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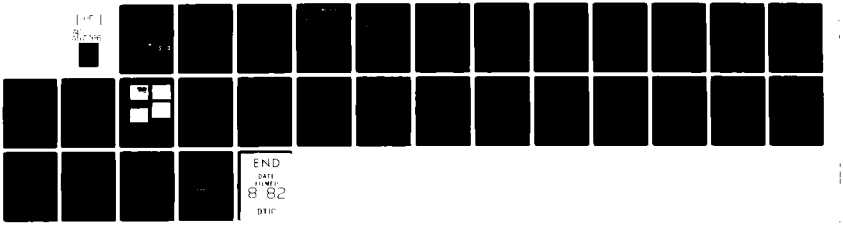

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the Scientific Literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

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

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BEHAVIORAL SCIENCES

STRESS AND COGNITION IN DIVING

Diving technology advances all the time, and specialized equipment now permits much safer underwater operations, but the diver still faces many discomforts, difficulties, and dangers. Some of his stresses are attributable to strictly intellectual load; such load occurs when the diver has to process a lot of information in a complex monitoring task. His own equipment, for instance, contains an array of gauges, and the environment has its complex constraints. A second and broader conception of diver load, put forward a few years ago by Dutch investigators, includes the emotional content of underwater activities. Sometimes it would be difficult to separate the two load factors from each other; as an example, consider the time when a diver is having to monitor his own fear reactions to an underwater threat.

In recent research at The Institute for Perception, (TNO), Soesterberg, the Netherlands, P.G. Jorna checked on the information processing of divers who differed in experience. The major hypothesis was that more experienced divers could cope better with a secondary task that was imposed on the operator. The work appears to be significant to the underwater research community for its substantive findings and also for its stress-measurement techniques. There were some subsidiary hypotheses involving the physiology of human subjects. Among these was the expectation that certain "spectral" components of diver heart rate could be measured during underwater operations and could be correlated with mental and emotional load. If these indexes proved to be reliable, they should change as a diver became more experienced in coping with the imposed primary and seconday loads.

Jorna's subjects were 18 young (early 20s) male divers from the Dutch Navy; 12 were novice diver trainees, and 6 were experienced (average of 75 to 100 underwater hours; some had frogman training). The test site was at an ocean training center with a flat sandy bottom. Visibility at depths of 3 to 5 meters was very limited, and the water was cold (4 to 8°C). Divers were dressed in an Avon dry suit and wore standard Loosco II equipment with a full face mask.

A continuous memory task (CMT) was devised to measure reaction time and percentage of error in a moderately challenging memory test. First, the subject memorized a set of letters known as the positive set; this set could be either two or four letters. After memorization, random letters were presented to the diver every 2.2 sec, so that a typical letter series of 141 to 146 letters would run about 5 min. The diver was tasked to decide whether each letter was in the positive set. The subject also had to keep a running count of the letters that were in the positive set; every time he heard a target letter, he had to "increment the counter" by one digit. About 25% of the letter stimuli presented were members of the positive set.

Presentation and recording of underwater responses were accomplished by a special TNO-developed system. A bone-conductor unit (usually placed on the mastoid) gave the stimuli, a cassette recorder took down the responses, and the heart rate and respiration signals were transmitted to the surface for on-line computerized monitoring. Most of the hardware was put into a compact package that was attached to the diver's air cylinders; the package did not interfere with swimming.

The inexperienced divers made three test dives: the first in the second week of training, when they had been in the water only for brief intervals, the second was in the fourth week, and the final testing took place in the seventh week. The experienced people made two dives, at the same times of the second and seventh-week dives of the novices. Both groups of subjects also took the CMT and physiological measurements under "dry" standard conditions on a raft.

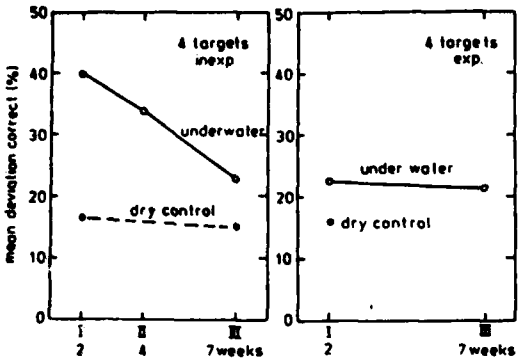
To start a data-taking session, ECG electrodes (left-right chest, sternum) were attached and the diver submerged and started an easy, regular swim near the bottom. When the experiment start button was pressed by the diver, the stimulus presentation began, and the diver had to keep the swim going as he worked on the CMT. No performance feedback on CMT was given, but each diver was told that his swimming path and performance were being monitored. Each subject also knew, of course, that his physiological and memory responses were being measured and sent to the computer above.

The results for two divers were dropped because of technical recording problems; other than that, all the scores were reliably obtained and analyzed. There were four CMT scores (percent deviation from correct, percent missing, reaction time, and counting errors made in incrementing the target counter).

Analysis of heart-rate data emphasized the cardiac interbeat interval, and power spectra were computed for interval signals. Previous work had shown that cardiac spectral power around 0.05 Hz was primarily respiratory and, furthermore, that frequencies about 0.10 Hz were nonrespiratory and probably responsible for the blood pressure component observed in cognitive tasks. Therefore, the mean power between 0.07 and 0.14 Hz was used as an index for the blood pressure "energy" being exhibited by a subject.

Inexperienced divers improved their underwater CMT scores over the 7 weeks; their deviation-from-correct scores went down from 40% to a little above 20%. On the other hand, the experienced divers had about the same CMT scores at the beginning and end of the experiment. The trends were exhibited on most of the performance measures for both two-letter

and four-letter-positive sets. The figure shows a typical result on the percentage deviation-from-correct score.



Deviation from correct in the four-target task for inexperienced and experienced divers at different training periods under wet and dry conditions.

Physiological results were reasonably consistent with the psychological test data. The inexperienced people increased their cardiac interval time (decreased their heart rates) over the 7-week training interval, whereas this index stayed about the same for the experienced men. The energy (blood pressure component) at 0.10 Hz for novices was lower than that for the experienced people at first, but figures for the two groups were nearly identical at the end of 7 weeks of training. In a similar way the respiration rates of novices, who were breathing relatively rapidly during early training, showed a significant decrease.

From a purely methodological standpoint, the TNO work is remarkable for its separation of variables that influence underwater performance. Taking the same memory tests under wet and dry conditions permits baseline determinations, and the successive testing over a 2-month training period gives a rather precise estimate of the adaptations that are taking place. With the special recording and telemetry package that they developed for such studies, the TNO researchers demonstrated that ECG and respiratory data can be obtained reliably in a moving underwater work environment.

The secondary memory task was handled better by the experienced people. This was not due to the fact that the experienced divers could process the information better; their dry scores were similar to scores from the novices. A more likely interpretation is that the experienced underwater man is better at time sharing his cognitive resources between the memory task and the incessant underwater monitoring of equipment and conditions.

Thus, coping behavior is demonstrably learnable and "trackable" in an underwater situation. Follow-on work will almost certainly be concerned with how such coping can be practiced and maintained and how it transfers from one underwater situation to another.

Nicholas A. Bond, Jr.

ONR London

TWO EUROPEAN SONAR DISPLAYS

The human-factors literature is replete with material on aircraft displays; every textbook reviews the design of aircraft items such as altimeters, attitude instruments, landing systems, and navigation aids. Sonar displays are not so widely treated. There must be several reasons for the relative neglect of the sonar area; perhaps the main one is the military classification of research having to do with the detection and location of submarines.

Below are described two active sonar displays, one Dutch and one French; both are now at operational or near-operational status in European navies. Both rely on considerable computer processing of signals, and the major modeling and computing problems reportedly have been solved. Though the display concepts are 2 or 3 years old, they do not seem to be much known in the American human-factors community.

The first display comes from the Institute of Perception (TNO), at Soesterberg, The Netherlands. As reported in a previous ESN (35-9:338 [1981]), TNO is one of the leading Dutch institutes for perception studies (the other is the Institute of Perception Research (IPO) at Eindhoven). The TNO display is remarkable in that institute psychologists were called in from the very beginning of the design process and were asked to provide research and advice on the best ways to present active sonar return information. The early incorporation of human-factors inputs should, one hopes, lead to a more human-oriented and therefore more effective system than is normally obtained, and indeed the hope seems to have been realized in this case. In the work, A. van Meeteren and A. F. Sanders were the principal TNO psychologists; they were assisted by Prof. van Schooneveld of the TNO Physics Laboratory.

To start with, there are at least four physical aspects that may be ascertained from a return of an active sonar ping: bearing, distance, intensity, and Doppler shift. The recent history of all these signal aspects can also be stored and perhaps transformed or replayed for greater appreciation of the signal information. Assuming that a visual display is to be attempted, there are many possibilities for presenting the information; there are also many physical constraints, such as the fact that, as sound travels about a mile a second in water, it will take up to 10 or 15 seconds for a reflection to be received from a target that is thousands of yards away. With a sonar operating over a 360-degree range and frequently updating its

returns, some kind of sectoring system might be necessary for showing the last-received signals and for displaying the recent history of other returns in the same sector. In the real case, some sectors usually turn out to be more productive or more critical than others, so they will receive more attention from the human operator.

TNO eventually came to experiment with the display shown in Figure 1. The three adjacent rectangular sectors cover 10 degrees each (there would be 36 10-degree sectors to cover the whole range.) Each sector displays reflections from nine pings, with real time going from the bottom to the top. Every little dash, or target, represents one reflection that was above a preset threshold; the target distance extends on the abscissa from left to right, in thousands of yards up to 10,000 (about 12 sec in time); the slope or tilt of the target line is controlled by the Doppler shift of the received signal. If the signal is genuine and the Doppler function performs accurately, the "slope" of a dashed target predicts where the tail of the target above will be in the next ping-cycle line. When several consecutive ping dashes are consistent with each other, a line will appear in the random noise. As an example, the display history shown below seems to indicate a target track at a range of about 6,000 to 6,500 yards; all the other target indications over this bit of history are false.

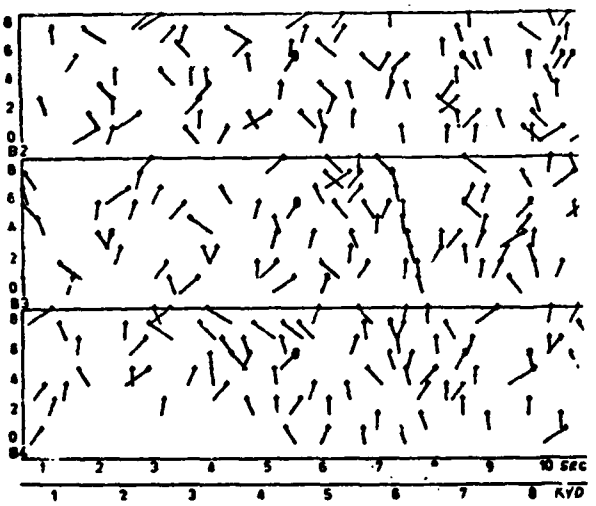


Fig. 1 Display of signals produced by an active digital SONAR system built by the Physics Laboratory TNO. The last nine pings are shown for three different radial sectors.

In a display like this, the head or tail of each target echo might be shape coded to represent signal intensity. Alternatively, the intensity of the signal might be shown by the brightness of the target line or by the length or flickering of the target line, because bright things, long things, and flickering things stand out in a noisy display. Actually, the TNO investigators chose intensity and length coding for evaluation. For intensity-mode coding, the luminance of each target line was determined by its signal-strength to threshold ratio, with seven luminance levels being used. The length mode representation also depended on this ratio, so that both modes were accomplished via the same basic signal to threshold manipulations.

For the experimental trials, which were driven by simulated signals, half of the pictures had one real target and half did not; the subjects knew the ratio. The simulation was arranged to approximate the physics of actual target echoes, with suitable randomization over target strengths and ranges. Each stimulus configuration was shown for 1 second; a human subject reacted by pressing one of five keys, thus showing his interpretation of the display (key 1 meant that a target was certainly absent, key 5 meant that it was certainly present, key 3 signified uncertainty, and so forth). During a series of self-paced practice trials, subjects received knowledge of results and were told whether a target was actually present or not. During the data-taking runs, the display was shown at a fixed rate of one presentation every 6 seconds, with no feedback. To the subject, the task probably seemed to be demanding but feasible and was probably similar to real detection work at a noisy screen.

Results from 12 subjects (1,440 pictures each) did not fit a simple noise and signal-plus-noise model of the target discrimination process, that is, the two distributions were not normal distributions with equal variances. Apparently the noise-response variance is relatively narrow, while the signal-plus-noise variance is quite wide. As expected, high signal strengths produced better detection performances. There were substantial individual differences in detection, indicating that some individuals might indeed be consistently better at the task. However, there was no statistical interaction between individuals and display modes, indicating that the superior operator does not need a different display from those who are less able; at least that was so for the display variables examined.

As to the display modes, there were interactions with display threshold. Figure 2 shows some of the relations. In the "sure no target" subjective ratings, intensity coding produced more detections for a high-threshold (few target) situation; with the display set at a low-threshold (many target) level, length coding was best. As it is usually not good practice to change display mode as a function of operating system parameters such as momentary threshold, a special experiment would have to be run to settle the display-mode issue for any particular sonar configuration. The TNO methodology provides a good starting point in such an endeavor. An incidental finding,

which has been observed in other contexts, is that it is harder to be sure there is not a target than to be sure that there is a target. Another minor result: target detectability was not much affected by display threshold. The human target-detector system apparently adjusts very well regardless of threshold, so it is encouraging to find that one of the possible design complexities can be eliminated.

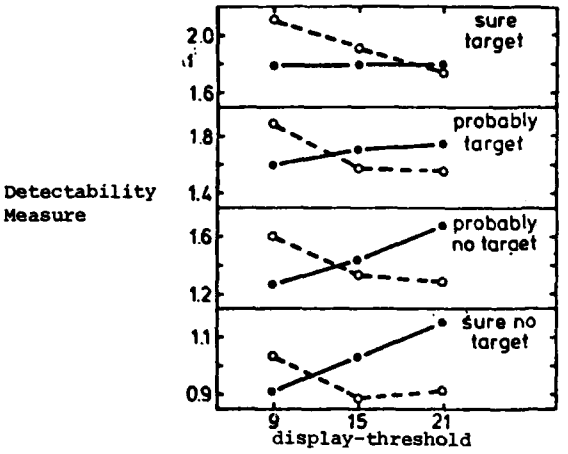


Fig. 2 The effects of intensity coding (closed circles) and length coding (open circles) as a function of the threshold setting.

The TNO display is attractive on several grounds. It reflects the present emphasis on a lot of digital processing, it apparently presents the operator with a feasible task, it is well within present technology for white-black display tubes, and it uses the unparalleled skill of a human operator to perceive a variety of tracks in a noisy field. In follow-on versions, there are possibilities for making a truly interactive display in which the operator can adjust various parameters to improve detection and to incorporate local conditions. Color may or may not prove to be worth the additional costs.

An obvious question: could a display like this be automated and an adaptive computer program written to detect the tracks in the display? If so, the human contribution would be to watch for outliers and absurdities and to correct the system if it started to drift. But how would such a system compare with human performance in a realistic case? The literature would suggest that, for a reasonably stationary environment in which the target statistics can be learned in a straightforward way, an automatic pattern recognition scheme might work quite well; but humans would be necessary for rapidly changing environments and for those subtle target evaluations that extend past a simple track discovery. (A Kalman filter can handle certain nonstationary error sources, if the statistics of these are known.) For further exploration of such issues, an important step would be the mathematical formulation of optimal detection performance. TNO has been working on that aspect of the display.

The French display was originated at the French Naval research laboratories in Toulon, in cooperation with Thomson, the French electronics firm. Though the display lacks some of the intensive human-factors analysis than went into the TNO sonar presentation, it has one novel and interesting feature. That feature is the confidence indicator, which consists of two lines that surround the estimated target track and target vector. A typical presentation is given in Figure 3.

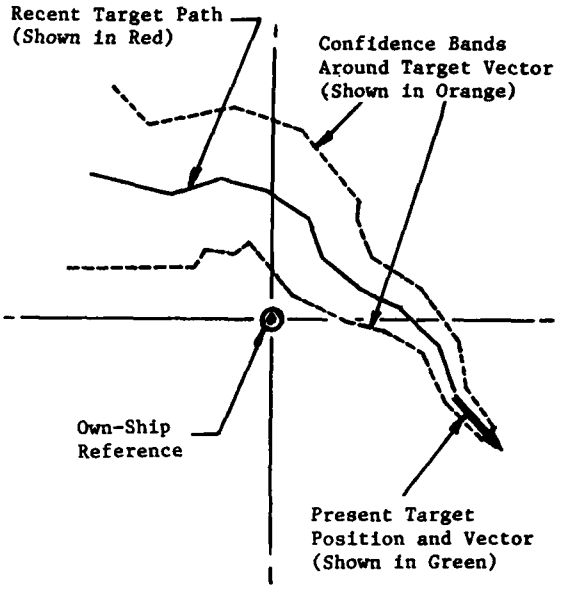


Fig. 3 French Sonar Display (for illustration, only one target shown).

The system works via a computerized fast-fitting process to stored sonar echoes. Starting track and vector parameters are inserted into the system and preliminary fits are computed; slight excursions of the starting values are then made, the whole stored history is computed again, and the residuals are compared with the previous best parameters. The process goes on; if successful, the system eventually is confident of the target vector. When this occurs, as in the example shown above, the confidence bands shrink down around the target, and presumably the sonar operator then can have considerable confidence in the tracks and vectors that appear on the screen. Of course, things do not always turn out so well; in some filter models the error covariances of an unstable system can grow unbounded unless corrective measurements can be made in the process noise. Absurd vectors and wildly fluctuating confidence lines could result.

The French system uses a special Thomson tube, and all the information is in sharp lines and brilliant color on a rather large rectangular display. This makes for a very pleasing display. Probably more important than the color is the track confidence concept. At present, something like a standard deviation around the best-fitted track is computed and shown, but such a representation of confidence might be improved in various ways. For example, an operator might want to be able to change the confidence criteria according to tactical, technical, or other conditions prevailing at the moment, or he might want to explore the sensitivity of the tracking system to inserted changes that are derived from tactical concepts. Indeed, the whole psychophysics of confidence in the output of a military sonar system seems to be an open area for research. Reliability modeling or other tricks might be used for obtaining some of the confidence numbers, but the interpretation of those numbers by humans will still require special analysis and support.

Nicholas A. Bond, Jr.

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ELECTRONICS

THE INSTITUTE OF ACOUSTICS SPRING CONFERENCE

The 1982 Spring Conference of the Institute of Acoustics was held during Easter week at the University of Surrey, Guildford, UK. Some 130 delegates were in attendance. The meeting focused on four main areas: environmental, transportation, and propulsion noise; physical acoustics and ultrasonics; signal processing in acoustics; and subjective auditory effects.

The conference opened in plenary session with an excellent lecture by Laurence Fincham (KEF Electronics, Ltd., Maidstone, Kent) entitled "Practical Aspects of Digital Processing in Acoustics." He described the pioneering work of his company over the preceding 10 years in the development of techniques for the measurement of loudspeaker performance using an FFT technique and a processing time short enough that an anechoic room is not required. While the basic technique has been reported elsewhere (J.M. Berman and L.R. Fincham, J. Audio Engrg; Soc. 25 (6), 370-384 [1977]), Fincham's presentation gave a clear idea of such practical problems as nonlinearities due to voice-coil heating and its movement out of the gap, hum at mains frequency and its harmonics, and the proper decay of the loudspeaker response to its transient excitation in the processing time available before reflections arrive.

The session on noise opened with an introductory talk by Prof. J.B. Large (Inst. of Sound and Vibration Research [ISVR], Southampton Univ., UK) on "Prediction and Assessment of Airport Noise." While most attention has been focused on noise generated by planes as they take off and land, there are many other sources of noise that affect the immediate environment. Considerable noise is generated as planes proceed along long taxiways and as pilots use reverse thrust to shorten the braking distance and thus the taxiing distance to the terminal bay. Again auxiliary power units, frequently mounted high in aircraft, create noise when they are used to provide ventilation and instrument power while planes are standing at the terminal. Still other problems are caused by the run-up of engines during maintenance (frequently at night), traffic noise, and the sound of the seemingly inevitable construction machinery so commonly in use at airports. All such factors need to be taken into account in designing terminal buildings and the facilities such as offices, hotels, and conference and exhibition centers that tend to congregate around airports. To enable the cumulative effect of these sources to be assessed, contours for each can be drawn around the areas in which they are generated and simplified calculations can be made.

Large's presentation was followed by other papers on aviation noise, transportation noise, and room acoustics. M. Barron (Univ. of Cambridge, UK), speaking about spatial impression in concert halls, suggested that the virtue of older high and narrow classical designs might be in their strong early lateral reflections. D.J. Meares and R. Walker (British Broadcasting Corporation Research Dept.) discussed the standards for broadcasting studios, and in particular the requirements for insulation both from outside sound and between studios; this has become a matter of increasing interest in Britain with the advent of local broadcasting which is often operating on a low budget, even making use of converted premises.

In a parallel session on Physical Acoustics and Ultrasonics, S. Gade (Bruel & Kjaer, Nagrum, Denmark) and F. Fahy (Univ. of Southhampton, UK) presented separate papers on sound intensity measurements, using a closely spaced pair of microphones, (as opposed to the more usual pressure measurement by a single microphone). There were several presentations on the measurement of the performance of transducers used in medical ultrasonics and for nondestructive testing. Three papers were given by scientists from the University of Surrey on measurements of the properties of materials. The penultimate paper, by C. Mathers (BBC Research Dept., Tadworth, England) discussed the design of loudspeakers for scale model tests. Models of studios are usually built to a scale of 1:8, and, in addition to actual measurements, it is useful to obtain a subjective appraisal of model performance by playing program materials speeded up by this ratio and recording them for playback

at normal speed. This requires a loudspeaker system with a good response between 400 Hz and 100 kHz. A high-frequency leaf tweeter of piezoelectric plastic, made by Matsushita, is used, together with a modified moving coil unit with a ferromagnetic fluid in the coil gap and a polypropylene diaphragm for the low frequencies. In parallel with the above series of papers was a third, in which signal processing in acoustics and subjective audio effects were discussed.

The annual meeting of the institute, which took place on the second day, was chaired by the outgoing president, Dr. Brian L. Clarkson, formerly director of ISVR and now dean of Sciences at Southampton University; he introduced his successor for the next 2 years, Dr. David E. Weston (Admiralty Underwater Weapons Establishment, Portland). It was noted at the meeting that the membership had increased during the year from 993 to 1,104. There are branches in different parts of Britain and one in Hong Kong, and there are also five disciplinary groups that organize specialized 1- or 2-day meetings in their own technical areas, the most active being in underwater sound and in musical acoustics. The business meeting was followed by the presentation of the Rayleigh Medal, which is awarded in alternate years to an acoustician from Britain or from abroad. This year's recipient was Prof. George B. Warburton (Univ. of Nottingham, UK) whose lecture was entitled "Rayleigh's Contribution to Modern Vibration Analysis." In his talk, he showed how Rayleigh's mathematical analyses always had a practical foundation in physical measurements. There was a third plenary session on the last day, with a lecture by Prof. John Lamb (Univ. of Glasgow, Scotland) on "Ultrasonics and Shear Wave Propagation in Liquids."

A feature of the meetings is that delegates receive a copy of the proceedings containing three- or four-page summaries of most of the papers that were to be presented (unfortunately not including the invited lecturers). Copies of the proceedings are available from the Institute of Acoustics Office, 25 Chambers Street, Edinburgh, Scotland, EH1 1HU.

G. L. Wilson

Pennsylvania State University

MATERIAL SCIENCES

CATHODIC PROTECTION THEORY AND PRACTICE - THE PRESENT STATUS

It is a well-known story that perhaps the first intentional application of cathodic protection (CP) was made by Sir Humphrey Davy in the early 19th century in order to reduce corrosion of copper sheathing on ships of the British navy. It is probably not so well known that Davy's solution to the problem was so successful that copper corrosion stopped, biocidal copper ions were no longer released, and fouling buildup reached the point where speeds were seriously diminished and cathodic protection had to be abandoned. No further application of the concept was made for many years after, so it may be salutary to remind those interested in applications of the conclusion of Sir Humphrey's story as well as the beginning.

Despite its initial problems, cathodic protection is widely used today and is one of the most effective means for controlling corrosion. The importance of the technique was manifested by the recent assembly of 170 delegates from 13 countries to review the status of cathodic protection theory and practice at a conference in Coventry, UK, from April 28 to 30, 1982. The topics discussed dealt with basic concepts, modeling, current status of anode development, practical design and experience, instrumentation, and practical problems.

V. Ashworth (Univ. of Manchester Inst. of Science & Technology) started the conference with a review of the fundamental electrochemical processes associated with cathodic protection and the application of the technique for corrosion control. Ashworth's talk was followed by three presentations relevant to mathematical modeling of cathodic protection systems: "The Problem of Predicting Potential and Current Distribution," by K.F. Sander (Univ. of Bristol, UK); "Application of Numerical Analysis Techniques," by M.A. Warne (IMI Marston Ltd, UK); and "Input Data for Modeling Marine Cathodic Protection," by J.N. Wanklyn (Consultant, UK). The authors, speaking primarily about cathodic protection systems for marine applications, sketched the mathematical approaches available to the system designer: analysis, physical modeling, and computer modeling. For the most part, however, they dealt with the limitations on system modeling imposed by uncertainty in criteria for satisfactory protection (i.e., what potential or current density is necessary at a surface to keep corrosion within reasonable bounds), by nonlinear boundary conditions caused by cathode polarization effects, and by changes in boundary conditions brought about by buildup of calcareous scale on cathode surfaces in seawater. The difficulties of incorporating cathodic polarization and scale effects into the mathematical models were seen as major constraints on further development of accurate modeling. According to Warne, the ability to design by computer a satisfactory cathodic protection system for a complex structure, that is, assign the number, size, and placement of anodes and specify potentials and current densities to be used solely as a result of computation, is very far in the future. At present, computer modeling is used primarily to check system geometries proposed by designers

working from past experience and empirical knowledge.

The status of sacrificial anode development was reviewed by C.F. Schrieber (Dow Chemical Co., US). He focused on the electrochemical limitations of the magnesium anode (large differences between theoretical and measured solution potentials and low current efficiencies—rarely above 50 to 60% of theoretical compared to greater than 90% of theoretical for Zn or Al anodes) and the possible reasons for these limitations (parasitic corrosion reactions resulting from protective film breakdown at the noble potentials associated with anode activity). He also discussed activation processes in Al-0.045 Hg - 0.45 Zn anodes and gave an economic comparison of zinc, magnesium, or aluminum anodes as system protectors (in seawater applications aluminum is most cost effective followed by zinc and then magnesium).

P.C.S. Hayfield (Imperial Metal Industries Ltd, UK) and L.L. Shreir (City of London Polytechnic, UK) provided a picture of the current status of impressed current anodes. Hayfield enumerated the large choice of materials available. They range from relatively inexpensive consumable metals and alloys such as steel and cast iron to more inert materials such as iron-silicon and lead-lead dioxide alloys and finally to fully passive materials such as platinum or platinum-coated titanium or niobium. Hayfield noted a trend to use more platinized titanium anodes, especially in high-current-density marine applications. He also said that enough different anode materials seemed to be available to satisfy the technical and economic needs of most foreseeable applications and predicted that no significant changes in impressed-current anodes would be introduced in the near future.

In the session on practical design and experience, the authors covered a broad range of cathodic protection applications: CP for ships, fixed-offshore and land-based structures, concrete structures, process plant and cooling water systems, and undersea and underground pipelines. No new concepts were offered, but a great deal of practical experience was described and a number of interesting case histories were detailed. The papers will be available in the published proceedings of the conference and should provide a useful source of practical reference material.

The session on instrumentation, consisting of papers concerned with equipment for offshore measurements, equipment for surveying buried structures, and power supplies and fixed monitoring systems, was also a detailed exposition of the many varied equipments and techniques available for applying power to CP systems and for monitoring the potential and current densities produced at protected structures. This session, in particular, brought home the difficult environments in which CP systems must operate, especially that of deep-water, offshore platforms, which make system monitoring a far-from-straightforward operation. As a result, the CP community has had to develop sophisticated techniques such as submersible monitors with accurate computerized position locators, fixed electrodes that can be interrogated remotely by means of ultrasonic transponders, and microcomputer systems for data collection and processing; the application of many of the techniques was illustrated.

The final sessions of the conference dealt with practical problems that can result from the use (or misuse) of CP systems. R.P.M. Procter (UMIST, UK) discussed the embrittlement and cracking that occurs in cathodically protected steels, often as a result of the overprotection (i.e., use of potentials lower than necessary to prevent corrosion) that is almost inevitable when complex structures are protected, but that sometimes occurs in properly protected systems. Procter illustrated the point by reviewing the serious problem of stress-corrosion cracking of gas transmission pipelines in carbonate-bicarbonate environments, the hydrogen embrittlement of offshore pipelines, and corrosion fatigue damage of offshore pipelines and platforms by hydrogen pickup. The latter two failures, he pointed out, were caused by overprotecting the structures. Carbonate-bicarbonate stress corrosion cracking, however, developed even though the gas lines were protected to the proper potential. In such cases it took the synergism of coating disbondment, generation of a carbonate-bicarbonate environment at the point of disbondment, moderately elevated temperatures, and slow monotonic or cyclic strains (plus periods of 10 to 25 years) to cause cracking to occur.

D.W. Trotman (British Ship Research Association, UK) talked about damage to coatings resulting from overprotective CP systems. Trotman mentioned the well-documented failure of paints due to the alkaline conditions produced by cathodic protection systems, especially attack of oleoresinous materials that fail by saponification. In addition, he emphasized that not only did paints of different types (epoxy, polyurethane, vinyl, etc.)differ in their degree of compatibility with cathodic protection, but paints of the same type from different suppliers often differed significantly in their resistance to blistering and breakdown. The reasons for the variations are not known. He also noted that recent work showed that the use of cathodic protection on painted surfaces could even accelerate coating breakdown if the surface had been poorly prepared for painting; in one case he cited, coating life was cut in half as a result of salt contamination of the substrate prior to painting.

The final talk on problems associated with cathodic protection systems was an interesting presentation by R.J. Moulton (Atomic Energy Research Establishment, Harwell, UK) on hazards to divers from cathodic protection systems. Moulton discussed the physiology of electric shock and the calculations that had been carried out to determine the currents associated with cathodic protection systems divers might

experience in the field. He concluded that although impressed current anodes represented a hazard, calculations so far had indicated that the probability of a diver receiving a serious shock from a local impressed current anode was low and specific precautions could be taken to prevent shocks. Higher gradients from remote anodes and with brackish water represent a more serious problem. Moulton mentioned, however, that when a diver is exposed to even minor shocks from contact with anodes, it is difficult to convince him that calculations show that he is in no danger.

In summary, the meeting showed that although cathodic protection has a sound basis in electrochemical theory, its successful application to complex structures still involves a great deal of empiricism and prior experience. A good part of that prior experience was brought to light at the conference. Judging from the large attendance and the types of questions asked, meetings like this not only serve to assess the current status of the field, but also are important vehicles for advancing it.

P. A. Clarkin

ONR London

INFORMATION TRANSFER AND PREDICTING CORROSION BEHAVIOR

The engineer today has a wealth of information from which to draw to help him do his job. Much of it, however, concerns how or why something happens or is in the form of myriad charts and tables documenting what happened under specific circumstances. Computerizing the information has been somewhat helpful, but, generally speaking, such information is seldom of any great value unless the engineer is willing to analyze and interpret further. What he really needs is something like an interactive computer system that, when presented with his particular set of conditions, circumstances, and concerns, will respond with what to expect based on current knowledge and experience or will make a realistic prediction when background knowledge is incomplete. Computer systems that have this capability have yet to be developed, but research on how to develop them is currently in progress at a number of universities.

Dr. C. Edeleanu and his colleagues at Cambridge University have been conducting research on computerized information transfer systems in the corrosion field. According to Edeleanu, corrosion information transfer, especially corrosion predictability, presents a particularly difficult problem because of the large number of variables that influence a corrosion process. To keep the problem within bounds, the group is limiting its objectives and concentrating on ways of predicting when a corrosion reaction will switch from a slow, or passive, mode to a fast, active mode, perhaps even resulting in catastrophic pitting, crevice corrosion, or stress corrosion cracking. Edeleanu points out that this is the type of behavior we have to be able to predict. If we cannot do so adequately, we will be forced to continue to use the very conservative design philosophy that penalizes industry with extra costs (Edeleanu speculates that the cost of using conservative designs rivals the cost incurred by inadequate use of existing corrosion information).

The group currently is working on a system for predicting the corrosion behavior of 304 stainless steel in aqueous solutions. The computer program being developed is based on experimental potentiodynamic polarization diagrams. The diagrams, separated into their anodic and cathodic portions, can be described by well-established equations. For example, the lower part of the anodic loop can be represented by

$$E - E^* = b_1 \log i - b_2 \log(1 - i/i_{limit}),$$

the passive range by a constant current, and the transition region between active and passive regions by an equation of the form

$$i_{anodic} = S\, i_{active} + (1-S)\, i_{passive},$$

where S is a function that has the value 1 at the top of the anodic loop and 0 at the bottom. The equation of the cathodic curve is the sum of equations describing the partial reactions that contribute to the total reaction. The coefficients are derived by using iterative curve-fitting techniques often supplemented by data obtained from rotating disc experiments. The program thus developed can be checked by comparing predictions with selected experimental corrosion evidence. The comparison also allows the program to be fine tuned. The propensity for pitting, crevice corrosion, and stress corrosion cracking is factored into the program on the basis of prior experience.

In the case of 304 stainless steel, the program developed at Cambridge predicts corrosion behavior over the following range of conditions:

temperature	0-100°C
Chloride ion concentration	0-500 ppm
oxygen pressure	0-200 mbars
pH	0-7
ferric ion concentration	0-1,000 ppm

The present output format from the program is illustrated in Figures 1 through 4. Figure 1 depicts one form of output, a bar graph, showing the effect of changing temperature while the other four variables are kept constant

($[Cl^-]$ -50 ppm, PO_2 - 200 mbars, pH - 0,

$[Fe^{+3}]$ - 100 ppm).

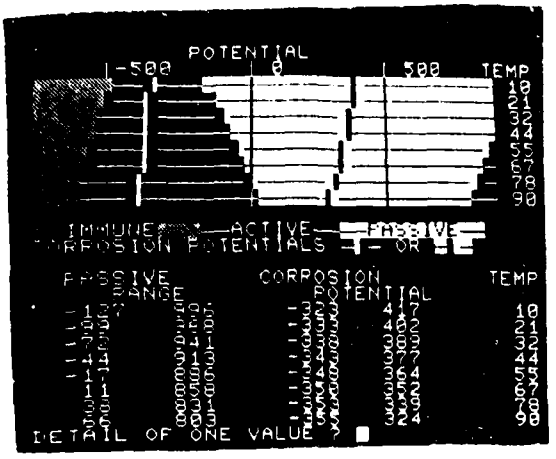

Fig. 1

Figures 2 through 4 show alternative types of information that can be displayed. Figure 2 displays predicted data on potentials, current, and assessment of probable corrosion behavior for the environmental conditions described in the figure.

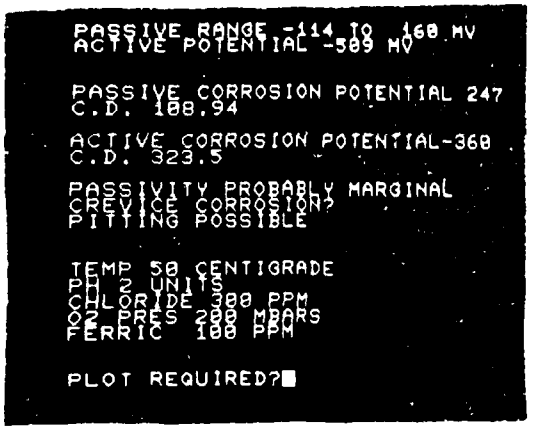

Fig. 2

Figure 3 is a calculated potentiodynamic plot at a sweep rate of 0.4 mV/s for conditions shown in Figure 2, and Figure 4 is an Evans diagram for the plot shown in Figure 3.

Although the program does a reasonable job of predicting the corrosion behavior of 304 stainless steel over a wide range of conditions, according to Edeleanu it still has a number of weaknesses. For example, it is incapable of predicting incubation periods, i.e., the observed ability of a passive alloy to be shifted to active conditions a number of times before it becomes fully active or localized corrosion begins. Nevertheless, the feasibility of developing an information transfer system with predictive capabilities has been demonstrated.

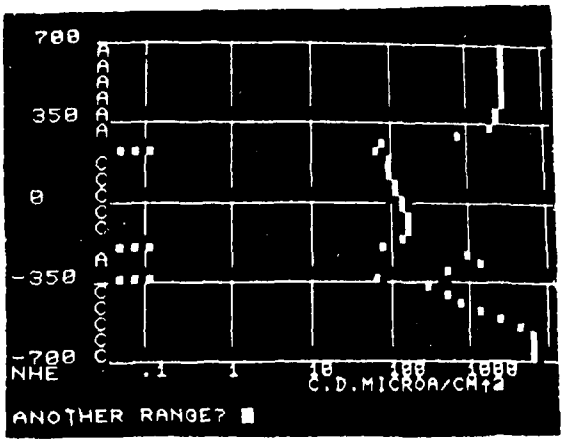

Fig. 3

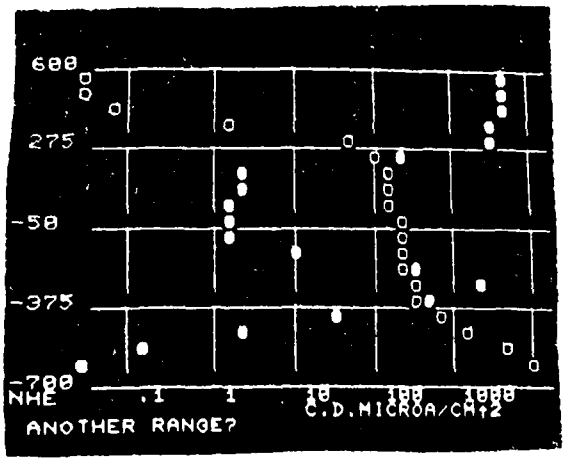

Fig. 4

At present, research is continuing at Cambridge on methods of presenting predictions and on writing a user-interactive program using data generated there and gathered by other laboratories. The development of an intelligent corrosion monitor is a long-term goal.

P. A. Clarkin

ONR London

MATHEMATICS

1982 DUNDEE CONFERENCE ON ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS

The 1982 Dundee Conference on Ordinary and Partial Differential Equations was held at the University of Dundee, Scotland, from 29 March through 2 April 1982. The conference, which was organized this year by E.R. Dawson,

W.N. Everitt, and D.B. Sleeman (all from the Univ. of Dundee) is a significant international event amongst the members of the differential equations research community. Some 75 papers, including 17 invited papers, were presented.

The first invited speaker, H. Kalf, of Darnstadt, presented a paper on a virial theorem in quantum mechanics in which he extended certain results for the so-called virial theorem for a class of strongly singular potentials. Next were invited talks by K.J. Brown (Heriot-Watt Univ.), and R.T. Lewis (Univ. of Alabama, Birmingham). Brown spoke on multiple steady-state solutions for nonlinear systems of elliptic equations that describe interacting populations. Lewis presented a new comparison theorem for quasi-accretive operators in a Hilbert space with illustrations of the new results using certain differential operators.

F. Newman (Brno) spoke on a survey of global properties of linear differential equations of the n-th order and L. Collatz (Univ. of Hamburg, FRG) discussed inclusion theorems for singular and boundary value problems. Newman reviewed the use of algebraic, topological, and geometrical tools and various techniques from the theory of dynamical systems and functional equations in the treatment of global properties of linear differential equations. Following some introductory philosophical remarks on the disparate interests of pure and applied mathematicians, Collatz discussed methods of solving ordinary and partial differential equations numerically and of putting bounds on the errors in such computations. He gave examples of error bounding methods for a number of problems in applied science based on fixed-point theorems of functional analysis and on various results from approximation and optimization theory procedures.

R. Grimmer (Univ. of Graz) gave an invited paper on weak solutions of integrodifferential equations in which he discussed a linear integrodifferential equation in a Banach space with a linear initial condition. He demonstrated that, with an appropriate definition of the concept of a weak solution and under suitable but mild assumptions on the kernel function of the integral in the integrodifferential equation, there exists a weak solution for every initial value in the Banach space if, and only if, there exists a suitable resolvent operator in terms of which the solution of the original integrodifferential equation can be expressed in integral form under further suitable conditions.

D.L. Colton (Univ. of Delaware) spoke about the inverse scattering problem for acoustic and electromagnetic waves. The problem is significant and has applications in such diverse areas as radar and sonar target identification, nondestructive acoustic testing in quality control, and noninvasive acoustic diagnostics in medical radiology. Colton appears to be making interesting contributions to the continued development of inverse scattering theory. P. Fife treated laminar flame theory with multiple reaction processes. He began by formulating the problem of determining the structure and velocity of plane flames and went on to review the standard high-activation-energy approach for a single one-step reaction. Then he discussed the comparable problem for multiple-step reactions under the assumption that various actuation energies are either very large or zero. Fife pointed out that many flame types are possible for a given reaction mechanism; he also referred to the cross-diffusion of different reacting species.

H.G. Kaper (Argonne National Laboratory) described his work in collaboration with A. Zetti (Northern Illinois Univ.) on linear transport theory and an indefinite Sturm-Liouville problem. Kaper and Zetti investigated a time-dependent electron-transport problem in which the free-streaming operator is the multiplicative coordinate operator in $L^2(-1,1)$ space and the interaction operator is of Legendre differential form.

S.O. Londen (Helsinki) delivered a paper on the asymptotics of some Volterra equations with locally finite measures and large perturbations; his remarks were much too detailed to report here other than to say that the Volterra equation he discussed was a convolution integrodifferential equation of scaler type with a linear initial value condition.

J.A. Burns (Virginia Polytechnic Institute and State Univ.) gave an invited talk on the approximation of nonlinear neutral functional differential equations. He discussed a number of physics and engineering problems—particularly certain problems concerned with space vehicles and their dynamics and problems concerned with transmission lines that can be modeled by neutral functional differential equations. He explained numerical approximation techniques for solving each equation using spline-based approximations to illustrate the theoretical results.

Four invited talks were given on the last day of the conference. J.R. McLaughlin (Rensselaer Polytechnic Inst., Troy, New York), spoke on higher order inverse eigenvalue problems for fourth-order self-adjoint systems with partially or wholly unknown coefficients and dealt with the problem of constructing the unknown coefficients from spectral data. D. Sanchez (Univ. of New Mexico and Aberystwyth) reviewed preliminary results for periodic solutions of matrix Riccati equations that occur in a variety of problems in filtering and optimal control. Some of the results he discussed, with appropriate examples, concerned the existence of periodic solutions for autonomous, homogeneous matrix Riccati equations. J.K. Shaw (Univ. of Virginia) described well-posed boundary problems for Hamiltonian systems of limit-point or limit-circle type and developed a theory of boundary problems for two particular singular end-point problems that extend to Hamiltonian systems results previously found for scalar singular boundary value problems due to Kodaira. D. Edmunds talked about entropy

numbers, s-numbers, and eigenvalues. Edmunds surveyed recent developments in the theory of bounded, but not necessarily compact, linear maps acting in a Banach space, with special emphasis on the connections between geometric quantities such as the entropy numbers and eigenvalues related to such maps and their further connections to eigenvalue problems for elliptic operators.

In addition to the invited talks, some 57 contributed papers covered a wide variety of topics. Among them was a brief report by the author on his collaborative work with M. Goldstein and D. Drinkard (Naval Underwater Systems Center) on certain new problems in nonspherical geometrical optics and their corresponding systems of nonlinear partial differential equations.

A commercially published conference proceedings, edited by Everitt and Sleeman, will be published by Springer-Verlag in the Lecture Notes in Mathematics Series.

R. L. Sternberg

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A NUCLEAR MATERIAL ACCOUNTABILITY MODEL

Dr. Rudolf Avenhaus has been working for more than a decade on problems related to safeguard measures that can be used to monitor dangerous materials in nuclear power plants, particularly in breeder reactors. His doctoral research and early academic efforts were in the area of theoretical physics. In the early 1970s he was a scientist at the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, one of the first researchers to be assigned to IIASA after it was formed. During that period, Avenhaus concerned himself with models for material accountability, arms reduction, and arms control. He is now professor of systems science in the Mathematics Department of the Hochschule der Bundeswehr Munchen (HBM), Munich, FRG. Avenhaus and Prof. Reiner Huber, the Mathematics Department chairman, plan to hold a symposium at HBM early next year devoted to the quantitative aspects of arms control, and Avenhaus is currently writing a monograph on the subject.

In what follows, a review is given of some of Avenhaus' recent work on material accountability problems. The work falls into two categories: a game theoretic model for material accountability and a two-test procedure for material accountability and data verification.

There are cases in which the material to be processed in an industrial plant is so expensive (minting gold coins, for example) or so dangerous (plutonium generated in a breeder reactor) that it is necessary accurately to account for it over precise time periods to determine whether any has disappeared. The problem is made difficult because there are generally errors in measurement of the material to be accounted for; if any seems to have disappeared, it could be due to diversion at the plant or to measurement error. This becomes a statistical-decision problem carried out over a sequence of inventory periods.

Let I_{i-1} be the initial inventory in a plant at time t_{i-1} and let D_i denote the sum of all material inputs in the ith inventory period (t_{i-1},t_i). The "book" inventory at time t_i is $B_i = S_{i-1} + D_i$, where S_{i-1} is the starting inventory for the ith period, and the material unaccounted for (MUF) for the period is $MUF_i = B_i - I_i$. There have been various proposals for selecting S_i; if one uses minimum variance unbiased estimates for the starting inventories, it turns out that the MUF values are uncorrelated (so if the measurement errors are normally distributed the MUF values are independent normal). If the detection thresholds x_1, x_2,... are used with the test statistics MUF_1, MUF_2,... in inventory periods 1, 2,..., the probability of detection of missing material when, in fact, some material has been diverted (the alternate hypothesis, H_1) in the period

$$(t_0,t_1)\text{"U"}(t_1,t_2)\text{"U"}\ldots\text{"U"}(t_{n-1},t_n)$$

is $1-\beta = 1-P[MUF_1 \leq x_1$, and $MUF_2 \leq x_2$ and... $MUF_n \leq x_n | H_1]$.

This can be given explicitly in terms of the normal distribution function, the amounts M_1, M_2... diverted, and the false-alarm rates α_1, α_2,...in the time periods. The overall false-alarm rate is given by

$$\alpha = 1-\prod_{i=1}^{n}(1-\alpha_i).$$

Assume that α is fixed, and let

$$M = \sum_{i=1}^{n} M_i$$

be the "sensitive" amount of missing material. Strategies for the inspector are of the form of vectors $(\alpha_1,\ldots,\alpha_n)$ and those for the adversary are of the form $(M_1,\ldots,M_n)$. The optimal guaranteed probability of detection is given by

$$1 - \min_{\alpha_1,\ldots,\alpha_n} \max_{M_1,\ldots,M_n} \beta,$$

subject to the constraints $\alpha = 1-\Pi\alpha_i$ and $M = \Sigma M_i$. Avenhaus has shown that this two-person zero-sum game has a unique solution, and he has suggested an algorithm for the computation of the optimal pure strategies. It turns out that the optimal inspector strategy does not depend on the total amount M of material to be diverted, which is important because that amount would generally be unknown to the inspector.

By general agreement, international nuclear material safeguards are organized in such a way that the plant operators generate all data necessary for the establishment of a materials balance. The inspectors must verify the operator's data, using a sample of independent measurements, and if there is no significant disagreement between the operator's data and the inspector's measurements, the operator's data are used to establish the materials balance at the end of each inventory period. The procedure implies two tests of significance: a "difference test" (D test) for comparison of the operator's data and the inspector's data, and a test (the MUF test) for the material balance establishment. The problem of finding a best overall test for the joint problem, with the goal of maximizing the overall probability of detection of diversion of material, is known as the MUF-D problem.

With several models for the difference test, involving various assumptions about the operator's diversion strategy and the inspector's strategy with respect to allocation of material measurement effort, Avenhaus gives the analytical forms of the corresponding Neyman-Pearson tests. The test statistic D for the difference test is generally a weighted average of observed differences between operator data and inspector data at corresponding inspection times. The D test is thus essentially a t test of the hypothesis that the mean amounts measured by the operator and the inspector are the same. (Avenhaus assumes the variances are known, so his test statistic is normally distributed.) For the combined test, the assumptions are:

$$\left.\begin{aligned} &E(MUF)=E(D)=0,\\ &\mathrm{Var}\ (MUF)= \sigma^2_{MUF},\\ &\mathrm{Var}\ (D) = \sigma^2_{D} \end{aligned}\right\} \text{ under } H_0.$$

$$\left.\begin{aligned} &E(MUF) = M_2,\ E(D) = -M_1,\\ &\mathrm{Var}(MUF) = \sigma^2_{MUF},\\ &\mathrm{Var}(D) = \sigma^2_{D1} \end{aligned}\right\} \text{ under } H_1.$$

The variables MUF and D are not independent, because they both involve the operator's data. Indeed, the covariance between the variables is σ^2_{MUF}. Avenhaus has shown that the optimum diversion strategy consists exclusively of falsifying data, in which case the best test statistic for the MUF-D problem is a linear function of (MUF) minus (D), which is known as the MUF-D statistic.

The results can be summarized as follows: under the pessimistic assumption that the operator uses a strategy that minimizes the probability of detection (by falsifying measurement data), the Neyman-Pearson test is just the MUF-D test. However, under appropriate additional conditions, a specific bivariate test may lead to a higher probability of detection than does the MUF-D test.

D. R. Barr

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RESEARCH IN STATISTICS AT THE UNIVERSITY OF KENT AT CANTERBURY

The statistics program at the University of Kent at Canterbury (UKC) is centered in the Mathematical Institute of the School of Mathematical Studies. The staff includes about a dozen statisticians, several of whom are assigned full time to the university's Applied Statistics Research Unit. Activities of various members of the staff and of the research unit are described below.

Prof. G.B. Wetherill is chairman of the institute. He has taught statistics at a number of colleges in London University, has served as professor of statistics at Bath University, and has been a visiting researcher at Bell Laboratories in the US and at the Free University of Berlin. Wetherill's research interests include sampling inspection and quality control, sequential methods, and regression theory. He has written several textbooks, including a recent one entitled Intermediate Statistical Methods (London, Chapman & Hall, 1981). He is currently writing a monograph on regression.

Under Wetherill's leadership, the statistics group at UKC and the the Applied Statistics Research Unit have been active in providing a service to industry and other bodies by working to solve the statistical problems they encounter. In return, the groups provide funding to help support the unit and the faculty, staff, and students working within it. Projects taken on by the unit vary considerably in duration and range from relatively straightforward consulting to strict research. Dr. P.M. North manages the Applied Statistics Research Unit under Wetherill's direction and also works actively on projects within the unit and does

research of his own in the area of statistical ecology, with particular applications to ornithology. Recent publications by North involve the use of statistical methodology in describing bird territories and bird survival. He was one of the organizers of the conference, "Statistics in Ornithology", held recently in the UK under the joint sponsorship of the Biometric Society and the British Ecological Society.

An example of a relatively large project undertaken by the unit is the development of a computer program for general multiple regression and response surface analysis. The program, entitled "UKCREG" (University of Kent at Canterbury REGression), was developed for ICI Ltd., Runcorn, UK. Written in the APL language, it is designed to be run in an interactive mode. The four main menu selections of the program are designed to accomplish the following: editing and transformation of data, data exploration, checking assumptions, and biased regression or prediction. The software has extensive "help and guidance" files that can be called on by the inexperienced user at just about any point in the program. In general, the program appears to be well designed, and, with the menu-selection format, error recovery features, and availability of user guidance, it is a "user-friendly" package. According to Wetherill, the unit plans to make the package available commercially in the near future. Several other software packages are being developed as unit projects, including programs for sample survey design, quality control applications, and design of experiments. It is expected that most of the programs will eventually be made available in forms suitable for running on microcomputers.

Among the smaller projects undertaken by the Applied Statistics Research Unit are short courses delivered by unit statisticians, either at the university or at the client's site. Recent topics have included analysis of variance and sample survey methods.

Dr. Byron Jones has been involved in the development of procedures to search for optimal experimental designs of various types. The use of computer algorithms in this pursuit has been increasing in recent years. As an example of how such algorithms can be useful, consider the construction of an optimal row-and-column design. In many experiments the plots form a rectangular grid, for example, agricultural plots on a rectangular field. In such a situation the experimenter may wish to use two blocking systems, one based on the rows of the grid and the other on the columns, in an attempt to eliminate effects of heterogeneity of plots in both directions. Designs for these situations can be considered in terms of their component designs, that is, the designs formed by the allocation of treatments with respect to the two blocking systems. The design formed by the blocks corresponding to the rows of the grid is the row component and that formed by the columns is the column component.

Assume there are v treatments and the design has b_1 rows and b_2 columns. Let the $v \times b_1$ incidence matrix for the row component be denoted by N_1 and the $v \times b_2$ incidence matrix for the column component be denoted N_2. Let r denote the vector of treatment replications and r^δ denote the diagonal matrix with elements those of r; $(r^\delta)^{-1}$ is denoted $r^{-\delta}$. Assume the experimenter is interested in treatment contrasts held columnwise in a matrix C, which have been assigned weights according to entries in a diagonal matrix ω^δ. The optimality criterion used in the algorithm is based on a weighted mean of variances of treatment contrasts (following Freeman, "On the Selection of Designs for Comparative Experiments", Biometrics, 32 [1976]). An optimal row-and-column design is thus one that minimizes the trace T of $C'\Omega C\omega^\delta$, where $\Omega\sigma^2$ is the variance-covariance matrix for the adjusted treatment means. Given N_1 and N_2, the matrix Ω^{-1} can be constructed, even though the two component designs have not been combined to form a row-and-column design, as

$$\Omega^{-1}=r^\delta-N_1N_1'/b_2-N_2N_2'/b_1+rr'/b_1b_2. \quad (1)$$

The component designs are considered optimal if T is minimized when they are used to define Ω through (1). The algorithm determines an optimal replication for each treatment and a connected starting design is constructed for the row component. A connected starting design with the same treatment replications is formed similarly for the column component. Once a starting design has been established, the algorithm searches for better designs by evaluating the effects (on T) of interchanging treatments between cells of the design, considering treatments in order of their strength. The procedure terminates when no interchange can be found that improves the design.

Jones has incorporated his research on algorithms for optimal experimental designs into a computer program package for determining experimental designs. The package is called INTED (INTeractive Experimental Design). As an interactive program, INTED consists of about 2,000 lines of FORTRAN code, designed to provide an experimenter with details of an optimal set of runs that will enable the estimation of a response surface. It can also be used to estimate the values of the independent variables that would give the optimum response. The program has extensive prompting and explanatory features and should be useful to users not having any particular knowledge of statistics

The package will be available from the Applied Statistics Research Unit in the near future.

Byron J.T. Morgan is one of the most prolific researchers at the Mathematical Institute. His investigations cover a wide range of interests, from the application of stochastic models to biological processes to the use of cluster analysis of large sets of data relating to social services clients. Morgan's current interests include the use of Laplace transformation estimation for parameter estimation. He described the procedure as follows: A common problem in computational statistics is the optimization of some criterion (a likelihood, say, or a sum-of-squares) with the aim of obtaining parameter estimates to fit a model. Frequently, parameter estimators are not obtainable in closed form, and then a numerical procedure must be used. However, the use of such techniques may pose problems for statisticians, who may be unfamiliar with the background theory and who may also have problems with equality and inequality constraints on parameters. In some cases a transform, such as a Laplace transform, of some aspect of the model is of a simple form in the parameters, allowing explicit parameter estimation if one can first estimate the transform.

Morgan's approach can be illustrated by an example involving the logit model for quantal assay data. In standard notation, the likelihood is given by

$$L = \prod_{i=1}^{m} \binom{n_i}{r_i} F(x_i)^{r_i} [1-F(x_i)]^{n_i - r_i}.$$

Here n_i individuals are exposed to a substance at dose x_i, and r_i individuals respond, $1 \le i \le m$. Setting

$$F(x) = [1+\exp(-\alpha-\beta x)]^{-1}$$

provides the logit model and maximum-likelihood estimates $\hat{\alpha}$ and $\hat{\beta}$ can be obtained. Notice that

$$[1-F(x)]^{-1} = 1+e^{(\alpha+\beta x)}.$$

Consider the transform

$$w(s) = s \int_0^\infty e^{-sx}[1+e^{(\alpha+\beta x)}]\,dx$$

$$= 1 + \frac{s\,e^{\alpha}}{(s-\beta)}, \quad \text{for } \beta < s .$$

One way of estimating $w(s)$ exploits the "product-mid-point" rule to give

$$\hat{w}(s) = \sum_{i=1}^{m} (e^{-sc_{i-1}} - e^{-sc_i}) \left(1 - \frac{r_i}{n_i}\right)^{-1}$$

where

$$c_0 = 0,\ c_m = \infty,\ c_i = (x_{i+1}+x_i)/2$$

for $1<i<(m-1)$

Other choices of the c_i's, and indeed methods of forming $\hat{w}(s)$, are possible. Equating $w(s)$ to $\hat{w}(s)$ for two values of s provides estimating equations that can be solved explicitly for $\hat{a}(s_1,s_2)$ and $\hat{b}(s_1,s_2)$. The problem is how to choose the values of s. One approach is to evaluate $L[\hat{\alpha}(s_1,s_2), \hat{\beta}(s_1,s_2)]$, vary (s_1,s_2), and select (s_1,s_2) that maximizes L. This is akin to reparameterizing the original problem but differs in that the constraint, $w(s) = \hat{w}(s)$, does not necessarily make available all of the original (α,β) space.

One might expect the choice of (s_1,s_2) to be less critical than the choice of (α,β). While Morgan has found this to be true, a further, empirical finding was that the maximum of $L[\hat{\alpha}(s_1,s_2), \hat{\beta}(s_1,s_2)]$ is obtained near the $s_1=s_2$ diagonal. This suggests using just one value of s and then using, as estimating equations, $w(s)=\hat{w}(s)$ and $w'(s)=\hat{w}'(s)$. One thus obtains a reduction in dimensionality (which generalizes also to higher dimensional problems) as one seeks to maximize $L[\hat{a}(s), \hat{b}(s)]$ with respect to s. Morgan said simulations had revealed that this approach can result in estimators with improved small-sample properties, as compared with maximum likelihood.

The above approach has wide potential applicability. The aspect of the model that is transformed can vary from a density function, in the case of a convolution, to mean values. Other general examples are provided from: (1) growth-curve fitting, in which one transforms $y(t)^{-\alpha_1}$, where

$$y(t) = \alpha_2[1+\alpha_1 \exp(\alpha_3-\alpha_4 t)]^{-1/\alpha_1},$$

in which t denotes time, the α_i's are parameters to be estimated, and measures $y(t)$ are taken at times t. (2) Compartment models, which result in expressions of the form:

$$y(t) = \alpha_1\alpha_3(e^{-\alpha_2 t} - e^{-\alpha_1 t})/(\alpha_1-\alpha_2).$$

A particular example appears in a model for polyspermy. In these examples a sum-of-squares, rather than a likelihood criterion, could be used.

In all such cases, a multiparameter search is reduced to a one-dimensional search, requiring only minimal computing facilities. Problems currently under research include how this approach can be useful from an inferential point of view, facilitating the construction of confidence regions.

In summary, the Mathematical Institute at the University of Kent at Canterbury has a small but active group of statisticians under the able leadership of Prof. G.B. Wetherill. Notable has been the establishment of the Applied Statistics Research Unit, which has provided financial support for the institute and has generated important research projects for university staff members and students. An important aspect of this arrangement is the close working relationship that has developed between the university and the various industrial groups taking advantage of the considerable capabilities the unit has to offer.

D. R. Barr

ONR London

OCEAN SCIENCES

SACLANT UNDERSEA AMBIENT NOISE CONFERENCE

The SACLANT Antisubmarine Warfare (ASW) Research Center at La Spezia, Italy, hosted a conference on undersea ambient noise from 11 to 14 May 1982. Most underwater acoustic conferences cover all aspects of this broad topic, but this was the first in a long time devoted exclusively to the topic of the ocean's background noise against which the detection of desired signals (usually submarine-generated noise in an ASW scenario) must compete. The conference was organized by R. Wagstaff and O. Bluy, two SACLANT staff scientists heavily involved in noise processing for the directional, passive, towed-array sonars being used in naval operations and research and development.

The meeting was well attended with representatives from seven European countries plus the US and Canada. Of the 83 participants, the largest contingent (43) was from the US. Due to the nature of the subject, most attendees were from military research and development laboratories. All papers were presented in English, and although the conference was limited to a classification of NATO secret, most papers were unclassified. Before the conference, all participants had to submit their papers in a camera-ready format; hence, the conference proceedings are expected to be published within a month of its close.

The purpose of the meeting was to exchange information between acousticians and environmentalists, theoreticians and applications-oriented researchers, laboratory scientists and seagoing experimentalists, and model developers and users. To this end the meeting was highly successful as it was readily apparent that each faction had something to contribute and to learn from the others.

The conference was divided into 6 sessions covering the following topical areas: background and programs (3 papers), low-frequency phenomena (6 papers), measurements (12 papers), models (8 papers), noise-model processing (6 papers), and topographic effects (5 papers).

The keynote address was given by CAPT T. McClosky, USN, Chief of Staff to CTF 66, the organization that has command responsibility for the ASW effort in the Mediterranean Sea. He emphasized that ambient noise is the major unknown in the sonar equation for the Mediterranean and many other naval operating areas. ASW efforts in the Mediterranean are concentrated at strategic choke points that are invariably in shallow water. Forecasters must be able to predict the noise level in such highly complex environments for a large mix of ASW platforms. Our capability to do this is poor today. Future operational forecasts must be capable of determining which of several ASW platforms can best operate in a specific location, as none is ideally suited for all the potential, environmentally complex ASW sites in the Mediterranean Sea.

The conference commenced with two background papers. D. Ross (Donanco, Inc., La Jolla, CA) provided a tutorial overview of the ambient noise problem, stressing that we understand the phenomenon but have a poor capability to predict it. He emphasized the need to understand the propagation paths traversed by the various noise sources, paths that are both seasonally and spatially varying. The other background paper considered the noise field generated by distant shipping, long known to be a major noise source in the 50 to 100-Hz band. J. Heine (Bolt, Baranek, and Newman, Inc.) described the source characteristics of shipping noise, both broadband and narrowband, emphasizing the role of propeller cavitation.

A number of papers and discussions centered on processing of the noise field as measured from directional, low-frequency towed arrays. Great strides have been made by the Ambient Noise Group of SACLANT under Wagstaff in both real-time signal processing and display and simulation modeling to develop a forecast capability. Of major concern is the situation dominated by few close-aboard ships. The directionality and fluctuation of the noise level become significant and increasingly difficult to model compared with distant shipping.

Noise sources in the infrasonic region were discussed by several authors. The impact on the noise field due to the passage of a large storm was shown by J. Wilson (SAI, Inc., Canoga Park, CA) to be governed by the local ship density, i.e., sites that are inherently noisy due to frequent passage of ships are less susceptible to storm-noise limitation. M. Strasberg (Naval Ship Research and Development Center, Bethesda, MD) discussed the contribution of infrasonic psuedonoise generated by turbulent flow over suspended, bottom-mounted, and freely drifting hydrophones. Virtually no oceanic measurements of this phenomenon exist but measurements in air show it to be highly sensitive to the turbulent flow speed.

Both the measurement and modeling sessions emphasized how site specific the noise field could be, especially in shallow water. Because the various propagation paths are quite depth dependent, the arrival angles of the noise field determine the noise level heard by a specific sensor. The paths change seasonally and the levels are significantly frequency dependent. Hence, predictive models must be sensitive to the complexities of the propagation path, especially interactions with the sea floor. This implies that ambient noise forecasting models must be regional in nature. Data bases should be established for the sites deemed strategically important and models developed or tuned to simulate conditions at each site.

The influence of noise blockage by seamounts and ridges was described in several papers. H. Medwin (Naval Postgraduate School, Monterey, CA) has shown through his laboratory studies that sound energy is diffracted around a seamount that fully blocks the sound path. S. Marshall (Naval Ocean Research and Development Activity) demonstrated how regional blockage of the shipping noise field could enhance the signal-to-noise ratio in otherwise noisy areas.

In general, the conference showed that many researchers were aware of the specific requirements for noise prediction for the various ASW platforms. However, accurate prediction is still a long way off. Incorporating fluctuation statistics in mean-level models is just starting. The question of whether increased sophistication in characterizing the propagation path is necessary in view of the ultimate accuracy required by fleet users was raised several times. Cases could be argued for both simplistic and complex approaches. It is clear that monitoring of future ambient noise measuring and modeling efforts will be required to keep them focused on fleet requirements. At the same time, fleet requirements must be clearly laid out. The danger is in drifting towards costly model complexity and sophistication that exceed fleet needs for accuracy.

R. H. Bourke

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PHYSICS

BRSG CONFERENCE ON OPTICAL TECHNIQUES IN MAGNETIC RESONANCE

The British Radio Frequency Spectroscopy Group (BRSG) Conference on Optical Techniques in Magnetic Resonance took place at the University of Hull, UK, from 31 March to 2 April 1982. Fifty-seven physicists and chemists attended. Thirty-two of the participants, representing 7 countries, came from outside the UK. The meeting was organized by the Department of Physics at the University of Hull with Dr. B.C. Cavenett as chairman. Dr. J.J. Davies, Mr. W.E. Lamb, and Dr. J.E. Nicholls served as conference secretaries.

Prof. R. Andrew (Univ. of Nottingham, UK), the BRSG chairman, noted in opening the conference that it was the 46th meeting of the BRSG and the first in Hull. Cavenett then welcomed the participants and observed that the conference was the second to address the area of optically-detected magnetic resonance (ODMR). The first was held in Dublin in 1977.

The program was divided into four subject areas: ODMR of triplet states of molecules, ODMR of defects and impurities in semiconductors, ODMR of defects and impurities in insulators, and techniques in ODMR.

The first formal session was concerned with molecular crystals. A.J. van Strien (Univ. of Leiden, The Netherlands) described work on the scattering of free excitons in a molecular crystal at low temperature. The study used electron-spin-echo techniques at zero magnetic field. J.U. von Schütz (Univ. of Stuttgart, West Germany) reported on the use of delayed fluorescence to study exciton trapping and decay in the temperature range from 1.2 to 12°K. C.J. Wincom (Free Univ., Berlin) discussed zero-field ODMR studies of the nuclear quadrupole interaction in excited states. The experimentally determined quadrupole parameters were compared with theoretical results. A.M. Achlam (Max-Planck-Institut, Heidelberg, West Germany) gave details of work on the narrow-band laser pumping of nuclear spins of an organic molecule. The experiments he referred to measured the quadrupole transitions of the ground state. The final paper of the session, by D.J. Singel (Univ. of Leiden, The Netherlands), was on electron-spin-echo studies of hyperfine interactions in the lowest, photo-excited triplet of free base porphin.

J.J. Davies (Univ. of Hull, UK) began the session on semiconductors with a description of the ODMR of donor-acceptor pairs (DAP's) in II-VI semiconductors. New resonances were reported from close pairs where the spin-exchange interaction is strong. The resonance appears at the mean g-value of the electrons and holes. R. Cox (CEN-Grenoble, France) told about work that had been done in analyzing the DAP exchange with pulse ODMR. Using a gated detector at long delays, narrow

lines were detected from the very weakly coupled pairs. The ^{115}In donor in ZnO was identified using optically detected electron-nuclear double resonance. N. Killoran (Univ. of Hull, UK) gave a paper on the ODMR of bound triplet excitons in GaS and GaSe. The experiments he discussed revealed the structure and optical properties of isoelectronic defect centers. D. Paget (Ecole Polytechnique, Paris) reported studies of the optical detection of NMR in GaAs using circularly polarized incident laser light. The spin-lattice relaxation of nuclei near shallow donors can be studied. R.A. Street (Xerox Corp., Palo Alto, California, US) discussed time-resolved ODMR of amorphous Si:H with different defect densities. The temperature dependence of different emission bands was given. S.P. DePinna (Univ. of Hull, UK) gave results on ODMR of amorphous V-VI compounds. Exciton and pair recombinations were resolved and compared with crystalline As_2Se_3.

There were a number of other talks on the ODMR of molecular systems and semiconductors. F.C. Bos (Univ. of Leiden, The Netherlands) discussed the measurement of spin-lattice relaxation rates in triplet state molecules. H.W. van Kesteren (Univ. of Leiden, The Netherlands) reviewed work on the dynamic nuclear polarization of protons in fluorene via photoexcited triplet states. A.J. Hoff (Univ. of Leiden, The Netherlands) described singlet absorption spectroscopy of pigments in photosynthetic reaction centers. J.E. Nicholls (Univ. of Hull, UK) gave a paper showing that Cu is in fact the deep acceptor of the "Cu-green" emission in ZnSe. Hyperfine structure from ^{63}Cu and ^{65}Cu was observed. F. Boulitrop (CEN-Grenoble, France) presented time-resolved studies of amorphous Si:H. Different ODMR signals were observed in the different time regimes.

The conference included a workshop on techniques, with contributions from many of the conferees. As all ODMR requires the simultaneous presence of light and radio or microwave energy simultaneously on a sample, many resonator designs were described. These included cavities, coils, slotted tubes, and helixes. The contrasts between zero and high magnetic field measurements were brought out. Two zero-field spectrometers were described in detail. Advantages of optical pumping and magnetic field modulation in the high field ODMR were described. The two time-resolved ODMR spectroscopics were also compared. In one case the laser is pulsed and the detector is gated with a variable delay. In the second case, the laser is modulated with lock-in detection at the laser modulation frequency.

The final session of the conference was devoted to discussions of insulators. W. Hayes (Clarendon Laboratory, Oxford, UK) described the search for self-trapped exitons in oxides. While lattice vacancies were found to be associated with the ODMR in yttrium-aluminum-garnet (YAG), data on the simpler yttrium-aluminum-oxide may be evidence for a self-trapped exciton. B. Henderson (Trinity College, Dublin, Ireland), reported work on F centers (anion vacancies) in CaO and MgO. ODMR was detected from a variety of F centers, which can trap two electrons. C.A. Hutchinson (Univ. of Chicago, US, and Clarendon Laboratory, Oxford, UK) described the magneto-optic rotation method of studying rare earths in crystals. He also discussed spin-spin cross relaxation between different rare earth ions. C.M. McDonagh (Trinity College, Dublin, Ireland) described energy transfer between defects detected by studying the spectral dependence of either the excitation or emission. R. Hond (Univ. of Amsterdam, The Netherlands) described cross-relaxation between F centers in CaO observed via the spin-echo decay. F.J. Ahlers (Univ. of Paderborn, West Germany) gave the final talk on measurement of magnetic circular polarization of the emission to study electron transfer between F centers in CaO.

The value of the conference was enhanced by the opportunity the participants had to view the variety of ODMR experimental setups and to tour the ion-implantation and crystal growth areas in the Department of Physics. To sum up, the author found the conference both enjoyable and stimulating.

T. A. Kennedy

NRL, Arlington, VA

THE 5TH INTERNATIONAL THIN FILM CONGRESS

The 5th International Thin Film Congress was held in Herzlia-on-Sea, Israel, from 21 to 25 September 1981. Approximately 325 scientists attended the meetings, with large representations from Israel (84), US (44), Poland (38), France (31), FRG (20), UK (18), Sweden (11), and additional representatives from 19 other countries. The program consisted of a plenary lecture, 17 topical sessions, and 4 symposia during which 235 oral and poster papers, including 32 invited papers, were presented. As full proceedings were to be published in June 1982, and in view of the large number of papers presented, comments here are limited to brief overviews of individual sessions and discussion of a few selected papers.

Transport Properties

A particularly interesting paper by S. Norrman and T. Andersson (Chalmers Univ. of Technology, Gothenberg, Sweden) addressed the temperature-dependent conductivity of gold films. Experimental deviations from the typical linear log (conductivity) versus inverse temperature curves in very thin films were attributed to more realistic distributions of particle sizes and spacings that are characterized by a temperature-dependent potential barrier. Origins of such barriers are traced to thin surface

layers on the substrate material that result from cleaning or preparation procedures. Inclusion of a temperature-dependent barrier resulted in excellent quantitative agreement between computed and experimental results.

Dielectric Properties

R. Coelho (Ecole Sup. d'Electricite, Gif-sur-Yvette, France) gave a paper on electrical breakdown of insulating films subjected to a high electric field over a few milliseconds. For this regime, a delayed thermal breakdown theory was presented as opposed to electronic avalanche breakdown for shorter pulses. The model is based on interplays between electrons in a free state or trapped in the surface states. The experimental data presented by Coelho were in good agreement with his theory.

Magnetic Properties

In an invited paper, M. Rosenberg (Ruhr-Universität Bochum, FRG), discussed new trends in three main areas of magnetic thin films. The challenge in working with metallic crystalline films is to deposit ultrathin films (1 to 10 atomic layers) of 3d transition metals suitable for use in sandwich layers to take advantage of reduced thickness and predicted electronic structure. Systematic studies of the amorphous magnetic thin films are required to improve understanding of the influence of the short-range order and to settle the controversy about the magnetic properties of the crystalline transition metals and alloys. Single crystal films of magnetic insulators must be developed further to increase the capacity of magnetic bubble memory devices.

Mechanical Properties

Hardness, stress, twinning, and elastic properties of various films were discussed in this session. S. Rokhlin et al. (Ben Gurion Univ. of the Negev, Beer Sheva, Israel) discussed use of surface acoustic waves as a technique to study the effective elastic properties of a gold-aluminum thin-film sandwich as multiphase diffusion occurred. An intermetallic new phase was observed with acoustic waves and compared favorably with x-ray diffraction and resistivity analysis. The relation between the growth of the intermetallic layers and the variation of effective elastic constants of the system was further discussed. The symposium session consisted of four additional invited papers, one of which was given by H. Pulker (Balzers, AG, Balzers, Liechtenstein) on the mechanical properties of various optical films. Applying a grain boundary interaction model in estimating tensile stresses in crystalline films, he was able to develop specially doped MgF_2 films that had highly reduced intrinsic stress levels. Other optical thin films were studied in attempts to reduce stress.

Optical Properties

An interesting paper was given by Y. Zerem, C. Bear, E. Greenfield, and E. Secemski (Jerusalem Coll. of Technology, Israel) on automatic computer synthesis used in designing various optical coatings. Starting with only the substrate index of refraction and a list of allowed coating material indices, the program provides for the design of a multilayer coating to achieve the desired performance. A paper by J. Dobrowolsk and F. Ho (National Research council of Canada, Ottawa) also discussed a thin film synthesis program that provides for the design of antireflection coatings for various window materials taking into account the dispersion of the optical materials. A coating for a germanium window was designed with a reflectance of less than 0.1%, with a fabricated sample displaying performance values to match. K. Rabinovitch (Electro Optics Industries, Rehovot, Israel) subjected several films to heat treatments with significant improvement in optical performance for applications at 1.06 microns. A transmittance of better than 99.95% was achieved by use of glass windows coated with a TiO_2 and ZrO_2 mixture (Substance 1). Water absorption-desorption and crystallization were proposed as possible explanations for the enhanced performance.

Nucleation and Growth

Techniques to study the onset of nucleation were reported, namely ellipsometry, resistivity, LEED, RHEED, Auger, TEM, SEM RBS, and laser interference effects. Several of the techniques were used by a group at the University of Mons, Belgium, to study the effects of laser-induced microcrystallization and laser annealing of thin films. Well-defined crystallized patterns with dimensions down to 0.1 micron could be obtained with a pulsed dye laser and optical fibers that directed and focused the beam. Such a finite technique has particular importance in microlectronics. Laser annealing at room temperature of Al and Sb sequentially evaporated films with microsecond pulses resulted in AlSb single crystals over 10 microns in diameter and 0.1 microns thick. Conventional thermal annealing required a temperature of 650°C for at least 100 sec before the transition occurred. The technique is therefore useful in depositions where substrate temperature changes are prohibitive.

Epitaxy

R. Vook (Syracuse Univ., Syracuse, New York, US) used Auger spectra ratios to identify layer growth in both thick and thin films. Further interpretation of the data provides topographic information on films. $Cd_xHg_{1-x}Te$ epitaxial films have been grown successfully on a CdTe (111) surface at 100°C by a French group. They state that the surface is free of contamination and shiny. Several layers with different values of x have been fabricated with good compositional homogeneity. Epitaxially grown films will obviously receive a great deal of attention from the semiconductor industry.

Deposition Techniques and Very Large Scale Integration

Very large scale integration is concerned with the precise fabrication of complex multifilm micrometer chips requiring extremely tight spatial and performance tolerances on each film. The general consensus was that advances in all facets of deposition and fabrication are required for future systems but should be within reach by pushing the state of the art in current technology. One approach to attain the dimensional requirements of 1 micron or less is to use laser beams to activate a reaction at a gas-solid interface. The beam can be focused to submicron size for a number of other processes, such as spatial control of reaction rates, initiation of product nucleation, adsorption or desorption by surface catalysts of contaminants, and surface annealing or crystallization.

Amorphous Semiconducting Films

The majority of the papers dealt with hydrogenated silicon films and covered fabrication and characterization methods. Some Fe and Ge films with various properties were also discussed.

Composite Thin Films

Interdiffusion and conduction mechanism in Cermet-type thin films were the main items of discussion. K. Roll (Universität Regensburg, Regensburg, FRG) fabricated a multiple-stack film of equal-thickness pairs to investigate the interdiffusion by Auger depth profile analysis. It was found that grain boundary diffusion plays a dominant role, at least for Cu-Ni films, as evidenced from Auger profiles taken on samples annealed at various temperatures.

Electronic Devices and Sensors

An invited paper by W. Spear, P. LeComber, A. Snell, and R. Gibson (Univ. of Dundee, Dundee, Scotland) treated recent developments utilizing amorphous silicon films in device applications. Liquid crystal display panels, photosensing elements, integrated logic circuits, and p-i-n junctions were addressed. Other devices described included laser materials, ultrafast photoconductive detectors, electronic transducers, and hybrid circuitry.

Superconductivity

Resistivity measurements on films far from continuity were conducted by G. Deutscher and M. Rappaport (Tel Aviv Univ., Israel). A thin film of In was evaporated onto CdS rather than onto insulating material. Because of the relatively low resistivity of CdS, the superconducting transition could be followed as In film approached continuity. Thus, superconductivity in the grains of In films was detected.

Interaction with Light and Luminescence

Optical processes in thin films are the basis for such devices as solar cells, detectors and sensors, diode lasers, and optical displays. C. Sella et al. (CNRS, Laboratoires de Bellevue) reported on its developmental efforts to deposit oxysulfide films to improve the brightness, resolution, and contrast of conventional visual display devices, e.g., the cathode ray tube. Oxysulfide films were RF sputtered in high purity deposition systems under UHV conditions. The films, as deposited, were amorphous and had low luminescent brightness. Appropriate heat treatment resulted in crystallization with maximum luminous efficiency approaching theoretical values. The apparent brightness of resulting films was dependent on substrate roughness. The use of an appropriately roughened substrate could increase the brightness by factors of five.

Transparent Conductors

The papers in this session dealt with thin metallic oxide films rather than with metallic films. Deposition techniques discussed included reactive sputtering, hot aerosol spray of metallic chlorides, controlled homogeneous precipitation, reactive evaporation, and magnetron sputtering. Substrates consisted primarily of glass, salts, silicon, and even a continuous roll of transparent plastic veneer. Dependence of optical and electrical properties on substrate temperature, dopant concentration, type of reactive atmosphere, and heat treatment were among the topics treated.

Thin Films Characterization

Almost all of the speakers discussed characterization schemes and application of such procedures to develop better understanding of the properties of films. The importance of characterization of films was emphasized in a dedicated session consisting of 14 papers. Elastic backscattering techniques to determine stoichiometry of specified film types were described. Other techniques included sputtered neutral mass spectrometry, x-ray diffraction, thermal desorption spectroscopy, Auger, XPS, SEM, TEM, SIMS, electron paramagnetic resonance, Rutherford backscattering, and optical spectroscopy. Other techniques were discussed in other sessions.

Interfaces

Most of the papers were concerned with surfaces and interface interactions relative to semiconductor materials. Impurity effects, ion implantations, silicide formation, interdiffusion, electronic structure, abrupt junctions, adsorbed layers, thin barriers, catalysis on oriented ultrathin films, Schottky barrier, and microstructure were topics of discussion during this session. L. Brillson (Xerox Webster Research Center, Webster, New York, US) suggested in his paper on interface chemical reaction and interdiffusion that the strength and character of microscopic interfacial bonding determines the chemical and electronic properties of macroscopic metal films on semiconductor surfaces. The results are based on soft x-ray photoemission spectroscopy, low-energy electron loss spectroscopy, and Kelvin probe measurements

as a function of atomic film thickness on samples cleaved in ultrahigh vacuum conditions. Chemical trapping and electromigration processes at the interface control the stoichiometry of the diffusion regions.

Thin Films for Solar Energy

K.L. Chopra (Indian Institute of Technology, New Delhi) presented an invited review of thin-film solar cells. He stated that efficiencies of approximately 10 to 12% have been demonstrated routinely with small-area samples but that drastic reductions of efficiency occur as the area is increased. From an economic as well as practical point of view, thin films will have to be used in lieu of single crystals. But problems need to be worked out in the areas of the interphase region, grain boundaries, passivation, diffusion, materials, property degradation, and life cycles in addition to scalability. The statement actually summarizes the entire conference.

Observations

The 5th International Thin Films Congress was a huge success. It brought together most of the world's leading scientists in the study of thin films. A surprising note was the large number of representatives from so many different countries, including Finland, Spain, Portugal, South Africa, Sweden, Venezuela, and Mexico. Obviously missing were representatives from eastern block countries, most notably Russia. It was evident, however, that there is a great deal of mutual admiration and respect among all of the scientists throughout North and South America, Europe, the Middle East, Japan, and India. With the exception of the invited papers from the US in the special symposium sessions, each session was dominated by contributors from various European communities. The dominance of the special symposia by the US reflected the directional leadership generally sought from the US by other countries, but a great deal of the pioneering work in thin films occurs in Europe and Israel. Most deposition equipment is being developed and built in Europe (Liechtenstein and Germany). Developments in thin film synthesis and fabrication by several groups in France and Israel appear to be more advanced than similar developments being conducted in the US. The emphasis on solar cell research has definitely shifted to European and Middle-Eastern countries, as has much of the research on special semiconductor types of thin-films. Areas involving mass production and miniaturization are being emphasized more in the US and Japan, with more of the fundamental basic research occurring overseas.

T. W. Humphreys

US Air Force European Office of
Aerospace Research and Development

NEWS & NOTES

ICEBERG RESEARCH NEWSLETTER

The Scott Polar Research Institute, Cambridge, England, has begun the publication of a newsletter "Iceberg Research." Number 1 is dated May 1982. The publication will focus on the scientific study of icebergs rather than the emotional effects of the awesome hulks and their ability to sink ships. The latter has been the reason for the International Ice Patrol, which has produced much observational data on the drift of icebergs and on oceanographic properties, but the physics and chemistry of the bergs have been largely unstudied.

The first issue includes articles on "The Oceanographic Impact of Melting Icebergs and Marine Ice Shelves," "Iceberg Response to Sea State," "Iceberg Towing - Why Not use the Wind?", "Southern Ocean Waves and Winds Derived from Seasat Altimeter Measurements," and what is called "Iceberg Anthology 1," an extract from R.H. Dana's "Two Years Before the Mast."

The Office of Naval Research is a major supporter of iceberg research for obvious reasons, but many others in the public and private sectors should be interested in research and engineering aspects of iceberg science. The new publication should introduce the subject to a wide audience. A reading of the introductory editorial "Why an Iceberg Newsletter" will sensitize many scientists to the importance of this research.

The editors of "Iceberg Research" are Dr. Peter Wadhams, Scott Polar Research Institute, University of Cambridge, Cambridge CB2 1ER, England and Dr. E.G. Josberger, US Geological Survey, Ice Dynamics Project, University of Puget Sound, Tacoma, WA 98416, USA. Dr. Wadhams should be addressed if you wish to be put on the mailing list.

F. A. Richards

ONR London

NEW DESIGN FOR SHALLOW WATER VESSELS

A new type of hull has been developed for shore-based lifeboats in Britain that may prove valuable to people who build other types of vessels to run fast in shallow waters. One of the obvious dangers in such operations is that propellers can be damaged or destroyed if a boat runs aground.

The design and construction of the two prototypes now being tested were funded jointly by the Royal National Lifeboat Institute and the UK Department of Industry. The RNLI has a special interest in such boats, because about 50 of the 130 lifeboats it operates around Britain's coasts must be launched from slipways for lack of suitable harbors. Clearly, boats going into

the sea in this manner must have protected propellers. Unfortunately, however, in most of the lifeboats now operating, the parts of the hull that shelter the propellers create turbulence and slow the vessel down. The current top speed of slipway-launched lifeboats in Britain is 9 knots.

The newly designed hull has two big "bilge keels" at the sides of the boat that protect the propellers on the slipway and in shallow waters. The engineers built about a dozen scale models, which they tested in tanks and in the open sea, before they settled on a final design.

RNLI hopes that the new design will enable it to obtain speedy rescue vessels with propellers that are safe in shallow waters. In 5 months of operation, the first of the prototypes has performed "very satisfactorily."

D. J. Peters

ONR London

THERMAL CAMERA AIDS FIREFIGHTING

A thermal camera has been developed by a British company that enables the user to see through smoke-filled areas and pinpoint the sources of fires. The camera has the capability of detecting infrared radiation and generating a television picture. As infrared radiation can pass through smoke, the viewer can obtain a clear picture of the exact location and extent of a fire. There is the added advantage that pictures can be relayed from the camera to a remote screen, so that a firefighting operation can be observed and firefighters controlled from a central point.

The camera, which is still on trial, was designed and developed for use by civilian fire brigades. In early June, however, the UK Ministry of Defense ordered 90 of the cameras, at a cost of £6,000 ($12,000) each, for use in ships.

D. J. Peters

ONR London

NEW SYSTEM FOR REFUELING VTOL AIRCRAFT

A UK patent application on a system for refueling VTOL aircraft from ships at sea has been filed by Rockwell International. The system is said to compensate for the pitch and roll of the vessel that, until now, have made such in-flight refueling impossible. The Rockwell design uses an articulated arm of air-sprung beams that stands out from the side of the ship and has a refueling drogue at the end. There are motion sensors and accelerometers at each joint of the articulated linkage that give an on-board computer a continual update of any drag on the system. When drag is reported, the computer activates a fan or high-pressure gas jet to counteract it.

D. J. Peters

ONR London

FERRANTI LASER BEACON SIMULATOR

A new lightweight laser simulator is being produced at Ferranti Laser Systems Group, Edinburgh, Scotland. The Model 312 design uses a neodymium yag laser and can be obtained in various field-of-illumination models (60° cone, 180° or 360° azimuth, etc.). With two rechargeable batteries, tripod, transit case, and remote cabling, the system weighs only 37 pounds. Reportedly, the system could be used for a variety of target and beacon simulations with laser-seeker-equipped aircraft. An extension to the system can provide automatic beacon data transfer.

Nicholas A. Bond, Jr.

ONR London

STEAM IN THE CYLINDERS

A device for inserting steam into any internal-combustion engine has been produced in Limburg, The Netherlands. The unit meters the amount of steam for the prevailing conditions of the moment and inserts it into the engine via a catalyst. Reportedly when the steam is injected at just the right place in the cycle, concentrations of noxious fumes in the exhaust can be reduced sharply, and there may also be fuel savings. In one recent 50-hour test of an ordinary automobile motor, the carbon monoxide content of the exhaust fumes went down from 3.5% to 0.1%. Nitrogenic and sulphurous acids emitted into the air by oil-consuming engines supposedly can also be reduced, sometimes by 90% or more.

The simplicity of the idea and the startling early claims for the unit may sound too good to be true. But there are already two types of unit on the market, one for closed combustion motors in trucks and cars, and another for industrial or "open" combustion systems. Belgium has ordered nearly 400 units already, and there are about 200 other orders from Switzerland and Scandinavia. Evaluation studies are under way at Eindhoven Technical University.

Nicholas A. Bond, Jr.

ONR London

CONTINUOUS SPEECH RECOGNITION SYSTEM

Progress on speech recognition continues in many laboratories, even though ultimate systems that can deal with real unconstrained speech still seem to be a long way off. A new British system, called LOGOS and manufactured by Logica Limited of London, probably represents the European state of the art.

LOGOS reportedly can provide continuous recognition of spoken phrases of any length if the phrases come from a set vocabulary of a few hundred words. Part of the technology involves the use of a "node" concept; at each node, certain connections to other words are legal and some are not; stored word-sequence rules can restrict the number of admissible words at any node, so the computational and storage requirements are quite reasonable (64K bytes for 120 words, 1M bytes for 2,000 words). The syntax rules can be inserted by the user, so there is room for a special "tailored flexibility." Recognition probabilities after short "training" are claimed to be in the high 90s for words and for long phrases.

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FOR WANT OF A WORD...

A single sentence, or even a single word, can make all the difference. The tragic ground collision of two big jets at Chicago several years ago may have hinged on the meaning of a plane-tower exchange involving "...the bridge." According to some accounts, one pilot believed he had sent a message to the tower which accurately depicted his position relative to the bridge (a local landmark); the tower perceived the message differently and issued takeoff orders that resulted in the collision. Dozens of lives and millions of dollars were lost.

In a recent British chemical plant explosion near Manchester, the interpretation of one sentence, and especially the significance of one key word, are believed to have been major factors in the accident. A company director called the plant and told an employee to "...switch off steam and wait half an hour for the vapor to disperse." The employee understood this instruction to mean "...turn the steam back on to the half-mark." Shortly after he did this, 1,200 gallons of hexane exploded; one man died, another was injured, and 1,000 nearby residents had to be evacuated.

For both the aircraft and chemical plant cases, the key words of "bridge" and "half" were certainly simple and known; but the human operators were busy and expecting certain items of information that involved those key words. Receipt of the word itself may have been taken as an indication that the whole anticipated message had been sent, when contrary information actually had been given.

Because context and expectancy effects are so difficult to control, there will probably always be some misinterpretations like the two cited here; what makes these cases special is their remarkable cost. There are some obvious lessons for system designers here, though; one is that certain key words or phrases should not be used for contrary or contradictory states or events. "Bridge," for example, would not be an admissible word for transmission to the tower unless the plane was in a safe state relative to bridge-area or bridge-relevant traffic. Then any transmission with "bridge" in it would relieve (or constrain) the tower operator, and so forth.

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OPERATIONS FOR DEAF SUBJECTS

If a person is profoundly deaf but still has some neural linkage between the cochlea and aural centers in the brain, there is a method for providing partial hearing. One procedure, first developed at University of California-San Francisco, employs an implanted transmitter-receiver unit, which sends a processed signal to eight pairs of electrodes placed along the spiral canal of the cochlea. Some spectacular successes have been reported with this technique; in London recently, a man who had been totally deaf for 29 years was suddenly able to hear the low-frequency components of his own voice.

An alternative procedure, developed by Ellis Douek at Guy's Hospital, London, does not invade the cochlea. The electrode is forced against the bone covering the cochlea by a spring; the ear drum is mechanically forced against the same bond. Douek's system at present allows for only one channel, but it is surgically much simpler than the UC-SF method. Evaluation studies of both methods are now in progress at the Phonetics Department, University College, London.

Nicholas A. Bond, Jr.

ONR London

BREATHING AID TO PREMATURE BABIES

There are many reasons why premature babies are more likely to die than those delivered at full term. Among the important reasons is surface tension in the film of water that covers the inside of the lungs. Surface tension, which is due to molecular forces in the water, resists the initial and critical inflation of the lung, and after inflation has occurred it still tends to close the microscopic air pockets. A normal baby produces a chemical surfactant, which automatically prevents the surface tension

from reaching dangerous levels; premature babies are less likely to have enough of the substance.

Colin Morley of Addenbrooke's Hospital, Cambridge, UK, has recently reported a simple and effective treatment for lung surface tension at a meeting of the British Paediatric Society. The treatment is to blow a very small amount of a solid artificial surfactant into the baby's lung. Chemical research for the artificial material was done by Alec Bangham at the Institute of Animal Physiology in Cambridge. The material itself is made up of two phospholipids.

A clinical trial gave highly encouraging results. Of 53 treatment babies born at less than 35 weeks, two died; in an untreated comparison group of 78 babies, 17 died. In those born at less than 30 weeks, the death rates were 8% and 44% for treated and untreated groups, respectively. Reportedly, several larger trials are planned for Britain within the next few months.

Nicholas A. Bond, Jr.

ONR London

SYMPOSIUM ON HALIDE AND OTHER NON-OXIDE GLASSES

The First International Symposium on Halide and Other Non-Oxide Glasses was held at the University of Cambridge, UK, from 23 to 26 March 1982. A total of 56 papers dealing with fluoride glasses, other halides, and chalcogenides were presented. For each group the structures, method of preparation, and properties were addressed and potential applications were discussed.

Most of the attention at the symposium was directed to fluorozirconate glasses in view of the promise they hold for use as waveguide, bulk-optic, and laser-host materials.

A bound volume of the papers presented, together with poster material and extended abstracts, is available from the Society of Glass Technology, 20 Hallam Gate Road, Sheffield, S10 5BT, UK.

D. J. Peters

ONR London

ONRL STAFF CHANGES

In June we welcomed aboard liaison scientists Dr. Ronald W. Armstrong and Dr. Robert L. Carovillano. Dr. Armstrong, a materials scientist, is from the University of Maryland, College Park, Maryland; Dr. Carovillano is a physicist from Boston College, Chestnut Hill, Massachusetts.

ONR CONSPONSORED CONFERENCES

ONR London can nominate two registration-free participants in the conferences it supports. Readers who are interested in such participation should contact the Chief Scientist, ONR London, as soon as possible.

International Meeting on Analysis of Sample Survey Data & Sequential Analysis, Jerusalem, Israel, 14-18 June 1982.

2nd International Conference on Databases Improving Usability and Responsiveness, Jerusalem, Israel, 22-24 June 1982.

NATO ASI on Numerical Taxonomy, Bad Windsheim, FRG, 4-16 July 1982.

1st Biennial National Atomic Spectroscopy Symposium, Sheffield, UK, 13-15 July 1982.

International Conference on Practical Bayesian Statistics, Cambridge, UK, 21-24 July 1982.

IXth IUPAC Symposium on Photochemistry, Univ. of Pau, France, 25-31 July 1982.

XI International Symposium on Mathematical Programming, Bonn, FRG, 23-27 August 1982.

4th Europhysical Topical Conference on Lattice Defects in Ionic Crystals, Dublin, Ireland, 30 August - 3 September 1982.

2nd International Workshop on "Ion Formation from Organic Solids II," Münster, Germany, 7-10 September 1982.

4th International Symposium on Gas Flow and Chemical Lasers, Stresa, Italy, 13-17 September 1982.

14th Europhysics Conference on Macromolecular Physics, "Polymer Crystals: Structure & Morphology," Vilafranca del Penedes, Spain, 21-24 September 1982.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Navy Lab./Org. to be Visited
Dr. L. Bengtsson	ECMWF, Reading, Berks	NEPRF, Monterey (June or July)
Dr. J. Cousins	Propellants, Explosives, and Rocket Motor Establishment, Westcott, Aylesbury, UK	NWC, China Lake, (1 July 1982) US Navy Consultant, Inst. of Technology, Pasadena, CA, (28 June 1982)
Prof. J.W.S. Hearle & Dr. M.A. Wongsam	UMIST	Synthetic Line Workshop (8-10 June 1982)
Prof. Dr. E.J. Neuhold	Institut für Infomatik, Univ. of Stuttgart	ONR (19 July 1982) NSWC, White Oak (20 July 1982) NSWC, Dahlgren (21 July 1982)
Dr. W.J. Stronge	Univ. Engn. Dept., Cambridge, UK	NRL NWC, China Lake NPS, Monterey (Late June or early July)

ONRL REPORTS

R-1-82 Area Report: Antenna and Progagation Related Work in Europe and Israel, by T. C. Cheston.

This is a report of visits made by the author to universities, industrial and other technical establishments while serving as a liaison scientist at ONR London from October 1979 to October 1981. The report begins by highlighting the most important topics, then goes on to describe research in France, Israel, Italy, The Netherlands, Switzerland, Turkey, West Germany, and Yugoslavia. A previous report covered activities in Denmark, Norway and Sweden.


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