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edited by Nicholas A. Bond, Jr. and Don J. Peters

31 October 1981

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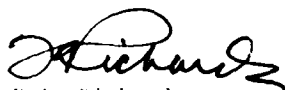
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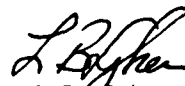
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BEHAVIORAL SCIENCES

AUDITORY WARNINGS IN AIRCRAFT: LOUDNESS AND MEMORY RESEARCH AT CAMBRIDGE

Pilots have complained that auditory alarms, such as takeoff warnings and fire bells, are too loud. In fact, an auditory alarm may be so loud that it is itself alarming; it may even distract the crew from everything else, except getting the noise shut off. There is a conservative engineering argument for very loud warnings, of course: when serious and potentially catastrophic events are occurring, the warning signal should certainly engage the attention of the flight crew. But the auditory warning area seemed to need systematic work on the setting of signal-power levels, on the composition of the alarm signals themselves, and on the learning and memory of these signals. At the MRC Applied Psychology Unit (APU), Cambridge, UK, Robert Milroy and Roy Patterson have been carrying out a research program on these issues under sponsorship of the UK Civil Aviation Authority.

Among the first tasks of the research was to establish a suitable power level for an auditory warning signal. When a test subject is presented with two noisy sounds, one of which has a signal embedded in it, his judgment of which sound contains the signal depends on many variables, with a most important one being how high the signal dB level is, above the background or threshold level. From such data, a "psychometric function" curve shows how the fraction of correct detections goes up as signal strength is increased relative to the threshold level. The shape of this curve is generally ogival. It turns out that, for ordinary noise and signal spectra of the aircraft domain, a signal is easy to detect when it is 5 dB above threshold. And when it is 15 dB above threshold, it is "hard to miss"; after that point, more signal power brings negligible improvement in detectability. This result argues that an auditory warning should be at least 15 dB above the threshold caused by ambient noise.

Patterson and Milroy further propose that making the signal-strength differential much more than 15 dB would be ineffective, annoying, and needlessly disruptive to normal communication on the flight deck. For such reasons, they suggest that warnings should be limited to about 25 dB above threshold, and so a good practical rule would be to provide a signal in the 15-to-25-dB range above threshold.

The next logical step was to determine typical flight noise conditions under various flight regimes, and this was done on the BAC 111, McDonnell-Douglas DC 10, and Boeing 707 and 727 aircraft. Five phases of flight were used: takeoff, steady climb, level flight, descent, and approach. The 727 and BAC 111 were the worst cases, so further analysis concentrated on these aircraft. Rather surprisingly, at least to this writer, the worst noise over the 1.0-to 5.0-KHz range in these aircraft occurs in the level flight regime at cruise speeds, where background levels on the order of 50 to 55 dB were observed (in these tail-engined aircraft, most of the noise comes from turbulence in the boundary air flowing over the nose).

From previous work at APU and elsewhere, Patterson and his associates had formulated a model of the human auditory filter; the model includes a function for the difference between the signal center frequency of the human filter and the "edge" of the masking noise. They also had a masking equation model for predicting effective signal power. The equation expresses the power of a signal at threshold as some constant, K , of the integral of the noise spectrum times the auditory filter. This formulation permitted the rather accurate prediction of threshold for any noisy environment that met the assumptions of the model. The output of all the modeling was a "design band," some 10 dB wide, and from 15 to 25 dB over threshold, which showed acceptable power levels of warning signals at various frequencies, for each aircraft. A plot of these "desirable" power levels, with the power levels of present alarm signals superimposed, was most informative. Such a display showed, for example, that present takeoff and undercarriage warnings on the Boeing 727 were about 20 dB too loud.

There are some other design factors that have to be considered in designing auditory warnings. With many middle-aged men on the flight crews, there may be significant high-frequency hearing losses in some crew members, and so alarm signals above 5 KHz are to be avoided. And there is no doubt that spectral specifications and consideration of harmonics and "warbles" can improve discriminability. Work from the US Navy Electronics Laboratory Center in the 1960s proved, for instance, that the harmonic pattern of a sound influenced the correct identification rate; also, experiments showed that confusion of signals was less likely if the signals differed on several dimensions (wave shape, number of formants, etc.), than if the signals differed on just one dimension. It was known, too, that sounds that could be referred to real "physical" sounds were better

learned; thus, the cognitive structuring performed by the observer on the sound stimulus can influence proficiency in discriminating and learning new signals.

Once the power-level problem was effectively solved, Patterson and Milroy went on to study the learning and retention of whole sets of auditory warnings. They used a set of 10 warnings now being employed in the four commercial aircraft mentioned previously; in fact, many of the signals were recorded in flight and then digitized and "cleaned up" for laboratory use. As an illustration of cleanup, the ground-proximity "chicken clucker" signal was constructed by taking one good cycle from the actual recording and then repeating that cycle over and over again. The whole experiment using 20 subjects was computer controlled, which facilitated the usual counterbalancing and data-taking problems.

Results were quite clear: during an initial training session of 45 min or less, subjects could learn to identify the 10 signals quite well. After learning the first six, though, the rate of learning of the remaining signals was discernibly slower. The material was retained well; a week later, the average number of correct identifications was about 7 out of the original 10, and it took only another 10 min or so of retraining to bring the performance up to near-perfect.

Errors made by the 20 observers were tabulated in a format with "true" signals listed in the left column and "called" signals listed across the top row. Inspecting this "confusion matrix" furnished a quick analysis of signal identifiability. The fire warning (ringing bell) was correctly identified 98% of the time; but the takeoff warning (intermittent horn) was correctly identified only 59% of the time, and it was often mixed up with disconnected autopilot and selective call sounds. The confusions were frequently "paired" or reciprocated; thus, takeoff was confused with disconnected autopilot, and disconnected autopilot was also frequently taken as the takeoff warning. Analysis of such pairings indicated that similar repetition rates can cause signal confusion, even though the spectral features are radically different. However, confusion between signals does not necessarily involve repetition rates: overspeed is frequently confused with ground proximity, but its rate is three times that of the ground-proximity sound. Milroy and Patterson believe that cognitive considerations may be involved here: both of these signals have little trains of pulses followed by a gap, and they are called "clacker" and "clucker," respectively.

But cognitive or perceptual cues that allegedly support discriminability do not always work well. The cabin pressure warning sound was a "train of bonks with a whirring swish"; the "swish" was presumably planned to give some realistic simulation of escaping air, yet 27% of these swish signals were wrongly identified.

The Cambridge research is methodologically satisfying; it is good to see that practical alarm signal design can involve a nice combination of theoretical, laboratory, and field work. And the engineering of auditory alarm systems can be related to psychophysics, which is one of the best developed fields of psychology, as well as to cognitive psychology, which is perhaps the hottest area at present. Indeed, it would be an interesting challenge to see if cognitive psychology can make any significant contributions to the practical display area. (Nicholas A. Bond, Jr.)

BIOLOGICAL SCIENCES

TRANSCUTANEOUS PAIN REDUCTION: TWO ITALIAN STUDIES

Judging from the Third World Congress on Pain (Edinburgh, 4-11 September 1981), drugs are still the preferred treatment for pain reduction. There are many other methods for dealing with pain, however, and one of the most popular is transcutaneous electrical stimulation (TES, TNS, or TENS). Say a patient has low back pain, with slight sciatic radiation. Two electrodes might be taped to the patient's skin over major nerve branches in the painful area. A constant-current stimulator then delivers square-wave electrical pulses via two electrodes at a frequency of about 50 Hz; the patient would adjust the current, and perhaps the pulsewidth, until a marked tingling was felt (usually <60 mA), or perhaps the current would be set to three times the patient's just-perceived threshold. "Mild but tolerable" pain is the idea. The electrical stimulation procedures are noninvasive, nonaddictive, and free of side effects and thus can be self-administered. The treatment might run for 10 to 30 min, and it might be given several times a day.

At the World Congress, many TES equipment manufacturers had booths. They gave free demonstrations of their stimulators, and although there were many variations in hardware and procedures, most systems consisted of a small portable package weighing less than 500 g. Many thousands of patients wear TES units

all the time. In addition to the "regular" application, some manufacturers recommend an "acupuncture-like TES"; in this type of stimulation, muscle contractions are desired, and so the electrodes are taped over large muscle groups that are innervated from the same spinal level as that receiving the pain signals. The frequencies tend to be low (~ 1 to 2 Hz) and the intensity enough (3 to 5 times threshold) to cause contractions.

At the Edinburgh Congress, two Italian research groups presented results of some TES trials on patients with low-back pain and on women during delivery. Drs. M. Maresca, P. Procacci, and M. Zoppi, from the Centro di Algologia (Pain Center) at the University of Florence, had a sample of 72 patients with low-back pain. There were seven different disease categories in the sample ranging from fibrositis (N=24) to cancer pain (N=4). In many patients "trigger points" were found; it was hypothesized that these myalgic spots might be especially effective in reduction of pain. All 72 patients had one 15-min stimulation each day for 10 days; the pulse width of the 50-Hz square waves was 1 ms.

Maresca's gross result was encouraging; 35 patients, nearly half of the sample, had long-lasting (≥ 2 months) relief. A breakdown of the sample according to denervation of peripheral nerve fibers and the presence of trigger points was instructive: of those 35 without denervation and with trigger points, 27 enjoyed long-term relief. Maresca believes that this is because the functional changes induced in the nervous system by TES are less effective when different fibers are damaged.

Another Italian study applied TES to 127 women in the maternity ward of the Cattedra II di Anestesia e Reanimazione in Milano; the investigators were L. Piva, G. Ambrosino, C. Nobili, R. Rossi, and A. Severgnini. Beginning at 5 cm of cervical dilatation, each woman adjusted the 50-Hz TES signal until moderate tingling was noticed. Electrode placements were varied systematically (T_{11} - L_1 , then S_2 - S_4 only; T_{11} - L_1 and S_2 - S_4 concomitantly, etc.) and patient pain response was recorded on a four-point scale (0=none, 1=fairly good, 2=good, 3=excellent). Percent decrease to Huskisson's test (also a four-level scale), (none, $\leq 50\%$, 50% to 70%, 70% to 100%), and a psychologist's four-point anxiety rating and "reaction to contraction" were also noted. Final scores could be from 0 to 12, with high relief counted as 10 to 12, medium relief from 7 to 9, and so forth.

TES was effective with 88, or about 69% of the women scored as receiving medium

to high relief. In no case did TES interfere with labor or with maternal blood pressure and heart rate; all infants had Apgar scores equal to or higher than 8, at both the 1st and 5th minute. All these indicators confirm noninvasive and non-interfering status of TES treatment.

There were no marked differences in TES effectiveness as a function of electrode placement, a finding confirmed by several Scandinavian investigators reporting at the congress. Since other results suggest that the experimental variation of pulse width and frequency can result in more pain reduction than intensity adjustment alone, the Milano experiment perhaps should be seen as a lower bound on what can be expected from application of TES in the maternity situation.

As results showing a 30 to 70% TES effectiveness rate accumulate, many workers now are attempting to extend the treatment and to get closer to the underlying mechanisms involved. Acupuncture-type TES can produce analgesia in something like an additional one-fourth of patients who do not respond to conventional TES, and acupuncture itself often has genuine pain-reducing effects somewhat like electrical stimulation. It is known that some conditions are extremely resistant to any pain-reducing regimen; psychogenic pain is one of these.

Prolonged analgesias after TES and acupuncture procedures are regularly observed; patients may go for months or even years without the recurrence of pain. At the Edinburgh Congress, Judith B. Walker and Ronald Katz (UCLA, USA) showed films of multiple-sclerosis and endometriosis patients who obtained near-total reduction in clonus and pain by means of subcutaneous electrical stimulation, with effects that lasted for up to 5 years. In their studies, 60 to 70 min of treatment often reduced clonic bounces in MS cases to zero. Other positive changes were noted: one patient who couldn't get out of bed without help was able after 6 months of regular electrical treatment to crawl alone, to walk 35 steps with assistance, and to perform a 30-lb leg press with a previously paralyzed leg. According to Walker and Katz, these effects cannot reasonably be attributed to placebo or psychological suggestion causes.

Much experimentation, and also much speculation, is being directed to the mechanisms that underlie the pain experience. Work with animals can be directed toward such phenomena as the irritability of the trigeminal sensory distribution, and can show the concentrations of agents needed to suppress irritability (a recent finding is that L-DOPA is effective in trigeminal

hyperesthesia in the rat.) In both laboratory animals and humans more information is being obtained on the thalamic and other pain codes, and more adequate neurophysiological explanations are now available for such phenomena as phantom limb pain, the painlessness of most brain surgery, and the fact that electrical stimulation of nociceptive neurons in the thalamus does not cause pain but actually abolishes existing pain. (Nicholas A. Bond, Jr.)

CHEMISTRY

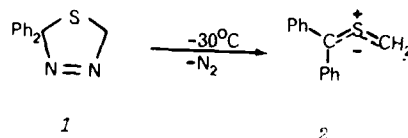
ORGANIC CHEMISTRY AT THE UNIVERSITY OF MUNICH

Munich, a city of 1,400,000, is on the banks of the Isar River, which flows from the Bavarian Alps on its way to the Danube. When the air is clear, the Alps, some 50 miles away, provide a stunning backdrop for one of the most interesting cities of Europe.

The Department of Organic Chemistry at the University of Munich is near the center of the city; my host was Prof. Klaus Gollnick, who has been a leader in the area of photo-oxygenation for several years. Gollnick, a student of Prof. Gunther Schenck, has contributed much to our present understanding of the mechanisms of singlet oxygen reactions with alkenes. His work in this field continues, and he is now investigating solvent effects on the reaction of singlet oxygen with alkyl-substituted olefins. Unexpectedly, he has observed approximately a 100-fold increase in the rate of reaction with substrates such as tetramethylethylene upon changing the solvent from an alkane to acetonitrile. The photo-oxygenation of dienes in the presence of azide ion is also under study. Schenck has observed the formation of three isomeric azido hydroperoxides in the reaction. It is of particular interest that these products are formed in the same ratio upon electrochemical oxidation of azide ion in a solution containing oxygen and the diene. Gollnick is considering several mechanisms for these unusual reactions, including the possible intermediacy of the as-yet-unknown hydroperoxyazide, N_3OOH .

The head of the Organic Chemistry Department is Prof. Rolf Huisgen, who has been professor of organic chemistry at the university since 1952. His classic studies on reaction mechanisms and their application to the development of new synthetic methods have won him many honors. Huisgen first published his

proposal of a concerted mechanism for 1,3-dipolar cycloadditions in 1960. His research in this area has made available many types of new heterocyclic compounds derived from 1,3-dipoles such as nitrile ylides, nitrile imines, azomethine ylides, and carbonyl ylides. Interest in these types of reactions has continued and a current investigation involves the addition of thiocarbonyls to diazoalkanes. Although this reaction was discovered by H. Staudinger in 1920 and A. Schönberg reported over 100 experiments with these substrates between 1930 and 1967, the mechanism of the reaction remained unresolved. In particular, the origin of products derived from 2 molecules of thioketone and 1 molecule of diazoalkane was not understood. Recent studies by Huisgen's co-workers, however, have provided definitive evidence for the intermediacy of thiocarbonyl ylides in these reactions. For example, the



addition of thiobenzophenone to diazomethane at -78°C yields 2,2-diphenyl-1,3,4-thiadiazoline 1, which subsequently loses N_2 upon warming to -30°C to form thiocarbonyl ylide 2. Huisgen has been able to effect 1,3-dipolar cycloaddition of this ylide to thiobenzophenone, thioxanthone, dimethyl acetylenedicarboxylate, maleic anhydride, tetracyanoethylene, and dimethyl azodicarboxylate. He indicated that similar experiments are in progress with other thiocarbonyl ylides.

Prof. Gerhard Binsch, who moved to Munich from the University of Notre Dame a few years ago, reviewed his current work on NMR spectroscopy. Binsch has been particularly interested in the use of dynamic nuclear magnetic resonance (DNMR) as a means of obtaining information about internal molecular motions of molecules, and about exchange phenomena. In collaboration with Dr. David S. Stephenson, Binsch recently developed a general iterative method for the automated analysis of high-resolution NMR spectra to obtain chemical shifts and isotropic coupling constants. The computer program, which has been given the acronym DAVINS (Direct Analysis of Very Intricate NMR Spectra), uses a least squares formalism and an algorithmic approach for the analysis. This program has been under development for 3 years, and Binsch and Stephenson are now involved in testing its performance on synthetic and experimental NMR spectra

of types that range from simple AX to complex ABCD. To date they have been able to analyze spin systems of up to 10 spins (1/2). Binsch informed me that they expect DAVINS or a later modification of it eventually to replace most, if not all, of the computer programs for NMR analysis currently in use. Therefore, they have developed what they refer to as calibration cases to be used by prospective users of DAVINS. Binsch described the results of analysis of four synthetic ABCD cases and 12 experimental (AB)₂C spectra of mono-substituted benzenes. Typically, an NMR spectrum is obtained on a 100-MHz spectrometer in either a CW or FT mode, with the experimental spectrum being recorded directly on a magnetic disk in digitized form. Subsequent analysis is carried out on a CDC CYBER 175 computer. Binsch explained that, for most calculations, only the frequency offset of the spectrum from a reference and the sweep width need to be supplied by the operator to the program. The program can truncate spectra, can remove unwanted peaks due to impurities, and can smooth the spectrum using a baseline-flattening algorithm. Binsch observed that for investigators who might not have the facilities to record the spectrum directly on a magnetic disk or tape, another option for analyzing the spectrum exists. Using that method, the spectrum is recorded in the "old-fashioned way" with line frequencies, intensities, and linewidth parameters serving as inputs to the program. From these data DAVINS generates a pseudoexperimental spectrum and proceeds with the analysis. Binsch pointed out, however, that the procedure defeats the purpose of the fully automated analytical procedure and also introduces an undesirable human bias. The first experiments by Binsch and Stephenson on their automated analysis for NMR spectra concentrated on spectra recorded in isotropic solution. They have now extended the technique to the analysis of NMR spectra of molecules that are partially oriented in liquid crystal solvents. The nematic-phase spectra are analyzed with a computer program called DANSOM, the anisotropic variant of DAVINS. Excellent results have been obtained from a study of the nematic-phase spectra of allyl fluoride, allyl chloride, and allyl bromide in N-(4-ethoxybenzylidene)-4'-n-butaniline. The analysis of these spectra provides information about the structure of molecules in solution and the dynamic processes of these molecules. Binsch indicated that the DAVINS program is being made available to other investigators through the Quantum Chemistry Program Exchange at Indiana University.

Prof. Günther Szeimes and his group are engaged in studies of the preparation and reaction properties of highly strained alkenes. They have been able to prepare a new C₁₀H₈ isomer, tricyclo[3.1.0.0^{2,6}]hex-1(6)-ene(3), which has the same carbon



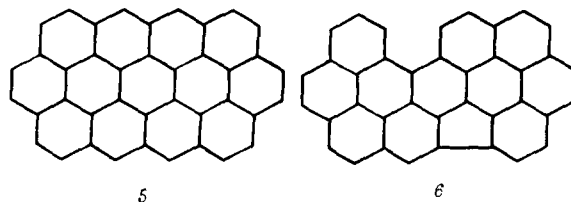
skeleton of benzvalene. The synthesis involves a dehydrohalogenation of 1-chloro-tricyclo[3.1.0.0^{2,6}]hexane at -20° in THF. This highly reactive olefin can be trapped by reaction with anthracene at -20° to afford the unusual propellane 4. X-ray analysis of 4 has shown an interesting structural feature of this molecule. The quaternary bridgehead carbons exhibit what has been called the "inverted tetrahedron phenomenon," in which these carbon atoms are located outside the tetrahedrons formed by their four respective substituents. As was expected, the bond length between the bridgehead carbons is remarkably long (1.54 Å). Another area in which Szeimes is interested concerns the stereoselectivity of the addition of free radicals to strained hydrocarbons. For example, his group has recently investigated the reaction of phenylthiyl radical with the central bond of tricyclo[4.1.0.0^{2,7}]heptane.

Dr. W. Schmidt and I discussed the work he has been doing recently with D. Biermann on the Diels-Alder reactivity of polycyclic aromatic hydrocarbons with maleic anhydride. Although this reaction was discovered over 50 years ago by Prof. E. Clar (Univ. of Glasgow), Schmidt informed me that no systematic kinetic study of the reaction had yet been made. Some of the polycyclic hydrocarbons that have been investigated have as many as 13 condensed benzene rings; they include examples from several classes of hydrocarbons: acenes, phenes, starphenes, pyrenes, coronenes, and fluoroanthenes. All of Biermann's kinetic measurements have been carried out at 91.5° C in 1,2,4-trichlorobenzene. Both the rates of reaction and the position of attack by the dienophile have been determined. Schmidt has used the results of the study to evaluate the ability of six theoretical models to predict reactivity and regiochemistry. The theories tested were Clar's sextet theory, Brown's para-localization concept, Herndon's structure-count method, free-valence indices, Fukui's

frontier orbital theory, and second-order perturbation theory. Almost all of the compounds that have been studied were from Clar's extensive collection of aromatic hydrocarbons that were prepared in his laboratory at Glasgow over a period of 40 years. According to Schmidt, Clar, who has retired and is living in Spain, has been pleased to see his compounds put to effective use in this study. In one study Schmidt measured the rates of reaction of 21 acene-type hydrocarbons with maleic anhydride. The second-order rate constants span a range of almost 10^7 , with hexacene being the most reactive and tetrabenzanthracene the least reactive. Schmidt said that all six theoretical models correctly accounted for the positional reactivity observed with these compounds. He found, however, that some of the models were more successful than others in the prediction of relative reactivities. Herndon's treatment and second-order perturbation theory were the most successful models, while frontier molecular orbital theory failed consistently. Schmidt was particularly enthusiastic about the use of W. Herndon's (Univ. of Texas) reactivity index as a predictor of reactivity. This index is defined as $\ln(SC_p/SC_r)$ where SC_p and SC_r are the numbers of classical Kekulé structures of the products and reactants. This theoretical model is especially attractive because it requires no computer operations, is simple to use, and provides useful results. For example, a plot of the logarithms of the rates for a series of acenes against the indices for these compounds has a standard deviation of only 0.236. As part of these studies, Schmidt has also investigated the correlations between rate constants and various spectroscopic properties: ionization potentials from photoelectron spectra, energies of UV absorption bands, and triplet lifetimes from phosphorescence spectra.

Schmidt recently collaborated with Prof. J.M. Robertson (Univ. of Glasgow) on an extensive study of the photoelectron (PE) spectra of these polycyclic aromatic hydrocarbons. Schmidt noted that a PE spectrum of an aromatic hydrocarbon with N carbon atoms has $N/3$ accessible π -ionization potentials that can be measured within 0.02 eV. He emphasized that, as a result, considerable information is available in a PE spectrum—more structural information, in fact, than is contained in a UV or a mass spectrum. This is particularly true for polycyclic aromatics, as the π -ionization potentials are sensitive to the size and shape of the hydrocarbon and can be calculated

with high precision by Hückel procedures. Schmidt pointed out that a comparison of experimental and calculated ionization potentials provides a test for assumed molecular structures. Using this approach, he has deduced the correct molecular structure for a black hydrocarbon prepared in 1956 by Clar, which was thought to have the circumanthracene structure 5. This hydrocarbon has been of particular interest for its photoconductive properties. After examining the PE spectrum of this hydrocarbon, Schmidt was led to question the assigned structure. The PE data have now allowed a revised assignment of the structure of this hydrocarbon as 6. Schmidt feels that the structures of as many as 1/5 of all aromatic hydrocarbons are subject to question, and he proposes to investigate many of these using his own techniques.



Dr. Johann Mulzer is a synthetic chemist who obtained his Ph.D. with Huisgen and was subsequently a postdoctoral associate with Prof. E.J. Corey (Harvard Univ.) in 1975. He is interested in the mechanisms of organic reactions and in the synthesis of novel compounds. Mulzer recently studied the stereochemistry of the aldol addition of metalated carboxylic acids to aldehydes. The ratio of the diastereomeric (threo and erythro) adducts as a function of both the aryl/alkyl groups of the acid and aldehyde and also of the counterion of the metalated acid has been investigated. In accord with previous work, Mulzer found that the ratio depends on the steric bulk of the groups. However, he has observed an interesting dependence of the ratio of the products on the counterions, which were varied from highly polarizing metal ions such as Mg^{2+} and Zn^{2+} to non-complexing ions such as $n-Bu_4N^+$ and K^+ , with 18-crown-6. The results have been interpreted in terms of a new view of the aldol reaction, which involves a *syn* transition state and a 1,3-dipolar-cycloaddition-like interaction between the allyl anion-type HOMO of the metalated acid with π^* LUMO orbital of the carbonyl group. Another area in which Mulzer is interested involves studies of the α -deprotonation of β -lactones. He has found that treatment

of β -lactones with lithium diisopropylamide in THF at -78° results in the formation of surprisingly stable 3-deprotonated β -lactones. The stability is attributed to the orthogonality of the π orbital with the C-O bond. Mulzer has been able to add various electrophiles at -78° to yield unusual functionalized β -lactones. The synthetic possibilities offered by the above results for the formation of new lactones and their subsequent conversion to olefins are being pursued by Mulzer and his group.

Even this brief summary indicates that the Department of Organic Chemistry at Munich has a wide variety of intriguing investigations in progress. With the excellent facilities available and the high caliber of both the staff and the students, we can expect major contributions from that group in the synthesis of organic compounds and the elucidation of reaction mechanisms. (A. Paul Schaap)

COMMUNICATION SCIENCES

THE GRANDES ÉCOLES DE TELECOMMUNICATIONS

The concept of the grandes écoles of France, i.e., high-level specialized education for a set of elite students, was described in ESN (most recently in ESN 35-7:257 [1981] and more completely in ESN 30-8:360 [1976]). Two of these super schools are sponsored and supported directly by the Secretary of State for Post and Telecommunications: the venerable (over 100-year-old) Ecole Nationale Supérieure des Télécommunications (ENST) in Paris and its 4-year-old offshoot, the Ecole Nationale Supérieure des Télécommunications de Bretagne (ENSTBr).

ENSTBr is in Saint-Renan, a suburb of Brest. Its campus is on a dramatic 50-acre site overlooking the sea. But: first age, then beauty.

ENST has four academic departments: Systems and Communications; Computer Science; Images, Sound and Life Sciences; and Physical Electronics. The total student population of 450-500 is spread across these respective departments in roughly 40-30-20-10 percent ratios.

My host at ENST was Prof. Henri Maitre, who is head of the Image Processing Laboratory, a part of the Department of Images, Sound, and Life Sciences. [The French acronym for the department's name is ISSV.] In his opinion, the two ENSTs have three significant advantages over other French schools that teach communications. For ENST in particular: (1) its method for selecting the incoming

student body assures that they will be highly motivated, especially toward research (only about 70 first-year students are admitted from a group of about 5,000 applicants, and entrance requirements at higher class levels are correspondingly tough); (2) its laboratories and technical support facilities are generally superior to those provided by the Ministry of Universities to its own schools; and (3) its research policy is more long-term oriented. In particular, most of the laboratory's activities are directed toward system realization in the 1985-1995 time period.

The Image Processing Laboratory was formed in 1969; Maitre joined it in 1972. In its early days, the research concentrated on holography. Their goal was to do real-time processing by optical filtering, deconvolution to correct for film and lens deficiencies, and pattern recognition to detect critical "shapes." Now they have generalized their image processing activities: inputs now come in either 2-dimensional optical form or 1-dimensional raster-scanned (TV-type) signals; processing is done both optically and numerically; and outputs are sometimes combinations of optical, TV, and numerical formats.

The applications being considered in a strictly telecommunications context include the picture-phone and general signal processing for network TV transmission and reception. In support of the life sciences interests within the department, the laboratory is involved in a set of studies to detect the presence of leukemia cells in magnified shadowgrams of blood samples, and to detect unhealthy segments in kidneys and muscles. Their semiautomatic technique for the detection of leukemia is based upon a statistical analysis of the radii of the displayed blood cells. Ideally, healthy cells will exhibit a unimodal distribution about a mean radius of about 3 μ . Leukemia is suspected if a significant number of larger cells are present. But a simple bimodal distribution may not occur; instead, a leukemia-induced mode may be hidden because of three non-ideal circumstances: cells may touch or overlap, cells are not strictly circular in cross-section, and several nominal sizes may occur for healthy cells. So, at least for the latter case, deconvolution techniques are needed to separate the individual modes of healthy cells before the operator is alerted to the possibility of leukemia being present in the blood donor. This work was reported in Dallas last August at the Pattern Recognition and Image Processing Symposium.

A second project under study by the group deals with a special type of coding applicable to the teletext-type of TV image. Alphanumeric characters, in combination

with simple graphics, are to be encoded into "compressed" braille for presentation to suitably trained blind users. The large data bases that are expected to be available in the future in teletext format would then be accessible by that group of subscribers. But if the variety of teletext displays is not to be restricted, broad freedom in the use of formatting must be allowed. This requirement leads to a significant set of complications. Simple optical character-to-braille transformation will not do because, besides the inherent meaning of the words themselves, information may also be carried in many other graphical details of the image, e.g., in the relative size of the letters (as in section headings). Significance may also be associated with color, column formats, the indentation that might exist, the isolation on the page of a group of words in a special format, the segmentation of the full page by line segments, etc. And the question still remains unanswered: whether braille can be a suitable channel for this type of communication. With reference to Maitre's earlier statement, regarding the students' strong motivation toward research, this project provided a special case in point. The student researcher is blind; he is working under the guidance of Dr. Alain Clainchard, a member of the staff who specializes in microcomputer-based image-processing systems. Clainchard reported that the nongraphical parts of the problem have already been solved, but the more difficult graphical aspects are just being started; the student's motivation is being put to a tough test.

Clainchard is also developing a fast, inexpensive processor for use with black-and-white TV signals. Processing is based on a table-lookup technique in which 3x3 picture-element arrays at the input are logically transformed into output element arrays that had been pre-computed and stored in memory. (The input elements are binary, based upon intensity threshold comparisons). The procedure's running time is negligible compared to the TV line-scanning period, so processing is essentially instantaneous.

Yet another of the many projects going on at the laboratory is one in support of the national electric power company, EDF. The EDF problem deals with the discharge of heated cooling water from power generating stations, primarily the nuclear power plants now being planned. The planners want to predict the flow patterns within the near offshore region, with the goal of having the hot water flow away from the nearby intake pipes—and stay away until

it has cooled down. To support this program, EDF has built a large test "pool", about 30 m by 70 m. In the course of a set of experiments, the shoreline and bottom profiles are changed, as are the orientation, flow rate, and some other characteristics of the discharge and intake ports. Meanwhile, a nine-camera photo-recording unit, located on a platform high above the pool, takes a series of pictures of the surface of the water. With the pictures as the input data, Maitre's group is attempting to derive two-dimensional vector flow information. But pictures of *clean* (or uniformly colored) water do not provide very useful data, and pollution of the water by anything with enough mass to affect the flow patterns is to be avoided. Several solutions to this problem were considered, and the one that was implemented has more than just a hint of the French touch to it: hundreds of wine corks are allowed to float on the water surface. The picture sequences are taken in pairs. First a long exposure (~1 s) allows each cork to "paint" a stripe whose length and direction provide local vector data—except for a 180° ambiguity in direction. Then, that ambiguity is resolved by a closely followed flash-lit exposure which allows each cork to assign a sense to its vector.

Maitre and the group were just starting to analyze some of that data and two types of problems were uncovered. The first one was in the data gathering: illumination over the large area was not uniform enough for good recordings. Secondly, in the data analysis phase, they ran into the situation where false data resulted from the overlapping of some of the corks' trajectories. To deal with this problem, they are in the process of devising algorithms that recognize and delete the false data. (But a more basic problem, that of correlating the important *undersurface* flow with the surface measurements, is outside the scope of their study. Maitre did not know whether EDF had done or was sponsoring any studies on that part of the problem.) The laboratory's work on this problem will probably be reported at the next international meeting of the IEEE Acoustics, Speech and Signal Processing Society (ASSP) meeting in Paris, in March 1982.

The Systems and Communications Department of ENST encourages research over a broad range of topics. Basic researches in stochastic processes, pattern recognition, and graph theory are applied to problems in both common-carrier telecommunications (e.g., filtering, coding, detection, synchronization, equalization,

and switching of digital signals, and the synthesis and recognition of speech) and also to special communication problems associated with "intelligent" industrial robots (e.g., scene analysis and object recognition).

The discussions with members of that group were limited to some of their telecommunications-related studies. Prof. Gérard Battail was my host; also present were Drs. Ghasson Kawas-Kaleh, Philippe Godlewski and Joel Le Roux. Battail described his current interest in "soft" decoding techniques. In a paper he expects to submit for publication in *Annales des Télécommunications*, he will discuss simulations and possible applications of the soft-decoding approach to diversity reception in both selectively and slowly fading channels (in the HF band). Both space and frequency diversity configurations will be considered. This work is a follow-on to work reported at the 1979 IEEE Information Theory Conference (held in Grignano, Italy). Kawas-Kaleh has been studying high-speed algorithms for use in adaptive equalizers. He reported upon this work earlier this year in Nice at the biennial National Colloquium on Signal Processing and its Applications (GRETSI). Godlewski, whose interest is in error-control coding and combinatorics, had just returned from the Information Theory Symposium in Budapest where he had reported on the results of a recently completed study dealing with the binary deletion channel. He had demonstrated a lower bound on the normalized capacity of that channel, equal to $1-q-H(q)$, but has since tightened that bound—to be equal to $1-q-\frac{1}{2}H(q)$, where $0 \leq q \leq \frac{1}{2}$ is the (random) rate of deletion. Le Roux described some of the speech research going on at ENST. He is working with some students in an attempt to replace the classical linear-predictive coding (LPC) representation of the full speech band, a representation that utilizes up to ~ 15 coefficients, with an alternate one that uses only a few coefficients per suboctave subband. Thereby, they hope to achieve a reduction in the total bit rate needed to transmit the speech signal. Low (<1000 bps) data rate transmission is also the incentive behind another method being considered. This method is a pattern-recognition technique, one in which a whole speech segment is classified at the source, and, instead of forwarding the whole segment waveform, the system simply transmits a number corresponding to that template which matches the signal segment best. The segments are about 20 msec long with about 10 msec overlaps. With clever

procedures (See ESN 34-11:503 [1980]), not all segments need be explicitly represented in the transmitted signal. Le Roux hopes to assemble about 10,000 spectral templates from many speakers and then to run an experiment based upon that library. He noted that other researchers (at CIT-Alcatel in Lannion, France) had run an experiment of this type, but it was based upon only 250 to 500 templates that were provided by two speakers. Quantitative results of those experiments were not available. In the same series of studies at ENST, a microprocessor-based system is being built to operate at a transmission rate of 300 to 500 bps.

Le Roux described the work of two other speech researchers in the department: Drs. L. Michlet and Yves Grenier. Michlet's interest is the automatic recognition of continuous speech. In his simulated system, he is processing parallel comparisons with 64 phonemes, using an Itakura distance to compare LPC coefficients. In a benign environment, using a single speaker, this technique achieved a score of about 80% recognition at the phoneme level. Grenier has been modeling the transition periods between phonemes in both the time and frequency domains with a view toward developing better speech synthesis systems. This ongoing work had been reported upon in August at an IEEE ASSP workshop on spectral estimation held in Hamilton, Ontario.

ENSTBr was decreed into existence in 1977, but its impressive modern facilities in Saint-Renan were opened only in January 1979. My visit, earlier this year, occurred while major pieces of laboratory equipment were still being installed—and much was yet to come. The institution is designed to accommodate up to 300 undergraduate students who will be trained both as communication engineers and as ambassadors, of a sort, to promote the fortunes of the French telecommunications industry. This secondary—or, for some, the primary—theme in their overall undergraduate program has led to several novel characteristics in the general environment, the organization, and the academic program at ENSTBr.

To start, approximately 20% of each year's entering student body are foreigners; this is a stated policy of the institution and represents a higher percentage of foreign students than that of any other grande école. Secondly, during the first 2 years of the 3-year program, the students are required to spend 20 to 25% of their class time studying foreign languages (English and two other foreign languages are required; in the latter category, Spanish, Portuguese, German, Arabic, and Russian are on the current list). Furthermore, courses in economics, international law, social studies

and the humanities are obligatory, and participation in sports activities is also expected. While these latter requirements may be near-normal for students at many American universities, this "whole-person" approach to higher education is quite novel—if not unique—in European universities, especially in those that specialize in teaching science and technology. The remaining 50 to 60% of the students' time during these 2 years is devoted to a prescribed set of science and technology subjects and is heavily weighted to laboratory-based instruction. So, at the completion of this part of the program, the student is expected to be a knowledgeable generalist.

The third year of the program is one designed to specialize. Six options are now available: telecommunications switching and integrated networks, space communication systems, data processing, microelectronics, signal theory, and "business" engineering with special emphasis on international operations.

Eventually ENSTBr expects to develop its own postgraduate program, one leading to the PhD-equivalent, Docteur-Ingénieur, and even beyond that to the Doctorat d'Etat. But for now, its Docteur-Ingénieur candidates pursue that work in residence at several other cooperating universities in France.

The research program at ENSTBr is just starting. I discussed some of the work with Prof. Alain Glavieux. He had just begun working with the nearby Centre Océanologique de Bretagne (COB) (See ESN 34-10:485 [1980]). COB is developing a new system for profiling the bottom of a deep channel, and Glavieux is studying the acoustic communication link that would operate as the reporting channel between the submerged camera in the system and the surface ship-mounted receiver. Bottom depths as great as 4,000 m were being considered. That link is going to be operating at 600 kHz with a bandwidth of 5 kHz. Two aspects of the problem were being studied by Glavieux: the development of a model for the nearly vertical transmission path (which can then be used to evaluate the different image processing methods) and the image bandwidth compression technique which will be needed. The model will need to incorporate noise, multipath, and absorption effects. At the time of our discussion, measurements of the medium's characteristics, which had been taken by COB, were being compared to a model he had simulated. That study effort is scheduled to end this month.

Glavieux was also starting a comparative study of modulation methods applicable

to single-channel-per-carrier satellite communication systems. (These systems have provided cost-effective "thin-route" capability for communications in undeveloped and underdeveloped areas, a type of system clearly consistent with ENSTBr's interest in the export market.)

The two related ENSTs, as they now stand, provide a dramatic comparison between the venerable and the upstart. Both, presumably, are going to be supplying the French telecommunications industry and ministry with their future leaders. One of ENSTBr's senior administrators who was planning to go to the US to meet his counterpart(s) asked, "What university (or universities) is the most prestigious training center for the future leaders of the American communications industry?" I had to admit to him that we had no counterpart to the ENSTs in that regard; I hope it didn't sound defensive. (Philip Fire)

COMPUTER SCIENCES

INTERNATIONAL CONFERENCE ON VERY LARGE SCALE INTEGRATION (VLSI81) IN EDINBURGH

VLSI 81, which was held at Edinburgh, Scotland, on 18-21 August 1981, was the first European conference dedicated to all the subjects involved in the exploitation of silicon as an implementation medium. In the past, various aspects of VLSI have been the subject of sessions at conferences devoted to a parent subject; for example, at computer science meetings or at signal-processing conferences. Due to the pioneering work of Prof. Carver Mead (California Inst. of Technology) and others, it has only recently become apparent that this emerging area of research embraces a wide range of disciplines from device physics to discrete mathematics. Research questions within the subject range from problems of design (at many levels) on to testing of chips and to the problems of complexity that arise from placing hundreds of thousands of transistors on a chip.

The tone of the meeting was set by Mead, who gave perspective to this broad nature of the subject by viewing the emerging VLSI technology as the most important opportunity since the industrial revolution. The vehicle of this revolution is the fact that enormously complex digital electronic systems can be fabricated on a single chip of silicon one-tenth the size of a postage stamp. Out of this technology, of course, systems are created that could radically change our modes of communication, commerce,

education, science, and military operations. Mead emphasized that VLSI is a statement about system complexity, not about transistor size or circuit performance. This is because VLSI defines a technology capable of creating systems so complex that coping with the raw complexity overwhelms all other difficulties. This is the key both to research in the subject and to the way that industry will respond to the challenge. The complexity issue makes VLSI different from other technologies, and historical parallels of technological development may not hold. Research in the subject must, in the view of both this writer and Mead, focus on harnessing and controlling the complexity of VLSI circuits. Mead sees two areas as needing research: large system design methodology and the organization and programming of highly concurrent systems. In both of these areas the fundamental conceptual apparatus remains to be discovered. Mead ended his talk by drawing an analogy between VLSI circuit fabrication and the printing of books. Although chip fabrication technology is the most sophisticated manufacturing technology ever undertaken, it is pattern independent, just as is the printing of books. A limitless number of system designs can be replicated by a single process. Mead sees the need for a technology analogous to printing, which will give designers access to fabrication in the same way that individual authors have access to printing. Mead believes that fabrication technology is at the point where one can create "silicon presses," which can turn designs into chips. Of course, great commitments of capital will be needed.

The many papers on the subject indicated that research in design methodology is in a very active state. Formal composition systems address the very essence of complexity management, hence this is a critical area. As of 1981, the tools that exist are not adequate. Some that were described offer automatic "place and route" tools which attempt to create a design that is compatible with a myriad of rules, which in turn are dictated by the electronics of the chip. A problem with the systems discussed is that they will not be able to keep pace with device densities. During breaks one heard tales of composition systems which were tying up large computers for weeks. An implication was that research should focus on means of representing designs — on producing a language of VLSI, so to speak. This should enable one to discuss and validate designs in a hierarchical way, and possibly to "abstract out" the complexity.

Some VLSI language questions were explored. In a potentially important paper, L. Cardelli and G. Plotkin of Edinburgh described an algebraic approach to VLSI design. They take over ideas from software, abstract data types and applicative language, and carefully apply them in the VLSI arena. Their approach is compatible with the hierarchical design methodology of Mead. Two novel VLSI architectures were proposed by ONR contractors. Prof. Larry Snyder (Purdue Univ.) described his configurable, highly parallel computer. Prof. H.T. Kung (Carnegie-Mellon Univ.) and a student, M.J. Foster, described a concept of programmable building blocks. Both papers were well received. Both efforts are important, as they address the question of how to utilize the vast processing capability available in VLSI.

The complexity of VLSI circuits was characterized by seeking optimal VLSI designs for problems such as matrix arithmetic, sorting and searching, FFT, and linear transforms. The paper by B. Chazelle and L. Monier (Carnegie-Mellon Univ.) described a model for analysis based on linear distances; the model demonstrates that the circuit time performance is a function of the chip geometry alone. A paper by F.T. Leighton and G.L. Miller (Massachusetts Inst. of Technology) described a clever mathematical approach to designing optimal shuffle-exchange graphs on a grid, although the application example which was presented for signal processing may not be realistic. Martin Rem (Eindhoven Univ., Netherlands) has developed a thesis that VLSI design clamors for a mathematical approach. He argues that the best way to control complexity is to avoid it through mathematical abstractions; in this way, it is possible to mask details when they are not pertinent. The thesis sounds good and has been applied in software, but so far it has met with only moderate success. However, VLSI is so different that mathematical abstraction may be the only way to design the ultra-concurrent computing structures on VLSI chips.

Testing of VLSI chips and designs clearly needs much research. There was widespread disagreement on causes of faults, on methods for verifying designs, and on methods for testing chip integrity. A good start at classifying failure mechanisms was made by B. Courtois (Laboratoire Informatique et Mathematique Appliquees, Grenoble, France); he gave a table which covers many faults in N-MOS (H-MOS) technology. He also exhibited a fault that could not be modelled by a logical "stuck-at" model.

Very few applications were described. That was appropriate in this meeting, and the organizers permitted only a few, well-chosen examples. One application paper concerned synthesis control of bit-serial

signal-processing architectures. Another described a VLSI network for detection of words in continuous speech. The authors, J.P. Banatre, P. Frison, and P. Quinton (IRISA, Rennes, France) took a new look at this problem. They have developed "pipelining" algorithms that have much regularity, and so these can easily be put into VLSI form. Their innovative ideas may lead to a breakthrough in this area.

The meeting was attended by about 350 people, with 200 from the UK, 60 from the US, and the rest from 15 other countries, primarily Western Europe. (R. Grafton, ONR, Arlington, VA)

SIGNAL PROCESSING AT SOCIÉTÉ INDUSTRIELLE
DES NOUVELLES TECHNIQUES RADIOELECTRIQUE
(SINTRA)—FRANCE

SINTRA Alcatel is part of the Compagnie Générale d'Electricité (CGE) group. SINTRA's Advanced Studies Group, with a technical staff of 50, is in Asnieres, a suburb of Paris. The organization devotes its entire effort to signal processing R&D. In 1981, the préprocesseur de signal (PPS), a modular programmable signal processor, was completed, and SINTRA is now developing an advanced version of this processor and its parallel interconnection schemes.

The PPS architecture was developed under a contract with la Direction Techniques des Constructions Navales, as the follow-on to a study sponsored by la Direction des Recherches et Moyens d'Essais (DRME). The basic 16-bit PPS (PPS 16) has two 16-bit wide buses: bus A for arithmetic data, with bus B for control and Input/Output functions. The unit contains a 4k x 16-bit bipolar memory configured in 32-bit words and each access is capable of providing double readout. The memory cycle time is 220 ns, and the basic machine cycle time is also 220 ns. The processor is controlled by 48-bit horizontal microinstructions, and a 2k microprogram memory is included in the basic system. Bit-slice microprocessor chips (AMD2900 series) are used for the control section of the PPS and a TRW 16x16 multiplier chip is used in the signal processing arithmetic section. For the 32-bit version PPS32, two A buses and two data memories are used and the width of the arithmetic section is doubled. The control section remains the same as PPS 16, but the microinstruction is 64-bit in this case. The PPS is packaged in 160 x 90 mm printed circuit cards and housed in a standard ATR (Air Transport Relay-Rack) enclosure.

It takes 5 PPS cycles (1.1 μ s) to complete a Fast Fourier Transform (FFT) "butterfly" (complex multiply). Block floating point arithmetic is used. For 1k-point FFT, 4 ms is required. For transversal filter and recursive filter applications, effective 220 ns product-sum speed can be maintained by PPS. PPS is intended for MIMD (multi-instruction multi-data) signal processing functions controlled by a general purpose computer, AMC MITRA 125 or 225. The initiation time for invoking a signal processing primitive is 1 to 4 ms. This can be overlapped with arithmetic; however, it ultimately will be the system bottleneck. All support software for MITRA computers and PPS microprograms are written in Fortran hosted on Digital Equipment Corp. PDP-11 or VAX-11 computer systems.

As semiconductor technology evolves, highly integrated signal processing components are becoming available for FFT, filters, etc. In all likelihood, a signal processor element such as PPS on a single (or a few) VLSI (very large scale integration) device will be obtainable within five years. In the world of ever increasing signal processing throughput requirements, SINTRA recognizes the need for efficient interconnections of large numbers of these signal processor components because a single bus or two bus system, as is in PPS, does not provide enough flexibility or speed. Furthermore, a single unit PPS is not sufficient for most acoustic and radar signal processing applications.

Conventional hardware interconnection schemes, such as cross-bar matrix or multibus systems, need considerable hardware. The amount required is directly proportional to N^2 , where N is number of units interconnected. SINTRA has been investigating a variety of interconnected matrix partitions in various triangular or sparse matrix partition configurations by introducing additional stages of delays and allowing access blockage. It is hoped that the various configurations can reduce the amount of hardware proportional to $kN \log_2 N$ or $k(N^2 - N)$ instead. This is analogous to the communication switching problem. Configuration restrictions will introduce software complications that cannot be assessed easily.

The basic circuit element of this arrangement is a family of 2x2, 4x4, and 8x4 ECL switches; it is known as a "commutateur" (or decoder), and has 3ns delays per stage. This family of devices is designed by SINTRA and manufactured by Laboratoires De Marcoussis, a French semiconductor manufacturer.

Using these components, SINTRA is currently building a 32-node system to study the PPS interconnection problems for both MIMD and S(Single)IMD cases.

PPS represents a balanced design for pipe-lined signal processing functions such as filters, FFT, beam form, etc. Its speed should be adequate for most channelized sonar applications. The data transfer bottleneck in the general purpose computer for invoking signal processing primitives in PPS, together with the limited memory size of PPS, severely constrains PPS from a general class of multidimensional and multisensor signal processing applications. SINTRA is aware of this problem. It is hoped that the continuing research in parallel interconnection approaches will lead to a satisfactory hardware solution. However, very little experience in the software complications has been published in the literature. Synchronization for MIMD and configuration inflexibility of SIMD systems still challenge the research community, as they have been doing for the past two decades. (Y. S. Wu)

ENGINEERING

ANTENNA AND MICROWAVE RESEARCH AT THE MIDDLE EAST TECHNICAL UNIVERSITY

The Middle East Technical University is on a spacious campus just a few miles outside Ankara, Turkey. There are about 12,000 students at the university, of whom 1,100 are in the Electrical Engineering Department (EED). Tuition at the university is almost free. It takes 4 years to obtain a BS degree, an additional 1 to 2 years to gain an MS degree, and a further 3 to 5 years to earn a PhD. At the time of my visit there were some 130 MS and 40 PhD students, with the latter usually being employed in the department as assistants or instructors. The EED has a staff of about 65, and a further 35 research and teaching assistants. Members frequently go abroad for a year or so, and in this way they keep up with developments in other countries, primarily the UK and US. My host for the visit, Dr. Altunkan Hizal, an associate professor, exemplified this policy: he was getting ready to leave for England to work on microwave antenna R&D projects at a British firm. And he was exchanging places with a colleague at that company who was returning to Ankara.

There is much interest in the EED in research on antennas, microwaves,

and propagation. Both Hizal and Prof. A.F. Fer, the department's assistant chairman, had obtained their PhD degrees at the University of Birmingham in this field. The antenna and microwave group has seven staff members. Funding for the group's activities comes from two sources. The first is the government, which supports the work either through the university, which has a separate budget for research, or through the Turkish Scientific Research Council; the second is industry.

Hizal described some of the antenna work. As is the case at the University of Belgrade, emphasis is placed on theoretical studies, which are aided by a large computer available free of charge. Still, experimental verification is frequently necessary, and the researchers feel the lack of an anechoic chamber. A thin wire antenna for a 400 MHz TV station was successfully designed by placing V dipoles around a circular cylinder. The radiation pattern was omni in the horizontal plane but had some directivity in the vertical plane and tilted downwards. A model was built and tested at 2 GHz. Various "thick" antennas also were studied and designed. In one, the radiator was in the shape of a stubby vertical cone, with the apex on top and only a small gap between the base and the ground plane. It was fed at the center with coaxial cable from below the ground plane. In another configuration, the shape of the radiator was mushroomlike. Octave bandwidth was obtained in both cases. The radiators could be less than $\lambda/2$ in height, and this suggested an application in which the antenna would be used for vehicles in which a low silhouette was desirable.

A computer program had been developed to predict the performance of vertical, horizontal, or oblique wire antennas over a lossy ground. The program was then extended to include an array of elements with mutual coupling taken into account. This led to the design of an array with 24 wire elements, which were arranged in a circle 150 m in diameter for the 3 to 10 MHz band. Eight of the elements were selected by switches and energized, with amplitude and time delay calculated to take all mutual and other effects into account. It was shown that this could be done such that a proper impedance match would be obtained. Time delay rather than phase was used for wideband performance and the quiescent array elements were resistively terminated. The calculations, however, included only 2 adjacent elements on each side of the array and ignored the other 12 elements. The study had not yet been extended to include the design of a network that would generate the required amplitude and time delay outputs for feeding the system.

Both Hizal and Fer have conducted a study of MF propagation for the Turkish PTT (Post Telegraph and Telephone). They determined that a ship-to-shore ground-wave communication system could be established in the Marmara and Black Sea region at 500 KHz with a range of up to 400 km. In other propagation calculations, they use a Swiss computer program which gives muf (maximum usable frequency) for HF propagation.

Hizal has given much attention to resonance scattering, that is, the scattering by objects of the order of a wavelength in size. The formulation of the problem leaves leeway regarding the state and nature of the scatterers, which may be composite, partly metallic, and partly dielectric; however, it is necessary for it to have rotational symmetry.

Applications of resonance scattering studies at the university extend to meteorology. Radar backscatter measurements from rain can give the raindrop size as a function of the ratio of the echo amplitudes obtained respectively with vertical and horizontal polarization; and hail and snow exhibit their own characteristics. This remote sensing technique is of importance for the country's water management. An experimental radar is available for that purpose, but, unfortunately, it is only available at X-band; S-band would have been desirable because there would be less attenuation. Another application concerns the acoustic mapping of underground streams within Turkey. Many such streams sink into underground channels and do not resurface until they are close to the ocean, with a resulting loss of potential water and water power. Small explosive devices are currently floated down the streams with timers. Geophones are strategically placed to monitor the explosions where they occur, and to locate their positions by a matrix inversion procedure. A better understanding of the scattering properties should enable the very long, roughly cylindrical underground inhomogeneities to be detected with a monostatic or bistatic system, and such a system is being studied. Yet another application includes scattering and absorption studies within the human body; this may be of interest in medical diagnostics for determining hot spots generated in a body in the proximity of a radiating system.

Prof. Dr. Canan Tokur works with microwave devices and has developed many microstrip and stripline components, from power dividers to phaseshifters and filters. In particular, he has been interested in wideband devices, both passive and active. With a 10 dB gain power amplifier, Tokur has achieved 1 W

output from 25 MHz to 1 GHz with 50% efficiency. He has devised a novel matching network for transistors consisting of nonlinear (exponential) transmission lines and has found this network most suitable above 1 GHz. Dr. Nevzat Yildirim, an associate professor who had studied at Wayne State University, analyzed nonlinear transmission lines and obtained general results applying to N coupled lines.

A rather interesting organization called Vakif exists in Turkey. It is a well-endowed foundation funded by gifts from private individuals or groups of people, and it is tasked to help supply the army. It is administered by a retired army general. Similar foundations exist in support of the Navy and the air force. Vakif has set up an electronics company, "Aselsan," just outside Ankara (it is about to set up another company to produce nickel cadmium batteries). I visited Aselsan and was shown around by Dr. Mahmut Karadeniz, the research manager, who is on leave from the Middle East Technical University.

Aselsan was started about 5 years ago with a staff of 4. It now has a staff of 400 and plans to double its size every year (every Turk would then be employed by the company in 17 years!). Certainly, the vigorous expansion plans were evident, with more than ample elegant buildings being available now and more being built. Apart from the general manager, the oldest member of Aselsan was 37 years old—a situation which is reminiscent of the rapid growth era in the early days of radar. At this time, the main products of the company are communications systems, with some being built under license, and some designed in-house. I saw a hand-held "walkie-talkie" that was claimed to be better and cheaper than comparable competitive equipment. It was said that the company had to be competitive, even though some laws were passed recently making it a preferred supplier to the army, in contrast to other suppliers from outside Turkey—and there were no other manufacturers within the country. (T.C. Cheston)

SOCIÉTÉ INTERNATIONALE DE TELECOMMUNICATIONS AERONAUTIQUES (SITA)—A PROFITABLE NONPROFIT ORGANIZATION (FRANCE)

Introduction

SITA was formed in the late 1940s by 11 international airlines, who pooled their existing worldwide telecommunication resources. In 30 years, it has grown

into an enterprise serving 240 airlines in 152 countries. In 1969, the SITA network became the first operational business packet-switch network. Today, the network consists of 163 switching centers, 11,000 teleprinters, and 5,000 CRT (cathode-ray-tube) terminals in 12,000 airline offices in 800 cities. In addition to the data network, SITA also operates a large reservation system in Atlanta, Georgia, which is shared by 30 smaller South American or Third World airlines. All major airlines' computers are connected with "SITANET" as a local area network (actually wide area coverage), to maintain their own reservation systems. Headquartered in Paris, SITA has a worldwide staff of 1,700. In 1980, SITA handled over 3 billion messages with a revenue of \$150 million. Thus, the average gross cost per transaction was less than 5 cents, certainly an impressive performance figure.

A Zero Working Capital & Infinite Debt-to-Equity Ratio Organization

The number of capital shares held by each member airline is proportional to that airline's participation and total usage of SITA services. There are 18 majority directors, each representing an airline with 20 or more capital shares, and 7 minority directors, each elected by a minimum minority aggregate of 50 shares; these 25 people constitute a managing board of directors. SITA is really a user-owned "Co-op." Costs are shared among users; therefore, SITA has zero working capital to cover its day-to-day operating expenses. However, SITA requires a 1-month "operating charge" deposit from member airlines for this purpose. To finance new capital investments such as equipment and buildings, amortized loans are obtained from member airlines, or bank loans are guaranteed by airlines. Theoretically, SITA has an infinite debt-to-equity ratio. But consider the residual value of amortized equipment, and of buildings such as the SITA headquarters building on Avenue Charles De Gaulle in Paris; these items show that a zero-book-value corporation can have substantial hidden equities in amortized and fully depreciated assets. Twenty percent of the SITA revenues are expended on R&D for new systems and services (compared to only 10% for IBM). This is a healthy percentage for R&D investments. In short, SITA is an organization without capital, but one, nevertheless, with sizable equity, capital, and research investments.

In a way, SITA is in competition with all the major airlines in attempting to sell its reservation services to smaller airlines, because all the major

airlines in the US and in Europe have surplus capacities in their "local area networks." However, its pooled resources, the worldwide network it operates, and its practice of hiring non-union local employees allow SITA to provide better services at lower costs. Furthermore, the present cash squeeze in the industry leaves SITA as the only viable R&D vehicle for airlines information systems of the near future.

SITA Services

(1) Worldwide Telecommunications Network

The SITANET consists of teletype (TTY) and data circuits and switching centers configured to provide a "fail-safe" capability with 163 store-and-forward switching centers. The high-level network includes 10 large switching nodes in major cities such as New York and London, linked by AVD (alternate voicedata) of 9,600 bits/s. Each circuit controls several medium-level centers in secondary cities. There are, in addition, 48 satellite processors scattered around the world, which serve as intelligent concentrators. Three levels of network hierarchy are interconnected by over 500 medium-speed (2,400/4,800 bits/s) and 5,000 low-speed (50/75/100 baud) common-carrier circuits. DEC PDP-11's (VAX-11's later) are used extensively at various levels of switching centers. The lowest level contains the time-division multiplexers and the manual-teletype switching centers. Standard RS-232C protocols are strictly observed. Medium-speed circuits are used for conversational traffic, and low-speed circuits are devoted to teletype traffic. The International Air Transport Association (IATA) is currently establishing an access protocol based on "high level data-link" control for standard SITA access interface.

(2) Reservation Services

SITA operates a shared airlines reservation system with a triple-Univac 1110 system located in Atlanta for those airlines that do not choose to have their own systems. Currently, there are 30 carriers using the system. There are 1,600 CRTs connected via SITANET to the system, which has an availability rate of 97.5% and an average response time of 3 s worldwide.

(3) Meteorological Data

Global meteorological data obtained from the US National Weather Service in Suitland, Maryland, are available on the net for flight-planning purposes. These data are updated twice daily.

(4) Baggage Tracing

IATA and SITA now operate a worldwide baggage tracing system via SITA computers, and CRT terminals in all airline offices have direct access to the system.

(5) Credit Authorization

The SITA network has access to the

American Express System in Phoenix, Arizona for validation of American Express and Diners Club cards. This service is offered to airlines only, in conformity with local PTT policies. It requires the conversational mode of CRT terminals, and therefore it is not available through TTY connections.

New Services Planned

(1) Departure Control

In 1981, SITA began to offer departure-control service at airports near cities in which SITA has excess processing resources; a stand-alone system can also be provided. This departure-control service is aimed at secondary airports with passenger volumes that do not exceed 1,000 per peak traffic hour. The basic functions of the system are: check-in, weight-and-balance calculations, boarding pass printing, and postflight reconciliation of reservation accounting. The airports at Budapest (Hungary), Sofia (Bulgaria), and Abidjan (Ivory Coast) were among the first to have this system installed.

(2) Advanced Network

This year SITA is also introducing an advanced network architecture, and the organization plans to make the conversion from the current system to the new architecture without disrupting the around-the-clock services already being provided. Phase 1 of this new development will be an automated network control system that will provide overall network supervision from a few regional centers and a worldwide center in Paris. The second phase of the effort will be a data-transport network that will assume the function of the present high-level network for transmitting data from one node to another, and from nodes to satellite processors. There will be two types of messages: Type-A, short conversational messages, which will have an average length of about 80 characters; and Type-B, teletype messages with about 200 characters. According to SITA analysts, the network traffic is expected to double by 1985 and the ratio of Type-A to Type-B messages will be 7 to 1. The justification for the advanced network is that it will be able to handle this increased traffic load. The expanded services associated with the advanced network are: (1) terminals to access different reservation computers (major airlines) or other network computers via medium speed circuits; (2) CRT terminals to handle Type-B TTY traffic; (3) computer to computer bulk data traffic; (4) query/response and message application among airline computer systems; and (5) multi-level security for Type-B messages.

(3) Air/ground Digital Communication (AIRCOM)

SITA is currently undertaking the development and implementation of an AIRCOM pilot system to demonstrate the feasibility of providing this service in the future over the SITA network. AIRCOM will have a 2,400 bps air-ground data link capability for automatic, accurate, real-time data exchanges between an aircraft and a ground-based network. The following are some of the aircraft-to-ground (downlink) messages the new system may handle: event times (out of the gate, off the ground, on the ground, ETA, etc.); fuel status; engine data; passenger-service data; and weather data enroute. And some of the ground-to-aircraft (uplink) messages that the system developers envision are time references, weather updates, and flight operation data.

The AIRCOM system is designed to provide better flight management and improved on-board passenger services. By the end of 1981, a pilot AIRCOM unit including 2 VHF ground stations and an AIRCOM service processor will be available for evaluation by KLM (Royal Dutch Airlines). From the ground stations, the AIRCOM service processor will address each message in Type-A format and send the message to the aircraft's final ground destination. The new system will be placed into operation in two separate phases. In the first, 50 VHF ground stations will be installed in Western Europe and the Mediterranean Basin. In the second phase, the geographical area will be expanded to include contiguous en route coverage above 20,000 ft.

Summary Comments

The SITA Advanced Network is probably the only worldwide packet switch network in existence. It works, and it works economically and reliably. It is the backbone of a worldwide airline C³ (Command, Control and Communication) information system. In contrast, ARPANET (Advanced Research Projects Agency Network) in the US has been in a university R&D environment (free of charge to users) for the past decade, although DCA (the Defense Communications Agency) took over the system responsibility several years ago. It exceeded its original R&D goals. The commercial TELNET venture (started by the ARPANET originators) is still struggling to break even. One may wonder if government R&D did not stifle the orderly commercial development unintentionally. SITA has demonstrated the viability and the need of such systems for one-industry-only applications. In this author's opinion,

the following are the main reasons for SITA's success: (1) It is a user-owned system. (2) Investments are amortized (pay as you go). (3) The R&D budget is high in relation to revenue. (4) R&D is carried out by people with operational and maintenance experience. (5) There is evolutionary phasing-in of new systems and services. (6) It is an industry-only application that circumvents PTT (Post, Telephone, and Telegraph) policy restrictions of various countries. In addition, the pooled resources at SITA's disposal ultimately lead to a high rate of utilization of both circuits and equipment (probably over 50% duty cycle), which contributes to the remarkable economy of the system.

It is always thought provoking to ask a "What if" question. What if all three military services in the US pooled their C³ assets, and DCA were to become an industrially funded nonprofit organization modeled after SITA. To operate, maintain, to conduct R&D, and to introduce all future new systems, and acknowledging that robustness and security requirements complicate the technical issues, could we have better worldwide military C³ systems at a fraction of the present costs? (Y. S. WU)

THE UNIVERSITIES OF LJUBLJANA AND BELGRADE: RESEARCH IN ELECTRICAL ENGINEERING

Yugoslavia is a country composed of people with several distinct national backgrounds, and each group has its own language. I visited the University of Ljubljana, where the instruction is given in Slovenian, and the University of Belgrade, where Serbo-Croatian is spoken and the Cyrillic script is used (exams may be taken in any language). These two universities have strong and active electrical engineering departments (EED) that are much involved in research. Both schools have many links with US universities through staff members who studied or taught there, or who are conducting research in cooperation with their counterparts in the United States. At the University of Ljubljana my host was Prof. Dr. Josko Budin, the dean of the EED. The university has some 11,000 students, of whom about 1,000 are in the EED, where most are pursuing an eight-semester course plus a thesis (4 1/2 years), which leads to the degree "dipl. ing." This degree, I am told, is not far short of an MS. About 10 new PhD students join EED every year, and most of them also work as instructors. The staff comprises about 70 professors or associate professors who teach, on the

average, for nine hours each week; and there are 30 assistants. Tuition is free in Yugoslavia, but unless they obtain scholarships, students must be supported by their families. Scholarships are offered by some state-owned industries and involve a commitment to work for that industry for twice as long as the period of the scholarship. It was said that there were not enough jobs available for youngsters leaving school; many of them therefore tried to enroll in universities, even though that meant another four or five years of parental support.

Budin's chief research interests are in the field of antennas; he has contributed many papers and has also written four textbooks for use within his department. He came to the university from the Iskra Company, which is the largest (state-owned) general electric manufacturing company in the country; it employs about 30,000 people, mainly in and around Ljubljana. Budin's transfer to the university was gradual and he still holds the position of scientific leader at Iskra. The laboratory at the university was jointly founded by the university and Iskra, and the two organizations share its facilities. Budin has been involved in the design of very-wide-band antennas, particularly those relating to the detection and location of radars. He has worked with corrugated horns and has achieved 3 to 1 band width with best horn angles and slot shapes and geometries. Another wide-band circularly polarized antenna used a conical horn with a printed spiral radiator in the throat. A number of these could be stacked around a circle, with each horn acting independently with its own receiver, resulting in 360° coverage.

Budin introduced me to members of his staff. The first of these was Prof. Dr. Joze Furlan, who had studied at Stanford. Furlan is vice dean responsible for student affairs, but his main interest is in solar cells; he has a scheme that he believes will lead to cheap construction and manufacturing methods. He is associated in this work with the Sandia Corporation in the US.

Ing. Gajsek is employed by Iskra, but he does his work at the university laboratory. He has worked with Budin on the previously mentioned wide-band multiple horn receivers for detecting and locating radar transmissions. Gajsek is involved in designing antennas for mobile communications systems and also for TV reception from satellites in cooperation with ESA (European Space Agency). His antenna test range includes alignment instrumentation that uses a laser at one station and a mirror at the other. This accurately defines the line between the two sites in such tasks as calibrating a DF system. He

plans to install an optical fiber linking the sites, and also to develop remote computer control of frequency, power, and antenna position. About 15 people at Iskra are working on antennas.

Prof. Alojz Kralj's fields of interest include biomedical engineering and industrial robotics. He is also director of the Yugoslav RSA (Rehabilitation Services Agency) and has much contact with the US, particularly with the University of Southern California, where his colleague, Prof. Kodornik, is working at the moment.

Kralj and his coworkers have been involved since the early 1960s in the electrical stimulation of muscles, and they have achieved remarkable success. People paralyzed on one side through brain damage (for example, through a stroke or accident) or completely paralyzed through spinal cord damage, still have a functioning and preprogrammed lower spinal cord, along with properly operating muscles with local-feedback systems that prevent them from being atrophied. Simple electrical stimuli have been applied successfully, for example, to correct for foot-drop by an energizing switch in the heel; devices of this sort were built in Yugoslavia in the mid-1960s. At the present time, more sophisticated models are being developed by Kralj's group and are becoming available commercially for both standing and walking. These improved devices give better timing and adjustments and they require less surgery for implantation. Using them, wheelchair patients have been able to stand for periods of up to 1 hour. The devices are still single-channel, but multi-channel systems have been used therapeutically in hospitals and are claimed to speed recovery considerably. Other aids include hand-control systems by means of which a paralyzed hand, for example, can be made to grip a glass firmly; still others assist in bladder control. The latter are aimed at patients who leak urine under physical stress or, in the case of some women, after childbirth. In most cases it was found that after short periods of electrically stimulated control, the patients relearned to exercise control in the normal way.

RSA has about 60 people involved in the research, most of them on a part-time basis. Funding for the work, which is carried out in cooperation with the university's medical department, comes from the Slovenian Research Committee, from industrial organizations that buy the patent rights, and also from the US through NIDH (National Institute of Handicap Research).

At the Electrical Engineering Department of the University of Belgrade there is a strong penchant for antennas. The antenna group is led by Prof. Dr. Branko D. Popović, who frequently contributes original papers at international meetings. A member of the Serbian Academy of Sciences, Popović is also much involved with the US and previously held a teaching position at the Virginia Polytechnic Institute (VPI), where he is now on sabbatical leave. In addition, he was an associate professor at McGill University in Montreal. At this time he is compiling a John Wiley monograph on the analysis and synthesis of wire antenna structures, and he expects that it will be published in 1982.

The university has about 60,000 students, of whom about 2,000 are in the EED. The courses and degrees are similar to those at Ljubljana. The EED has 130 faculty members, of whom 80 are professors or associate professors; the remainder are teaching assistants involved in laboratory work and tutorials.

Popović introduced me to some of the members of the antenna group: Dr. Momčilo Dragović, Dr. Antonije Dordević, and Dr. Alex Marinčić. The work is mainly theoretical and much of it concerns small (in terms of wavelength) structures; this emphasis on theory is probably more cause than effect, for the group's laboratory is fairly simple and lacks sophisticated equipment. When complex experimental work does become necessary, they have access to the laboratory of their friends at the University of Ljubljana.

The antenna group has made some detailed analysis of cylindrical radiators consisting of short metal sections interlaced with narrow dielectric sections. The first paper on this work was presented in 1973. Since then, general solutions for dielectric-loaded dipoles and monopoles have been found and used for obtaining broad-band solutions. In a typical application, a 3:1 frequency band was obtained with the radiator being about $\lambda/2$ at the lowest frequency. In another application, cylindrical resistive material was used in conjunction with metal, and 4:1 bandwidth was achieved with a VSWR (voltage standing wave ratio) as low as 1.3 and an efficiency of 80%. Again, the overall length was $\lambda/2$ at the lowest frequency. It was claimed, to my surprise, that the resistive radiator showed drastically reduced mutual coupling properties with adjacent similar radiators, compared to those normally found with metallic radiators.

A computer program has been devised for the rapid numerical analysis of

antenna structures in the form of multiple straight-wire segments. The work has more recently been expanded to include wires that are completely or partially covered by dielectric materials. The approach is claimed to be more general than previous work. In all cases good experimental agreement has been obtained.

Other studies of the group involved investigations of scattering by near-resonant sized objects. This subject is discussed in the article on page 381 of this issue. (T.C. Cheston)

ENVIRONMENTAL SCIENCES

NATURAL AND MANMADE AEROSOLS—THE PARTICLES IN THE AIR CAN FOOL YOU

One of the undisputed gods of aerosol science is Prof. Christian Junge (Max-Planck-Institute, West Germany) honored throughout the world by the common description of the size ranges of atmospheric particles as "Junge distributions." Basically, the Junge distribution describes the observation that suspended matter in the air falls into specific categories by size and overall mass, with few large particles and many, many tiny particles in any given air parcel. The big particles fall out quickly, while the fractions with diameters between about 0.1 and 10 micrometers are significant, both as respirable threats and as nuclei for formation of clouds, fogs, smogs, and hazes. A good deal of the research on this topic was directed by Junge while he was associated with the US Air Force Office of Scientific Research nearly three decades ago. Publishing in the international atmospheric science journal *Tellus* at that time, Junge was apparently the first to note that there was an anomalous abundance of nitrate-rich particles adjacent to coastal regions, and that neither marine nor continental sources could explain the uniquely high concentrations.

In just the past few years, Junge's observations of this anomaly have been confirmed by field measurements of collected aerosols from many other locations, notably from coastal sites along western North America and from the North Atlantic Ocean off Newfoundland. Interesting, but still speculative, is the apparent correlation of the geographic locations of these anomalous distributions of aerosolized particulate matter with the "anomalous gray shades" regularly seen in satellite and high-altitude aircraft imagery obtained by remote sensing devices. Since large numbers of examples are

available where these anomalous gray shades do not obviously reflect water temperature differences, fog banks, low stratus decks, or industrial pollutants, the standard interpretation offered by the environmental effects manuals of the Naval Environmental Prediction Research Facility has been that "marine haze" is somehow augmented in these areas by surf, wind, off-shore breeze, or related conditions adjacent to some coastlines. Junge's observation, now confirmed and extended by a large data base gathered during numerous studies of the marine boundary layer, suggests that the anomalous gray shades may be providing truly remote analytical signatures for suspended atmospheric matter of peculiar chemistry. Indeed, scientific teams working with the Coastal Zone Color Scanner satellite program have recently shown that empirical knowledge of the absorption and scattering coefficients of certain natural aerosols allows immediate, algorithm-directed computer correction of satellite images, so as to provide true ocean-color data representative of actual water concentrations of suspended chlorophyll and other pigments. With established ground or sea locations for objects of known reflectivity, the computer program can obviously be "run backwards" to establish the needed absorption and scattering coefficients for aerosols of unknown character. Such information can be used to identify hazardous aerosol clouds, to pinpoint specific particulate sources or sinks, or to provide appropriate corrections for terminal homing sensors.

In regard to the latter use, it is important to recognize that natural atmospheric particles and most man-made aerosols, smokes, or other obscurant agents usually have specific absorption bands in the region most often used for guidance functions, that is, at around 10.6 micrometers, where carbon dioxide lasers function best. Some of these issues are discussed in the compilation of papers recently published by the Society of Photo-optical Instrumentation Engineers (SPIE) in the volume entitled *Image Processing for Missile Guidance*. A follow-up symposium in June, 1981 addressed the specific topics of boundary-layer meteorology, which is so important to the understanding, prediction, and control of the opening and closing of various "electromagnetic windows" through the atmosphere. The resulting symposium volume should be a most valuable reference document. Prior to the meeting, one conclusion had already been presaged in numerous earlier reports, and verified in NATO-sponsored trials in Meppen, Germany. It is that knowledge of the atmospheric aerosol composition and particle distribution in one area cannot be safely or correctly extrapolated to distant locations, or even to

nearby areas with supposedly identical features. For example, characteristics of the air mass over one area of "open" ocean cannot be taken to be those for other areas of "open" ocean.

It is certainly important that electro-optical guidance systems must adjust for continuously shifting atmospheric backgrounds. This problem will be most severe when a missile must traverse a horizon from "matching information" about marine circumstances, and must cross a peculiar coastal region, to anthropogenically influenced continental targets. The reverse path is equally troublesome. It has been known for years, of course, that the major component of the true marine aerosol is sea salt, with infrared absorption bands being dominated by the strongly coupled water of hydration of marine sulfates. It is also well documented that continental aerosols are overwhelmingly dominated by atmospheric particles of the ammonium sulfate class, with infrared absorption slightly shifted from the marine case but still uncomfortably close to the major operating band of CO₂ lasers.

These same particles, of both the sulfate and nitrate classes, serve as effective nuclei for the aberrant precipitation known as "acid rain," and could serve equally well as nuclei for a host of aerosol obscuring agents designed to mask targets from specific probes of electromagnetic radiation. Exploitation of satellite or high-altitude aircraft anomalous gray shade values, together with augmentation of the ground truth data base from additional field studies, may allow more rapid, reliable prediction of these effects. Obviously, should a conflict arise, the side with the most complete environmental intelligence will be at a significant operational advantage. (CDR Bob Baier, Advanced Technology Center, Buffalo, NY)

MATERIAL SCIENCES

INTERFACIAL SCIENCE AT THE UNIVERSITY OF SURREY

In its latest brochure describing research in progress, the Department of Metallurgy and Materials Technology, Univ. of Surrey, points out that..."The Department was originally established as a centre for the study of Metallurgy at Battersea Polytechnic some 40 years ago, and grew rapidly in the post-war period to become one of the largest metallurgical centres in the South of England. In the mid-1960s it formally enlarged

its scope to include Materials Technology and with the rest of the College became part of the University of Surrey which is now established on its present site in Guildford."

I recently visited the department to observe the research on surfaces under the direction of Dr. J.E. Castle, Professor of applied interface science. At the same time, I had the opportunity to visit briefly with Prof. M.B. Waldron and to meet Dr. A.P. Miodownik. Waldron was formerly the head of the department, but he has temporarily stepped aside to serve a 3 to 4 year term as dean of the faculty. Miodownik is the current department head. I did not have the opportunity to visit the well-known Composites Group under the direction of Prof. J.I. Bailey, but the research activities of that group were described in ESN 35-8:307 (1981).

The department has a reputation for pursuing materials research topics highly relevant to industry. This approach is readily apparent in Castle's fundamental research on the mechanisms responsible for corrosion of alloys used in heat exchanger tubing, mechanisms of delamination of gas line coatings, the wetting behavior of brazing alloys, and the formation of passive surface films in pressurized, high-temperature water. To carry out these studies, a formidable array of the latest tools of surface science has been assembled. Among these, Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), hot stage scanning electron microscopy (HSSEM), and several other surface techniques are available for systematic studies of surfaces of interest. In addition, some of the techniques can be used simultaneously. For example, it was demonstrated how a small area of a sample could be probed and both the Auger and X-ray spectrum shown in a superimposed display. This, in effect, gives the scientist a limited, in-depth profile of the composition of the sample at that particular point. Other versatile equipment features give Castle a great deal of flexibility in his approaches to research problems.

A major interest of the group over the past several years has been the corrosion of aluminum brass condenser tubes. This alloy is seldom used in the US for this application, but it is widely used in power plants in Europe and other parts of the world. Samples of corroded tubing from many of these plants have been received and extensively examined using X-ray photoelectron spectroscopy. As a result, it has been possible to postulate a reasonable model for the

corrosion behavior of the alloy, notwithstanding its complex behavior in the marine environment. Basically, the alloy seems to owe its good corrosion resistance to the gel-like formation of the mineral hydrotalcite on its surface upon exposure to seawater. Hydrotalcite acts as a buffer against local acidity by release or uptake of magnesium ions. What is perhaps as interesting, however, is the behavior of the iron compounds regularly injected into these tubes during power plant operation in order to lengthen tube life. The prevailing belief was that iron, injected in the form of ferrous sulfate, reacted with the seawater flowing through the condenser tubes to form compounds such as lepidocrocite. These compounds then settle on the tube wall to form a protective corrosion barrier coating on the alloy. The present studies favor a somewhat modified role for the iron compounds. They indicate that primary corrosion protection is provided by the buffering action of the hydrotalcite. The iron compounds, which form on top of the hydrotalcite layer, act as a protective barrier to prevent erosion of the gel-like hydrotalcite by the flowing seawater.

In a closely related study, the compounds formed on the surface of commercial (iron bearing) 90-10 Cu-Ni alloy tubing are being investigated. This work, recently started, has shown that in 5.5% NaCl solution the corrosion reaction is cathodically inhibited, and the inhibition is related to the selective enrichment of ferric oxide or hydroxide on the surface. This layer is tightly bound to the alloy and has no influence on the anodic behavior of the alloy, as revealed by polarization studies. Future studies are to be carried out in natural seawater to determine the effect of constituents such as Mg on the iron-rich layers. Some of the research has been carried out in conjunction with research at Pennsylvania State University under an Office of Naval Research contract.

A practical outgrowth of the group's interest in corrosion of condenser tube alloys is a project concerned with methods of *in situ* repair of corroded condenser tubes. In normal operations the extensive runs of tubing in condensers are periodically inspected by, for example, high-speed, eddy current probes to determine roughly the location of thin spots. More accurate sizing of the flaws can be carried out using eddy current hand probes. But when through holes develop, the tubes have to be plugged. Eventually, when enough tubes are plugged, the heat

transfer efficiency of the condenser is reduced to such a low level that it has to be closed down and re-tubed. The expense of replacing tubes plus the loss of revenue when the power plant is closed down is substantial. The method developed by Castle's group under industrial sponsorship could not be disclosed, for proprietary reasons. Nevertheless, I was told that the method consists of selectively drying, acid cleaning, passivating, and lacquering the thin spots without affecting other parts of the tube. Already, they have been able to perform this repair process as far as 12 feet from the tube mouth, and several tubes with 4-inch lacquered patches have performed satisfactorily for 2 years. Current plans call for them to repair the tubes of an entire power plant condenser for long-term testing.

Another study concerning alloys for marine use was a photoelectron spectroscopy (XPS) study of fouling on copper, aluminum brass, and cupro-nickel alloys. The research was carried out by following changes in carbon concentration and type after exposure of the alloys to seawater; it was reported this year in the conference "Progress in the Prevention of Fouling in Industrial Plant" at Nottingham University. The findings were: while all of the materials resist macrofouling, on the microscale their mechanisms for doing so are quite different. When the surface of the alloys exhibits copper in the Cu(I) state, organic carbon is adsorbed, but no evidence of carbon is seen in the form of the carbohydrates that are typical of fouling layers. Copper shows this type of behavior at all stages of exposure. Aluminum brass also behaves this way in the early stages, but as the surface minerals on this alloy tend to form hydrotalcite, carbohydrates also begin to form on the surface. The XPS spectrum for carbon from these surfaces closely resembles that from a glass surface that has been exposed to fouling conditions. On the other hand, cupro-nickel alloys, whose surfaces, like copper, exhibit only the Cu(I) state during exposure, behave quite differently from copper. In these alloys, carbon in the form of carbohydrate structures appears almost immediately and remains during exposure. Thus, it is apparent that these well-known fouling-resistant alloys obtain their resistance in a different manner than does copper.

John Watts is a doctoral candidate in Castle's group. He described for me his research on disbondment of polymeric coatings on cathodically protected pipelines. For the initial studies he used polybutadiene as the coating for ease of observation, but he now has progressed to studies using an epoxy coating. In addition to conventional electrochemical measurements, he studies the interface by dissolving the steel substrate with methanol-iodine solutions and observing

the XPS/AES spectra of the residual oxide layer attached to the polymer coating. This can be profiled down to the interface by ion-beam milling. Although studies are incomplete, it is already apparent that the picture of hydroxyl ion disbondment is too simple, and complex oxide reduction steps are also involved in the process. This work is to be extended using impedance measurements, such as those now in vogue with US investigators of protective coating systems.

An elegant example of the use of surface science techniques to study practical problems is research on the wetting behavior of brazing alloys used for joining high-temperature components for gas turbine engines. Many of these alloys, such as Au-Ni, are quite satisfactory for this application. They are very expensive, however, and cheaper alternatives are being sought. Among other things, any substitute alloys developed must have the same or very similar wetting behavior as the Au-Ni. But until this investigation, that behavior had not been characterized and it is the motivation for the present research.

The wetting studies were carried out on the hot stage of a scanning electron microscope (HSSEM). The alloy, 82w/o Au - 18w/o Ni, was melted in contact with Jethete steel, an oxidation-resistant stainless steel. The use of the HSSEM in conjunction with Auger spectroscopy and ion probe microanalysis allowed the wetting mechanism to be defined in great detail. The investigation showed that the steel initially was covered with a Cr_2O_3 layer about 100 nm thick. When the Au-Ni alloy melts it does not wet this oxide and spread. Instead, the oxide is broken down under the center of a molten droplet and the braze alloy spreads by penetration of the interface between the oxide and the metal substrate. The initial breakdown step is theorized to be a reduction of Cr_2O_3 by Si of the alloy in the low oxygen environment that exists beneath the center of the braze metal droplets. Of particular interest to me was the detailed information that was obtained on a microscale b, bringing a number of surface science techniques to bear on the problem. Certainly, this approach should enable researchers to undertake many investigations that have not been possible in the past. One such type of research that came to mind as we were discussing this project was a study of the oxidation of high-temperature gas turbine alloys by ingested sea salts—the "hot corrosion" problem.

In yet another research project, Castle's group is investigating the

incorporation of metal ions from water into growing passive films on stainless steel. This research is done in high-temperature water in autoclaves under 330 psi pressures. The phenomenon is, of course, of importance in reactors where a potential build-up of elements, such as radioactive cobalt, is possible due to the closed-loop cycles used. This could result in fixed contamination of the piping alloys.

While I was not able to visit Bailey's group, Castle did tell me about one interesting facet of the research of that group that was of particular relevance to him; that was their findings with regard to structure development during hydration of Portland cement, a research area of increasing importance to the group. By scanning electron microscopy, Bailey found that fibrous growth took place from the hydrating surface. It was theorized that the surface is a semi-permeable membrane, and that the osmotic pressure built up during the hydration process resulted in localized rupture of the surface, with subsequent fiber growth through the point of rupture. Castle felt that the corrosion products on some of the alloys he has been investigating might grow similarly because of their nature. Subsequent examinations have shown this to be true. What this means in terms of the properties of films formed in this manner is open to conjecture.

Waldron told me about some of his interests in our brief meeting. Besides his interest in refractory materials, gained by his prior association with the UK Atomic Energy Research Establishment, he is very interested in the effect of composition on creep behavior of the 7000 series Al alloys. For these studies, he is using scanning calorimetry and both hot stage and transmission electron microscopy. He also is active in powder metallurgy research. Currently, he is looking at topics such as the effect of variability in powder characteristics on subsequent sintering behavior. The effect of strain in the powder appears to be a critical factor here. In addition, he is investigating high-speed tool steels made by powder metallurgy techniques, trying to obtain better uniformity of carbides and finer grain size to effect better properties. To carry out this work, Waldron has assembled a fine laboratory for particle classification and characterization. The laboratory contains about every type of instrument devised for powder characterization, including one of the first laser granulometers, which can size

a sample in the range of 1 to 2000 μm in 5 min. Research is currently being undertaken to improve this equipment in order to reduce errors due to particle morphology, such as would be encountered in powders with needle-like shapes.

Miodownik's physical metallurgy research, which I did not review, includes studies on martensitic transformations and alloy thermodynamics. He is particularly active with the CALPHAD group, which is an international group concerned with computation of phase equilibria. Another member of this group is MANLABS, Inc. in Cambridge, Mass., whose pioneering work in this area was sponsored for many years by the Office of Naval Research.

A visit to Surrey reveals high-quality materials research activities which are providing solutions to vexing technological problems. (Philip A. Clarkin)

2ND EUROPEAN CONFERENCE ON NON-DESTRUCTIVE TESTING

The 1st European Conference on Non-Destructive Testing (NDT) was held in Mainz, FRG, in 1978. This second conference was held 14-16 Sept. 1981 in Vienna, Austria.

The meeting was large, with 23 European and 9 overseas countries being represented, including the People's Republic of China. Of the 659 participants, the largest contingent (286) was from the FRG. About two-thirds of the more than 150 papers were presented in German, with the remainder fairly equally divided between French and English; most papers were simultaneously translated into German, French, or English. However, because of the large number of papers accepted for the meeting, the organizers decided to hold three concurrent sessions instead of the two originally planned. Unfortunately, for the author, simultaneous translation could only be supplied for two of the three concurrent sessions. And despite the theme of the conference, "New Developments and Special Processes of Non-Destructive Testing, Physical, Technological and Economic Limits," paradoxically, it was the sessions on Special Methods of Non-Destructive Testing were those for which no simultaneous translation was provided.

The inaugural lecture for the conference was by Prof. W. Koschatzky. His lecture, which was quite appropriate for the venue of the conference, the elegant Congress Center of the Hofburg, appeared out of place for the technical meeting that followed; Koschatzky is associated with the Albertina (Collection

of Graphic Arts) and gave a superbly illustrated talk on the history and masterpieces of Albrecht Dürer housed in the Albertina.

The technical meetings for each of the three days of the conference were initiated by a hour-long plenary lecture. No new results were revealed by these lectures, but they did give a reasonable overview of the current status of NDT. Prof. J. Dubresson (Inst. de Soudure, Paris) gave the first, a review of some of the various NDT methods used by industry and their limitations. For the conventional techniques, such as dye penetrant crack detection, he spoke of the improvements brought about by research on surface tension of the penetrants and on the design of developers that upon exposure to UV light fluoresce with colors to which the eye is most sensitive. He also spoke on penetrants for use up to 200°C for welding applications, and the use of krypton 85 radiography for detecting cracks in the 0.05 to 0.1 μm range. He mentioned the parameters affecting magnetic test procedures, such as the strength and character of the magnetizing field and the test time, he showed curves of the sizes of defects detectable as a function of field, and he discussed the advantages and disadvantages of alternating current vice direct current for generating the fields. For eddy current testing, the dependence on permeability, conductivity, and geometry was discussed, along with the use of multi-frequency probes and advances in equipment for test automation. In the case of radiographic examinations, Dubresson touched on various problems with conventional radiography, such as the subjectivity of the technique, radiography. In the area of ultrasonics, he pointed out the dependence of the technique on materials' properties: composition and structure, both microscopic and macroscopic. He mentioned the difficulty of detecting cracks in weldments using ultrasonics due to the inhomogeneities of the structure and the concomitant variations in sound velocities, and to the often complex geometry; he considers the technique to be most useful when used as a complement to radiography. Finally, Dubresson referred to holographic techniques; here he chose to discuss the application of holography as a quality control measure for cathodes of TV tubes.

The plenary lecture on the second day was given by Prof. E. Mundry (Bundesanstalt für Materialprüfung, Berlin). His subject was the determination of the type and size of defects by NDT, and the limitations of NDT techniques for this purpose. One of the things he mentioned was the benefits of using multi-frequency eddy current testing rather than the single frequency techniques normally employed. He also talked about pulsed eddy current

techniques for determining the depth of defects below the surface. Computerized Axial Tomography (CAT), he said, was in its infancy as far as nonmedical use was concerned, and it was time consuming and expensive. In addition, objects of complex geometry were difficult to handle with CAT. Especially troublesome was the inability to maintain a specific source-object-detector geometry. Mundry was enthusiastic about acoustic holography as a very promising technique, with economics that make it applicable today.

The final plenary lecture was given by S. Wise (British Railways Board, UK). He talked primarily about the application of ultrasonic techniques for NDT of railroad equipment, rails and axles. A good part of his lecture was concerned with the difficulty of using ultrasonics for determining defects in components of complex geometry. In these items, defect indications can often be masked by unusual interactions of the ultrasonic beam with the boundaries of the part being tested. He also illustrated this with a clever photoacoustic technique for determining the interaction of ultrasonic waves with various steel parts; essentially, it is the same technique used for photoelastic stress analysis. The part of interest is modeled in plate glass and observed with polarized light in transmission. The passage of ultrasonic waves through the model can be observed due to changes in birefringence of the glass brought about by pressure variations. Since the velocity of longitudinal and shear waves in plate glass is almost the same as in steel, Wise feels that one can get a good idea of the interaction of ultrasonic waves with steel components in this manner.

The technical sessions that followed the plenary sessions were on generation and propagation of ultrasound and its use for defect definition; radiographic techniques; dye penetrant and magnetic particle detection of surface flaws; use of eddy currents for NDT; acoustic emission methods; determination of residual stresses by X-ray and ultrasonic techniques. The following sampling of the papers is only representative of the meeting content.

About one-third of the papers were concerned with some aspect of ultrasonics. A few were on techniques for generation of ultrasonic waves in materials, for instance, L. Niklas (Krautkraemer-Branson Int., FRG) spoke on the sound field produced by short pulses and shock waves. He uses a YAG laser both to produce the shock wave in the material and to measure the wave by laser interferometry. Changes

are observed in the shape of the pulse front as it transits the material and in the return pulse by moving the detector about the specimen axis. He was particularly concerned with distortions in the near field and a comparison of those produced by the laser method and by piezoelectric transducers. H.J. Salzburger (Frauenhofer IZFP, FRG) described equipment called EMUS-OP, for exciting ultrasonic surface waves by electromagnetic induction, along with the results of experiments on specimens with real and model flaws. H. Seiger (Krautkraemer GMBH, FRG) and K. Høgmon (Det Norske Veritas, Norway) gave some details on new developments in ultrasonic probes. With Seiger's probe the head could be electrically adjusted to change the beam angle and size. Høgmon's development involved a probe in which coupling to the work piece was through a rubber wheel. The wheel probe works at speeds up to 6 m/s for thickness measurements, and has been used for probing corrosion damage on offshore pipe lines. P. Dalberg (Det Norske Veritas, Norway) described a four-probe ultrasonic technique for surface crack sizing. One transmitter and three receivers are set up to detect longitudinal waves. The principal advantages of the technique *vis-à-vis* the two-probe technique are: it is not dependent on separation of transmitter and receiver, and no symmetry about the crack is required. In applications such as T-butt weld crack detection it would be more flexible than the two-probe technique, but it is less accurate and sensitive than the two-probe technique.

Several papers on methods of focusing and scanning beams were given in the ultrasonics sessions. For example, B. Kuhlrow (Tech. Univ., Op. Inst., Berlin) gave the results of his calculations of sound fields formed by spherical lenses and Fresnel zone plates. He also showed Schlieren photographs, made with a pulsed laser technique, of the sound fields produced in water by using the various focusing methods. P. Bardouillet (Frametome-Servise Documentation, France) described an apparatus for focusing and scanning beams electronically. The prototype system consists of 128 flat piezoelectric plates, 32 of which can be excited at one time. The system at this time is limited to operation on flat surfaces. H. Wüstenberg (Bundesanstalt für Materialprüfung, Berlin) compared the performance of focusing probes using lenses with focusing achieved by electronically controlled annular arrays. His principal conclusion was that the electronically controlled arrays were

superior because the focal spot length could be increased without increasing the sidelobe levels.

Typical of papers on the characterization and measurement of the sound fields produced by transducers was that by H. Gundtoft (Risø Nat. Laboratory, Denmark) on three-dimensional scanning of ultrasonic sound fields in water. The apparatus was a modified milling machine. The transducer to be studied was mounted in the rotating chuck and immersed in a tank of water on the movable table. A ball reflector in the tank could be accurately positioned in three dimensions with respect to the transducer, and the field was characterized by the intensity of the echo from the reflector. Data were stored in a computer for later analysis. Another interesting paper on transducer characterization was given by J. Vrijen (B.V. Neratoom, The Netherlands), who described a prototype machine, the Neravite, in which liquid crystal detectors were used to probe the sound field of a transducer in water. The acoustic energy was detected by thermally induced color changes in the liquid crystal. The method gives qualitative differences in acoustic energy and can be calibrated with independent techniques to reveal quantitative dB differences in the sound field. The measuring range is presently limited to about 8 dB with a resolution of about 1 dB. Plans are to extend the range to 25 dB with about the same resolution. The Neravite has been demonstrated using transducers in both the pulsed and continuous mode.

The bulk of the papers of the ultrasonics sessions were on practical ultrasonics for both stress and flaw determination. Typical of the applications were detection of cracks in nodular cast iron automotive castings; residual stress measurements in bolted joints by transit time measurements; acoustic holography for measuring cracks in clad materials; ultrasonic testing of weld seams; detection and quantification of slag inclusions in steels; flaw detection in diffusion welds of materials with marked differences in composition, such as Al-stainless steel; testing of electron beam welded turbine wheels; control of welding processes for large diameter pipe; and automation of ultrasonic testing processes. Several papers in the application sessions dealt with the problems associated with the detection of flaws in austenitic welds brought about by weld geometry and by the variability of sound velocity in the weld and parent metals.

Papers in the sessions on radiographic inspection techniques could be categorized as (1) Those describing methods of obtaining more information from radiographs.

Typical of these were the description of factors affecting the practical speed of industrial radiographic film by L. Coutel (Kodak-Pathe, Paris); defect size measurements using a microdensitometer on a radiograph, described by M. Delenze (C.F.A., France); methods of optimizing lighting conditions for viewing radiographs, given by R. Bollen (AGFA-GEVAERT NV, Belgium); and a Monte Carlo method for simulating a radiographic system to arrive at the influence of metal screens on the quality of radiographic images, presented by W. Aerts (Katholieke Univ. Leuven, Belgium). (2) Papers concerned with high power sources for use in radiography.

Among the topics represented were the use of a 10-MeV linear accelerator for X-ray generation by M. Hampejs (Hauptstelle f. Zerstörungsf. Prüf., Czechoslovakia) and of the use of a 35-MeV machine for neutron radiography by H. Heidt (Bundesanstalt für Materialprüfung, Berlin); the design of a new microfocus X-ray machine by J. Madsen (Andrex N.D.I. Products Ltd, Denmark); and digital gammagraphy for steel by J. Dumont-Fillon (IRSID, France); in his system, the radiographic film was replaced with scanning scintillation detectors to obtain digitized images which could also be enhanced.

(3) Presentations on tomographic methods. F. Lévai (Tech. Univ., Budapest), for example, described a method in which a moving film was exposed by an X-ray beam that had transited a rotating specimen. The radiograph produced, which he called a sinogram, revealed the flaws present in the exposed section. Different types of defects could easily be identified and located by analysis of the patterns on the sinogram. Similarly, P. Reimers (Bundesanstalt für Materialprüfung, Berlin) a simulated CAT scans for arbitrarily shaped test objects and compared the results with actual scans. (4) Descriptions of equipment development. Typical

was the presentation by Baltean-Shelumberger (Balteau S.A., Belgium) on the development of a new series of lightweight X-ray generators; weight reductions of 50% have been accomplished (200-KV generator weight reduced from 45 to 21 kg), primarily by reducing transformer weight. (5) Presentations on applications of radiography to real problems. These constituted the majority of papers in the session. Sample topics addressed were radiographic testing of welds between tubes and tube-plates of heat exchangers; radiographic testing of steel-fiber reinforced concrete in tension and three point bending; radiography of gas transmission pipeline welds; computerized calculations of exposure required of radiographic film using source-object-film parameters; and problems with radiographic inspection of Ni superalloy castings due to inhomogeneities of composition and structure.

The presentations on the detection of surface flaws with fluorescent penetrants

were concerned with the effect of surface tension, viscosity, and temperature on penetrability, the structure of developers and the relationships of powder size to ability to detect cracks. Spherical developer powder of 20 to 40 μm diameter appears optimal, and there are economic advantages of electrostatic spraying methods for penetrant and developer application. New, biodegradable penetrants are being developed to meet more restrictive environmental laws, and several new penetrants with sensitivity and costs competitive with currently used penetrants have been developed.

In the session on detection of surface or near-surface flaws using magnetic particle inspection, major emphasis seemed to be on methods of automating or speeding up the inspection process. Both H. Scharlemann (Klöckner-Werke AG, FRG) and V. Deutsch (F.A. Karl Deutsch, FRG) spoke on automated techniques for determining defects in, for example, rails. Scharlemann employed powder spraying, magnetization with alternating current, and video inspection. Speeds of 0.5 m/s could be used while detecting cracks as small as 0.2 mm thick and 2 to 5 cm long. Deutsch's system was developed under sponsorship of the German Federal Ministry for Research and Technology. It used orange-red fluorescent particles for crack definition and a video scan with programmable pattern recognition capability for detection. In another paper describing a method for speeding up inspection of complex components, W. Kern (Tiede GMBH & Co Risspruefanlagen, FRG) spoke on the use of multiple magnetizing circuits for picking up cracks of various orientation. Up to eight magnetizing circuits were employed, using alternating current and phase shifting of the circuits to effect changes in magnetizing direction.

Sessions on the use of eddy currents for NDT were primarily applications oriented, with tube and rail inspection of particular interest. D. Plaschke (Kontrolltechnik GMBH, FRG) talked on internal inspection of ferromagnetic tubing using eddy currents. He showed how spurious "flaw" signals in a conventional eddy current test that were caused by local permeability variations could be separated from the signals from real defects by pre-magnetizing the material under test. His equipment could detect defects at speeds up to 30 m/min. P. Scholten (Thyssen AG, ABT. Mess-U. Prueftechn., FRG) had an automated system for detecting flaws in rails at speeds of 1.5 m/s. In the test, signals from eddy current probes were compared with signals obtained by cataloguing 60 different types of

defects. If the probe signal exceeded a defect threshold signal, a marker system was triggered. R. Becker (Fraunhofer IZFP, Saarbruecken) and W. Polanschutz (Voest-Alpine AG, Austria) both talked on the use of eddy currents for sorting plain carbon and low alloy steels, and on the effect of differences in a material's conductivity and permeability on the usefulness of the technique. M. Stadthaus (Bundesanstalt für Materialprüfung, Berlin) described a pulsed eddy current technique for detecting covered cracks emanating from fastener holes in riveted aluminum sheet structures. Difficulties associated with the low conductivity of the titanium fasteners were overcome by computerized signal processing methods.

The author did not attend sessions on Special Methods due to lack of translation facilities, but according to the program, papers were presented on the following subjects: (1) the application of synchrotron radiation for conventional X-ray stress analysis and for Lang and Berg-Barrett topographic analysis of dislocation structures; (2) the development of a portable X-ray device for stress analysis using position sensitive detectors; (3) residual stress measurement with ferromagnetic and magnetoelastic methods and their dependence on microstructure; (4) residual stress determination by combined time-of-flight and attenuation measurements using polarized ultrasonic shear waves; (5) the use of thermography for detecting laminations in sheet steels; (6) methods for reducing the influence of variable sound velocities on the localization of acoustic emission sources; (7) the use of acoustic emission to monitor mechanical tests on heavy structures, crack initiation and propagation at welded joints, and corrosion fatigue damage.

To summarize, the large number of attendees and papers at this conference attest to the importance of nondestructive testing methods to industry. The presentations certainly showed that European industry is actively using state-of-the-art NDT tools and techniques. By a considerable margin, ultrasonic and radiographic techniques were of most interest to the audience. Less refined techniques, such as acoustic emission, were of secondary importance; completely new NDT methods were not in evidence. In the areas of ultrasonics and radiography, the presentations reflected the desire to "fine tune" the techniques, to enable the operator to extract more specific details of defects observed. Papers on eddy current, magnetic particle, and dye penetrant inspection methods indicated the desire to automate, both to speed up inspections and to remove operator subjectivity. (Philip A. Clarkin)

OCEAN SCIENCES

MARINE TECHNOLOGY AT STRATHCLYDE UNIVERSITY

The Department of Civil Engineering at Strathclyde University, in Glasgow, has seven senior staff members who are doing research in marine technology and oceanography. It is interesting to note that there have been no personnel changes in the group during the last decade. I was able to interview five of the seven during a recent visit and also to learn about marine technology activities in other departments of the university.

The head of the department, Prof. D.I.H. Barr, is a mathematical modeler. He said that his principal interest was in the application of theoretical mathematics to practical engineering problems. He gave me two examples showing how he had developed mathematical models and then tested them with physical models in the laboratory. One had to do with the dissipation of heat from a projected large power plant on the tidal portion of the Firth of Forth, and the second was concerned with sediment transport in estuarine channels of various sizes and shapes and with varying amounts of runoff. His latest paper was on improving methods of teaching dimensional analysis to engineering students.

My host during the visit, Dr. P.H. Milne, has probably devoted more of his time to marine technology than the other staff members. He has worked on the engineering aspects of aquaculture, underwater engineering, and storm surges. Most of his more recent research has been concerned with the North Sea oil industry. He has been concerned with the design, development, and testing of a combined underwater closed circuit television (CCTV) and underwater acoustic navigation system for divers. The system is for use in underwater inspection, maintenance, and repair in the North Sea oil and gas fields. Several thousand divers are employed in the almost continuous underwater surveillance required on the drilling and production platforms, and on the very long seabed pipelines that connect the oil rigs to processing plants onshore. This work is required to maintain certificates of fitness, to assure the operators that the structures used are reliable and safe, to carry out repair work associated with accidents, and to make modifications.

The system is now being used by hard-hat divers. The CCTV is called SIMON (Strathclyde, Inspection, Maintenance On Navigation). The position fix and

navigation system is called SARAH (Strathclyde Acoustic Range and Height). The system is quite complicated and complete. It allows an operator on the surface, from either a fixed oil platform or a ship, to see continuously and record exactly what the diver below him sees, to keep in constant voice contact with the diver, and to keep track of the diver's exact position and depth. It even has bail-out breathing tanks for the divers if they get tangled up. The whole system is computer controlled.

Milne had completed most of the work on SARAH and SIMON when I visited him and was starting on a new project that was funded by the Science Research Council. He is now designing floating breakwaters for the protection of shorelines and offshore engineering structures, harbor repair operations, and marinas. At the moment, he is considering double and triple lines of floating structures. Individual units may be as much as 300 m long, which is about the limit of the length of structures that can be built in present shipyard facilities.

Mr. R.C. Collar has been working on problems associated with estuarine pollution. Most of his work has been associated with practical engineering problems in estuaries and on the coast. The river Clyde, which flows through Glasgow west to the Atlantic Ocean, carries a heavy load of industrial pollution from factories and shipyards that line the river and its estuary for miles. Collar had developed and built a physical model of the Clyde estuary to study pollution and circulation, and in particular to investigate the potential effects of modifications to the geometry of the estuary on the circulation of the estuary. Modifications under study were fills, cuts, and major channel deepening. The model has been closed because it was found that a modern computer-based mathematical model that is tuned with field data is reliable, faster, and less expensive than Collar's physical model.

Recently, Collar's work has moved in the direction of applied hydrology. He mentioned that 75% of the department's students are from underdeveloped countries. Many of the problems that their governments face are related to hydrology rather than to marine technology. A technical problem is to develop statistical techniques for extracting information from small amounts of data.

Dr. J. Ellis is interested in the mathematical modeling of tide and bore propagation in estuaries. He has developed and perfected a tidal model of the Clyde river and estuary system. The model is now used to predict the effects of future changes in the geometry of the Clyde, such as restricting dredging to the lower reaches of the estuary, filling large docking areas that have been cut into the banks, changing the position of weirs,

and placing engineering structures in the estuary. Ellis also has studied the various methods that have been developed for using computers to model unsteady flow in open channels, and he has concluded that no one method enjoys a monopoly of advantages.

Dr. J.F. Riddell's area of interest is dredging from the viewpoint of a consultant. His PhD thesis was on density currents in locks. He has also written a book entitled *Clyde Navigation - a History of the Development and Deepening of the River Clyde*. The importance of dredging in the Clyde is borne out by the fact that in one 30-km (18.6 miles) segment, nearly half a million cubic meters of sediment are removed each year, and five dredges (only a few less than the number of dredges that the US Army Engineers operate on the west coast of the United States) are kept busy during the height of the dredging season.

Riddell is interested in all phases of sediment movement and removal in rivers and estuaries, beginning with the control of rivers that supply sediment. His studies are directed to the effects of altering channels, and to determining what size new channels should be, in order to prevent flooding upstream, scouring on the banks, or shoaling on the bottom downstream. Riddell is dedicated to increasing the efficiency of dredging and to developing methods of preventing fraud by quantifying exactly how much solid material is actually being removed. He feels that control of contract dredging should be tightened (much of the dredging around Great Britain is done by foreign firms). Riddell teaches classes in all aspects of dredging as part of the curriculum in civil engineering, and he also conducts short courses for authorities and companies involved in dredging.

Methods of determining the density of sediments on the bottom and within dredges and barges have not been very exact in the past. Riddell uses a silt density probe consisting of a source and sensor for cesium 137. Gamma rays pass into the silt and are scattered or reflected. The number reaching the sensor is a function of both the density and nature of the sediment. With the probe, Riddell can determine accurately the density distribution within a dredge or barge or on the bottom.

One interesting fact that he has discovered is that the efficiency of certain types of dredges can almost be doubled in the Clyde estuary by overdredging. To accomplish this, areas where rapid silting takes place are selected and overdredged well beyond the design

depth to form sediment traps. As a result, the material dredged the next time is compacted, and it arrives at the dredge with about half the water content of materials dredged elsewhere.

A number of researchers outside of the Department of Civil Engineering are also working on marine-oriented projects as part of Strathclyde University's Project MASS (Maintenance Activities Subsea Surface). About 5 years ago the university was one of four selected by the Science Research Council for large-scale block funding; the idea was to assemble an interdisciplinary team that could speed up the development of marine technology, with special reference to the North Sea oil operations.

Prof. W.W. Fletcher and Dr. R. Kirkwood of the Biology Department are endeavoring to develop an understanding of the composition, distribution, development, and effects of marine growth (fouling) in offshore structures, particularly those related to the oil and gas industry, so that they can predict the nature and extent of fouling liable to occur on a structure at any given location. They are also undertaking a critical review of the present state of the art in control of fouling organisms. The review will extend the scope of identification work that is already being carried out, and should also determine whether existing expertise in the field of pesticides can be applied in the marine environment. In collaboration with Milne, Drs. C.J. McLeod and T.S. Durrani of the Department of Electronics and Telecommunications (Dept. of E&T) are designing an ultrasonic wave device for examining thick plates and welds. The device is part of an automated system for inspecting and testing offshore structures *in situ*. These scientists have also helped Milne with the SARAH and SIMON projects.

Prof. A.M. Rosie (Dept. of E&T) is leading a team working to provide wide-band wireless communication systems for use near large underwater structures. One advantage of such a system is that it would give remote, closed-circuit television capabilities to surface-controlled, unmanned, untethered submersibles like Heriot-Watt University's ANGUS (ESN 34-9:458 [1980]). Closed-circuit TV now requires an umbilical cord between the submersible camera and the surface ship or platform. Successful prosecution of wireless control would be a tremendous boost to the development of oil rig inspection systems that do not employ human divers.

In the same department, Prof. C. Kuo's team is working on improved methods for handling manned submersibles and other

equipment through the air-sea interface. The team is also attempting to improve mooring systems and to develop better remotely controlled underwater manipulation systems. Kuo has work going on remotely controlled manipulative systems for carrying out a variety of underwater jobs.

Dr. K.J. MacCallum (Dept. of Shipbuilding and Naval Architecture) and Dr. K.J. Christopher (Dept. of Operations Research) are developing systems models of various aspects of offshore inspection and repair. They wish to identify those technical areas of offshore inspection and repair that might benefit most from future research work.

Mr. S. Parinson and Dr. M.A. Saren (Dept. of Marketing) are analyzing the contribution made by new technology to the success of companies that supply subsea inspection and maintenance services to the offshore oil industry. They are endeavoring to indicate to companies and other institutions the most efficient approaches to developing new technologies in the offshore industry. In addition, they are providing information concerning future technological and market conditions to members of Project MASS, the offshore industry, and others as an aid to R&D and marketing decision making.

The diving effort in the North Sea is perhaps the world's largest; it is very expensive and very hazardous. Millions of dollars a year are being spent at Strathclyde University, Heriot-Watt University, and other research centers to make divers more efficient, to improve their safety record, and, where possible, to cut down on the number of divers needed. (Wayne V. Burt)

OPERATIONS RESEARCH

BUDAPEST DECISION CONFERENCE

Understanding and improving decision making necessarily involves a variety of disciplines: psychologists to clarify what decisions people want to make and what methods are used intuitively, economists and operations researchers to propose ways to make those decisions optimally, and management scientists to make those formalizations useful to people and organizations. Although these professions should interact, it is not often that they do. One of the occasions that regularly brings them together, however, is a biennial European Conference on these matters rather clumsily titled, "Subjective Probability, Utility and Decision Making." The eighth of these conferences was held in Budapest, August 24-28, 1981.

In addition to its disciplinary mix, the conference has other unique characteristics. A prosaic one is that it has no visible means of support. There is no continuous sponsoring organization, no institutional benefactor, no endorsement, not even a permanent organizing committee. Rather, the final session of each conference is devoted to "volunteering" a committee and site for the next meeting. That committee is then entrusted with finding essential local facilities to hold the meeting and with ensuring the quality of the scientific program.

One of the essentials is the provision of supplementary hard currency funds for scientists from Eastern Europe who would otherwise be unable to attend. There is also a strong commitment to creative working ties among scientists in eastern and western countries, and this serves to promote a remarkable sharing of experiences between students and practitioners of decision making in different places.

Although Eastern Bloc scientists are known for their contributions to mathematical models of decision making, some of the more interesting presentations at the meeting dealt with the experiences of practitioners there. For example, Prof. Oleg Laricher (All-Union Institute of System Sciences, USSR) reported his disappointment with overly formalized approaches to decision making. These, he felt, failed to capture the decision maker's true concerns, and they were not compatible with the needs of organizations. To be useful, Lariche maintained, the models have to be supplemented by "soft science" techniques that can elicit from decision makers what their problems really are. Interestingly enough, he illustrated his thesis with examples from US strategic decision making; perhaps this choice was due to the unavailability of comparable material from the Soviet Union. Other application experiences with decision-making methods came from Bulgaria, Poland, and Hungary. The Hungarian Office of Industrial Planning, incidentally, was one of the local sponsors of the meeting, along with the Hungarian Academy of Sciences.

A western application that generated considerable discussion was reported by Dr. Rex Brown (Decision Science Consortium US). The goal was to devise an optimal scheme for inspecting facilities containing radioactive materials to detect thefts and diversions. While the problem might seem to be just a matter of sampling and evaluating evidence, it becomes rather more complicated when one considers the differential usefulness of separate kinds of information. The result is an elaborate decision analysis that considers the possible action options and the consequences that might be associated with each (e.g., if you announce a suspected diversion, you might cause the accused country to pull out of the inspection

program). A necessary component of any attempt to model a decision problem is finding out what outcomes the decision maker would like. But Brown's case showed how eliciting those values becomes quite difficult when organizational constraints or diplomatic protocols prohibit candor, or when decision makers have difficulty in discriminating among their own well-being, that of the organization that employs them, and that of the society in which the organization resides.

These problems arise, of course, in less esoteric settings than those associated with international inspection of critical materials and events. Indeed, value elicitation was another recurrent topic of the conference. In a provocative major paper, Dr. Henry Montgomery (Univ. of Goteborg, Sweden) argued that people simply do not have rigid value structures that enable them to make explicit trade-offs between different values (how much of X would you be willing to forfeit in order to gain an additional unit of Y). Rather, people have a rough idea of what they want, and they experiment with various ways of thinking about a choice problem until they find some perspective that allows them to identify some one option as superior to all others. As a result of this kind of processing, people's choices can be very sensitive to what perspectives happen to come to mind or are suggested to them from nearby sources. Montgomery's position indicates that considerable subtlety is needed to discover what people really want.

One group of researchers that seems to be taking this message to heart is comprised of those who are studying people's attitudes toward technological hazards. In this area, a number of largely independent research efforts, as well as a working group convened during the conference, seem to be reaching a quite similar conclusion. It is this: lay people's attitudes are more complex than is usually acknowledged by technical specialists. When experts and lay people disagree about the acceptability of a particular technology and its associated hazards, it is not always because they view the facts differently. At times they are simply using terms (e.g., risk) differently, and often they disagree about what the decision problem is. In this setting, Dr. Stephen Watson (Cambridge Univ., UK) advanced a "phlogiston theory of risk," arguing that "risk" is not a unitary substance about which sensible decisions can be made. Empirical attempts to find out what people expect from undertaking risks were described by scientists from Holland, Sweden, Hungary, the UK and the US.

A final issue that appeared and reappeared at the conference was the concern over the disparity between research and application. How can research be made more relevant to practitioners? How can practitioners ground their efforts in empirical evidence of efficacy? These questions engaged many participants. Dr. A. Lock (Kingston upon Hull, UK), Dr. D. Drianov (Bulgaria), Dr. R. Hogarth (Univ. of Chicago, US), and Dr. A. Vari (Hungary) all looked at organizational barriers that tend to distort decision-making procedures and that cause them to stray from the "ideal" solutions indicated by research. Dr. H. Kunneuther (Laxenburg Center for Systems Analysis, US), Dr. J. Linnersoothe (Austria), and Dr. J. Lathrop (Woodward-Clyde, US) proposed ways in which credible decision-making procedures could deliberately be altered to accommodate the perspectives of the participating parties. Drs. R. Ferrell (Arizona State Univ., US) and M. Bar-Hillel (Hebrew Univ., Israel) and Dr. L. Phillips (Brunel Univ., UK) described some research and made some speculations on how the non-optimality of peoples' intuitive judgments presents problems and prospects for the purveyors of decision-making methods; problems because the methods often have unrealistic expectations about the quality of judgmental inputs, and prospects because psychological research often points to reasonable adjustment of the idealized models. As several investigators noted, a great contribution to the linking of research and practice was working meetings like this one, where researchers and practitioners can meet to discuss their problems.

The ninth conference in the series will be held in Gronigen, The Netherlands, in August 1983; the organizer is Dr. Charles Vlik, Psychology Department, University of Gronigen. Proceedings of the Budapest conference are now being edited by Dr. Patrick Humphreys (Brunel Univ., UK) and Dr. Anna Vari (Budapest). The volume will be issued jointly by North-Holland Press and the publishing house of the Hungarian Academy of Sciences. (B. Fischhoff, MRC Applied Psychology Unit, Cambridge)

PHYSICS

FIRST EUROPEAN CONFERENCE ON INTEGRATED OPTICS

The First European Conference on Integrated Optics was held in London at the Institution of Electrical Engineering

(IEE) on 14-15 September 1981. Organized by the IEE in association with the Institute of Mathematics and the Institute of Physics, and with the support of the Convention of National Societies of Electrical Engineers of Western Europe, the meeting had 9 single sessions over the 2-day period. Delegates from 23 different countries attended, and although the conference was labeled "European," there were attendees from much farther distances: Japan, Korea, Australia, Brazil and the US. Of the 254 delegates, the largest group was from the UK (132), followed by FRG (28), France (15) Japan (15), Italy (14), US (12), Sweden (7), and Switzerland (5). In the 30 contributed, 5 invited, and 6 post-deadline papers, the subjects covered were materials and passive devices, theory, modulators, electro-optic devices, new devices, lasers, semiconductor devices, acousto-optic devices, signal processing, and fiber sensors.

Work on lithium niobate (LiNbO_3) received considerable attention. Optical wave guides made by diffusing Ti into lithium niobate were discussed by V. Langmann (Inst. für Elektronik, FRG), who noted that chemical etching of diffused optical waveguides on the +c and -c faces of c-plate (Z-cut) lithium niobate showed different characteristics.

This crystal orientation, with the optical crystal axis perpendicular to the substrate surface, is often used for directional couplers, but so far, little attention has been given to the choice of +c or -c faces of the substrate for device utilization. In the experiments discussed by Langmann, directional coupler structures of 3 and 5 μm waveguides were fabricated on both the +c and -c face. After diffusion by heating in air at up to 600°C, etching of the faces revealed different characteristics. Undiffused lithium niobate remained nearly unchanged on the +c face after etching, whereas the -c face showed triangular or conical etchpits. The authors believe that these differences are a result of the crystal structure; and they conclude that because the treated -c faces have less complex structure, they are to be preferred for integrated optical circuits.

Other work on lithium niobate was discussed by A.D. McLachlan (Univ. of Glasgow), who presented results on slab waveguides fabricated by the electron beam evaporation of Ti onto y-cut lithium niobate substrates, followed by diffusion at 1,000°C in a sealed system. The measured effective propagation constants for these waveguides agreed with those calculated for propagation of TE modes in slab waveguides by the numerical

analysis of a multilayer structure. Channel waveguides were also fabricated; these had poorer agreement between theory and experiment. An additional consideration is that the power propagated by a 10- μm channel waveguide was found to vary with time. The higher the throughput power, the more pronounced the damage and the quicker the effect occurred. For 85- μW throughput power, the waveguide power diminished to less than half in under 10 seconds.

End fire coupling between fibers and strip waveguides in lithium niobate was discussed by M.B. Holbrook (Univ. of Glasgow). Butt-coupling was found to have a loss of approximately 6 dB when using a multimode fiber. This figure is expected to improve with the use of single mode fibers, with the use of waveguides whose dimensions are designed to optimize the field overlap between the fiber and the waveguide, and with the use of antireflection coating. The method does, however, have the difficulty of adjusting the fiber in its kinematic mount. Alignment of the fiber with the waveguide by means of grooves milled in the lithium niobate is another proposed method, but this is difficult because the material is not amenable to chemical etching. Holbrook's group has worked with ion-beam milled alignment grooves. The groove depth required is in excess of 3 μm , which introduces difficulties in the construction of suitable masks. Carbon was used in the construction of a demonstration device, but the resulting mask was poor. Holbrook said that more work is being put into the development of high quality carbon masks.

An interesting temperature-compensated prism coupler was described by F. Auracher (Siemens Research Laboratory, Munich). Prisms of lithium niobate are efficient devices for coupling into planar waveguides. However, one difficulty is the strong temperature dependence of the coupling angle upon temperature—in many devices a temperature change of only 5°C causes a loss in coupling efficiency of 3dB. To have the input angle for the laser beam independent of temperature, it is necessary that the coupling prism and the lithium niobate substrate have compensatory temperature coefficients of the index of refraction. This is not possible with a single prism made of any commonly available material. Auracher and his colleagues have solved the problem by using a combination of two prisms, one of lithium niobate and the other of a different material. Calculations of a suitable parameter range for the other material show that plexiglass is on the borderline, and that polystyrene falls well within the acceptable range of desired negative temperature coefficient of the index of refraction. A combination prism constructed of lithium niobate and polystyrene gives essentially

zero change of the required coupling angle over the temperature range from 0 to 100°C.

Ion exchange waveguides in which silver ions are deposited into a glass substrate were discussed in several papers. E. Voges (Fern Universität, Hagen, FRG) stated that the profiles of ion exchanged strip waveguides are mainly influenced by the applied external field and that the precise calculation of the resulting index profile is possible. The calculations and the experimental profiles visualized by interference contrast show great similarity. The results of loss measurements in this type of waveguide were presented by J. Viljanen (Technical Research Center of Finland), who stated that the main reason for loss was the scattering and absorption by submicroscopic silver particles. The introduction of colloidal silver particles is an ancient process for making yellow stained glass, and the colloidal silver is evident in these waveguides in the 400-nm absorption peak. Soda-lime, borosilicate, and BK-3 glass were used as substrates in the studies, with the latter two materials showing less attenuation. Iron in soda-lime glass contributes a small absorption peak in the near infrared (1100 nm) and also, it is claimed, serves to neutralize the silver, which then can precipitate as a neutral particle. Therefore, another conclusion of the paper was that to produce low-loss waveguides, it is necessary to use substrate glass that is free from iron. Directional couplers and waveguide bends in silver ion exchange glass were the topic of the paper by R.G. Walker (Univ. of Glasgow), who showed a picture of the divergent output arms of a directional coupler in which the ratio of the intensities was 5 dB. Walker also showed pictures of bends in strip waveguides down to radii of 130 μm .

Fabrication of strip waveguides in organic photochromic materials was described by A.G. Hallam (Allen Clark Research Centre, Towcester). The photochromic material of a class known as organic fulgides and an optical fiber to which the waveguide will be coupled are sandwiched between two layers of Plexiglas at an elevated temperature. The strip waveguides are formed by writing on the photochromic fulgides with a focused UV light beam. Absorption of the UV light causes the photochromic fulgide to be converted to the colored state, which has a higher index of refraction than the uncolored one. Writing is done by focusing the light from a low-powered He-Cd laser onto the photochromic material, whose motion is controlled by a computer-

driven mechanical translator. Hallam claims these waveguides are stable to temperatures over 100°C and have a lifetime at ordinary temperatures in excess of 10^4 years.

Geodesic lenses are well known to microwave workers. In optics they have not been used much except in integrated devices. In integrated optics, a geodesic component is a depression in the waveguide whose guiding properties permit the optical beam to enter the depression region. The actual path of a ray can be determined from Fermat's principle, and it turns out to be a geodesic over the depression region. For a spherical depression, the geodesic path is the arc of a great circle. Unlike an ordinary lens, focusing of a beam results from changes in the actual geometrical path.

V. Russo (CNR Electromagnetic Research Institut, Firenze) discussed construction of integrated optic spectrum analyzers using geodesic lenses and a transverse surface acoustic wave grating. (Some other components are discussed in *J.O.S.A.* 70 1230 [1980].) According to Russo, a first analysis showed that in a conventional arrangement of lens-grating-lens, the device would be quite long (140 mm) and therefore quite costly to manufacture. Introduction of a third lens on the output side was found to allow considerable reduction in length. However, Russo pointed out that to achieve the proper design, the location and fabrication of the extra lens was quite critical.

In a post-deadline paper, (G.F. Doughty, Univ. of Glasgow) discussed various fabrication techniques for geodesic lenses in lithium niobate. Grinding by ultrasonic impact has been used to form aspheric lenses. Polishing with a standard polishing machine of very small amplitude has been carried out successfully, but the results are difficult to reproduce. Consequently, a dedicated, computer-controlled polishing machine is now under construction at Glasgow.

Calculations of the diffraction effects in geodesic lenses were presented by J. van der Donk (Univ. of Ghent, Belgium). The difficult problem of propagation in a two-dimensional non-Euclidean space of constant index of refraction can be transformed into one of propagation in a two-dimensional Euclidean space of variable index. The resulting index profile is then considered to be divided into a set of idealized thin lenses through which different portions of the beam propagate. This so-called beam propagation method gives accurate focal spot sizes for wide beams (gaussian optics is sufficient for relatively narrow beams),

and it is amenable to showing the effects of fluctuations in the index of refraction or of scattering on the focal spot size.

Participation by US scientists, which featured papers from Bell Laboratories (2), University of California (1), and the Naval Research Laboratory (3), is only noted because the research work in the US is presumably familiar to ESN readers. The conference proceedings (IEE Conference Publication 201), which contains copies of the invited and contributed papers, can be obtained from the IEE Publication Sales Department, P.O. Box 26, Hitchin, Herts. SG5, 1SA, UK. The next meeting is tentatively scheduled to be held in Geneva during 1983. (John R. Neighbours).

UK PHYSICAL ACOUSTICS MEETING

In the fall of 1980, a 1-day meeting on physical acoustics was convened at the University of Bath by Dr. D.P. Almond, who saw a need for discussions with other research workers in the UK. That meeting was so successful that a second was held under the direction of Dr. P.J. King at the University of Nottingham on September 17, 1981. Both meetings were small, informal, and specialized. They were held without the sponsorship of any UK physics or acoustics organization, and as a result, the attendance costs to participants were dramatically lowered.

At these meetings, the ambiance was reminiscent of the author's student days in the US, when American Physical Society meetings were small enough to be held at universities and colleges. The Nottingham meeting had a total attendance of 30 from nine different universities. The 10 papers presented were by workers in seven different universities. Although the meeting was small, the quality of research represented was quite high.

Phonon spectroscopy of Cr doped GaAs using superconducting tunnel junctions was discussed by Dr. P.J. King (Univ. of Nottingham), who noted that the phonon distribution can be made essentially monochromatic by modulating the bias of the tunnel junctions about a particular DC voltage. When GaAs crystals are grown, the process usually introduces many shallow donors (Si) and Cr is often introduced to compensate them. Many experimental results have been explained by using a model in which Cr in various valence states substitutes for Ga in the GaAs lattice. King and his coworkers have made measurements on n-type, p-type,

and semi-insulating samples originating either from Czechoslovakia or England, over the range from 3 to 24 cm^{-1} (90 to 720 GHz), at a temperature of 1K. Results for p-type and semi-insulating samples were similar and show three partially resolved resonant absorptions at 4.2, 4.9, and 5.6 cm^{-1} , and a stronger, broader absorption in the region of 10 cm^{-1} . These lines are little affected by subband-gap illumination (1.13 to 1.55 μm) provided by a suitable filtered quartz iodine lamp. In contrast, the phonon spectrum from n-type material is photosensitive; none of the resonances described above are found if the sample is cooled to 1°K in total darkness. However, if the sample is illuminated with subband-gap light after cooling in darkness, all of the above-described features appear. When the light is removed, the features decay with a time constant of about 3 h. The set of lines near 5 cm^{-1} may be attributable to substitutional Cr in a +3 state.

When the low-temperature magnetothermal conductivity is measured as a function of applied magnetic field, maxima appear; this has been known for at least 20 years. The maxima are interpreted as frequency-crossing signals that occur when two phonon transition frequencies between the Zeeman split energy levels of the paramagnetic ions become equal. Dr. A.A. Ghazi, (Univ. of Nottingham) gave results of frequency-crossing phonon spectroscopy, using techniques described in a recent publication (*Rev. Sci. Instr.* 50 1634 [1979]). At 166 GHz, an instrument resolution of ~ 25 MHz has been obtained, which is more than sufficient to resolve the hyperfine splitting of V^{+3} impurity ions in Al_2O_3 . The limit of this technique is approximately 10^{-4} ppm, which compares favorably with the results obtained from resonance methods. Ghazi and his coworkers have used frequency-crossing spectroscopy to study surfaces. The sample was an Al_2O_3 crystal bar doped with Fe^{+2} in one half and V^{+3} in the other half. In all, there are eight crossings of all types, Fe-Fe, Fe-V, V-V, of which several Fe-V crossings ($\Delta m=1$) were examined. The signals were observed to decay with distance from the interface; this was interpreted to be a result of inelastic scattering at the crystal surface. It was concluded that a resonant frequency in one part of a crystal can be measured by tuning that of another ion in a different part of the crystal. A preliminary report of this work was given at a recent phonon conference in Bloomington, Ind., and full details are being readied for publication in the *Journal of Physical Chemistry*.

Relaxation peaks occur in many physical processes and often these peaks are broader and more asymmetric than simple Debye-like theory would predict. Such effects are

usually explained as a distribution of relaxation times, even though such an assumption may be unjustified physically. Dr. D.P. Almond (Univ. of Bath) advanced a new interpretation of mechanical relaxation peaks in ionic conductors and dielectric solids; most of his material had just been published as a letter (*Phys. Rev. Lett.* 47 431 [1981]). Almond pointed out that in dielectrics it has been shown (*Nature* 256 566 [1975]) that the response to a step function is characterized by two processes: at times which are short compared to a characteristic time, the primary response is the adjustment of dipoles, whereas at longer times the response is that in which the local charge screening is adjusted. In general, dielectrics display this two-stage response, with the second process being faster. Only very dilute concentrations of dipoles display Debye-like behavior, with a simple exponential response to a dielectric step function. Almond and his coworker, A.R. West (Univ. of Aberdeen), have taken the idea of the response being the result of the interaction of two independent many-body processes and applied it to the analysis of internal friction peaks. They fitted the internal friction peaks in γ alumina by a two-parameter function of the same type as that used to fit the dielectric loss data (for γ alumina). Fits of the internal friction data taken at frequencies ranging from 5.6 kHz to 240 MHz are convincing, and Almond and West suggest that this result may be evidence for cooperative ionic motion. Almond also emphasized that an important result of this interpretation is that the concept of a relaxation time is meaningless.

Some results on the laser generation of ultrasound using a NdYAG Q switched (30 ns) laser were presented by Dr. S. Palmer (Univ. of Hull). The laser pulse generates bulk longitudinal and transverse waves and surface waves. Standard transducers (4 to 10 MHz) are used to receive the ultrasonic signal. Two regimes are observed; these are dependent upon the incident laser beam intensity. For intensities up to $\sim 10^6 \text{ W cm}^{-2}$, the generation of ultrasound is in the thermoelastic regime, wherein the laser beam merely heats the surface so as to form an elastic dipole as a result of differential thermal expansion. At power densities of $\sim 10^7 \text{ W cm}^{-2}$ and greater, a plasma is generated adjacent to the sample surface. In this regime, the longitudinal signal increases (by 5 to 10 fold) and the shear signal disappears. In both regimes, the directivity of the generated wave agrees with theory, with the longitudinal wave agreement being

better. In addition to bulk wave generation, the laser beam is a strong source for the generation of Rayleigh waves, and Palmer points out that these waves may be directed by changing the shape of the laser beam spot. Palmer and his group are continuing these experiments, and they also are working on development of a standard source for acoustic emission, using a laser beam fired into a conical cavity.

Diffraction of a laser beam by a sound field is being used by Dr. S. Amit-Amer (City Univ., London) to visualize ultrasonic fields. The work is in the Raman-Nath interaction region, in which the square of the light wavelength is greater than the product of the width and thickness of the interaction region. A lens placed behind the interaction region gives the Fourier spectrum of the field. Amit-Amer blocks the zeroth order and measures the variation of the resulting intensity. He has measured the profiles of plane and cylindrical waves and the beam from variously shaped transducers. The method can obtain the distribution of pressure across a beam at various points, and combination of these data shows how a focused beam peaks in intensity. Amit-Amer claims to be able to obtain absolute calibration of a transducer by this method.

Impulse deicing of aircraft engines was discussed by Dr. G.J. Lewis (Univ. of Nottingham). This work, carried out in conjunction with Rolls-Royce, is concerned with the leading edge or "intake lip skin" of the engine nacelle. Present methods of deicing use hot air from the engines, with a resultant loss in thrust. Lewis is working on a system using impulse coils placed around a periphery of the lip skin; his scheme is covered by a Russian patent and has been taken up by workers in the US, France, and Britain. The impulse coils induce eddy currents in the plate, which then react with the coil field so as to move the plate slightly and crack any ice forming on the lip skin. The coils are driven by discharging a capacitor (2 to 750 μf) charged to 2.5 kV into the impulse coil by means of a thyristor switch. A large capacitor is best for damping the oscillation of the plate but it is quite bulky, so that some trade-off in parameters is required. The resulting impulse, which is proportional to the square of the charge voltage, is measured with a ballistic pendulum. Impulses of up to 2000 kg-m-s^{-1} have been obtained. As a function of plate thickness, the impulse delivered tends to saturate at a thickness dependent upon the particular material. The

saturation of the impulse curve is a universal one when the thickness is scaled in terms of the skin depth of the material. Lewis is continuing this work in order to find the most efficient coil shape; the Rolls-Royce group is studying the various modes of oscillation of these rather large structures (~ 8 ft. diameter).

After adjournment in the late afternoon, it was generally agreed that the meeting was successful in transferring a large amount of information between workers in a relatively exotic field. It is expected that another meeting will be held next year. (John R. Neighbours)

NEWS AND NOTES

NUCLEAR MAGNETIC RESONANCE IN MEDICAL DIAGNOSIS

Nuclear Magnetic resonance (NMR) methods for use in medical diagnosis are under development in several countries in Europe as well as in the US. Recently, a new application of NMR was announced. Called Topical Magnetic Resonance (TMR), the technique is used to study biochemical processes in living tissue. Working in close cooperation with the Oxford Instrument Company, a group of Oxford University biochemists led by Dr. G. Radda has successfully monitored biochemical processes in the arm of a 51-year-old patient. The procedure helped to disclose a rare genetic defect, McArdle's Syndrome, which prevents muscles from obtaining sufficient energy for continuous exercise. Oxford Instruments feels that the method has great promise beyond the uncovering of obscure diseases and has recently set up a subsidiary corporation, Oxford Research Systems, to develop TMR technology.

Present systems have magnets large enough for the insertion of an arm or leg and are priced at approximately \$400,000. The company is developing a larger system which will accommodate the entire body. The superconducting magnet for this system will have a 60 cm bore, suitable for normal sized adults, and will weigh about 4 tons. Clinical trials are scheduled to begin at the Radcliffe Infirmary in 1982. The large system is priced at nearly \$1 million, with a principal market expected to be in the US. (John R. Neighbours)

ULTRASONIC IMAGING AT IBM-TECHNION

At the Technion IBM Research Center in Israel, Dr. Israel Berger and Dr. Dov Ram are engaged in a project to develop an ultrasonic imaging system for medical application. Their system uses backscatter information generated by US-made focused transducers, with center frequency at 2.25 or 3.5 megahertz. This arrangement produces a focused signal at 8 to 12 cm. Because the beam is focused, travel time is equivalent to normal range. Therefore, imaging does not require inversion, but display capability, in order to produce the geometry of the operating system on a screen. The system will shortly be moved to a hospital.

Dr. Ram and a graduate student are carrying out direct modeling studies of the propagation from the transducers. Their method is a variant on the Born approximation, in which their elementary operator has variable coefficients and the geometrical acoustics transmitted field is used as the unperturbed field. The preliminary results look very encouraging.

Another part of the project involves work with all sorts of statistical formulas on "known" data sets. The objective here is to determine empirically those relations—e.g., correlations or power spectra over a window of pixels—which distinguish healthy tissue from diseased tissue. (Norman Bleistein, Univ. of Denver)

ADAPTIVE AUTOPILOT FOR SHIPS

When a ship follows a straight course under autopilot control, everything works fine as long as calm deep-water conditions prevail. At such times, an actual plot of the vessel's path will be extremely straight, perhaps better than that achieved by any human helmsman. Rudder corrections will be gentle. In adverse weather conditions, however, a closed-loop autopilot may respond excessively to weather-induced yawing. This is because yawing creates two kinds of drag: rudder drag (a vector that increases roughly as the square of the rudder angle) and hull drag (when a rudder angle is set, the ship's head turns and the stern moves sideways; this mass of "displacement water" is pushed or dragged along and thus impedes the ship's forward movement). Both kinds of drag, of course, reduce the ship's efficiency and increase fuel costs.

At Racal-Decca Marine Controls in Croydon (UK), an adaptive autopilot has been announced which should reduce unnecessary rudder and hull drag in bad weather. The system separates the effects of ship characteristics from the effects of the weather. It does this by means of a three-term nonlinear model of the ship's movement

in calm weather. The controlling is done according to the ship's (calm-state) model, not according to the instantaneous state of the ship; thus, during bad weather, the sea is allowed to act rather freely on the hull—the result is that only small-angle and infrequent rudder movements are actually made, and the propellers are not continually "fighting the rudder." The ship may average a straight line fairly well, but the ship's head will not be on course all the time (as it would be in standard autopilot steering). The ship will, of course, traverse a slightly longer total distance, but slight yaw actually has only a negligible effect on the distance traversed.

Of particular interest is the adaptive feature of the ship's model. Starting with some good-guess estimates, in the early part of a voyage the model "learns" or adjusts itself to the ship's actual response to rudder movements while the ship is still operating in smooth water, and eventually the model settles down to an accurate simulation. Except for unusual circumstances such as close-inshore operations, the rudder movements run according to this "learned" response pattern, and the ship thus ignores the weather (some gradual response to weather is provided by the system). Nobody has yet calculated or determined experimentally the expected fuel savings from such an autopilot system, but reductions in the number of rudder movements are expected to be above 50% in some sailing conditions. (Nicholas A. Bond, Jr.)

STABILIZATION OF HEAD-COUPLED DISPLAYS

In a vibrating environment, helmet-mounted displays may be more difficult to read than are panel-mounted displays. This is largely due to the fact that rotational vibration causes retinal image movement. For example, when slight pitch-and-yaw movements of the head are caused by low-frequency (2.5 to 10 Hz) vibration, the eyes tend to remain stationary. Thus the head and collimated display may be rotating when the eyes are not.

At the Institute of Sound and Vibration Research University of Southampton, UK, this problem has been under active investigation, with the work being sponsored by the US Air Force and the UK Ministry of Defence. Three possible solutions were considered:

(1) *To monitor the eye movements relative to the display, and "correct" the display for these movements.*

(2) *To estimate a "transfer function" between the vibrating floor and the display. Filter theory could then be used to deflect the image.*

(3) *To monitor the display and use feedback (accelerometers) to move the image so it would be stationary with respect to the eyes.*

Option 1 was rejected because of the state-of-the-art in eye-movement-measuring techniques; available systems were not precise enough, and as they were oriented with respect to the head, they would not compensate for relative movement between eyes and head. Option 2 was found not to be feasible because of the individuality and sensitivity of human transfer functions in the usual display conditions. This left Option 3, which has been pursued by the Southampton researchers.

In the present experimental system, the rotational display movement is transduced and fed back to the display so as to stabilize the image. For pitch-axis stabilization, two accelerometers were installed in the subject's helmet—one near the ear and the other about 5 inches in the frontal direction, near the corner of the left eye. Yaw stabilization was derived from a rotational accelerometer mounted on top of the helmet. The accelerations were double integrated to give display offsets.

On a number-reading task, the two-axis stabilization system led to greatly improved performance, in both reading time and reading accuracy, at vibration frequencies below 10 Hz. This general result was obtained with both the Hughes Model RL/HMD-202 and the Ferranti Type 101 displays. The most marked improvement over the nonstabilized condition occurs at around 4 or 5 Hz.

Flight testing and further simulation work are planned for the next year, again under joint US and UK sponsorship. The investigators are M.J. Wells and M.J. Griffin of the Human Factors Research Unit. (Nicholas A. Bond, Jr.)

LE TRAIN ORANGE

On September 27, France began regular service with its Trains à Grande Vitesse (TGV). Running at an average speed of 260 kilometers per hour, these trains are now the fastest in the world. By November, 38 of the trains will be operating. They will shorten passenger times drastically; for instance, when the new high-speed line is completed in 1983 to Combs-la-Ville, near Paris, the Paris-Lyons run will take exactly two hours.

Each train has an electric locomotive and about 8 cars. Even higher speeds are anticipated: last February, a TGV hit a world-record of 380 kilometers per hour on the special Paris-Lyons track. The new cars are about 2 feet lower than conventional ones. At 260 km per hr,

the operator cannot easily read signals along the roadbed; instead, he works from a visual display system inside the cab. Also, the driver is monitored and given a "block of track" by radio controllers in much the same way as airspace is assigned. The French system is efficient: the estimated energy cost per passenger is about the same as 2 gallons of gasoline, for the 500-kilometer trip from Paris to Lyons.

Among the technical features of TGV are a special roadbed, concrete ties, welded rails, a minimum 4,000-yard radius on curves, and extremely high power, with electric motors on 12 different axles to distribute the weight. This power, in turn, permits very steep (1 in 28) gradients and thus avoids expensive tunneling.

Not all recent fast train developments have been successful. Starting in 1967, Britain worked on an advanced passenger train concept; the idea was to use new lightweight carriages that would readily tilt on curves and thus would make high speeds possible on the older and relatively winding British trackbeds. The acceleration forces on curves, however, turned out to be too severe for standing passengers. A parallel British development, the diesel 125 High Speed Train (125 mph top speed) has worked well; it uses a locomotive at each end of the train.

West Germany plans to have a magnetically levitated test vehicle operating by next summer. The vehicle will be raised 10 mm above the track; it will be propelled by a long-stator linear motor (stator on the track, secondary winding in the vehicle). In one design, the cars or "bogies" from the vehicle wrap around the track, and the lifting is done by attractive force between magnets on the vehicle and magnets on the bottom of the track structure. A test track about 31.5 km long will be built near Ems, Germany. At the 1979 International Transport Show in Hamburg, a demonstration "mag-lev" vehicle was operated; it carried 68 passengers at 93 km per h over a short route. The German trial at Ems should help to resolve controversy over the energy, control, and economic factors in "mag-lev" trains; some present calculations indicate that such trains could be competitive with air transport in Europe and America. (Nicholas A. Bond, Jr.)

CASH PRIZES FOR RESEARCH PROFESSORS

UK's National Research Development Corporation (NRDC) will award five substantial prizes for academic scientists who start a new business based on their findings. For each of five British regions, the cash prize to the winner will be £20,000 (\$37,000 US); and the overall winner for the whole country will get an additional £30,000, for a total cash award of about £50,000. This overall prize is believed to be the second-ranked financial reward for research in the world; it pays almost half as much as the Nobel Prize.

NRDC may also invest up to £250,000 in a new enterprise stemming from academic research. Reportedly, some of the richest scientists in the world are those who have worked in such fields as in "genetic engineering," patented some procedures, and then held shares in small companies which might utilize the patented technology. The UK prize-and-support system should help to enlarge the select circle of wealthy researchers. (Nicholas A. Bond, Jr.)

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

<u>Visitor</u>	<u>Affiliation</u>	<u>Navy Lab./Org. to be Visited</u>
Lt. Yehuda Agnon	Headquarters, Israeli Navy, Tel Aviv, Israel	COMNAVOCEANCOM, NAVOCEANO, NORDA, ONR NRL, CNO (October - November 1981)
Mr. Brian M. Count	Marchwood Engineering Labs, Southampton, UK	Civil Engr. Lab., NCBC (19-20 October 1981) FLENUMOCEANCEN, NEPRF, NPS (21-23 October 1981)
Dr. G. Dearnaley	Nuclear Physics Division, AERE Harwell, UK	NRL (19 October 1981)
Dr. J. R. Gannon	Standard Telecommunications Labs, Ltd, Harlow, Essex, UK	NRL (13 October 1981)
Dr. J.A. Johnson	School of Mathematics & Physics Univ. of East Anglia, Norwich, UK	NPGS, Monterey (12-17 December 1981) Oregon State Univ. (18-22 December 1981)
Dr. Leonid Kasovsky	Dept. of Elect. Eng., Ben Gurion Univ. of the Negev, Beer Sheva, Israel	NSWC White Oak (19 October 1981) NOSC (5 October 1981)
Dr. E. Pelletier	Ecole Nationale Supérieure de Physique Université de Saint Jérôme	NWC China Lake (9-10 November 1981)
Prof. Ian O. Sutherland	Dept. of Organic Chemistry, Univ. of Liverpool, UK	NRL (9 or 10 November 1981)

ONRL REPORTS

C-4-81 9th Scientific Meeting of the International Epidemiological Association, by Michael Stek, Jr.

The epidemiological conference discussed here was attended by some 900 participants from more than 60 countries. The program covered a wide range of topics related to the epidemiology and prevention of acute and chronic diseases. In this report, the author directs his attention to the discussions about tropical and infectious diseases, which are his areas of special interest.

C-7-81 International Symposium on Nuclear Techniques in the Study and Control of Parasitic Diseases of Man and Animals, by Michael Stek, Jr.

This is a report of a meeting at which ideas were exchange on the application of nuclear techniques and the use of radioisotopes in the research and development of serodiagnostic and seroepidemiological procedures, antiparasitic vaccines, and chemotherapeutic agents. Techniques which the author judged to have special significance are discussed.

- C-8-81 Third National Reliability Conference, Birmingham, England, by M.B. Kline

This conference on the subject of reliability covered a broad range of topics, from the many aspects of reliability management to considerations of hardware, software, and the human factors involved. The author summarizes some of the latest ideas in these many areas as they were presented by the featured speakers.

- C-9-81 Biophysics of Water: A Working Conference, by P.T. Beall

A working conference on the biophysics of water was held at the University of Cambridge, England, on June 29 - July 3, 1981. The conference highlighted four major areas of research: Molecular Hydration and Biological Function, Surface Forces in Biological Systems, Water as an agent of Homeostasis in Organisms, and Physiological Water Stress. This report contains discussions and observations on presentations that were of special interest to the author. It also contains recommendations about future areas of research.

- C-11-81 Ninth International Conference on Sarcoidosis, by John C. Rose

In this report on the most recent international conference on sarcoidosis, the author discusses the current status of sarcoidosis research and the latest developments in clinical treatment as they were related at the conference. He also refers to the differing opinions that were presented about diagnosis and treatment of the disease, as well as recommendations that were made as to future areas of study.

- R-5-81 A Technical Assessment of Aeronautical Engineering in Israel, by Joseph A. Strada, CDR, USN

A variety of Israeli academic and industrial institutions are discussed with an eye toward assessing research and development activities in aeronautical engineering disciplines. Each institution is described in brief and some of its current research projects are listed. Research in aerodynamics, guidance and control, propulsion and combustion is discussed and industrial product lines are described where appropriate. Some conclusions are drawn in an effort to assess the country's overall capabilities in aeronautical engineering.