanitarian uses of communications satellites and very small, easily portable earth terminals; and secondly, I developed the concept while at Comsat Laboratories. The paper, by N. Helm (Comsat Labs.) entitled "Disaster Communications Via Satellite," describes a highly portable earth terminal, for use with the high-powered CTS satellite. The terminal is capable of being made available to disaster areas originating from floods, hurricanes, earthquakes, fires, and other natural disasters. The terminal is of such a compact nature that it can be delivered by small aircraft, motor launch, station wagon, or parachute. It can be assembled by one technician in a matter of hours. The system has been tested with the cooperation of the Canadian government, NASA, the Red Cross and many local police and fire authorities.

The entire transmit/receive station, less its prime power supply, weighs

only 65 kg in its current configuration. It utilizes a 1.2-m reflector antenna with Cassegrain feed and a 20-W traveling-wave-tube amplifier as the final transmitter. The receiver consists of a low-noise (noise temperature 275 K parametic amplifier. The transmitter and receiver, mounted directly behind the antenna reflector, sit atop a lightweight metal tripod with a base that allows full movement in azimuth and elevation to allow easy aquisition of the satellite. Since the successful demonstration of the terminal, many modifications have been made to upgrade its performance without sacrificing its mobility. The initial terminal could handle 5 two-way voice channels while the upgraded model can carry a nearly full-quality color video and associated voice channel.

The Congress was closed with an award banquet at which Professor L. Fedov of the USSR received the coveted Guggenheim award for his work in the field of space relativity. Because of the very large attendance by many prominent scientists and engineers from all fields of space science and technology and the high quality of papers presented in these fields, this Congress was one of the most successful ever attended by this writer. The realization that so much effort is being devoted to space research and development, even by institutions and nations of meager resources, is a tribute to the role the space age continues to play in the advancement of man's scientific and technological advancement. (Robert W. Rostron)

NEWS & NOTES

A FIRST FOR BRITAIN

The world's largest commercially available anechoic chamber for electromagnetic measurements, built and developed by Plessey, Ltd. for the Hawker-Siddeley Dynamics Division of the newly formed British Aerospace Corporation, has been completed at a cost of over $1.3 million. The chamber is designed for a variety of measurement techniques in the radio-frequency range of 100 MHz to 15 GHz. A total of 14 tons of profiled pyramids of microwave-absorbent impregnated polyurethane foam is used to line the 975-m^3 chamber. It has a quiet zone measuring 3 × 3 × 3 m with a reflectivity performance of -15 dB at 100 MHz rising to -50 dB at 15 GHz. With reduced quiet-zone requirements, reflectivity performance improves considerably as expected.

The chamber has already been utilized to test the engineering model of the OTS (Orbital Test Satellite) communications satellite (which failed to achieve orbit in September because of a failure of the Delta launch vehicle) and is currently being used to test the MAROTS maritime communications satellite to be launched next year. Both satellites are being developed under the direction of the ESA (European Space Agency). When not being used by Hawker-Siddeley Dynamics, the chamber will be available for lease to organizations carrying out microwave-development work. (R.W. Rostron)

UPDATE ON ORACLE

Since 1 October the British Independent Television's teletext system, Oracle (*ESN* 31-2:72), has been fully updated seven days a week between 09:30 and 22:30. This is an extension of the previous service with its Monday to Friday 09:30 to 18:00 updates. The system, said to be the most advanced in the world, is being watched with interest throughout the world and in particular in Germany, Sweden, and the Low Countries.

The service is operating currently with 350 pages of information with an average 40-sec waiting time. It can be extended to 800 pages, but the worst case waiting time will then be some 3 minutes—this is not considered to be generally acceptable. Improvements on these times can be achieved by the use of more than the 2 lines/field in use at present. The service, which can be viewed anywhere throughout the country by any viewer possessing a TV receiver equipped with a decoder, is already being seen in between 2,000 and 3,000 homes. According to the British Radio Equipment Manufacturers Association there will be 12,000 sets available by the end of

year, with 50,000 and 250,000 projected for 1978 and 1979, respectively, in addition to "Add-on" units.

In the long term, a number of extensions to the service are feasible, a national air-call being the most striking as the signals could be received virtually anywhere in the country on pocket receivers incorporating decoders to provide selective calling.
(N.M. Blachman)

NUFFIELD FOUNDATION TO FUND MORE RESEARCH

According to its latest annual report, the Nuffield Foundation has decided to spend more of its income on research that would normally be supported by the four Research Councils of Great Britain. The Foundation was founded in 1943 by Lord Nuffield (William Richard Morris), the head of the Morris car dynasty and the "Henry Ford" of the UK, for the advancement of health; the prevention and relief of sickness, particularly by medical research and teaching; for the advancement of social well-being, particularly by scientific research; for the care of the aged and for the advancement of education.

In the past, the Nuffield Foundation has only supported projects that fell between the Research Councils' spheres of operation or had been turned down for reasons the Foundation thought unjustified. Its new policy will help counteract the danger that "...the sheer abruptness with which some of the research councils are being required to reduce their expenditures in real terms will mean that research of acknowledged worth is brought to an untimely end, or that young men and women who would in normal circumstances be embarking on distinguished careers in research are now prevented from doing so for lack of support." The report says, "The Foundation expects that the flexibility which it enjoys may be especially important during the years immediately ahead. The trustees therefore wish it to be known that they welcome, now, as always, applications for funds to support outstanding research in science and medicine even though the research councils may often seem the most obvious recipients."

JET SITED

As long ago as September 1975 (*ESN* 29-9:388), we first published an article on the European Economic Community's thermonuclear fusion project, the Joint European Torus (JET). Those of our readers who may have missed the announcement on 26 October might like to know that the choice of location for this project has finally been made. After nearly two years of dispute, the EEC's research ministers have agreed to site the project at the UKAEA's Culham Laboratory in Oxfordshire. Latest estimates of the project's cost over the next five years amount to $180 million, of which Britain, as the host country, will contribute 25%—the largest share—while the remainder will be shared among the other eight EEC members. The ministers also agreed that should JET be eventually followed by JET 2, sites in every EEC country except Britain will be considered.

PERSONAL

Dr. L. Stuart Bark and Dr. Evan Wyn-Jones, Readers in the Department of Chemistry and Applied Chemistry at the Unif. of Salford, have been promoted to professorships.

Dr. G.T. Best, Senior Research Associate at the Centre for Atmospheric Research, Univ. of Lowell, MA, has been appointed to the Chair in Physics at the new University of Ulster.

Dr. N. Crawford, Reader in Biochemistry at the Univ. of Birmingham, has been appointed to the Cotton Chair of Biochemistry at the Institute of Basic Medical Sciences, Univ. of London, as of 1 January 1978.

Professor John Barry Dawson, Professor of Geology at the Univ. of St. Andrews, has been appointed to the Chair of Geology at the Univ. of Sheffield.

Dr. A.T. Diplock, Reader in Biochemistry at the Royal Free Hospital School of Medicine, has been appointed to the Chair of Biochemistry at Guy's Hospital Medical School from 1 January 1978.

Mr. J. King, Lecturer in the Department of Naval Architecture, Univ. of Newcastle upon Tyne, has been appointed Professor in the Department of Maritime Studies at the University of Wales Institute of Science and Technology (UWIST), Cardiff.

Professor C.W. Rees, Heath Harrison Professor of Organic Chemistry at the Univ. of Liverpool, has been appointed to the Hofmann Chair of Organic Chemistry at Imperial College, Univ. of London.

Lord Todd, the first Chancellor of the Univ. of Strathclyde and Professor of Organic Chemistry at the Univ. of Cambridge from 1944 to 1971, has been made a member of the Order of Merit. Membership in the Order is limited to twenty-four. Since 1975, he has been President of the Royal Society.

Dr. A.F. Williams has been appointed Director of the Medical Research Council's Cellular Immunology Unit at the Sir William Dunn School of Pathology, Oxford, in succession to Dr. J.L. Gowans.

Dr. R. Williams, Lecturer in Chemistry at the Univ. of St. Andrews, has been appointed Head and Professor of the Department of Chemistry at UWIST, Cardiff.

Professor Eric Wilson, who previously held a personal professorship in Hydraulic Engineering in the Department of Civil Engineering at the Univ. of Salford, has been promoted to the Chair.

ONRL REPORTS

R-9-77

LIAISON TECHNOLOGIST PROGRAM: OCEAN FACILITIES ENGINEERING
by R.N. Cordy

This report summarizes the findings of a review of ocean-facilities engineering technology in Europe. Principal investigation areas included cable/pipeline burial and trenching, undersea work systems, underwater inspection and nondestructive testing, geotechnical properties of seafloor materials, seawater hydraulic-power transmission and diver electrical safety. The investigation which this report summarizes was conducted during May, June, and July 1977. Of particular interest to readers from Naval Laboratories will be the Appendix to this report which describes the Liaison Technologist Program under which this investigation was performed. The Appendix also describes the investigation techniques and concepts on the benefits of the Program. For more detailed technical information the reader is encouraged to contact the writer at the Naval Civil Engineering Laboratory, Port Hueneme, California 93043.

R-10-77

RESEARCH IN FRANCE by A. Barcilon

This report reviews some of the mechanisms of research support in France as well as the major organizations dealing with research. It also provides a glimpse at the mood of French scientists in the face of shrinking research budgets.

C-7-77

HYDROGEN-IN-METALS CONFERENCE, PARIS, JUNE 1977
by W.N. Cathey

The Second International Congress on Hydrogen in Metals was held in Paris, 6-10 June 1977. This report presents a review of a few important papers. Most of the papers were related to applied problems. In particular, problems of H-related damage to engineering alloys were treated extensively. In addition to work on H in pure metals such as Pd, Nb, and other transition metals, some work was also reported on H in alloys such as Nb-Ti, Pd-Ag and various steels. Storage of H in intermetallic compounds such as $FeTiH_x$ or $LaNi_5H_x$ was of great interest because of their importance as energy converters.

C-10-77

SIXTH ANNUAL CONFERENCE OF THE INTERNATIONAL SOCIETY FOR EXPERIMENTAL HEMATOLOGY, BASEL, SWITZERLAND, 28-31 AUGUST 1977
by R.I. Walker

This report summarizes a meeting held in Basel, Switzerland (August 1977) in which over 300 scientists from Europe, United States, and several other countries interchanged current information regarding clinical and laboratory experience in hematology. The presentations concerned regulatory mechanisms behind cell proliferation and functional aspects of matured cells. Applications of these basic science principles to treatment of hematologic disorders in human and animal models were described.

THIRD SYMPOSIUM ON NEUTRON DOSIMETRY IN BIOLOGY AND MEDICINE, 1977 by L.S. August

The major topics discussed at the Symposium are summarized, including depth-dose studies, dosimetry and monitoring, sources and facilities, spectrometry, radiation-quality studies, ionization chambers, solid-state detectors, novel dosimetry systems, and dosimetry intercomparisons. Post-symposium visits to two UK neutron cancer-therapy centers are also briefly discussed.

OPTICAL FIBERS, INTEGRATED OPTICS, AND THEIR MILITARY APPLICATIONS, LONDON, ENGLAND, 16-20 MAY 1977 by V.N. Smiley

A review is given of some of the papers presented at a Conference which was held in London, 16-20 May 1977. Emphasis is placed on past, present, and future devices for military applications. The review is organized in the same manner as the Conference format under the subtitles: systems, integrated optics, propagation, sources and detectors, and couplers.

SEVENTH INTERNATIONAL CONFERENCE ON AMORPHOUS AND LIQUID SEMICONDUCTORS AT EDINBURGH by S.G. Bishop, T.L. Reinecke, U. Strom, P.C. Taylor, and C.C. Klick

A review is given of the Seventh International Conference on Amorphous and Liquid Semiconductors held in Edinburgh at the end of June 1977. Topics covered in the report include the nature of localized states in chalcogenide glasses, dispersive electronic transport, electronic conductivity at the $Si-SiO_2$ interface, amorphous Si and Ge, thermal and vibrational properties of amorphous solids, luminescence in oxide glasses, and disordered organic solids.

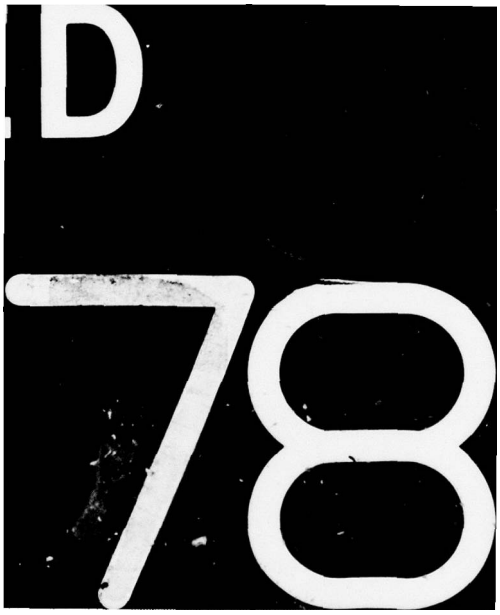
MICROWAVE MAGIC by J.B. Bateman

This is a report, with critical comment, of a meeting convened by a microwave research department within the French national research center for space and aeronautics in order to present the results of current French research on the biological effects of microwaves. The report proper is preceded by notes on the sponsoring organizations and by critical remarks on a series of papers describing the remarkable biological properties of the physically uncharacterized radiation emitted by an apparatus assembled by the inventor, A. Priore. The topics discussed ranged from specific effects of microwaves on microorganisms and on the vertebrate central nervous system, to discussions of microwave thermography and microwave heating in the diagnosis and treatment of cancer. The empirical approaches generally used deflected attention from any thorough-going attention to the vexed question of thermal versus non-thermal effects, although a useful distinction was drawn between the conditions under which non-thermal effects might be detectable and those under which such effects would be obscured by temperature changes.

C-15-77

ACOUSTIC DETECTION OF NEUTRINO INTERACTIONS IN THE OCEAN: THE 1977 DUMAND SUMMER WORKSHOP, MOSCOW, 26-28 JUNE 1977
by A. Roberts

This was the third in a series of Workshops to foster the collaboration of high-energy, cosmic-ray, and theoretical physicists, astrophysicists, astronomers, acousticians, computer scientists, geophysicists, oceanographers, ocean engineers, and other assorted enthusiasts, all captivated by the objective to use the ocean as a gigantic neutrino detector.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