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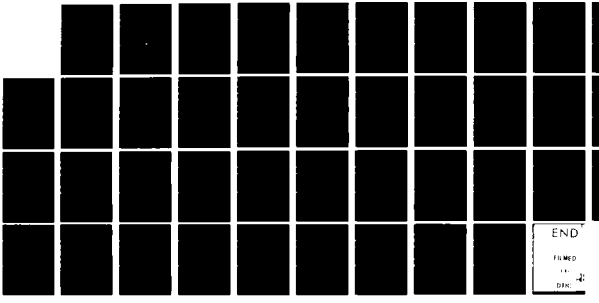

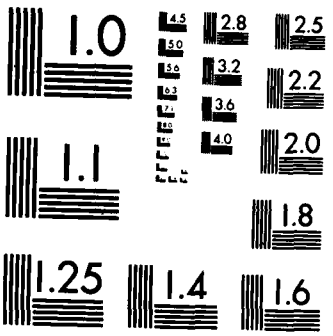

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European Scientific Notes (ESN) is a monthly publication with brief articles on recent developments in European Scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the

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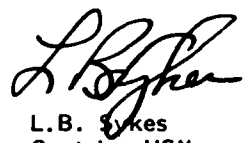
F.A. Richards
Chief Scientist



L.B. Sykes
Captain, USN
Commanding Officer

BEHAVIORAL SCIENCES

ACCURACY OF PERCEIVED ROLL ANGLE AND ROLL RATE

Human reaction to "roll" is an important feature of aircraft flight. The conventional aid to roll control is the artificial horizon indicator. The instrument shows the vehicle's instantaneous roll status relative to a horizontal reference line and can also be fitted with supplementary "command" lines and bugs of various kinds. A large part of the visual information on roll can be shown on one small display. In the extreme, roll can be automatically programmed, and the operator's task is reduced to simple monitoring and occasional off-line calibration of the horizon indicator. However, the horizon indicator is not a complete cue system by itself. Motion cues, as experienced in dynamic simulators and real aircraft, can give rapid vestibular inputs that do not interfere directly with other visual tasks. At the visual level, peripheral displays seen "out of the corner of the eye" can furnish additional information on the motion of the vehicle. When the pilot is busy with other tasks, the supplementary cues can be decisive in maintaining good roll control.

At the Department of Aerospace Engineering, Delft University of Technology, the Netherlands, basic studies into manual and aided aircraft control have been going on for many years. The work reported here started with some closed-loop control experiments in the Delft simulators. F.J.A.W. Hosman and J.C. van der Vaart confirmed in a simulator that experienced pilots showed better roll control when motion cues were used and the cabin experienced realistic accelerations. Performance was also improved when peripheral stimuli were introduced off to the side of the main instrument panel. The changes were quite discernible, and indeed were reflected in the human transfer functions that were fitted to the data. Hosman and van der Vaart proceeded to analyze further just how the performance was being improved by the additional information.

Two simulator experiments were performed. In the first, roll angle was presented on a conventional type of horizon display (moving horizon, stationary aircraft wing line). For the second experiment, roll rate information was furnished to the subject both straight ahead and peripherally. Exposure time was systematically varied. The expected outcome of the research was a set of baseline thresholds and error curves for roll perception.

The Dutch investigators used video technology to present the displays. A simulated horizon instrument had a radius of 10 cm, and the (moving) horizon line was updated 50 times a second so that it appeared to move smoothly across the instrument. For the peripheral display, a pattern of checkerboard squares moved at a repetition rate of 30 frames per second; the movement, of course, was closely tied to the roll information appearing on the horizon instrument in front of the pilot.

Subjects responded by means of a digital keyboard and were told to judge the amount and direction of roll and to press an appropriate "correction" key on the keyboard. When a new roll stimulus was presented it was accompanied by an audible tone in the subject's head phone. At that instant, the stimulus was exposed for a preset time (say for 0.04, 0.06, or 0.08 s), then it was blanked or "masked." The blank display was simply near-black video; when masking was programmed, a horizontal line moved randomly over the horizon display. (Masking was investigated because of Sperling's demonstration some years ago that perception of short-exposure stimuli is degraded if the test stimulus is immediately followed by a "noisy" random-dot display. Presumably the noisy presentation affects short-term memory for images. In the present research, masking proved to have little effect for stimuli exposures of 0.03 s and longer. For this reason it was later dropped as a major experimental variable.)

Error feedback information was presented to the subject immediately after an output was received. The displayed error was computed as the difference between the subject's response and the "real" roll parameter value. There were several hundred practice and training runs during which the pilots familiarized themselves with the scoring procedures and watched their performance errors over a long series of trials. All the practice, stimulus presentation, recording, and scoring were computer controlled. The experiments are among the most elegant in this field and certainly seemed to get very close to the "net" roll-control behavior for well-trained human subjects.

Three criteria were evaluated on each set of data. One score, called S_c, is really a variance ratio; that is, the subject's response variance to the computer input was divided by the "true variance" of the input signal. The number of correct judgments and reaction time were also recorded.

Figure 1 shows the S_c score for roll attitude at five different exposure times. The results indicate that it takes some 60 ms to make a reliable judgment of roll; when fully focused on this one task, the highly practiced operator does not "need" more time. The graph shows that at very brief exposures of about 40 ms, the human variability increases enormously, especially under a masking condition; this not only confirms Sperling's result but also helps to explain how "mental dazzle" in the pilot may occur from scanning several instruments in rapid succession. The score curve for the number of correct responses resembled the one for S_c, so one can say that

exposures below 50 ms are apt to result in improper performance.

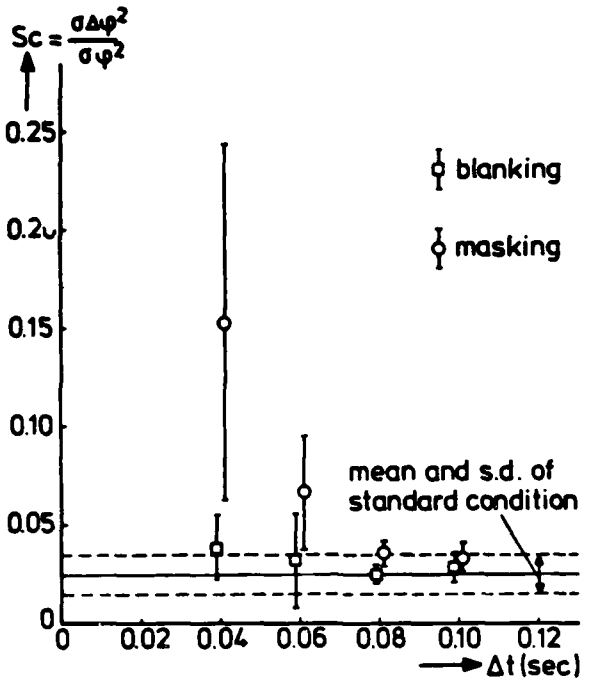


Fig. 1 Score Sc for roll attitude perception as a function of exposure time.

For evaluating roll rate perception, the same controlled exposure time setup was used, with additional peripheral display cues in some trials. There were then three main display conditions: central only, peripheral only (with subject instructed to look straight ahead), and central-plus-peripheral. The results using the S_c measure seem quite clearcut. In Figure 2, for example, under central-display-only (C) conditions, reduced exposure time results in a larger (i.e., worse) S_c score, but this is not the case for either the peripheral (P) or central-plus peripheral (CP) presentation.

As expected, the error in human estimation of roll rate varies with the roll rate itself; the effect is seen in Figure 3 for the central display only. What is less obvious is that roll rate judgments can be made fairly well from the peripheral display alone, and that the smallest average errors and the shortest reaction times were obtained with a combined central and peripheral setup.

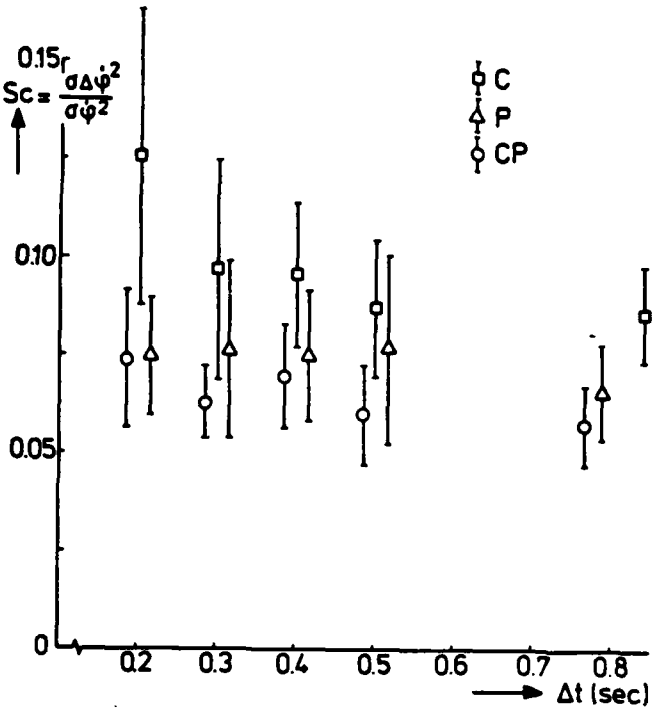


Fig. 2 Score Sc for roll perception as a function of exposure time.

Accurate roll rate estimation is generally much more difficult than is roll attitude judgment. The rate task requires nearly eight times the exposure of the dynamic stimulus (0.40 s compared to 0.05 s) before the judgment can be made reliably. Also, the mean S_c score parameter was considerably higher for roll rate (0.86 vs .025), and the slope of the fitted error curve as a function of the stimulus index is steeper for the rate perception. As Hosman and van der Vaart observe, all such differences must be due to the differential perceptual processes required, as the keyboard entry task was the same for rate and for attitude estimation.

Peripheral displays certainly proved to be effective stimulus devices, at least under the rather barebones experimental conditions depicted here. The peripheral-only rate estimate was actually better than that found with the central display only, and the aiding effect of peripheral information was more pronounced at the shortest exposure times. These are rather surprising results.

Hosman and van der Vaart did not intend for their baseline research to be immediately extrapolated into practical aircraft

instrumentation. But the response curves probably will constitute a significant contribution to the handbook

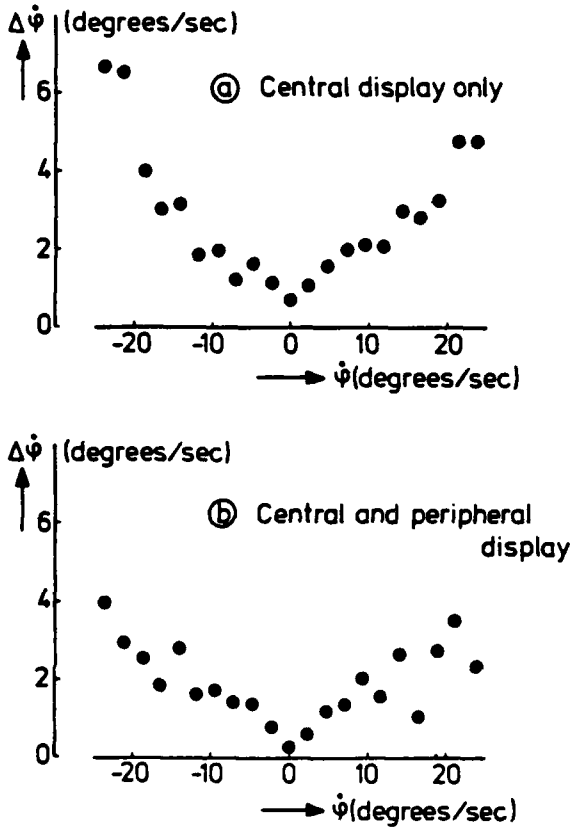


Fig. 3 Mean error Δ of perceived roll rate as a function of displayed roll rate

literature and to future editions of classic textbooks like Roscoe's Aviation Psychology. Furthermore, the methodological sophistication of their work suggests how experimentation in the man-machine field is being carried out: tight computer stimulus control and scoring, long practice and data-taking runs with rather few highly skilled subjects, automatic feedback of error functions, and gradual accretion of complexity in display and control devices as the processes studied become better understood. The conventional short psychological experiments with captive college students seem blunt and inefficient by comparison.

Though they are not used routinely for display engineering and design, there are mathematical models of the human visual pattern-detection process. The models include variables such as modulation contrast, display noise, retina-referenced display area, visual efficiency at a given retinal image position, adaptation luminance, and so forth. Basic parametric work like the Delft studies should hasten the development of such models for dynamic aircraft control tasks. The human threshold performance for moving objects has already been modeled for some simple bar targets, and it will be interesting to see whether such models can easily accommodate new information from the aeronautical research community such as the peripheral display effectiveness mentioned above.

N.A. Bond, Jr.

ONR London

HEART RATE AND MENTAL WORKLOAD

Heart rate is relatively easy to monitor and at the extremes is related to task characteristics such as stress, novelty, and the amount of information processing required at any given moment. For these reasons many investigators have tried to correlate heart-beat data with task features; some have even explored the idea of using heart rate as an objective criterion of mental workload. Recent studies from Britain and the Netherlands approach the heart-rate technical issues from slightly different standpoints, and still they complement each other in an interesting way.

The British work was at the Royal Aircraft Establishment (RAE) in Farnborough (Hants, UK) and reported by A.H. Roscoe (RAE Tech Memorandum FS(B) 464, 1982). For some years the RAE has been taking in-flight heart records, and the basic recording problems were solved long ago. At the Bedford base, many RAE pilots routinely applied their own cardiac electrodes and ran their own recording system checks. A data base of more than 3,000 "good" plots of heart rate during standard pilot tasks was available from flight trials. Much of the RAE flight data was obtained in a twin turbo-prop Andover aircraft. With this large data base, the main research emphasis was on questions such as whether, from a good recorded signal, the relationship between perceived workload and heart rate could be demonstrated convincingly. The Cooper-Harper rating scale (originated at NASA a decade ago) was used to assess workload; it has a 10-point scale, with descriptive wordings for each category.

In standard air maneuvers such as landing according to a set glide-slope profile, the correlations between perceived workload and heart rate may be quite high. An illustrative plot is shown in Figure 1, where a senior pilot landed under 3°, 6°, 7½°, and 9° approach angles. The steeper gradients would be

expected to produce higher workloads, and indeed the mean heart rates agree rather well with that idea; at the 9° approach, mean rates are some 15 to 20% higher than for the 3° approach.

When the initial turboprop studies were continued with a large VC-10 four-jet transport, the in-flight heart recording system became more elaborate and beat-to-beat rates could be computed continuously during phases

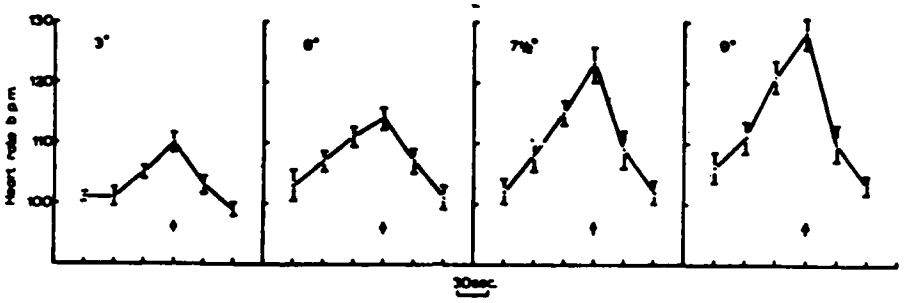


Fig. 1 Overall mean 30-s heart rates (±SE) for four experimental approaches in an Andover turboprop.

When the pilots had to change from a 7½° to a normal 3° slope, they initially believed that the transition would produce a high subjective workload. After having tried the maneuver a few times, however, they often found that the two-segment approach was just as easy and perhaps even easier than the normal 3° descent. Figure 2 shows the results from these flights, with the heart-rate data slightly favoring the transitional approach.

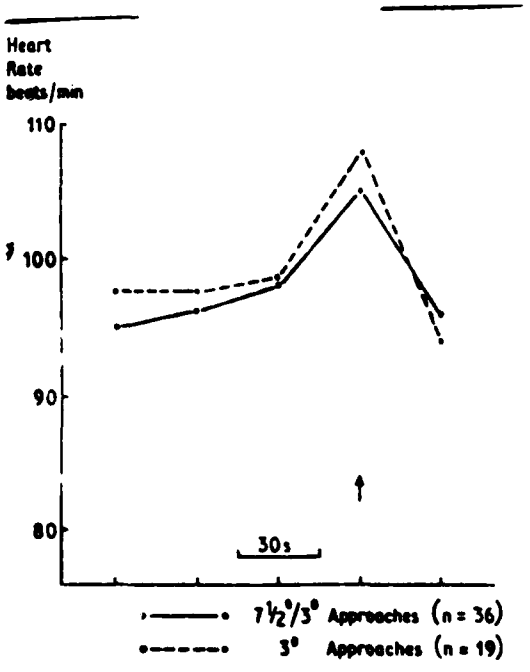


Fig. 2 Overall mean heart rates for 7½°/3° and 3° turboprop approaches

of flight. Plots could then be studied for cardiac events at key task points such as encountering the outer marker or transitioning at 500 feet. The two plots in Figure 3, taken from two pilots, give an idea of the general heart-beat trends and also show the kind of individual differences that can be expected. In the last minute before landing, the heart rate built up for both pilots, and decreased sharply right after touchdown, even though the curves themselves are far from identical. Another result using the same beat-to-beat setup was that the heart rates for Harrier VSTOL takeoffs from a "ski-jump" ramp tended to be slightly lower than those observed during conventional short takeoffs. The result agreed quite well with pilot's subjective workload ratings of the two situations. When the same cardiac measurements were made during autopilot approach and manual flare and touchdown, the highest heart rates often appeared in the time interval between decision height (50 or 60 feet) and touchdown.

When operating in real fog conditions the workload ratings can vary rather widely, and the spread gives a good opportunity for correlating heart beat and rated workload. One plot from fog data found a Pearson r of 0.64, suggesting moderately high quantitative correlations, though there may be some spurious correlation in a series of repeated measurements on the same person.

From a review of all the studies, the RAE conclusion was generally positive: heart rate is a good indicator of mental workload during flight operations, it can be measured reliably, it goes up and down when it "should", it is moderately but not perfectly correlated with subjective measures, and for new situations and systems it can give useful and interpretable information. Sudden jumps in the

instantaneous heart rate may, for instance, signify task "surprise" to the human operator and thus alert system designers and users to previously unsuspected problems. RAE experience shows that there are some practical cautions about using heart rate as a separate criterion. One is that subjects should be rather well practiced in the actual task involved before attempting to interpret small heart-rate differences; in fact, a working rule might be that if a task is full of unexpected inputs, baseline heart rates might be so consistently high that steps should be initiated to bring them down.

There probably is no simple answer to the question of whether heart rate is an appropriate substitute for subjective estimates of processing load. A simple combination of two standard scores for the subjective rating and heart rate might be a satisfactory procedure, and it would sidestep somewhat the problem of what to do with moderately correlated measures.

As noted above, the RAE recording techniques were so developed that beat-to-beat rate changes could be plotted against a task time line. The subject is presumed to be responding to the task demand shown on the time line. In the Netherlands, Paul Milgram has carried this "instant correlation" approach even further. He used a car-driving situation, and the driver wore an electrically-controlled visual occlusion device mounted on a bicycle helmet. In resting position, a translucent sheet was normally over the driver's eyes, but on the driver's signal, the occluding frame raised quickly (30-ms lag) and gave the driver a glimpse of the road lasting 0.55 s. Drivers were told to "drive safely" along a straight road in Holland at a prescribed speed with the visor closed, and to take "looks" only when they felt it was necessary. By this means, time records of looks commanded by the driver could be obtained and a heart-beat record could be directly correlated to each look. (Proper safety precautions were taken, of course; there was always an experimenter in the front seat, dead-man's safety switches were provided, and so forth.) Milgram is now at the Nationaal Lucht-en Ruimtevaartlaboratorium (NLR, National Aerospace Laboratory) in Amsterdam; much of his driving behavior research was performed at the Institute for Perception (TNO) at Soesterberg, Netherlands, in collaboration with Han Godthelp and Gerrard Blauw.

The research vehicle was a Volvo 145 sedan specially fitted for the road runs. A preset servo system mounted under the accelerator pedal kept the car at one of seven desired speeds from 20 to 120 km/hr in 20-km increments. Each subject first drove the Volvo under ordinary road conditions. Then there were three sets of six occlusion trials, each set having one run at each speed. Appropriate counterbalancing of speeds was part of the experimental design. The heart measure taken was the cardiac average evoked response (AER); with such a technique, the electrical observations were reportedly alias-free.

To investigate their time-series monitoring model of driving behavior, Milgram and his associates kept continuous records of the Volvo's lateral position y and heading angle ψ. A typical record of the two parameters is shown on a time line in Figure 4, along with indications of each look through the occlusion visor. The record indicates quite regular looking and rather good lane-holding behavior, with occasional heading angle adjustments of up to several degrees. As one part of model validation, the investigators forecasted the

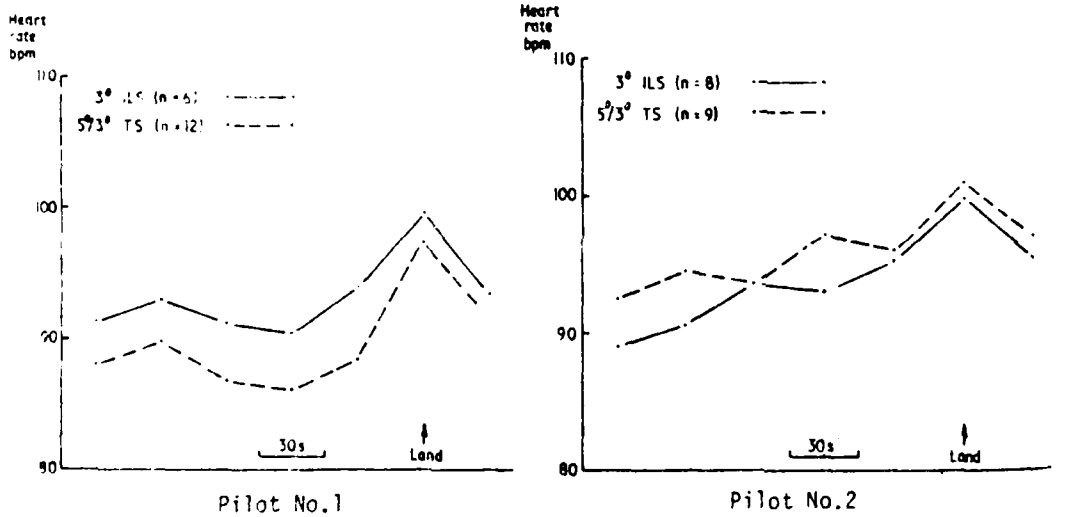


Fig. 3 Overall mean 30-s heart rates for two pilots on 5°/3° approaches (VC-10)

behavior after a look. They found that the lateral position and heading angle behavior just after a look were quite predictable, given the parametric information that was computed just before the look. In fact, confidence intervals were computed around actual and forecasted trajectories of the two model parameters. The accuracy of prediction was remarkably good.

A small surprise was that the speed of the car seemed unrelated to uncertainty, at least when the speed was below 120 km/hr. This supports the idea that at moderate speeds a human driver sets a fairly constant level of desired "information gain" or redundancy; at what is perceived as a high speed, there may be a step function in the gain demanded. On

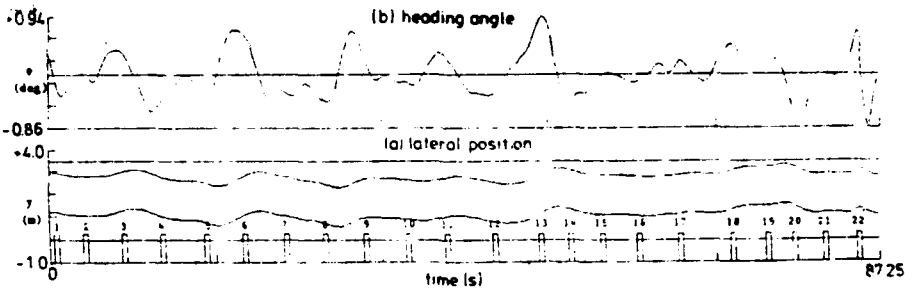


Fig. 4 Lateral position, heading angle, and looking behavior.

To see what the typical heart-beat responses were just before and just after a look at the road, Milgram plotted AER signals over some 22 looks (see the sides of Figure 5). In the center of Figure 5, the "averaged" AER from over looks 2 to 22 is given as a smooth curve. The averaged AER takes a definite downward turn just before new information is obtained, followed by a rapid acceleration. Milgram thus documented that the AER measure is highly correlated with the operator's instantaneous uncertainty level. When the window closes just after a look, uncertainty is low, but it grows steadily until the operator decides to look again; the pattern of decline and buildup cycles every few seconds.

Milgram's demonstration of the relation between cardiac AER and information (uncertainty, redundancy) is remarkable. AER tracks closely the functional work of the operator, and over a repeated series such as the 22 looks shown in Figures 4 and 5 the correlation is quite convincing and can be observed for nearly every subject.

A second feature is that in the TNO mathematical model of driver behavior, instantaneous uncertainty is well defined and can be calculated for the different road conditions. As one example of this kind of analysis, drivers apparently can tolerate less uncertainty in their lateral position than in their heading angle; that is, they demand two or three times more redundancy for lateral position than for heading angle. "Total" redundancy was greater than the sum of the two estimated redundancies, suggesting that there are other uncertainties in the operator's cognitive structure of the straight-road driving task.

reflection this seems to be a reasonable behavior, considering the more serious implications of errors at the higher speeds.

Milgram observed incidentally that breathing rates in the drivers were closely related to the instantaneous AER cardiac signals. Further trials will be necessary to determine how substantial the cardiac-respiratory correlation is and whether it will be useful for modeling or for practical systems work. The models and measurements are now being studied to introduce factors such as steering wheel inputs, forgetting, curved road driving, vehicle following, and so forth. Some of the factors have already been analyzed mathematically. The car-following problem is well known in applied mathematics, and the conditions under which car following occurs without collision are well defined in that literature.

In summary, the British find heart rate to be an acceptable correlate of mental workload; the Dutch do a micro-analysis and show a consistent pattern of cardiac output changes to "instantaneous uncertainty" buildup and reduction. Both groups find heart rate to be a good index. Theoretical explanations of the phenomena differ considerably and are a function of the data gathering techniques used. To explain the general correlation between heart phenomena and subjectively rated workload, the RAE investigators propose that the concept of "arousal" may be invoked; an aroused human is better prepared to handle a challenging task, and there are cardiac components in this arousal. Some experimental psychologists have postulated an inverted U function which relates degree of arousal to performance; thus, neither an inattentive nor an over-stimulated operator

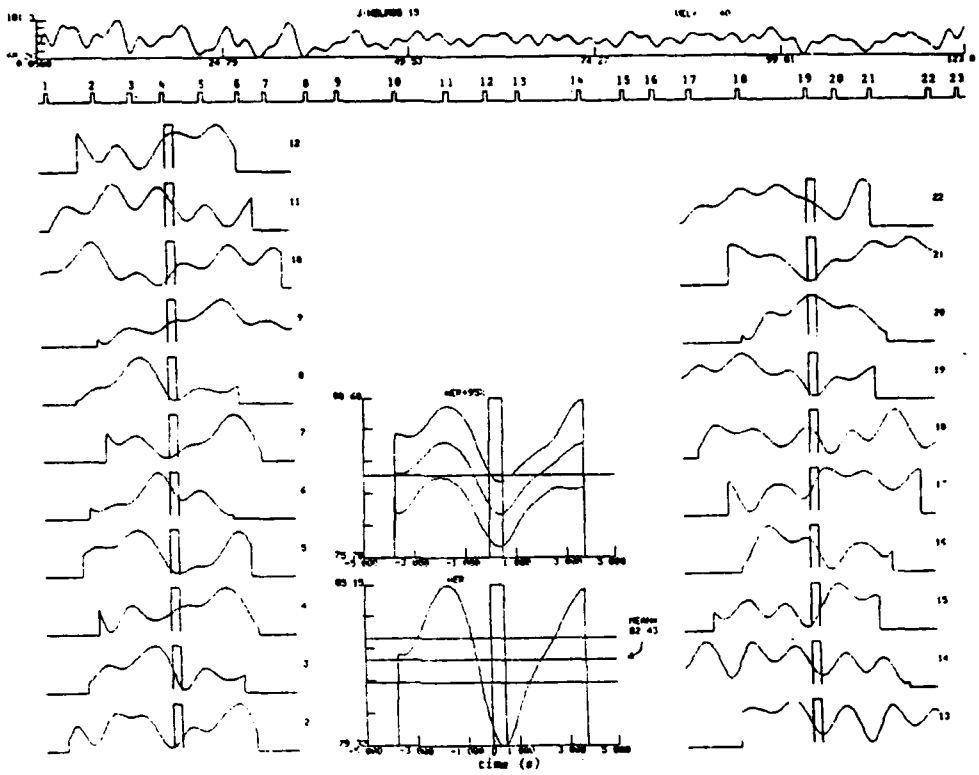


Fig. 5 Computation of cardiac average evoked response (AER).
Top: heart rate signal, alias-free sampled (4) and digitally zero phase shift low-pass filtered.
Below: series of 0.55-s look events: up—helmet open, down—closed.
Sides: heart rate signal look events numbers 2 to 22, plotted from the end of the previous event to the start of the following event (button push).
AER: average of heart rate signal numbers 2 to 22, plotted over shortest interval with respect to common time=0 at start of look event. Horizontal lines are mean and 95% confidence intervals about mean.
AER+95%: same AER as below plus 95% confidence intervals. All vertical axes are scaled in beats per minute (bpm).

would be an optimal performer, and moderate levels of arousal are best. The arousal concept has been partially confirmed at the neurological level, as direct stimulation of the reticular system in animals can produce increased alertness and preparedness to respond. Arousal may also explain some inadequate performances.

A good illustration comes from some RAE runs at the Bedford base. The RAE researchers were recording pilot heart data during approach control. On one landing, the usual increase in heart rate at passing over the runway threshold stripes did not appear; shortly thereafter, the aircraft landed very hard, and it took 3 weeks for the undercarriage to be repaired. Knowing this outcome, one could say that the pilot was not aroused enough at the threshold. But the arousal concept remains rather vague and unsatisfactory, and sometimes it is nothing more than a term loosely used to summarize complex relationships and summations.

In the Dutch view, the practiced human operator is represented as an adaptive, two-parameter time-series controller with a flat information gain demand over middle velocity ranges, and heart rate is conceived as one physiological correlate of the information-seeking behavior. There is no need to invoke a central activation or arousal concept. What you really need to know, according to the Dutch model, are performance parameters of directly estimable quantities; if such estimates account for enough of the performance variance (heart rate could be one of them), no further explanation is necessary.

Choice between the different explanatory models is probably a matter of taste and of the research setting. Aircraft pilots and researchers probably would find the Dutch visual occlusion technique to be rather unsatisfactory, and might also judge the general RAE correlation between heart data and flight regimes to be quite adequate for systems development and equipment evaluation. On the other hand, the extreme precision of the Dutch controller model has it own fascination, and the way it relates such concepts as information gain to cardiac activity has a large potential impact on psychophysiology.

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ONR London

CHEMISTRY

IUPAC (INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY) SYMPOSIUM ON "INTERRELATIONS BETWEEN PROCESSING, STRUCTURE AND PROPERTIES OF POLYMERIC MATERIALS"

The meeting was in Athens August 29th - September 2nd and was the first IUPAC meeting to be held in Greece. It was opened by Merlina Mercouri, the Minister of Culture and Science. About 350 attended from about 30 countries, and 97 papers and 50 posters were presented. Each poster was preceded by a 5-minute summary presented formally in rapid succession in an adjacent lecture hall. The procedure added greatly to the value of the poster session itself.

The opening plenary lecture was by Professor Paul J. Flory (Stanford Univ.). The second plenary lecture was by Professor G. Astarita (Univ. of Naples) on the effects of heat and mass transfer during the processing of polymers and the effects of sorbing and desorbing water in epoxy resins. Unusual changes in the amount of water sorbed with different temperature cycles were shown. In general the water sorption increased with different cycles but appeared eventually to level off. The results were ascribed to structural changes in the epoxy resin.

The final plenary lecture was by Dr. John Halpin (USAF), who recounted the history of thermosetting resin technology and fiber composites together with a unified processing science approach.

The symposium then divided into three concurrent sessions. The topic of the symposium itself and the sub-topics indicate the state of the art. Polymer science and technology has tended to move away from the synthetic and purely chemical aspects towards the physics and engineering of polymers. The symposium was probably the first major meeting devoted to the interrelations between processing conditions and the structure and properties of the resulting materials. There was more emphasis on morphology and structural changes during processing than on properties, reflecting the current status of research. There was also a growing emphasis on highly oriented structures and liquid crystal polymers, significant areas that have led to the development of industrially viable processes.

Highly Oriented and Liquid Crystal Polymers

The invited paper by A.J. Pennings (Univ. of Gronigen) showed the remarkable strengths that can be developed by special methods with highly oriented large molecular weight polyethylenes. G. Capaccio (BP UK) described structural changes during the formation of ultra high modulus polyethylene. At relatively low degrees of plastic deformation the stiffness results from orientation phenomena, which occur with both the amorphous and crystalline phases; birefringence increases together with the alignment of the crystallographic axis. At draw ratios of 10 to 15, crystalline orientation is essentially complete. The bulk of the crystalline phase is still of the conventional $\sim$ 200 Å thick lamellae, but crystalline bridges are also formed creating crystalline sequences spanning as much as 600 Å.

G. Hinrichsen (Tech. Univ. of Berlin) showed that multiple drawing of polyethylene terephthalate fibers led to fibrillar structures with high molecular orientation. Monofilaments with a tenacity of 1100 MPa and a Young's modulus of 15 GPa were obtained. A novel extension of such work to multiaxially oriented polymers was described by A.E. Zachariades (IBM-San Jose). Both crystalline and liquid crystalline polymers have been investigated. Multiaxially oriented polyethylene films have been prepared that are fibrillar and have a cross-ply laminated structure resembling that of a fiber-reinforced composite. The impact strength was more than eight times that of conventional polyethylene film.

It is well established that fibers spun from liquid crystalline solutions have unusually high tenacities and modulii. There were seven papers on the subject, four from the US and one each from Japan, France, and the UK. Professor M. Takayanagi (Kyushu Univ.) presented an invited lecture showing that the addition of a few percent of aramid rigid molecules to ionomers or nylon 6 or 66 remarkably increased the modulii, yield strength, and heat resistance. The addition of two percent of aramid polymer, for example, was three times more effective than carbon fibers in increasing the yield stress of ionomers. Such molecularly reinforced materials could be classified as a new type of plastic. Liquid crystalline copolyesters were discussed in two papers by G.L. Wilkes and coworkers (VPI). The optical

texture of copolyesters was correlated with their molecular organization in a paper by A.H. Windle (Univ. of Cambridge). The effect of electric fields, up to 40 KV/cm, during solidification from the melt was discussed by S.I. Stupp (Univ. of Illinois). Enhanced crystallinity and intermolecular cohesion was indicated. C. Noel (Laboratoire de Physicochemie Structurale et Macromoleculaire France) described the structure of a series of copolyesters formed from thermotropic aromatic liquid crystalline segments formed from hydroquinone and substituted hydroquinones and flexible spacers formed from diacids including adipic and terephthalic acids. The copolymers were insoluble but formed birefringent melts on heating. Their structures were determined by magic angle NMR, infrared dichroism, and other means. The whole field of liquid crystalline solutions of polyisocyanates (n-alkyl and n-alkylaryl) was reviewed in an invited lecture by S.M. Aharoni (Allied Chemical). The polyisocyanates and polyisocyanides appear to be unique in their behavior in solution.

Composities and Resins

A part of the meeting was devoted to composites and related matters. In addition to the plenary lecture by John Halpin there were 12 papers and 5 posters. F. Ranogajec (Rudjer Boskovic Inst., Zagreb) discussed the use of dielectric spectroscopy and thermomechanical analysis to monitor the cure of unsaturated polyester resins. A multiplicity of glass transitions occurred during curing leading to the conclusion that curing took place in two stages. They were related to the molecular weights between crosslinks and indicated that a heterogeneous structure resulted. G. Marom (Casali Institute, Jerusalem) discussed factors correlating the dimensional changes normalized to the gravimetric water uptake, termed the hygroelastic coefficient. Both polyester and epoxy resins were studied. In general more open networks led to higher water sorptions and sorption rates. This was attributed to the greater free volume available. With epoxy resins microphase separations dominated the hygroelastic behavior. Experimental and modelling studies were presented by J.C. Seferis (Univ. of Washington, Seattle) on a standard commercial epoxy system used in high performance composites. C. Voto (Aeritalia) reported on the long term aging behavior of epoxy resins in water and other liquids. Both diffusion and polymer relaxations were found to be responsible for changes in the physical behavior of the resins.

Several presentations were from the laboratory of Professor P.S. Theocaris (National Technical Univ. of Athens). They concerned the resin matrices and glassy polymers in general as well as composites themselves. These importance of the interface regions in controlling crack propagation in biphase epoxy systems was examined. The regions were found to be more important than the material properties of the actual phases. New criteria for fracture of both ductile and brittle glassy polymers were described, in addition to experimental studies of slow stable crack growth in polymethyl methacrylate. The importance of studying the elastic-plastic boundaries developed along the crack tips was emphasized. Experimental results showed good agreement with theory. Other work on composites included a theoretical model for evaluating adhesion efficiency between the filler and the resin matrix. The possibility of distinguishing between a graded seal or a flexible layer type of interface appeared to be inherent in the model. Experimental studies used thermal and dynamic measurements for determining the degree of adhesion between filler and resin. Iron (particles)-epoxy and asbestos-nylon 6-6 composites were studied in detail.

European contributions included discussion by S. Piccarolo (Univ. of Palermo, Italy) of the thermal expansion of laminated composites and the stresses developed in them. Glass fiber orientation during flow was discussed by M. Vincent (Ecole Nationale Superieure des Mines, France).

Transport Behavior in Polymers

A surprisingly large number of papers (14) and posters (22) dealt with the transport of small molecules in polymers. This was undoubtedly inspired by the extensive and excellent work in the field by J.H. Petropoulos, P.P. Roussis, and their coworkers at the Nuclear Research Center "Demokritos" in Athens. The Demokritos group presented six posters. Transport in membranes with a gradient of structural inhomogeneity was analyzed by Petropoulos. The inhomogenity could be due to crystallinity, copolymer composition, or other property changes across the membrane. Numerical solutions for a number of representative forms of the structural gradient are being developed. A new theoretical description of concentration dependence of diffusion was presented by Petropoulos and his coworkers. A study of the diffusion of water in glassy polymethyl methacrylate was presented by P.P Roussis. Considerable clustering of the water molecules in the polymer was indicated. Sorption and desorption kinetics were complex and are still under investigation. Other topics reported from Demokritos included the relationships between acetone sorption and dimensional changes in cellulose acetate, and a study of ionic sorption and diffusion in regenerated cellulose membranes. Seven of the fourteen lectures on transport behavior were by US scientists including J.L. Duda (Penn.State Univ.), A. Peterlin (NBS), H.B. Hopfenberg, W.J. Koros, V.T. Stannett (all Raleigh, NC), A.R. Berens (B.F. Goodrich), and H.L. Frisch (SUNY, Albany). A.H. Windle (Cambridge Univ.) presented a new model to explain Case II

"relaxation controlled" sorption in glassy polymers. Two basic parameters were included in the model, the diffusivity of the penetrant and the viscous flow rate of the glassy polymer. The rate controlling process for transport is seen as the diffusion of solvent down an activity gradient coupled with time-dependent mechanical deformation of the glassy polymer in response to the swelling stresses. The model can predict a wide range of observed transport phenomena. The kinetics of the sorption process is highly sensitive to both the mechanical and thermal history of the polymer due to the role of the viscous flow rate. J. Fuhrmann (Univ. of Kaiserslauten) presented a unique treatment of diffusion in semicrystalline polymers. The process was described in terms of a three-phase system consisting of the crystallites, the crystallite surface regions, and the noncrystalline matrix. Interphase processes can take place during diffusion. The three phases clearly change character and proportions during processing variations. The effect of polymer morphology on diffusion in semicrystalline polymers was investigated experimentally by microinterferometric measurements of refractive index changes during diffusion. Isorefractive solvent-polymer systems such as o-xylene in polyethylene were used. Other topics were dye diffusion in anisotropic polyamide fibers (I.D. Rattee, Univ. of Leeds), the effect of crystallininty on large molecule diffusion in poly 1-4 butadiene (G.S. Park, Univ. of Wales), sorption and diffusion in homogeneous and asymmetric cellulose acetate membranes for reverse osmosis (W. Pusch, Max Plank Institute, Frankfurt), and transport properties in capillary membranes, e.g., for gas separations (E. Drioli, Univ. of Naples).

Polmer Blends

A number of papers were devoted to various aspects of polymer blends. B. Jasse (Laboratoire de Physicochimie Structurale et Macromoleculare, France) discussed the influence of stretching conditions on the orientation of compatible polystyrene (PS)-poly 2,6 dimethyl phenylene oxide (PDMPO) blends. The latter orients in a different way to PS and remains higher at all compositions. The stretch-induced orientation of polyvinylidene fluoride (PVF_2)-polymethyl methacrylate (PMMA) was studied by D. Broussoux (Thomson-CSF, France). The orientation of the crystalline chains of PVF_2 increased with decreasing PMMA content. Two glass transitions were observed. One was attributed to pure separated amorphous PVF_2 and one to the amorphous blend, higher in PMMA than the initial concentration. The mechanical and thermal characterization of poly-ε-caprolactone (PCL) and chlorinated polyethylene blends (CIPE) was reported by N.K. Kalfoglou (Univ. of Patra, Greece). The blends were compatible at all compositions and resembled in many ways the corresponding polyvinyl chloride-PCL compounds. PCL at small percentages (∿ 10%) improved the elastic properties. Higher contents increased the yield and ultimate strength and toughness. The melt rheology of high and low density polyethylenes was investigated by D. Curto (Univ. of Palermo, Italy). When the rheological properties of the homopolymers were similar, there was a synergistic effect at a well-defined composition. In other cases the properties of the blends lay between those of the homopolymers but no additive rules were obeyed. Blends of isotactic polypropylene and high density polyethylene were studied by R. Greco (Res. Inst. of Polymers, Naples). Undeformed samples showed random orientation of the crystallites of both components with no cocrystallization. Some synergism in the yield values was found at high polypropylene contents.

Rubber toughened plastics including styrene-acrylonitrile (ABS) and polymethyl methacrylate (PMMA) have continued to be investigated by C.B. Bucknall (Cranfield Inst. of Technology, UK). Tensile creep, tension at constant strain rates, and tension-compression fatigue measurements were made. The principal mechanism of creep was crazing with ABS and shear with toughened PMMA. The rate controlling factor was the stress carried by the glassy matrix itself. Both ABS and PMMA yielded by shear in the fatigue measurements. A study of the effect of orientation on the morphology and mechanical behavior of ABS polymer was reported by G. Groeninckx (Univ. of Louvain, Belgium). The morphology consisted of the glassy styrene-acrylonitrile (SAN) matrix with dispersed SAN inclusions inside polybutadiene particles. The yield and fracture stresses and strain hardening all increase with increasing draw ratio. The elongation and tensile toughness, however, exhibited a maximum. The impact strength and creep resistance also improved with orientation. Self-reinforced plastics were obtained by extruding a crystallizable polymer such as polypropylene blended with a little or non crystallizable matrix such as polystyrene (A.K. Van der Vegt, Univ. of Technology, Delft, Holland). The possibility of using such self reinforcing blends in screw extrusions and injection molding is being explored. A number of other papers dealing with the melt rheology and other properties of heterogeneous polymer blends were presented.

Polyvinyl Chloride

A number of contributions were concerned with rigid polyvinyl chloride (PVC). The ultimate properties of PVC pipes were studied by B. Terselius (Royal Inst.of Technology Stockholm, Sweden). The importance of optimizing the gelation level was stressed. Biaxially oriented rigid PVC pipes were examined by C.E. Anastassakis (Petzetakis, A.G., Greece). The tensile and impact strengths and the aging resistance were all better than in conventional rigid PVC pipes.

The interrelations between processing conditions and defects in calendered rigid PVC were discussed by J.F. Agassant (Ecole Nationale Superieure des Mines, France). Sheet matting appeared when the maximum shear stress in the roll gap was above a certain critical value. Air bubbles appeared in the sheet when the maximum pressure in the gap was lower than a critical value. The critical values were determined using a small laboratory calender and could be calculated by computer for large industrial machines. J.P. Villemaire from the same laboratory reported on his studies of the melt rheology of PVC using a rheoplast rheometer. No molecular degradation could be detected. Destructuring of the microcrystalline regions at the processing temperature was invoked to explain the experimental findings. F.N. Cogswell (I.C.I., UK) reported on the current results of a working group comprising eight industrial laboratories on the influence of acrylic processing aids on the rheology and structure of PVC (an IUPAC working party). Extensibility without great changes in the stress-strain to failure behavior and supression of formation of various defects was found. The study indicates a flow mechanism involving continued rupture and reformation in the connective tissue between flow units about 100 nm in size. The acrylic processing aids are dispersed on the boundaries of the particles acting as stress transfer agents. Finally J.M. Liegeois (Univ. of Liege, Belgium) described the mechanical behavior of core-shell homo PVC polymers. They were prepared by multistage emulsion polymerization by varying the reaction temperature from one stage to another. The new "alloys" were about as tough as rubber modified PVC except at higher strain rates. Several of the preparations also gave notched impact strengths comparable to rubber modified PVC, but these were strongly dependent on processing conditions.

Other Structure-Property Relationships

An analysis of the behavior of polyethylene using scaling laws was presented by J. Rault (Universitie Paris-Sud). It was possible to predict the variations in the crystallinity, to calculate the number of tie molecules, and to estimate the mechanical properties. The mechanical properties of high temperature elastomers prepared from a new series of exactly alternating copolymers of siloxane and styrylene moities were described by P. Dvornik (Inst. of Chemistry, Technology and Metallurgy, Yugoslavia) in cooperation with R.W. Lenz (Univ. of Mass.). The new materials should attract considerable attention as sealants, gaskets, O-rings, and coatings for extreme service conditions.

A detailed investigation of the mechanical properties of polystyrene over a wide range of temperatures and frequencies was reported by F. Schwarzl (Univ. of Erlangen, FRG). The time-dependent shear showed three major relaxation transitions at the glass-rubber, the entanglement, and the flow transitions. All could be described by the WLF-shift equation with different constants. The mechanical properties, thermal expansion behavior, volume relaxation, and time-temperature shifts were measured over the glassy state, the glass-rubber transition, the rubbery plateau, and the melt.

K.P. Grobkurth (Inst. für Baustoffe, FRG) discussed the effect of processing changes on the morphology and mechanical properties of molded amorphous polymers. Electron microscopy after etching was used. Different orientations were detected in the cross-sections of molded specimens increasing in the direction of injection. These were accompanied by increases in the tensile and impact strengths in the injection direction. A tactic polystyrene moldings were found to craze internally while the highly oriented material at the surfaces remained uncrazed. Areas of low strength and internal weak points were found with the lower molecular orientation regions. The plastic behavior of glassy polycarbonate was discussed by C. G'Sell (Laboratoire des Physique du Solide, France). Plastic deformation in simple shear up to large strains (200%) were studied with a new testing apparatus. No crazing occurred, but well-defined shear bands initiated and spread. Such behavior was replaced at elevated temperatures with diffusion-controlled homogeneous deformation. J.F. Pierson (Ugine-Kuhlman, France) described the influence of rheological behavior and processing conditions on the structure and properties of polyvinylidene fluoride (PVF_2).

Two types were studied, one prepared in suspension and one in emulsion. The number of average molecular weights were held constant at 150,000, but the polydispersities varied. The rheological behavior correlated well with the thin film extrusion behavior. The films were uni- and bioriented by stretching between 20 and 150°C. The α (monoclinic) and β (orthorhombic) forms varied in their proportions under different stretching conditions. The β content varied form 0 to 100% with decreasing temperature. Above 90°C the α content increased abruptly with increasing temperature.

The selection of papers to discuss from such a large multisessional conference has been difficult. In general, except for a few specific areas, non-US work has been stressed. Apologies are tendered to those whose contributions have been neglected.

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COMPUTER SCIENCES

ACTIVITIES AT THE INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE, ROCQUENCOURT, FRANCE

During a visit to the Institut National de Recherche en Informatique et en Automatique (INRIA), the author was given an overview of the work of the institute and a more detailed presentation on project NADIR, the work on robotics, and applications in numerical techniques.

INRIA is a government-supported research institute of about 400 people, 225 of whom are scientists and engineers. The annual budget is about 146 million francs. Branches are at Rennes, Rocquencourt, and Sophia, with the branch at Rocquencourt by far the largest. INRIA functions under the direction of the Ministry of Industry and has two general objectives, to conduct research in computer science and automation in liaison with public and private organizations, and to develop, in cooperation with industry and users, experimental computer science and automation systems. The activities of INRIA are organized along eight themes: numerical techniques and modelling, automation, images and robotics, algorithms and programming, languages and specifications, information systems, man-machine communications, and computer architecture.

Project NADIR

Project NADIR is an experiment in the interconnection of local area networks through satellite links. It is in the information systems section. Project NADIR was launched at the beginning of 1981 by the Ministry of Industry and the French PTT (Posts, Telephone and Telegraph). The aim is to investigate new types of computer applications that use satellite communication systems. The interconnection of local area networks (LANs) through satellite links is under study.

Within the French satellite system, TELECOM 1, scheduled for 1983 launch, five transponders will be shared for business communications. Numerical links will be provided either on a call-per-call basis or semi-permanently. Multi-point and point-to-point links will be available at data rates from 2400 bit/s to 2 Mbps. Point-to-point links will be either simplex or duplex.

A satellite systems simulator has been developed by the NADIR group to emulate TELECOM 1 links. It offers the same interfaces as TELECOM 1 will offer and enables the NADIR team to establish a variety of link configurations between computers within the NADIR laboratory, with varying data rates, bit-error-rates, and propagation delays. The LAN type being used for the development work is DANUBE, developed at INRIA. DANUBE is based on a coaxial cable, shared by up to 256 stations through an access method offering a "datagram" service, with each frame carrying a destination and a source identification. Connection, error recovery, and flow control are available on an end-to-end basis at the transport level.

Using the simulator and the DANUBE network, an experimental internal network will be built for a large organization and an interconnection between the DANUBE and the TELECOM 1 networks.

Large companies have factories and research and development organizations at locations remote from headquarters, and governmental organizations have regional offices. Within a given site LANs can provide for data communications. Through the use of satellite links between LANs a relatively inexpensive internet can be built.

The NADIR internet designers are endeavoring not to introduce restrictions on services like datagrams or broadcast messages already available on existing local networks. With this goal in mind the interconnection of two local area networks of the DANUBE type using a medium data rate (64 to 128Kbps) point-to-point link was studied. End users on either DANUBE network can communicate with end users on the other through gateways, which will initially be CII-HB "Mini 6" computers. Experience gained from them will lead to the design of special gateways.

Each packet transmitted on the DANUBE network carries source and destination addresses. In designing the internet project, NADIR implementors assume that a destination address is unique for the entire network. Routing is then easily performed by the gateway. Packets travelling on the local network are examined for the destination address; if it is on another network, the packet is transmitted on the satellite link and forwarded by the gateway on the other network. To facilitate routing, addresses are composed of two fields, one designating the local network, the other designating the user within the network.

Users connected to various local area networks with incompatible addressing schemes may wish to exchange data through TELECOM 1. The question then arises as to what link protocols shall be used in the satellite link and what network protocols shall be used on the LAN and in TELECOM 1.

A user connected to DANUBE can at any time send a packet to any other user. As TELECOM 1 is a circuit-switched network a call must be set up before data can be exchanged. Consequently there is a need for a network protocol on DANUBE to enable a user connected to DANUBE to place or receive a call on TELECOM 1.

The gateway from DANUBE to TELECOM 1 has several addresses - one for the gateway itself and one for each possible circuit. To access DANUBE, a call request message is sent to the gateway. The message indicates the TELECOM 1 number of the TELECOM user to be

connected and the facilities to be requested such as link data rate and forward error correction. After receiving such a message, the gateway chooses an interface and performs appropriate signalling. When the call is established a message is sent by the gateway to the caller. The message indicates that the interface is ready for data and gives the DANUBE address of the interface. The same procedure is used on incoming calls.

ROBOTICS: Geometric Sensors

The geometric sensor was conceived and developed at INRIA, as well as at other research centers. The sensor measures the coordinates X,Y (in two dimensions) or X,Y,Z (in three dimensions) of the points on a surface. It depends on the principle of active stereoscopy. The setup required in two dimensions includes a light source, a galvanometric mirror, and two cameras. The beam from the light source is deflected by the rotatable mirror to different points on the surface observed by the two cameras. The coordinates of each point are determined by triangulation. The sensor carries out the measurements point by point.

The sensors have their own logical units (microprocessors), which control the different parts of the system-deflection system, cameras and light source, find the image point on each camera, and calculate the coordinates of the point. The logical decision unit asks the sensor for a direction, which permits calculating the coordinates of a point on the surface.

The fine resolution and precision obtained permit the use of the above type of sensor not only for recognizing mechanical pieces but also for industrial control. Two possible uses of the sensor are: (1) Suppose it is necessary to recognize one by one the pieces from a foundry placed in a bin and to be fed to a machine tool. Shadows from other pieces prevent recognition of a given piece using classical methods of imagery. However, a three-dimensional sensor can determine the contours well enough to find the best grasping point without recognizing the piece. The piece is then detached, identified, and its position determined. (2) A two-dimensional sensor can be used to sweep lightly a solder joint upward from the arc to measure the position of the joint with precision and to correct the trajectory of the robot for errors in positioning the solder and thermal deformations.

Numerical Techniques

(1) Basic Numerical Methods. The numerical simulation of phenomena or systems modeled by partial differential equations requires, upon reduction to finite difference equations, the solution of systems of equations or inequalities with 10^4 to 10^6 variables. Similar difficult requirements arise from solving problems in unbounded domains. To cope with such problems, it is necessary to use new procedures. The following two approaches can be used separately or combined: (a) the use of highly parallel super-calculators, often using both elementary algorithms and ad-hoc algorithms that relate to the particular architecture of the machines, (b) the use of sophisticated algorithms, implemented on standard machines of today.

Concerning approach (a), methods based on the decomposition of a problem into simpler sub-problems is useful. M. Fortin and R. Glowinski, INRIA, published a book in 1982 devoted to the use of augmented Lagrangian methods to solve problems by decomposition. The book describes basic methods and treats convergence properties and numerous applications in mechanics.

Concerning (b), INRIA has implemented methods to solve problems in infinite domains by transforming to domains more suitable for calculation while conserving the algebraic simplicity of the differential operators in the problems. Some applications are underway for the numerical treatment of transonic fluid flows of the Navier-Stokes type. The methods must permit, in particular, simplification of the calculations at very high Mach numbers and the obtaining of a better understanding of asymptotic conditions. The application of such methods must also take advantage of appropriate decomposition mentioned above for handling array processing systems.

A study was begun in 1981 on the use of decentralized schemes for the numerical integration of the equation of continuity, which enters into the description of a large number of phenomena such as fluids, semi-conductors, and electrical charge:

$$\frac{\partial \rho}{\partial t} + \bar{\nabla} \cdot \rho \bar{V} = 0$$

Several difference schemes are being tested.

(2) Numerical Methods in Fluid Mechanics. This is a subject rich in applications and very difficult from a theoretical and numerical point of view. Problems arise in meteorology, oceanography, nuclear engineering, and aeronautical engineering.

Methodologically, the solution of problems of fluid mechanics encompasses the complete arsenal of numerical methods. The impact of fluid mechanics on computer science is very important, and the numerical solution of problems in fluid mechanics has top priority for large-scale computers.

INRIA, not having had available a very large scale computer, has become oriented on the one hand toward the study of sophisticated finite difference methods to enable a reduction in the number of discrete points used and on the other hand toward the study of parallel processors, in liaison with the aeronautical and computer industries and with researchers in other laboratories.

INRIA has developed iterative methods of rapid convergence of the conjugate gradient

type, preconditioned for problems in fluid mechanics. Other methods use characteristics for the integration of transport equations such as the equation of continuity. It appears that such methods have application in other domains.

A few examples of problems studied using novel methods of solution were: The Navier-Stokes equations for incompressible, viscous fluids using (a) linearisation methods, with approximation by finite discontinuous elements and upwinding of non-linear terms (reference: F. Thomasset, "Implementation of Finite Element Methods for Navier-Stokes equations" Springer-Verlag, 1981); (b) non-linear least squares methods with approximation by conforming finite elements, without upwinding of non-linear terms and solution by preconditioned conjugate gradient; (c) variations of the above methods obtained by use of current and vortex functions; and (d) methods of finite characteristic elements.

Other examples under study at INRIA are simulation of compressible fluid flow, problems of optimal conception in fluid mechanics, numerical methods in plasma physics, and simulation of oceanographic phenomena.

General Comments

The NADIR project in France is similar to the UNIVERSE project in the United Kingdom, although not so far along toward completion. The UNIVERSE project uses the Cambridge ring for its LAN whereas the NADIR project will use the DANUBE system developed in France.

The robotics work in France is carried on at several locations including INRIA, Rocquencourt; INRIA, Rennes; Recherche Laboratoire Automatique et D'analyse de Systems, Toulouse; and Laboratoire D'Automatique de Montpelier. Work at the other locations will be the subject of a later article in ESN.

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THE WORLD CENTER FOR COMPUTER SCIENCE AND HUMAN RESOURCES

On March 15, 1982, The World Center for Computer Science and Human Resources was officially established in Paris at 22 Avenue Matignon. M. Jean-Jacques Servan-Schrieber was appointed chief executive officer and chairman, Prof. Nicholas Negroponte, MIT, was appointed director, and Prof. Seymour Papert, MIT, was named chief scientist.

President Francois Mitterand was led to create the World Center with its ambitious program for a number of reasons, which were discussed in some detail by Servan-Schrieber when he appeared before The Committee on Science and Technology, Sub-committee on Investigations and Oversight, and Subcommittee on Science, Research and Technology of the United States Congress on May 19, 1982. The reasons given included: (1) There should be a close organic link between technological and social progress. Such undesirable phenomena as inflation, lowered productivity, mounting unemployment and shrinking international trade stem from our failure to manage properly the forces of the scientific and technological revolution around us. We need to conceive and implement changes in our society that effectively use the enormous productive power of modern technology without harmful side effects. (2) The world economic system has, in the last decade, failed to arrest the aggravated social crisis created by the explosive scientific development of automated systems, which increasingly displace, in all fields, the work of human beings. America and western European countries have reached a level of unemployment of about 10%. There are more than 30 million unemployed in the OECD countries alone. Experts believe that by the end of the decade more than 50 million people in these countries will be jobless. (3) By the end of the decade more than 3 billion people in developing countries will be searching for the means to survive. The industrial world needs to make the Third World a true partner in development. An effort along the lines of the Marshall Plan in Europe after World War II is needed. But with the mounting numbers of robots able to work more efficiently than human beings, the traditional approach to development in the Third World will not work. Cheap labor will become less relevant and the proper development of the human resource through education will be required.

These problems and conceptual solutions were discussed at length in Servan-Schreiber's 1980 book "Le Defi Mondial."

Prof. Nicholas Negroponte explained the mission of the center to the author during a visit on September 27, 1982. There are three main categories of efforts. First, there is technical research in interactive media and telecommunications including the use of audio and video discs; man-machine systems with emphasis on speech synthesis and recognition; expert systems for the use of computers in medicine with emphasis on relatively simple ideas with substantial impact; and systems architecture. Second, there is work in social science with experiments in psychology, anthropology, language, and linguistics with a pilot project in Marseilles, France. Third, there is on-going and planned work to promote development in the Third World. A project is underway in Dakar, Senegal under the auspices of the Ministry of Science and Education with a staff of eight local specialists who were trained in Paris. Projects are projected to start in 1983 in Pakistan, India, Colombia, and Saudi Arabia.

Unemployment is an urgent problem not only in developing countries but also in

industrialized countries. Prof. Raj Reddy, Director of the Robotics Institute of Carnegie-Mellon Univ., directs the programs for people displaced from their jobs by robots. The industrialized countries with major unemployment are not those that make the most use of robots. Japan, with no important unemployment problem, has installed 70% of all industrial robots in the world. In 1979 Japan had 47,000 robots, FRG had 5,800, and 3,300 were in the United States. In 1980 Japan produced 21,000 industrial robots, a 50% increase over her 1979 production.

A better understanding of the nature of the technological revolution may help to identify the reasons for the unemployment problem. Robots that are conceived and manufactured today are programmable through the integral use of microcomputers. Such robots can rapidly move from one activity to another and can work long hours in a hostile environment with a greater degree of precision than a human worker. The capacity to adapt permits them to follow the changing conditions of needs and circumstances. Perhaps a nation refusing or even too slow in introducing robots risks unemployment due to lack of competitiveness in the world market.

A major source of expanded employment for the future will be in the electronics and information industry. Twenty years ago in the United States there were only tens of thousands of employees in the electronics industry. Now there are more than a million. Forecasts are that by the end of the present decade the electronics and information industry will employ the largest number of people of any sector-more than a third of the total employment force. In some countries, Japan and France for example, the information sector may account for half the national employment. It is consequently necessary to institute programs to prepare people to function effectively in such an important industry.

A second important source of future employment may be in the efforts of the industrialized countries to speed up the education of people in the developing countries. Today less than 50% of the world population consumes more than 80% of its goods and services. If the quality of life in the developing countries were raised to the level of the industrialized countries, the demand for goods and services would greatly surpass our present capacity for production. The real question is how people in the developing countries can pay for the additional goods and services. Reddy says "The response is unequivocal: it is necessary that the education level of the people of the Third World develop very rapidly, approaching ours in less than 10 years - by the use of all the means that personal computers can bring to the development of each of them."

A third way to reduce unemployment will be our capacity to invent the equivalent of war in time of peace, according to Reddy. In a society where robots can furnish products and services, only a small fraction of the active population will be engaged in the production system as we have known it. In the United States less than 3% of the active population is engaged in agriculture, which supplies food for half the world. We must begin to imagine how to furnish, through creativity and invention, all the requirements of society with everyone more and more free from work in the classic sense. We should spend our resources, not on immense military budgets, but on creative activities rooted in the human capacity for development of knowledge and cultural and artistic enrichment.

Finally, unemployment can be reduced in the future through a systematic reduction in the work week. In the last century people worked 12 hours a day, 7 days a week. The work week can be reduced below its present level as a result of the effective use of modern technology.

Medicine

Negroponte stated that emphasis in medical research is on areas not necessarily of interest to science, economics, or business. Emphasis is on the application of straightforward methods that can have a large impact. The center plans to develop information systems of use to para-medical personnel responsible for first aid in rural zones of developing countries. The objective is to enable the user to record the necessary clinical information in electronic form and then to prescribe treatment based on the diagnosis made at some central location. In the future the dossiers could be used in medical units and the Ministry of Health as statistical information for policy guidance, for research relative to epidemics, placement of medicine and equipment according to needs, and to institute quality control over local medical assistance. Dr. Harold Goldberger is director of medical research at the center.

Expert Systems

In expert systems the emphasis is on self-explanatory systems with expertise about themselves. Today the documentation for a personal calculator may be more complicated than the calculator itself. A self-explanatory system must be interactive and deductive in order to be able to understand what the user is likely to ask. Such a system can correct typographical errors as well as deeper unintentional ones.

Each user has a certain level of knowledge of a system and a tendency to repeat certain types of errors. A model of the user can help an expert system diagnose the user's errors in the frame of self explanation. It is easy to decide whether the system is succeessful: can the user use the system without assistance from another person or from a written text?

Systems and Architecture

The general plan is to use Motorola 68000 chips to arrive at a new architecture for personal computers.

Consideration is being given to an extension of the Thomson TO-7, trustworthy personal computers, disposable computers, and partitioned systems. The Marseilles project, which is discussed below, plans to use at least 2000 Thomson machines by the end of 1983. The TO-7 has a number of original characteristics, in particular a graphics level, but it lacks speech generation, true video compatibility, and mass memory. The center must decide what could extend the use of the machine to the full spectrum of users.

The TO-7 is not a completely tested machine; it is planned for home use. The center plans to explore the constraints of trustworthiness with which it can meet the needs in the Third World; operation by battery or solar radiation, or a combination, resistance to rain and to shocks, are to be considered.

The center plans to study several very advanced ideas on the foreseeable frontier. The concept of disposable computers can be studied in conjunction with fabrication from new materials. This may permit the introduction of computing capability with minimum investment.

There is today a tendency toward decentralized systems, which raises two questions: (1) Should the tendency be applied to the internal architecture of personal computers? (2) Must a personal computer function in a decentralized, interconnected system in a network of wide or narrow band width? It seems that the response to both questions is yes. Therefore the center proposes to explore the architectural principles permitting the interconnection of numerous processors, some of which are specialized for precise tasks, others non-specialized and available in parallel for the execution of more general tasks.

Human Sciences

The center was founded to explore computer science, human science, and social experiments. Computer science easily attracts the most advanced thinkers because of the sophisticated equipment available. On the other hand, the human sciences require more effort to be successful but involve equally pertinent objectives. The task of human sciences at the center is to integrate such disciplines as languages, psychology, and anthropology.

One role of the center will be to understand languages and linguistics in the framework of computers, in a particular cultural context, with expressions varying among the countries.

In psychology the World Center has established a rich and promising collaboration with the psychologists and epistemologists in the forefront of the discipline at the Univ. of Geneva, where Piaget did his fundamental work. The most important social results are those that fill the gaps, which traditional schools cannot, for children coming from a culturally and intellectually handicapped environment. Results may be more thoroughly determined by putting personal computers among the disadvantaged.

One of the missions of the World Center is to explore the use of personal computers to transfer knowledge between cultures and between countries. Until now, such efforts have been through use of the computer as a tool for education and training - often this has amounted to no more than a translation. The center's efffort will be more ambitious. The working assumption is that the fundamental changes concerning the exchange of knowledge will be made possible by use of the computer as a medium. This includes changes of epistemologic structure of the subject treated and of the preferred mode of interaction.

An aim of the center is to resolve a fundamental dilemma that has impeded the transfer of certain types of knowledge, particularly in science and mathematics. The belief is that a computer representation of knowledge of science and mathematics can present a large variety of different models allowing each culture to invent new models compatible with its structure and fundamental thoughts.

Social Experiments

(1) The Marseilles project. In the short term training in computer science opens opportunities for work in the field. The need for programmers today exceeds the number of jobs displaced by computers. It is reasonable to believe that automation can create more jobs than it displaces. However, the people who lose their jobs have different qualifications from those employed as programmers and in other parts of the automation industry. One of the objectives of the center is to bridge this moat.

The Marseilles project started with an entire sector of the city. Computers have been placed in public institutions so that people can become initiated and acquire a true interest in information science. Computers are available to people of all ages who wish to use them. The project involves 2500 people and 1200 personal computers are available and can be taken home upon request. The community is comprised of 17,000 people including 3500 children. Twenty-three schools and 12 associations are participating in the program.

(2) The Dakar Project. Because of the great interest of the Minister of Science and Technology in Senegal, the Daker project started quickly. In fact the project started even before the formal establishment of the World Center in Paris. The project is a collaboration between the World Center and the government of Senegal and involves three groups of six children each, using personal computers and the language Logo developed at MIT under the direction of Professor Seymour Papert. The children range in age from 7 to 11 years.

The Dakar project is aided by the following professionals in Senegal: two elementary school teachers, one computer scientist, one

sociologist, one psychologist and one administrator in l'Ecole Normal Superieure of Dakar.

Similar projects are planned for Pakistan, India, Colombia, and Saudi Arabia.

Equipment

Most of the equipment planned for the World Center has already been installed. The Digital Equipment Corporation gave about $15 million worth of equipment including a DEC 20/60 and a VAX 780. Other equipment from outside France includes 50 Apple Computer Systems, 2 Nippon Electric DP-200's, a Prototype Videodisc Memory, 2 LISP Symbolic Machines, and Sony Videodiscs. In addition, the following equipment is to be delivered from within France: 50 Scorpion terminals, 500 T-9000s in 1982 and a further 2000 in 1983, 20 Thomson micromega 32s, and 100 Matra terminals.

The center's programs are most ambitious but will almost certainly meet with a measure of success. The center has the strong endorsement and support of the President of France, it is adequately financed and equipped for its start-up, it has an initial staff of experts who are among the best in the world, much technical support will come from the computer industry world-wide and from the excellent telecommunications industry in France, and the French government leaders seem to have an understanding of the need to assist Third World Countries.

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ELECTRONICS

"EIGHTH EUROPEAN SOLID STATE CIRCUITS CONFERENCE HIGHLIGHTS"

The Flemish speaking campus of the Free University of Brussels was the site of the Eighth European Solid-State Circuits Conference held 22-24 September 1982. The conference responded to the concept that whereas energy transfer was the basis of technology past, information transfer is the theme of technology future. Accordingly, the emphasis was on digital circuits, techniques, and subsystems. Indeed, a formal proposal was put before the conference delegates to change the name of the conference to something representative of "electronic systems-on-a-chip" in anticipation of the soon-to-be achieved 1,000,000 devices on a single chip of silicon.

The topical areas covered by the conference were: Telecommunications Circuits, Data Conversion and Bipolar Analog, Analog MOS Circuits, Computer Aided Design, GaAs Circuits, Digital CMOS Circuits, Speech Processing, Digital NMOS Circuits, Memory, and Signal Processing.

With the world-wide automobile market racing toward more energy efficient and pollution-free cars and the universally acclaimed solution to be solid state electronic circuit processors, it was rather disappointing to find only one paper on the subject. There was also only one paper on medical electronics.

The Electronic Ear

In a paper entitled "A n-MOS Eight Channel Programmable Current Generator for Auditory Nerve Stimulation" by M. Van Paemel et al. of the Catholic University of Leuven, Belgium a technique was described for restoring hearing to the deaf who have lost the sensing hairs of the cochlea. In such cases, a conventional hearing aid is useless and direct stimulation of the auditory nerve is the only means to regain some hearing sensation.

The system works as follows: an audio signal is first separated into eight distinct frequency channels. The amplitude is continuously sampled in each of the frequency channels and converted to a pulse whose width is proportional to the audio signal amplitude. A bundle of eight pairs of bipolar electrodes is inserted into the cochlea. Each electrode corresponds to a different frequency channel and has a different length than the pair representing adjacent frequency channels. The bundle is inserted such that each electrode pair reaches the part of the cochlea whose original resonant frequency was at the center of the channel represented by that particular bipolar electrode pair. The maximum stimulating current for each electrode pair is 1 milliampere (ma) although the normal operating range is between 0.1 and 0.6 ma. A current resolution of 10 microamperes characterizes the circuit. Although the present system does not restore hearing in the conventional sense, auditory communication is possible with training.

Digital-to-Analog Converters (baseband spectrum)

As video information transfer continues to permeate both military and commercial systems, a higher performance digital-to-analog converter (DAC) has been sought with increasing diligence. With stringent demands for performance accuracy, low glitch energy, exacting differential gain and phase requirements, and latching operation, only DACs built from discrete components have been able to satisfy video equipment designers. Their cost and size, however, are increasing; clearly a monolithic version is needed to provide the demanding performance desired at a reasonable cost.

In a paper entitled "An Ultra Low Glitch, 50-MHz High Speed 20-bit Digital-to-Analog Converter", T. Hayakawa et al. of NEC described a high performance, monolithic, 7[illegible] DAC that meets the requirements of all but the most demanding video systems. The key [illegible] the

success of their DAC is a new resistive ladder, which is a modification of the more conventional R-2R ladder network (Fig. 1). The efficacy of the modified ladder is that its output resistance is 2R versus 2/3 R in conventional ladder arrangements. This, in turn, provides several additional advantages. First, for a 75-Ω system, each individual resistor is 37.5 versus 112.5Ω. This not only reduces the area required by the ladder network by 2/3 but also significantly improves the RC time constant by a factor of 9. As such, fast current switching, short propagation delay, fast settling time, and low glitch energy accrue. As seen in Figure 1, the 8-LSB current source values are identical while the 2-MSB current source values are weighted by factors of 4 and 2 higher. The higher bits are driven by parallel-connected identical current sources and switching transistors. With such an approach each current source and switching transistor is made identical and carries identical loads; given uniform switching speeds among bits, further reduction of glitch energy results. Emitter coupled logic (ECL) is used in conventional differential amplifier circuits. The reduced ladder network size, however, permits the use of an identical ladder as a dummy load on the normally unused output leg of the differential amplifier current switch, greatly improving overall DAC performance. Pertinent specifications are as follows: 30 pv-sec glitch energy, 0.3° differential phase, 0.5% differential gain, 11-bit equivalent accuracy, ±0.15 linearity error in LSB, and 50-MHz clock. Other characteristics are: 500-mw power dissipation, 50ppm/°C T.C.R. of internal voltage reference, and 20 nanosecond settling time.

Other video speed DAC and A/D converter developments using the slower NMOS circuits were reported by Valvo of FRG.

In other DAC developments H.J. Schouwenaars of Phillips Research Laboratories presented a paper entitled "A Monolithic 14-bit A/D Converter". He described a clever current averaging scheme called "dynamic element matching" wherein each current source, current source switch, and load is a parallel connection of identical components so as to average out the errors in each. Using the method, a monolithic, monotonic 14-bit DAC was designed that eliminated the resistive ladder trimming operation so characteristic of DACs of greater than 10 bit accuracy. The complete device operated at 44.1 KHz sample frequency and exhibited a [illegible]sec conversion time.

[illegible] Speed Adders

[illegible] et al. of Thompson-C.S.F. [illegible] work on "GaAs Low Power [illegible] for Ripple Carrier Adder". The [illegible] aggressive R&D program [illegible] high speed GaAs technology. [illegible] efficient 2 bit adders were [illegible] operate as one 4-bit adder with carry. Dual gate MESFETs characterized by 2-μm gate separation were used in a buffered FET logic (BFL) circuit. Total power consumption was 45 mW, average propagation delay was 380 ps/gate at 1.5 mW/gate for a power delay product of 0.6 pj.

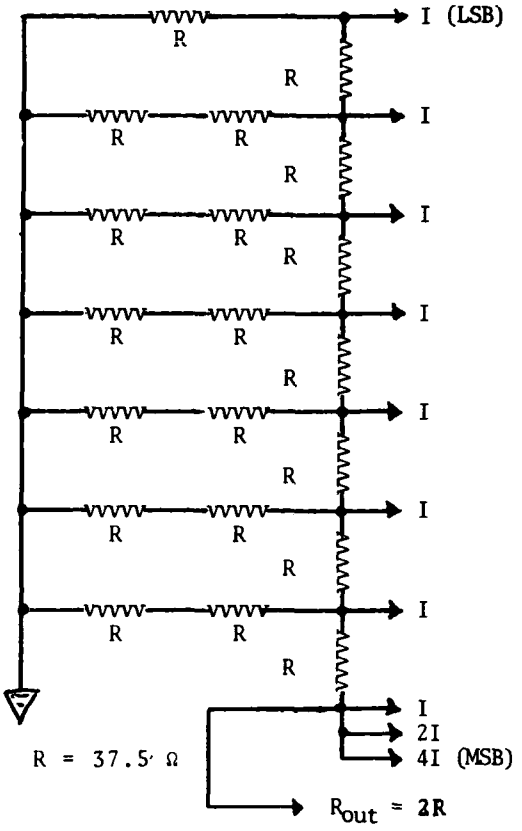

Fig. 1. Improved Ladder

5X Improvement in Broadband Limiting Amplifiers

Using an improvement in the well-known SPICE model to account for large signal operation, P. Saul et al. of Plessey Research have designed and tested a 6-stage limiting (log) amplifier whose base band frequency extends to 1.35 GHz, or 5 times that of previous silicon-based circuits. They used GaAs MESFETs in the circuit. Their improved FET model (upon which the design was based) modelled the MESFET as having a Zener diode and a capacitor connected in parallel across the gate and drain; a similar combination is in parallel across

the source and gate. Gain was 60 db in six stages. The application is for high performance radar systems where a.g.c. techniques are too slow.

Silicon Foundry Concept Gains Followers

A highlight of the conference was Lynn Conway's invited paper on VLSI design methods in which she chronicled the making of her best selling book and the impact it has had in the US and Australia ("Introduction to VLSI Systems", by C. Mead & L. Conway, Addison-Wesley, Reading, Ma. 1980).

In a paper by Denyer et al. of the University of Edinburgh the technique of Conway was elaborated upon. They went on to illustrate actual L.S.I. monolithic circuits designed by systems designers and fabricated in the "foundry". This is believed to be the first implementation of the concept in Europe.

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"MICROWAVES IN EUROPE"

The first practical use of microwaves came about with the development of the magnetron during WW II. The first international conference on microwaves occurred in 1946 and lasted 3 months! Lest one imagine that the microwave art has now reached the point of diminishing returns, there were three conferences devoted to microwaves in Europe during the fall of 1982, the 12th European Microwave Conference (EMC) held 13-17 September in Finland, Radar '82 held 18-20 October in London, and Military Microwaves '82 (MM 82) held 20-22 October in London. This report provides two types of information concerning the conferences - general observations and scientific and technical highlights.

General Observations

There was no infrared (IR) coverage at either Radar '82 or the EMC, while MM 82 treated both active and passive IR. As could be expected only RADAR '82 included subjects such as radar systems, moving target indication (MTI), sequential detection, HF/VHF, coherent processors, target recognition, L.P.I., and signal processing techniques. Other Radar '82 subjects included solid state, monolithic circuits, passive components, theory, medical applications, and optical fibers but not communications, satellites, IR, remotely piloted vehicle (RPV) techniques, optical processing, broadband techniques, high speed digital, and (conspicuously) radiometry. Only MM 82 included active and passive EW, navigation, and IR components.

Regional interests were represented by papers from Finland entitled "Microwave Sensor for Snowpack Wetness and Density Profile Measurement", "Microwave Methods for Strength Grading of Timber and for Automatic Edging of Boards", and "Microprocessor Controlled Microwave Radiometer System for Measuring the Thickness of an Oil Slick". Seafaring Denmark produced such papers as "Sea Clutter Statistics" and "Classification of Ships Using an Incoherent Marine Radar", while "Estimation of Ship's Maneuvers with a Navigation Radar" and "Industrial Applications of Microwaves" came from Sweden. Papers from other countries were primarily related to propagation, theoretical, or military systems oriented. Papers relating to microwave components and their development came from countries with a healthy components industry (e.g., UK, France, FRG, and USA) while systems concepts were most representative of papers from other countries and regions.

The Future of Microwaves

Three of the hardest-hitting papers pointing the way to the future came from Thompson-C.S.F. (Domaine de Corbeville, Orsay, France). The first was an invited paper "Microwave Integrated Circuits on GaAs" by Dr. John Magarshack. In the EMC proceedings he provided a bibliography of 163 papers on gallium arsenide (GaAs) monolithic microwave integrated circuits (MMICs), the most comprehensive such bibliography every published. His paper gave examples of French, British, German, and US efforts in the field, tracked the rapid progress, compared MMICs with the older hybrid MIC technology, and projected MMIC future. His main conclusion was that MMICs would never totally replace hybrid MICs, but that hybrid MICs would continue to incorporate more and more MMICs. He made a strong case for MMICs on the basis of reliability, reproducibility, and cost. The latter is based on a manufacturing concept incorporating multiple functions on a single chip - even when all functions would not be used in the same application. The emerging MMIC distributed or traveling wave amplifiers capable of decade and greater instantaneous bandwidth were also emphasized

The second Thompson-C.S.F. paper was by Professor Michel H. Carpentier on "Impact of the Evolution of VLSI Components on the Future of the Radar". A theme was to convince radar engineers to free themselves from current approaches to systems design and to consider what large scale integration of logic and memory functions could provide. He considered a surveillance radar of 100-km range and 20-m range resolution. If each revolution requires 4 sec and the pulse repetition frequency is 1 kHz, then there are 2×10^9 range cell pulses per revolution. Considering 60 db of dynamic range for distance requirements, 50 db for target size dynamics, and 20 db for margin, a 130-db system is needed. This can be adequately coded with 22 bits of both

inphase and quadrature (I&Q) channels such that the number of bits of memory required for a single revolution is 8.8×10^7. (While 22 bits of dynamic range on a single A/D converter may not be possible soon, the most significant bits could be separately derived from an analog automatic gain control loop.) A digital radar built on such a principle should soon be considered; it would be ideal in jamming or in natural or artificial clutter conditions. Optimum results become possible using parallel processing and autoadaptation modes when all data from previous scans are recorded and available.

In a second example, Carpentier discussed digital target recognition radar and its component requirements. He considered a radar with a range resolution much better than the maximum dimension of the target. The receiver for the radar contains two basic filters, the first a conventional filter programmably matched to the nature of the transmitted signal, the second a fast 40-bit digital transversal shift register whose response depends on the nature of the target and its presentation angle. If the latter filter is essentially made redundant for nearly all possible responses and targets of interest, the response sensitivity to a given target is enormous while the response sensitivity to clutter is minuscule. The circuitry required to implement such a system can be calculated by considering a target whose maximum horizontal dimension is 20 m and whose radar echo response is completely changed when the horizontal orientation is changed by 5 milliradians. Similarly if the maximum vertical dimension is 2.5 m, its response is "new" with every 40 milliradian change in vertical orientation. Assuming all possible configurations are possible for any target, then the total number of possible signatures per target is $4\pi/5 \times 10^{-3} \times 40 \times 10^{-3} = 62,832$.

The total possible signatures for 200 targets would be nearly 7 million while the corresponding number of bits for recording all the signatures is around 1 billion. While 62,832 separate filter recognizers per radar may never be considered practical, an enormous number of target aspect returns are irrelevant. For example, with inbound targets ±60° to the horizontal and ±9° to the vertical, first detection would require 400 configurations in the horizontal x4 in the vertical, or 1600 per target. Consider also the limitation imposed by maneuvering forces on the target at ±5g horizontal and -1g to +4g vertical. After detection the radar shifts to a tracking mode, requiring only 160 configurations in the horizontal x10 in the vertical. Thus 1600 filters instead of 62,832 are required to detect and track the target.

With mass memory and high speed digital logic growing at the present rate, it is useful to consider an organization in which all relevant configurations are completely described in a mass memory. The radar would be implemented with a relatively limited number of high-speed recognizer filters programmed from the slower mass memory. Such a radar would not only depart considerably from conventional design, but it would offer vastly superior target characterization and identification.

The third Thompson-C.S.F. paper was by G. Nuzillat, "The Emergence of GaAs IC's Technology for High Speed Digital Signal Processing". Nuzillat described GaAs IC fixed ratio frequency scalers operating at maximum frequencies of 10.2 GHz, variable prescalers operating in the 1 to 2-GHz maximum input range, and 4-bit shift registers operating in excess of 1 GHz clock speed. Other logic functions discussed were 4-bit ripple carrier adders, 4 bit arithmetic logic units, and 8x8 multipliers operating in the 2 to 5-nanosecond range. He described RAMs with 0.6-nsec performance at 8 bits to 50 nsec performance at 256 bits and word generators of 100 gate complexity output at 5 Gbits/sec. He noted figures of merit of present day GaAs ICs of up to 10^{13} gate-Hz/watt and expects 10^{15} gate-Hz/watt as lithography and heteroepitaxy advance.

The French effort suggested by the above examples is only a fraction of the 5-year, $20 billion French electronics effort reported in the July '82 ESN.

New Capability for EW/ECM

The work reported in an ECM paper "GaAs Monolithic 1GHz Video Amplifier Using Ti/W Silicide Gate Technology", by Yukio Takeda of Fujitsu may have a major impact on EW systems. As spread spectrum and frequency hopping radars and communications systems continue to widen the spectrum over which they operate, EW/ECM systems are forced to use baseband amplifiers of greater frequency response. Because such amplifiers require high gain, good linearity, and wide dynamic range, they are most frequently built as differential amplifiers necessitating the use of carefully selected field effect transistors (FETs). As such strict control over FET parameters is required, the devices have not been reproduced successfully as monolithic circuits. Using a new self-aligned Ti/W silicide control gate technology, the Fujitsu group has developed a well-controlled and reproducible technology by which the ill-controlled offending surface depletion layer of the FET can be eliminated. Another innovation is the total elimination of inductors and capacitors from the amplifier, resulting in a baseband-to-1-GHz video amplifier with a 12-db gain. The present device uses a 2-μm long control gate; use of a 1-μm gate is expected to extend the frequency response to 3 GHz and the gain to 13 db. The units are cascadable for added gain.

Reliability and Military Environment

Microwave device performance degradation in adverse environments is important to military

E/M systems designers. Physicists and engineers have long argued over the effect on microwave FETs of certain electron and hole traps in the semiconductor material from which they are made. The consensus is that many of the traps have no adverse affect and some traps seem to improve characteristics. A re-evaluation of the finding now seems in order. In the paper "Improvements in Receiver RF Burnout Characteristics and Reduction of Post Overload Degradations in Low Noise GaAs FETs", H.J. Finlay (Plessey Research) reported evidence that traps account for significant performance degradation over extended periods of time if the device is subjected to an RF overload as is characteristic of a battlefield environment. The traps responsible for the overload degradation (and even device failure) are generally at the Schottky barrier interface and at the buffer-active layer interface. Using purer materials, the adverse effects can be largely overcome.

Medical Aspects of Microwaves

For a number of years microwave technology has been used to detect and destroy tumors and cancers close to the body surface. Microwave thermography is most noted for its use in detecting breast cancer by mapping temperature distribution in the tissues in a radiometer mode of operation. A single aperture antenna has been used in such applications, resulting in the inability to "focus" on the deeper underlying tissue. Using interferometer techniques first developed for radio astronomy, researchers at the Center for Hyperfrequencies and Semiconductors, Univ. of Lille, France have combined double aperture antenna probes and a new process based on coherent detection of noise to measure thermal gradients in tissue. As the signal-to-noise ratio of a temperature gradient signal is higher than that of the absolute temperature signal, the system can respond to deeper sources even if the signal is not focused. If focused, even greater sensitivity is obtained. Sources as deep as 40 mm can be laterally resolved to within 5 mm in the unfocused mode. In the focused mode, lateral resolution can be as good as ±1mm. Further information on the subject may be obtained from Drs. A. Mamouni, Y. Leroy, and L. Bellarbi at the university.

Problems affecting the performance of a microwave radiometer in monitoring the human body are thermal drift, variation of the emissivity of the body surface as a function of spatial and temporal location, and variation of the reflection coefficient of the antenna-skin interface. S. Osterrieder and G. Schaller of the Inst. for High Frequency Techniques, Erlangen-Nürnburg, FRG, seem to have simultaneously solved all three problems. In the paper "An Improved Microwave Radiometer for Measurements on the Human Body", they described a device that uses a dual purpose noise source in a time-multiplexed manner. The source both compensates for thermal drift and acts as the low-power transmitter source of an integral miniature radar used to calibrate the radiometer antenna probe mismatch and local body emissivity. They can measure body temperature to within ±0.1°C and emissivity from 0.45 to 1.0. The time required for any given measurement is 0.2 sec.

Propagation on Microstrip

Microstrip transmission lines are rapidly becoming the circuit designers' choice for propagation in MMICs. As MMIC designers are constantly striving for increased bandwidth, space requirements for passive microstrip components such as impedance matching transformers, Wilkinson hybrids, and couplers-splitters are becoming excessive if reflection coefficients (Γ) are to be kept low. In the paper "A Multi-Octave Matched Quarterwave Microstrip Taper", F.C. de Ronde (Phillips L.E.P., Limeil-Brevannes, France) described a powerful approach toward saving "real estate" without sacrificing Γ. Figure 1 illustrates a multi-octave matched 2-way power divider. A concave circular taper tangential to the input end is used to prevent reflections in the forward traveling wave. The variations in the lengths of the transverse slots also follow the circular taper, but elementary reflections at slot edges do not cancel each other completely at the lower end of the band; to compensate, capacitive stubs are added at the input. To isolate the output ports, a resistive layer is applied to the taper to act as a broadband load for the odd mode. Because the load is multiply severed by the slots, the load does not adversely affect insertion loss. The device pictured provides >20 db isolation between output ports over the 2 to 12-GHz band.

LADAR MTI

Laser Detection And Ranging (LADAR) suffers from the range vs. range-rate ambiguity problem just as RADAR does at lower frequencies. As Doppler shifts are much larger (e.g., 200 KHz/m/sec) at terahertz illuminating frequencies, the transmitter coherence time must be in good agreement with the formula $\tau = 1/\Delta f_d$, where τ is the coherence time and Δf_d is the Doppler frequency shift. Additional problems encountered by LADARs relate to the determination of maximum pulse length consistent with Doppler broadening induced by target vibrations (wavelengths of acoustic waves on the target surface may also be close to the E/M wavelength of the laser signal). All these problems seem to have been overcome, according to the paper by K.F. Hulme of the Royal Signal and Radar Establishment "A CW Laser Rangefinder/Velocimeter Using Heterodyne Delection".

A CW CO_2 laser is used in the Hulme LADAR. Its output is frequency-shifted in an acousto-optic modulator such that the output is a repetitive train of alternating up-chirp and

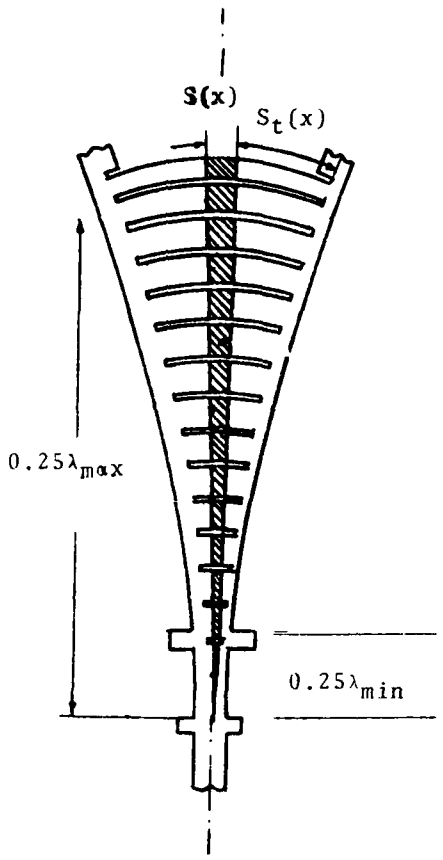

Fig. 1

down-chirp waveforms. The laser is the same as used in the local oscillator for the associated homodyne receiver, whose detected output is fed to the pulse compression receiver. The linear chirp modulation was chosen for its good tolerance to Doppler shift. If the chirp duration is T, the frequency excursion B, and the Doppler shift Δf_d, then the effect on the LADARS performance is: the peak correlated output signal falls to ½ its value when Δf_d = B/2, the temporal position of the peak correlated output signal is displaced by $\Delta f_d T/B$, and there are no large temporal sidelobes.

Because a positive Doppler shift creates a temporal position (range) error of opposite sign for up and down chirps, the range ambiguity is eliminated by averaging the apparent up and down chirp ranges. Target radial velocity (MTI) is derived from the difference between the two ranges.

Airspeed, Gust, and Shear Determination (or Aircraft Crash Prevention)

Wind shear is frequently associated with weather fronts and thunderstorms, but large, local wind changes are frequently found in clear air remote from obvious features such as heavy rain. This means that often an air traffic controller can provide only a general warning of wind shear and cannot state its severity or precise location. Without prior warning, wind shear can result in an aircraft developing large sink rates before corrective action can be taken. Several fatal airline crashes are known to have been caused by wind shear, and various carrier landing accidents are suspected to have been so caused. Several seconds are required for jet engines and wing flaps to exercise their full dynamic range. During take-off and landing there is not enough time to correct for severe wind shear without a real-time warning system.

J.M. Vaughan of Royal Signals and Radar Establishment in a paper "Infra-Red Laser Velocimetry" has developed a laser-based, aircraft-mounted Laser True Airspeed System (LATAS) for detecting wind shear and providing advance warning to the pilot. In doing so he has made several innovative electronic advances. His system uses a 3-watt CO_2 continuous waveguide laser as both the transmitter and the local oscillator for the coherent homodyne receiver. The laser radiation is beamed toward the region to be traversed. Atmospheric aerosols backscatter part of the beam to the receiver. The back scattered signal is detected and its Doppler shift is measured with a surface acoustic wave (SAW) spectrum analyser from which the line-of-sight (radial) wind velocity is determined. A major advance in sensitivity was made during the development of the system. Whereas coherent homodyne/heterodyne optical detection schemes have been known for years and are well documented, their actual performance has been about 10% of that predicted. (The best ever reported previously performed at 25% of theory.) A remarkable aspect of Vaughn's system is that its performance is within 85% of that theoretically possible. The additional sensitivity provides the pilot with advanced warning commensurate with pilot-aircraft response time. Another critical aspect of LATAS is its 15-cm diameter germanium lens, which has proved to be extremely rugged. While hail and debris encountered in flight badly chipped paint and marked the adjoining aircraft structure, the unprotected lens showed no apparent damage.

Principal findings of the LATAS experiments to date are great variability of backscattering signal strength and pattern change under different meteorological conditions, large changes of scattering with small height increments indicative of strong layering effects, particularly large reductions of scattering near inversion or stable layers often over intervals as short as a few hundred meters, and large

increases in scattering from incipient cloud formation.

Overcoming Component Limitations

Nyquist theory sets the lower limit of the sampling frequency to be twice that of the signal frequency being sampled. Failure to observe this requirement leads to false or ambiguous results. As radar and communication instantaneous bandwidth spectra extend towards the gigahertz region, it becomes increasingly difficult to obtain analog-to-digital (A/D) converters, sample-and-hold (S/H) circuits, and related components capable of operating at sample (clock) frequencies sufficiently high to meet the Nyquist criterion. In the paper "A New Technique for the Measurement of a Microwave Pulse Using Sub-Nyquist Sampling" by Prof. C.S. Aitchison of Chelsea College, a novel approach was presented that circumvents the frequency limitations of sampling components. Simply put, the signal of interest is split three ways and is simultaneously sampled by three different sub-Nyquist frequencies. The sampled outputs are passed through individual low pass filters (LPF) characterized by pass bands $\frac{1}{3}$ the individual sample frequencies. The LPF outputs are fed into a common processor. The technique appears to be particularly good for use in ECM systems.

Radiometry

The highlights of several papers are reported. Süss et al. (Univ. Köln, FRG) reported on airborne measurements of both a 90 and a 140-GHz system. The system used a frequency-doubled Gunn device as a local oscillator and a GaAs Schottky barrier detector diode cooled to 20°K. Noise temperature for the 90-GHz system was 256°K while that of the 140°K system was 250°K. Temperature resolution of the 90-GHz system was <0.6°K while that of the 140-GHz system was <0.4°K.

In a flight encountering low ground fog that completely obliterated CCD visual imaging, there was no loss of target contrast at 90 GHz. The 90-GHz system had four times the dynamic range of the 140-GHz system while mapping vegetation and generally exhibited three times the contrast. The 140-GHz system, as expected, provided 1.5 times better resolution when antenna sizes were the same.

A. Sume et al. (Swedish National Defense Institute) reported comparisons between a 35 and a 94-GHz system. The system temperature resolution was <0.13°K at 35 GHz and <0.1°K at 94 GHz. Their general findings were that the 94 GHz system performed poorly in rain, fir branches were ideal camouflage material for vehicles against both the 35 and the 94-GHz systems, thin ice was much easier to detect with the 94-GHz system, and the response of the 35-GHz system to burning solid rocket propellant was superior to that of the 94-GHz system.

A. Resti et al. of a three-way Italian consortium reported work on a four-frequency system operating at 9.8, 15.5, 36.6, and 95 GHz. He reported measuring a 10°K temperature contrast between ships and sea at a range of 2.5 miles when scanned on the horizon.

M.N. Yoder

ONR London

10TH INTERNATIONAL MICROELECTRONIC CONGRESS HIGHLIGHTS

The International Microelectronics Congress has been a Munich-based biennial event since its inception. On alternate years "Practronica" hosts electronic systems developments. Beginning next year the congress will become an annual affair held alternately in Paris and Munich, reflecting the fast-growing French microelectronics effort (see July '82 ESN). Although the congress was billed as international, 82% of the delegates were German and over 80% of the papers were delivered in German. Simultaneous translation into English was generally provided. There were fewer Japanese papers than American papers, but they tended to be benchmark papers. This year the theme of the congress was "gate array" logic chips with a special peripheral session on sensors. (A gate array is a semiconductor chip into which a large number (e.g., 1-8K) of logic gates representative of the six basic Boolean functions are fabricated. The semiconductor manufacturer later interconnects these gates by a 2-level metallization process according to the specifications of each systems designer customer. Thus gate arrays represent semi custom technology.) More conventional subjects such as microprocessors, software, and applications were also addressed.

An exhibition known as "Electronica '82" was held along with the congress. Although 1903 electronic vendors participated, only a few exhibits were of microelectronic components.

Gate Arrays

At first glance it may appear strange that European emphasis on gate arrays is so late in coming, especially in view of current US, UK, and Australian emphasis on advanced concepts such as the silicon compiler and the silicon foundry that have very large and fully customized complex logic circuits. The rather belated continental emphasis is better understood when options to gate arrays are considered. The basic hierarchical levels now available to circuit designers to produce electronic hardware are as follows: PC board using off-the-shelf logic circuits, gate array technology, standard cell array design, and fully customized VLSI circuits. When compared to PC board construction, the advantages of gate

arrays are fourfold: significantly reduced size and weight, shorter interconnection lines providing higher performance, fewer soldered interconnections thereby increasing reliability, and reduced cost in volume production. The only contention among speakers on these factors was regarding the crossover point at which gate array-based circuits become less costly to design and build. Production runs as low as 100 and as high as 1,000 were given as break-even points - the figure evidently dependent on the experience of the circuit designers.

The break-even point (at the upper end of the production count) at which gate arrays begin to lose out to higher order approaches was less well defined. If (and only if) the design can be implemented by the 6 Boolean functions normally available in a gate array, then it probably would not be profitable to go to standard cell based design for production runs under 5,000. Between 5,000 and 10,000 pieces, standard cell design appears to be worth considering. Above 40,000 units, fully customized circuits provide a substantial economic advantage. So, to place the European gate array emphasis in proper perspective, it must be appreciated that European electronic hardware seldom achieves serial production exceeding 40,000 units before competition forces design changes.

Basic concepts, state-of-the-art achievements and product availability, and "applications and support" of gate arrays received much attention at the congress. An underlying theme appeared to be a conscious effort to convince the systems engineers present that if their products were to be competitive, they should switch from printed circuit board to gate array construction as soon as possible.

In the paper "An 8,000 Gate C-MOS Gate Array", the Fujitsu Corporation of Japan stole the show. They not only have available a product with 8,000 logic gates on a single chip but also guarantee enough remaining area (between and among the gates) for interconnecting wires to use over 90% of the gates. Other features of the chip are polysilicon gates, 2.3-μm lithography, 160 input-output buffers, 80 MHz operation, and 100-mW dissipation at 1 MHz.

The German Eurosil firm described their best device as having 1444 gates using an ISO CMOS technology based on 5-μm lithography. To evaluate the question of the maximum number of logic gates available on one chip array, it must be realized that most pieces of electronic hardware use fewer than 2,000 logic gates (not including memory, to which the question is not applicable).

Fujitsu also has the largest number of logic gates in an ECL- compatible, bipolar technology array. They offer an array of 2,000 gates with an internal structure based on low-power Schottky technology but with ECL input-output buffers.

Generally accepted projections for gate array advances (as measured by the maximum number of gates in a single array) by 1990 are 4,000 for bipolar technology and 50,000 for CMOS technology.

Sensors

There were numerous illustrations of how intelligent sensors reduce manufacturing costs and computational load. Generally these involved no new principles but were applications of well-known techniques to equipment and systems previously controlled manually. Two exceptions, however, were described. The first was of the Wiegand effect and some applications in a paper by G.H. Kuers (DODUCO, FRG). The Wiegand effect is the occurrence of hysteresis in a ferromagnetic wire when the outer shell is under greater physical stress than the inner core. Such a state is generally achieved by subjecting the wire to rapid cooling, leaving the core magnetically soft and the shell magnetically hard. The effect is observed by placing a winding (e.g., 1,500 turns) around the wire and subjecting the assembly to an external magnetic field. No voltage is induced across the winding until the external field intensity reaches the point at which the wire shell "flips" its polarization. At this point a 20-μs pulse of 2.5 Volts is generated with a source impedance of 500 ohms. The effect requires no external power, it is virtually burn-out-proof and radiation hard, it has a large temperature range, and it is short-circuit-proof, self contained, and cheap. Although the primary applications to date have been in counting and speed control, its "memory" feature is being exploited by embedding Wiegand wires into credit cards to identify the user.

The second new sensor concept was that of an ion-sensitive FET by M. Kuisel (AEG-Telefunken, Germany) who found that tantalum pentoxide gates for FETs create ideal sensors of acid-alkali (pH) level in solutions. The Ta_2O_5 films appear to be much more sensitive than earlier gate films of Si_3N_4. Other films are being used to detect Ca^{++} and K^{+} levels in boiler water of power plants; and the hardness of domestic water may soon be controlled much more precisely and economically than by the common timer-controlled water softener.

D. Hesse (AEG-Telefunken, Frankfurt) described some preliminary work on the ability of certain snakes to sense infrared radiation gradients to within 0.003°C.

Other

A new concept was introduced to the congress by American Microsystems, Inc. (Santa Clara, Calif.). The concept is an "alterable microcomputer" and lies someplace between standard cell design and fully customized IC design. The device uses a 16-bit microcomputer as its basic standard cell. Other fully compatible functional cells can be

incorporated on the same chip. Such functional cells include RAM, ROM, bidirectional I/Os, counters, clock generators, drivers, and asynchronous serial communication cells. Using the concept to its fullest, many entire electronic systems may be monolithically integrated onto a single silicon chip.

M.N. Yoder

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MATERIAL SCIENCES

FROM SIMS FOR DIFFUSION TO XRDT FOR DEFORMATION AT NANCY

Professor G. Champier is Directeur, Laboratoire de Physique du Solide, École Nationale Supérieure de la Métallurgie et de l'Industrie des Mines (ENSMIM) de Nancy, Institut National Polytechnique de Lorraine, France. He is also honorary president of the National Polytechnic Institute of Lorraine and Director of its Department of International Exchange and Cooperation. His laboratory is supported by the Centre National de la Recherche Scientifique (CNRS). CNRS is the French counterpart of the US National Science Foundation and supports research through separate CNRS laboratories, through contracts of association with universities (Champier is in Laboratoire Associé No. 155, CNRS), and through designated research projects (grain boundaries research and amorphous metals research are two such projects in materials science).

Research in Champier's group is divided along the two traditional lines of materials science activities, namely: point defects, relating to mass transport by diffusion, and plastic deformation, mostly based on dislocation considerations. The group is composed of about 20 persons who have produced approximately 20 publications annually in recent years. Roughly one third of the published articles are written in French. The group is well known for its high quality research and for its special and successful cooperative research projects with leading outside groups around the world. For example, such recent projects have been with Japanese, German, Polish, Canadian, and US researchers.

POINT DEFECTS - DIFFUSION

The work on atomic mechanisms of mass transport in solids spans both theoretical and experimental studies. G. Edelin, P. Pecheur, G. Toussaint, M.O. Selme, M. Gerl, and colleagues have worked on the theory of point defects in intermetallic compounds; in transition metal nitrides, carbides, and borides; and in pure and compound semiconductors. Thermopower calculations have been done for anisotropic metals. Single vacancies, divacancies, and the split [100] interstitial defect have been analyzed theoretically for silicon. Diffusion is being measured on semiconductor materials by secondary ion mass spectrometry (SIMS). Diffusion profiles have been determined on a nanometer scale for ^{117}Sn and ^{125}Te in SnTe by S. Scherrer, H. Scherrer, G. Pineau, and S. Weber. Diffusion measurements in PbSe, InP, and GaSb are of interest, also.

A major effort has been the development of a neutral primary beam-SIMS method (NPB-SIMS) to avoid the surface charge effect encountered when an insulator surface is bombarded by charged particles in the SIMS process (see G. Borchardt, S. Scherrer and S. Weber, "Secondary-Ion Mass-Spectrometry on Insulators with Neutral Primary Particles", Mikrochimica Acta [Wien], 1981, II, p. 421-432). The authors, with H.J. Franek and H. Scherrer, presented a paper "Neutral Primary Beam SIMS Analysis of Surface Layers on Glass" at the Ninth International Spectroscopy Conference, Vienna, 30 Aug. to 3 Sept. 1982. In this work beams of energetic neutral primary Ar atoms are made by charge exchange in the gas phase. Borchardt while working at Nancy is appointed at the Institut für Theoretische Metallurgie, TU Clausthal, FRG. The NPB-SIMS method is applied to surface corrosion studies of industrial soda-lime-silica glass, to organic corrosion of bio-glass candidates for prosthetic devices, and to the investigation of sodium-hydrogen interdiffusion during the leaching of sodium silicate glass. The NPB-SIMS glass corrosion studies will provide needed information on materials suitable for containing nuclear waste products.

The hardware of the SIMS apparatus at Nancy represents a cumulative investment of about $450,000. Diffusivities, D, in the range $(10^{-15} \geq D \geq 10^{-19})cm^2/s$ can be determined. The apparatus is used in conjunction with neutron diffraction and small angle x-ray scattering measurements to analyze the actual surface structure of metallic glasses, and especially the influence of the glass surface structures on diffusivities. Edelin and C. Tete have measured the diffusion of P in amorphous $Fe_{85}B_{15}$. They plan to conduct diffusion measurements in metallic glasses near their crystallization temperatures.

PLASTIC DEFORMATION

Fundamental work has been done to specify the constitutive relations for the movement of individual dislocations in nearly perfect single crystals of silicon. A. George, G. Michot, G. Champier, and colleagues have measured the mobility for various types of dislocations as a function of shear stress,

temperature, and (alloy) doping. The individual dislocation results are now being compared with microstrain compression tests on bulk crystal specimens. For example, the activation energies for the observed movement of individual dislocations and for bulk specimen displacements are being compared. The dislocation structures are observed by x-ray diffraction topography (XRDT). Most recently, such observations have been made at the Laboratoire pour l'Utilisation du Rayonnement Electromagnétique (LURE) synchrotron facility. LURE is a CNRS laboratory at l'Univ. de Paris-Sud, Orsay. George and Michot have reported the development of "A High-Temperature Deformation Stage for X-ray Synchrotron Topography. Applications to Dislocation Mechanisms in Silicon", J. Appl. Cryst. 15, 412-416 (1982). With this apparatus, in situ observations can be made of dislocation processes at approximately 800°C, a sufficiently high temperature for crack-free silicon to be reasonably ductile.

The XRDT method has been used to observe dislocation structures initiated at the tips of pre-cracked silicon crystals when tested in the form of fracture mechanics specimens. The method has provided important information on the role of dislocations in shielding the crack tip stress field (see "Fourth European Conference on Fracture", ESN 36-10:250 [1982]). From in situ observations, the growth kinetics of dislocations emitted at crack tips can be studied at constant applied stress (see "In-situ observation by x-ray synchrotron topography of the growth of plastically deformed regions around crack tips in silicon under creep conditions", by G. Michot and A. George, in Scripta Met. 16, 519-524 [1982]). Current experiments deal with the application of cyclic stress intensities to specimens in a fracture mechanics mode III geometry.

A. George has begun an investigation of the interaction of individual slip dislocations with the special grain boundaries produced in silicon bicrystals having coincident lattice sites at their interfaces. Such boundaries occur naturally between adjacent grains in cast polycrystalline material. George suggested that silicon is an excellent model material for studying dislocation grain-boundary interactions during the plastic deformation of polycrystals.

Champier has helped to establish the US-France Cooperative Science Program entitled "Applications of X-ray Topographic Methods to Materials Science". The first seminar in this program involved 63 participants and was held under the direction of Professor A. Authier at the Laboratoire Minéralogie-Cristallographie, Université Pierre et Marie Curie, Paris, 11-13 March 1980. The second seminar has been arranged by Professor S. Weissmann (Rutgers University) to be held at Snowmass, Colorado, 7-10 August 1983 following the joint meeting of the American Crystallographic Association (ACA) and the Denver Conference on Advances in X-ray Analysis, also at Snowmass, 1-5 August. X-ray topography sessions are scheduled for the ACA-Denver diffraction conference as well. For further information, contact Weissmann at Rutgers, College of Engineering, Department of Mechanics and Materials Science, Busch Campus, P.O. Box 909, Piscataway, N.J. 08854; tel: 201-932-2245.

Other deformation studies at Nancy include tensile and bend testing of rapidly solidified metals and alloys and testing of polymeric materials in tension and in simple shear. C. Tete and colleagues have investigated the crystallization of amorphous iron-silicon-boron alloys of (iron-boron) composition similar to those for which the phosphorus diffusion measurements described above have been made. The metallic glass materials formed by rapid solidification are so hard that wear of the hardened steel knife edges used to transmit the bending forces is a problem in doing repeated tests. An objective of the metallic glasses research is understanding the temperature-dependent transition in the plastic deformation from non-homogeneous to homogeneous flow, particularly with regard to their crystallization temperatures. Rapidly solidified aluminum-iron, aluminum-silicon, and their ternary alloys are to be produced by spraying the molten materials onto a spinning plate.

Polymer deformation studies are intended to characterize and interpret the behavior of amorphous polymers, such as polycarbonate, polymethylmethacrylate, and polyvinylchloride materials, compared with semicrystalline polymers such as polyethylene and polybutene. C. G'Sell, who did leading XRDT work with Champier on dislocation structures in zinc crystals, has spent a major effort (at Nancy and with J.J. Jonas at McGill Univ. in Canada) to understand better the stress-strain results from tensile testing of polymers. Particular attention was given to achieving deformation at a constant strain rate within the locally constricted (or "necking") parts of test specimens. Structural information was obtained by optical microscopy, x-ray diffraction, birefringence, small angle light scattering, and differential scanning calorimetry. Most recently, G'Sell has become enthusiastic about obtaining meaningful test results for such materials in shear, for example, as described in a paper co-authored with S. Boni and S. Shrivastava "Application of the plane simple shear test to the determination of the plastic behavior of solid polymers at large strains", to be published in the Journal of Materials Science.

R.W. Armstrong

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YIELD, FLOW, AND FRACTURE IN POLYCRYSTALS

On the retirement of Professor Norman J. Petch from the University of Strathclyde, a scientific meeting took place in Glasgow, September 15 and 16, 1982 on "Yield, Flow and Fracture in Polycrystals" (see ESN 36-7:169-170, 1982). The meeting was organized by Dr. T.N. Baker (Dept. of Metallurgy, Univ. of Strathclyde). Proceedings of the meeting will be edited by Baker.

Most invited papers dealt with some aspect of the grain size relationship generally known as the Hall-Petch equation,

$$\sigma_\varepsilon = \sigma_{o\varepsilon} + k_\varepsilon d^{-\frac{1}{2}} ,$$

where σ_ε is the polycrystal yield or flow stress, $\sigma_{o\varepsilon}$ is the inherent crystal deformation stress adjusted for polycrystalline behavior, k_ε is the local stress intensity at the boundary obstacle, and d is the grain diameter or boundary obstacle spacing. Since it was first stated by Hall and studied in detail by Petch and co-workers in the 1950s, the Hall-Petch equation has been recognized as the fundamental relation between strength and microstructural boundary spacing, with application to the yield, flow, and fracture not only of steels but also of most other engineering alloys.

The theme of the conference was set by the lead speaker, R.W. Armstrong (Univ. of Maryland and US Office of Naval Research, London), who reviewed the grain size effects in bcc, fcc, and hcp polycrystalline metals and pointed out new trends in the application of Hall-Petch analysis to ultrafine grain sizes, unidirectionally solidified eutectics, and deformation at varying strain rates including creep testing. The wide ranging application and practical use of the Hall-Petch relationship in the steel industry was described by T. Gladman (British Steel Corp.) and F.B. Pickering (Sheffield City Polytechnic) showing that the pioneering effort of Petch has led to amazing alloy development and immense monetary rewards. Another example of the pervasive influence of the Petch viewpoint is the alloying and processing optimization achieved by understanding the structure-property relation in modern structural steels, as cited by W.B. Morrison (British Steel Corp.) with co-authors R.C. Cochrane and B. Mintz.

N.J. Petch (Univ. of Strathclyde) summarized his recent work with J.T. Al-Haidary and E.R. de los Rios on the deformation behavior of polycrystalline aluminum as a function of purity, dislocation density (ρ), grain size (d), and temperature. One of the main conclusions is that, at room temperature and 200°C, the hardening is proportional to $\rho^{\frac{1}{2}}$, but there remains a $d^{-\frac{1}{2}}$ contribution to the flow stress because of slip transmission across grain boundaries. R.R. Preston (British Steel Corp.) discussed the effect of pearlite in steels on the stress intensity factor, k; J. Gurland (Brown Univ.) gave an overview of the plastic behavior of two-phase alloys; and J.H. Woodhead (Univ. of Sheffield) stressed the necessity for high quality statistical evaluation in the Hall-Petch analysis. Discussion papers were given by J.M. Gray (with F. Heisterkamp, Niobium Products Ltd., Dusseldorf) and A.M. Sage (Highveld, South Africa).

Fracture and related microstructural size effects were other topics of great interest at the meeting. J.F. Knott (Univ. of Cambridge) discussed fracture mechanics criteria related to the microstructure ahead of a crack tip and to the observed bi-modal fracture behavior of upper bainite-martensite mixtures. He suggested the possible applicability of mathematical "catastrophe" theory to the problem. J. Congleton (Univ. of Newcastle-upon-Tyne) presented an interesting picture of crack-branching in alumina, as it may be caused under the right conditions by the propagation and acceleration of "advance cracks" in parallel with and eventually connecting to the main crack.

A paper by A. Cottrell, FRS (Univ. of Cambridge) read by D. Hull, dealt with the Cottrell-Petch dislocation pile-up model of brittle fracture. The author now suggests an explanation for the apparent discrepancy between the observed values of the effective surface energy for cleavage and the ideal or true value. An effective surface energy equal to the ideal value is obtained if cleavage in the parent grain is considered to result from a combination of very short slip bands with very long microcracks at the critical condition of brittle-ductile transition.

E. Smith (Univ. of Manchester/UMIST) in a paper read by J.F. Knott pointed out that the important effects of flow localization and shear band decohesion on the mechanics of crack propagation may account for fracture instability in the presence of a pre-existing crack. In a somewhat related paper, J.W. Hancock (Univ. of Glasgow) described the effects of anisotropy due to oriented, eccentric void growth during plastic flow on yield surface and ductile failure processes.

The last three papers dealt with the difficult problem of the superposition of various strengthening effects. T.N. Baker (Univ. of Strathclyde, Glasgow) discussed problems encountered when the components of the friction stress σ_0 are studied experimentally, namely dislocation density, precipitates, particles, and sub-grains. H. Chandra-Holm (Inst. für Umformtechnik, Zurich) described her work with J.D. Embury at McMaster Univ. on the strengthening role of dislocation substructure and flow processes in Al and Al

alloys. N. Hansen (Riso National Laboratory, Roskilde, Denmark) showed the still uncertain relationship between the theory of dislocation density, plastic strain, and grain size, with the experimental observation of deformation structures in a number of non-ferrous metals that obey the Hall-Petch equation.

In the conference summary words of Norman Petch: "that's that", and he did not imply thereby that there is little left to do in understanding and expanding the scope of applicability of the Hall-Petch relationship.

J. Gurland

Brown University

OPERATIONS RESEARCH

INTERNATIONAL RELIABILITY AND MAINTAINABILITY CONFERENCE

The Third International Conference on Reliability and Maintainability was held in Toulouse, France 18-21 October 1982. About 100 papers on topics including contractual aspects of reliability, human factors in system reliability, safety, software, modeling and estimation, and tests and diagnostics, were presented to approximately 400 attendees. Most of the papers were in French with simultaneous translation into English. The conference was organized by the Centre National d'Etudes Spatiales (CNES) in cooperation with the European Space Agency (ESA), the Centre National d'Etudes des Télécommunications (CNET) and the Société des Electriciens, des Electroniciens et des Radioélectriciens (SEE). A few of the papers are described below.

A paper on "Software Redundancy for Error Detection in Distributed Systems", by J.M. Ayache and A. Sobai (Centre National de la Recherche Scientifique, Toulouse) and B. Loyer and J.C. Paul (Cit-Alcatel, Velizy) was given in a session devoted to fault tolerance. An approach to the problem of real time detection of error (hardware, software, and human) in a distributed processing system was described. In such an environment it is common to implement on-line tests such as check-sum tests and routine hardware module tests. Such tests are essentially hardware fault detectors and are closely linked to the technology used. While they tend to be independent of the specific application, the tests are costly to develop and inadequate in that they cannot meet error detection requirements for a group of communicating processors. The authors stated that the inadequacy is still a problem, despite the work being carried out on protocols at various levels, because any protocol will ignore errors due to the hardware that implements the protocol. They suggested that problems of error detection in data processing systems should be taken into account at the design stage, which can be done using the concept of an "observer" and applying it to communication protocols.

J.N. Benso, R. Fourre, P. Larger, and P. Legris (Compagnie de Signaux & d'Entreprises Electriques, Paris) described their work on a self-checking control processor designated PAC. PAC is a dual processor with a fail-safe checker that compares the processing units at each clock cycle and initiates a by-pass if there is a problem. The system is designed to meet stringent safety requirements in applications to railway switch control and control functions in nuclear plants. Common mode failures are reduced by providing separate power supplies for the two processors, by making the second processor differ from the first (by permuting bits in its registers) and by delaying one of the processors a few clock cycles behind the other. The authors stated that it is possible to calculate the safety protection provided by PAC in specific controller applications.

A paper entitled "Multicriteria Optimal Allocation of Spares for Electronic Devices" was given by D. Ostojič, S. Opricovič, and R. Krtolica (Mathematical Institute, Beograd, Yugoslavia). The problem of allocation of electronic spare parts in a logistic network supporting a system of spatially distributed electronic devices was considered. The authors described a number of single criterion measures for which traditional optimization methods could be carried out. Some of the measures are total cost of spares, prescribed down time, total reliability of the system, and total system availability. They then described a compromise programming method of optimization of spares allocation. Compromise solutions are those that are closest, by some distance measure, to the "ideal" solution obtained by separate optimization for each criterion.

A paper on "Maintenance Procedures for Maximising the Availability of Stored Items by the UK Armed Forces" was given by J.M. Sheppard (Rex, Thompson & Partners, Farnham, UK) and A.A. Wingrove (Royal Aircraft Establishment, Farnborough, UK). The paper concerned scheduling tests of guided weapons for which it has been found that a significant number of failures are caused by the testing itself. The purpose of periodically testing stored equipment (such as missiles) is to identify and repair failures that may arise during storage and to provide information about the availability of the equipment. Apart from the fact that storage failure rates are lower than was anticipated when many existing maintenance policies were formulated, two further factors that have impact on maintenance policies are now known: testing itself can cause failures and tests generally cannot detect all failures in complex equipment. Thus it is desirable to establish the best compromise between the need to find and correct failures

and the need to keep testing to a minimum. Several policies were considered, varying from periodic to no testing. It was shown that in some circumstances periodic testing at unequal time intervals can be better (in terms of availability measures) than testing at equal time intervals. It becomes evident that, in formulating a policy, more than simply the storage failure rate should be considered. Specifically, the effectiveness of the test and the damage caused by it are critical; the scrap or refurbishment point for the equipment must also be considered. The authors believe the current policies in the UK are far from optimum. There are far too many tests, which has resulted in decreased availability of the systems.

K. Takakura (Mitsubishi Electric Corp., Japan) gave a paper with nine co-authors on "A Computer Aided Test and Diagnostic System for the Reliability Evaluation of Plastic Encapsulated 64K Dynamic RAMS." According to Takakura, under recent rapidly increasing integration of dynamic random access memories (RAMS), tests and diagnostic methods for analyzing miss-operation (one-bit errors) due to design, manufacturing, and soft alpha particle-induced errors have become a serious problem. A procedure at Mitsubishi involving a computer-aided test and diagnostic system was described. One feature of the procedure involved assessment of soft error rates using accelerated tests carried out by placing a strong alpha radiation source near a large bank of the 64K RAMs. Each RAM in the bank was continuously checked for bit errors over the test period. Results over a two-year period indicate that the observed soft error rates agree well with theoretically predicted rates. According to Takakura, the plastic encapsulated 64K dynamic RAMs have achieved extremely high quality through improvements carried out in design and materials. (For example, a polyimdide resin surface coating has apparently improved the alpha particle-induced soft error rate.) Soft error and latent error rates of less than 0.005%/1000 h have been claimed.

C. Johnston (British Telecom, London) and F.H. Reynolds (British Telecom Research Labs, Ipswich) gave a critical review of the failure rate prediction models offered by the US MIL-HDBK-217 and the French CNET Handbook of Reliability Data in the paper, "An Appraisal of Integrated Circuit Reliability Prediction Models." It was stated that the MIL-HDBK model is pessimistically biased when applied to civil applications of integrated circuits (ICs) in computers and telecommunication systems; the CNET model is more acceptable, at least in terms of its temperature weighting factor. However, the CNET model was optimistic for plastic ICs under humid conditions, so the authors suggested incorporating a stress-weighting factor which bridges the gap between the values given by the MIL-HDBK and CNET models.

Authors were required to submit manuscripts of their papers well in advance of the conference, allowing for a proceedings volume to be published and distributed to each attendee at the time of registration. The 700-page volume is available from ESA priced at 200FF (about $29 at the current exchange rate). [T.D. Guyenee (Compiler), Reliability and Maintainability, Document ESA SP-179, Agence Spatiale Européene, 8-10 rue Mario-Nikis, 75738 Paris 15, France (Sept 1982).]

D.R. Barr

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PHYSICS

THE FOURTH INTERNATIONAL SYMPOSIUM ON GAS FLOW AND CHEMICAL LASERS

High efficiency, high average power, CW operation and unique emission spectra are some of the advantages that make gas lasers attractive for research, industry and military applications. With the advantages come particular problems to be researched. Solid-state lasers absorb broad bands of the optical spectrum so that (visible) light pumping can be used to excite lasing transitions. Gas atoms and molecules, on the other hand, are transparent to light of most wavelengths. Excitation of lasing transitions in gas by hydrodynamic, chemical, or electrical means is usually required. For high-power systems, the gases must flow to remove heat and reaction products. The dynamics of high-energy-density gas flow and the development of system components for the flow environment are other important gas laser research areas.

Problems of gas-laser design and development and their applications were the subjects of the 4th International Symposium on Gas Flow and Chemical Lasers held in Stresa, Italy in September 1982. About 100 invited and contributed papers were presented by researchers from the United States, Western Europe, the Soviet Union, the People's Republic of China, and Japan. About 70 papers dealt with research and development of gas lasers. New operational laser systems, the hydrodynamics and mixing of constituent gases, laser spectroscopy and the associated atomic and molecular physics, and component design were discussed. Material processing for industry, led by a strong and well-organized Italian program, was the application area of importance to most western European researchers. Atmospheric propagation of gas-laser beams was the other major application area of interest. This report will concentrate on European research concerned with the two applications. The Italian industrial processing program is briefly

sketched to serve as an introduction to that subject. Laser beam-matter interactions important to, and laser systems dedicated to, material processing are considered next. Finally, atmospheric propagation research presented at the conference is reviewed.

THE ITALIAN SPECIAL PROJECT ON HIGH-POWER LASERS

Alberto Sona, director for the Italian National Research Council Special Project on High Power Lasers opened the conference with a review of project objectives. The project was started at the end of 1979 to promote the use of new laser technologies in manufacturing systems. The task was divided into four sub-projects: heavy mechanical applications, light mechanical applications, laser source development, and medical applications (not discussed at the conference). The heavy mechanical element has as its objective the investigation of industrial metal working processes such as welding, cutting, drilling, heat treatment, surface alloying, and cladding. Design criteria for automated manufacturing systems were to be determined and commercial laser sources were to be tested and evaluated for these processes. To these ends, a partnership of industrial firms was formed to establish an Application Center within the Institute for Technological Research and Automation in Turin. The center is equipped with a 15-kW AVCO CO_2 laser with work stations devoted to welding, cutting, and surface heat treatments. With the laser, a data base consisting of working parameters such as processing speed, power, focal length, etc. is being developed for various steels. To date, technology for 10 processes has been transferred to national industries in the automotive, nuclear, and aeronautics fields.

Light mechanical applications, limited to processes requiring laser powers less than 1 kW, are under study at five centers in different parts of Italy. Welding, drilling, cutting, and heat treating are being studied for ceramics, glass, plastics, rubber, paper, wood, textiles, and thin metal sheets. Appropriate lasers have been incorporated into control and automation systems with movable optics to study specific applications. Aldo La Rocca (Fiat, Turin) informally summarized the main accomplishments of the two mechanical subprojects. In addition to completed specific experiments with stainless, carbon, and alloy steels and the above-mentioned nonmetallic materials, he described associated ongoing experimental and theoretical research on the radiation-matter interaction. High-speed cinematography, time-resolved Schlieren and shadowgraph analyses, and time-resolved spectroscopy were compared with hydrodynamic models to understand better each of the basic processes.

The laser-development subproject is developing laboratory prototypes of high-power CO_2, Nd-YAG, excimer, and dye lasers for industrial and medical applications. Researchers at the Politechnico and CISE Labs in Milan are evaluating three types of CW CO_2 lasers for material processing with respect to sustained power level, electro-optical efficiency, and beam uniformity. The largest laser is transversely excited by an electron beam and has operated at 8 kW for hours and 11 kW for some minutes at an electric-to-optical efficiency of about 13%. The second laser is excited by an electrical discharge transverse to the gas flow and operates at 5 kW. The third prototype is a compact 2-kW longitudinal discharge laser with supersonic flow. A 400-W pulsed Nd-YAG laser for metalworking is also being tested.

At the Valfivre Laboratories in Florence, the manufacture of optical components for industrial applications is under study. Techniques are being developed to provide substrates with high optical quality and suitable surface geometry, and coatings with specific reflection and transmission coefficients. Vacuum-deposition techniques are being evaluated for fabrication of reliable optics in high-energy-density-beam environments.

The strengths and emphases of the Italian gas-laser research program were indicated by the number and distribution of papers at the conference. Of the 11 talks devoted to the laser-beam matter interaction and material processing, 6 were by Italians. Of the 8 papers devoted to optics, 3 were by Italians. There was only one contributed paper from Italy in the 70 or so devoted to laser R&D although informal reports on elements of the laser development subproject were provided by Dr. Sona. No applications other than materials processing were reported by Italian researchers. It is clear that the Special Project on High Power Lasers provides specific direction to Italian gas-laser research in accordance with its stated objectives.

THE LASER-MATTER INTERACTION

Dr. G. Herziger (Institute of Applied Physics, Darmstadt, W. Germany) described the important beam-target interactions for materials processing in an invited talk. Two types of interactions can be distinguished: low intensity (for hardening, welding , etc.) where optical absorption in the target is balanced by in-depth heat conduction, and high intensity (for cutting and drilling) where the radiation is primarily absorbed by plasma above the target surface. Herziger stated that low-intensity phenomena, characterized by CW laser intensities of 10^6 W/cm^2 or less and wavelength-independent absorption in solid or liquid matter, is well understood. He therefore concentrated on the high intensity interaction.

At high intensities, the laser energy is absorbed by inverse bremsstrahlung in the ablation plasma above the material surface. Energy is removed from the laser focal region by heat conduction into the solid and by convection in the expelled liquid and vapor.

Vapor and plasma hydrodynamics therefore determines the recoil pressure on and heating of the solid sample being processed. Pressure must be kept to a minimum to prevent deformation or shock damage. Heating must be controlled to obtain the desired hardness and surface finish.

The laser absorption coefficient at high flux depends both on the radiation wavelength and intensity. For metals irradiated below about 10^8 W/cm^2, absorption approaches unity for wavelengths near 0.1 μm, is about 50% for 0.3 μm, and drops to about 10% at 1 μm and above. As the intensity is raised above the critical intensity, $I_c \approx 8\times10^7$ W/cm^2, long wavelength absorption rapidly approaches unity because of laser-induced electrical breakdown. Absorption just above I_c leads to a sharp increase in the speed at which material can be processed. Further increase in the intensity, however, leads to plasma shielding of radiation from the target and a saturation of the processing rate. For drilling, the penetration speed saturates at about 2,000 cm/s. Drilling efficiency is enhanced near I_c by a lensing effect of the expanding plasma. Higher-than-critical intensities drive turbulent splashing and vapor emission. Herziger showed samples of laser drilling at intensities of I_c and above, which illustrated the cleaner processing associated with the lower intensity. He also pointed out the advantages of monomode (single wavelength) laser operation for precise control of processing. Examples shown using a high-power monomode laser included precise hardening contours, drilling in sapphire, and superfine computer-controlled drilling matrices in quartz.

Drs. Massimo Germano and Maria Sandra Oggiano (Politecnico of Turin, Italy) described a model for the gas-dynamic evolution of the shock wave formed by the emitted vapors pushing against the ambient atmosphere. They generalized 1-dimensional calculations performed by Knight (J. of AIAA, 17, No. 5 [1979]), who developed analytical jump relations at the surface Knudson layer and the vapor-atmosphere interface by assuming time-independent laser irradiation. Germano and Oggiano allowed for an arbitrary variation of laser flux with time and developed a numerical procedure to study the vapor emission and shocked gas. They used the Knight conditions to relate the density, temperature and velocity of the vapor to the corresponding surface-side quantities. They then solved the 1-d, time-dependent fluid equations for these variables plus entropy and heat flux using a two-level, predictor-corrector finite difference scheme. Uniform volumetric heating due to laser-beam absorption was assumed. They presented three particular solutions for aluminum targets in a reduced air atmosphere. In one solution, a constant irradiation in time was assumed. The subsequent evolution showed a uniform pressure profile and linear velocity ramp indicating that self-similar solutions apply. Germano and Oggiano hope to incorporate a complete radiative treatment into their model, which can be used to predict realistically the shocked vapor-atmosphere interaction for the materials processing program.

Dr. P. Gay (Fiat, Orbassano, Italy) described solutions of the heat transfer equations applied to various material processes. Results of both 1-d and 3-d models were compared with metallurgical transformations observed in steel samples treated with the 15-kW CO_2 laser. Surface-transformation hardening and other processes without surface melting require precise control of the temperature profile and time variation. Thermocouples placed at two depths in the samples were used to determine the 10.6-μm absorption coefficients for various surface conditions. For given material and process characteristics such as cut or weld thickness and surface hardness, the code determined the appropriate laser-irradiation area, power, and processing speed for the desired temperature profile and time variation. Dr. E. Ramous (Univ. of Padua, Italy) described a similar model applied to the surface treatment of metals. He also determined the processing parameters and laser specifications with a heat transfer calculation using surface-absorption data.

Two other experiments using the Italian 15-kW laser were described at the conference. M. Cantello (RTM, Vico Canavese, Italy) and coworkers from Milan and Turin described experiments to analyze the plasma-absorption waves created by the laser on aluminum and stainless steel targets. Although the laser illumination was continuous, high speed photography showed the growth of fireballs moving away from the target surface at 20-ms intervals. A 2-W CO_2 laser probing the plasma at various distances above the target recorded the laser absorption profile. As each laser-supported detonation wave formed, the transmission of radiant energy to the surface dropped from nearly 100% to almost zero for a few milliseconds as the beam was absorbed in the highly conductive fireball. Such fluctuations limit the power and processing speeds that can be used because of processing variations produced along the length of the sample. Large variations are unacceptable in industry because of the cost of an additional mechanical finishing operation.

An example of processing variability was provided by G. Dionoro (Istituto di Meccanica, Cagliari, Italy). He described inert gas-assisted cutting of low-carbon steel sheets with the 15-kW laser. A nitrogen gas flow covering the cutting zone prevented exothermal chemical reactions and removed heat so that higher power than required by a stationary, ambient atmosphere was necessary for cutting. Thirteen samples of 4-mm-thick steel were cut with

laser powers ranging from 5 to 10 kW, cutting speeds of .5 to 2.5 m/min and N_2 gas pressures of 0.2 to 0.8 MPa. Irregularities in surface roughness and hardness due to the screening of the laser beam by the variable ablation plasma were recorded as functions of the processing parameters. Much of the cut surface showed intolerable material dripping. Although dripping could be minimized by increased gas pressure, this adjustment led to an inferior hardness profile. Operation under vacuum should improve quality by allowing free (and therefore presumably steady-state) vapor expansion. However, such conditions are difficult to achieve in an industrial environment. The authors hope to improve processing by further optimization of parameters and better understanding of the interaction between the laser, cover gas, and target. V. Sergi and coworkers (Univ. of Naples) described similar experiments on low-carbon steel sheets using oxygen as the cover gas, lower cutting speed, and the 500-W Valfivre CO_2 laser.

Talks involving industrial processing and other laser-matter interactions were presented by speakers from France, Germany, Austria, England, the Soviet Union, and the United States. D. Schuöcker (Technische Univ., Wien, Austria) described a model for and experiments on the cutting of 4-cm-thick steel with a 1-kW CO_2 laser. For samples 1 cm thick or less and a given beam power, a reciprocal relationship between cutting speed and thickness is expected from energy considerations and is observed. For samples thicker than 1 cm, the cutting speed is lower than predicted from the relationship. To explain the thick-sample data, Schuöcker developed a new model that included guidance of radiation and reactive gases by the walls of the cut channel and attenuation due to absorption by the ablating vapors. He solved a set of 2-d hydrodynamic equations involving the density, velocity, and temperature of the molten and vaporized materials and the reacting gas. Numerical solutions were presented for steel cutting with oxygen gas, which showed much closer agreement with experiment than the usual reciprocal relationship.

The German and English papers described new laser systems for materials processing and their use in welding plates. C. Carlhoff and coworkers (Univ. of Düsseldorf, FRG) emphasized the importance of good mode behavior and frequency stability to high-quality processing. To this end, they developed a monomode CO_2 laser with separate oscillator and amplifier components. Usually, CO_2 lasers incorporate both functions in a single cavity. The oscillator is a tunable, stabilized 10 W CO_2 laser. The main amplifier is a 10-m long device consisting of 14 convectively cooled glass segments. The He, N_2, CO_2 gas mixture is excited by a 150-mA, 22,000-V discharge and is cooled by forcing the gas to flow in a helical fashion to provide good wall contact. The output power is 3.5 kW with an estimated 10^7 to 10^8 W/cm² at focus. The system was tested in a seam-weld experiment on 0.2-mm-thick tin plate. At full power and best focus, a maximum processing speed of 50 cm/s was obtained. In agreement with theory, the speed varied linearly with beam power and inversely with material thickness. A.S. Kaye and coworkers (Culham Lab., Abington, UK) discussed initial welding trials using a 10-kW CO_2 laser. Two 5-kW transverse-flow modules coupled within a single optical resonator produced a nearly diffraction-limited output with an overall efficiency of 7%. Intermittent powers of 12 kW were achieved. Key-hole welding of 2-cm-thick steel was demonstrated with a processing speed of 1 cm/s. For steel 0.8 cm thick, 4 cm/s was achieved.

As mentioned above, the presence of an ambient atmosphere determines the way vaporized and ionized material escapes from the target surface. The details of the ablation process then determine how the sample is heated and pressurized. C. Creput and coworkers (IMFM, Marsaille, France) investigated the thermomechanical effects induced by a pulsed CO_2 laser on aluminum and carbon targets in reduced-pressure atmospheres. The e-beam excited laser produced target irradiances up to 1.5×10^9 W/cm² on targets in 10^{-5} Torr to 400-mbar air. The shock pressure exerted on the target, the shock-front velocity, and the flow density profile were measured. The measurements yielded the ambient density regimes in which different types of hydrodynamic flow occurred. As the air density ρ was reduced, an increase in axial flow velocity inversely proportional to $\rho^{0.3}$ was observed. Below 1 mb, the plasma response took the form of a spherical blast wave.

From the laser parameters, target materials, and instrumentation, one would guess that Creput's research is associated with material response for defense rather than industrial applications. Such was certainly true for the eight invited talks given by US personnel. (Of the invited talks, 80% were of US origin while less that 20% of the contributed papers were.) In fact, none of the 40 or so US and Soviet papers related directly to industrial processing. In the area of beam target interactions, J.D. Daugherty (AVCO Everett Research Laboratory, Mass.) described experiments with KrF, XeF, DF, and CO_2 lasers (λ = 0.25 to 10.6 μm) operating with pulse durations of 0.5 to 20 μs and power densities of 10^5 to 10^8 W/cm² incident on metals, ceramics, laminates, and optical materials. He stressed the differences in the phenomenology of the thermomechanical response of metals and insulators by detailed

analyses of aluminum and glass-fiber-reinforced plastic composites. The Russian contribution to the laser-matter topic was provided in a poster-session paper by A.I. Korotchenko and three coworkers (Lebedev Physical Institute, Moskow, USSR). The work analyzed the response of bismuth and lead targets in air to sub-ms Nd-glass laser pulses in the 1 MW/cm² regime. They derived analytical expressions for the pressure loading as a function of incident laser intensity, compared analysis and experiment, and attributed discrepancies to energy carried away by a radial melt flow. The reason for the choice of materials is obscure (though both have low melting points) because no one who could answer questions on this paper was present. The 20 or so Russian papers submitted were presented by six attendees. Although this case is extreme, it represents a common conference practice that makes acquisition of good information about Soviet research difficult.

ATMOSPHERIC PROPAGATION

Participants from France and the Soviet Union showed interest in long-range laser-beam interactions with the atmosphere. Beam spreading, loss of coherence and attenuation due to the presence of turbulence or aerosols, and the use of lasers to clear the atmosphere were considered. Michel Billard and coworkers (Office National d'Etudes et de Recherches Aérospatiales, Châtillon, France) described a laboratory simulator for the effects of thermal turbulence on optical propagation in the atmosphere. Outdoor measurements of beam degradation and experiments with corrective devices (such as adaptive optics) are constrained by incomplete knowledge of the turbulence along the optical path and the variability of meteorological conditions. A laboratory facility was constructed to overcome such difficulties. The turbulence is driven by injection of alternating streams of hot and cold air transverse to the optical path. Design parameters (box and stream dimensions) were chosen to create thermal-turbulence spectra that would reproduce conditions in the real atmosphere. The turbulence could be controlled by adjusting the stream velocity and heated-air temperature. Multiple reflection in the 2-m long box provided an optical path length of 30 m. Measurements of HeNe laser beam spreading vs turbulence strength were compared with two models developed by L.R. Bissonnette and H.J. Yura (Appl. Opt. 10, No. 12 [1971]). Good agreement between theory and experiment for radial spreading up to a factor of three demonstrated the ability of the simulator to create realistic atmospheric turbulence.

P. Vigliano and coworkers (IMFM, Marseille, France) compared four hydrodynamic models of aerosol-induced breakdown of the atmosphere created by high-power, pulsed-laser propagation. The high-pressure plasma generated by the breakdown expands to fill the beam cross section and absorbs the radiation. Vigliano compared the plasma growth predicted by a 1-d detonation-wave model involving shock-front conservation laws in an ideal gas, a 2-d Legrangian-hydrodynamic model for the mixture of gases in air, a spherical self-similar-expansion model with nonlinear coupling between equations, and a numerically-integrated blast-wave model. The models were compared with fast-framing, streak, and Schlieren photographs of the expanding plasma luminosity and shock wave created by 30-J, 50-ns and 130-J, 2.5-μs CO_2-laser pulses brought to convergence by a long focal length mirror. Breakdown occurred in small spots at many sites, which then expanded and merged into a cylindrical channel. Similar behavior has been observed by R. Gregg and coworkers at the Naval Research Laboratory in Washington D.C. When the data were plotted as expansion radius vs time, good agreement was found with the 2-d and similarity-solution models.

The reported Soviet work was concerned with the interaction of laser radiation with aerosols in the atmosphere. Three papers submitted by workers from the Institute of Experimental Meteorology in Obninsk were presented by O.A. Volkovitsky, coauther on two. One by R.Kh. Almaev et al. concerned broadening of a CO_2 laser beam during propagation in an aerosol of absorbing solid particles. When the intensity is below the breakdown threshold, beam spreading is due to refraction in heated air layers (called aureoles) surrounding the particles. The authors developed an expression for beam spreading based upon the change in the radiation coherence function due to propagation in a randomly inhomogeneous medium and compared the analysis to experiments with a 2 kW/cm² beam and an Al_2O_3-particle aerosol. Good agreement was obtained with both large (5 to 10 μm) and small (0.1 to 1 μm) particles. A paper by V.Ya. Korovin and coworkers described laser-induced flows in liquid and solid aerosols. Particle flow in the beam direction and transverse to it is easily understood. However, flow towards the laser source can also occur under certain thermal-conduction, radiation-absorption and surface-tension conditions. In such cases, inhomogeneous radiation absorption induces capillary convection in liquid particles which, because of air viscosity, can produce a net force towards the laser. The analysis suggests that laser beams in the 50 W/cm² regime may be useful for removal of water and pollutant aerosols from limited volumes. A second paper by R.Kh. Almaev and coworkers described application of a diverging CO_2-laser beam to cloud clearing. A theory for the interaction of the beam with the water aerosol and background atmosphere was developed and compared with experiments with a cloud chamber. Numerical calculations provided an

approximate analytical expression for the cleared cloud medium transmittance that agreed with data. Finally, V.I. Bukaty and coworkers (Altai State Univ, Barnaul, USSR) discussed a model and experiment on the combustion of soot aerosols and black smoke with a Nd-glass laser beam of 10 to 100 J/m² energy density.

Abstracts and proceedings of the 4th International Symposium on Gas Flow and Chemical Lasers can be obtained from the conference chairman, Dr. Michele Onorato, Politecnico di Torino, Corso Duca degli Abruzzi, 24-10129 Torino.

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PHYSICS IN THE SCIENCE OF PHOTOGRAPHY

The conventional silver halide photographic process involves much solid state science. The formation of an amplifiable "latent image" speck depends, among other factors, on the indirectness of the electronic energy gap, the presence of highly mobile interstitial silver ions, and the existence of a sub-surface ionic space charge. The same properties also make experiments possible on single crystals of AgBr and AgCl that are simply not feasible for more conventional ionic substances such as alkali halides and oxides. Thus, in many respects we understand lattice defects and the properties of photoelectrons and holes much better in the silver halides than in any other ionic material. Nevertheless, in spite of the progress and in spite of many decades of intensive research into microscopic details of the photographic process, we still do not understand the physical mechanisms of much that goes on between the opening of a camera shutter and the appearance of a negative image in the development bath. The fundamental cyclic mechanism proposed so many years ago by Gurney and Mott appears, in the main, to be valid, but when attempting to understand quantum efficiencies, stabilities and instabilities of various configurations, the roles of defects and of impurity ions, the sequences of events, and so on - then we enter a world of informed speculation.

To consider such questions, the International Congress of Photographic Science met at the University of Cambridge, 6-10 September 1982. Approximately 150 papers dealt with topics ranging from the fundamental solid state science of the silver halides to technical problems related to the preparation of high performance photographic products. Only the former concerns are described in this note.

The solid state-oriented papers at ICPS '82 dealt with a number of topics. The properties of lattice defects, especially the cation vacancy and the interstitial silver ion, were discussed by several authors. They dealt with ionic conductivity, ion migration, and ionic space charge effects. Electronic defects, the photoelectron and photohole, were the subject of several other contributions. Much emphasis was given to trapping processes, recombination, and the effects of ionizing irradiation on the production of new traps. Many authors considered the photographic latent image and pre-image specks: mechanisms of formation, stabilities, and interactions with other ionic and electronic defects. Also relevant to such questions are the effects of cation solute ions incorporated into the silver halide microcrystals and of other substances adsorbed on the grain surfaces. The latter substances include photographic dyes that can dramatically change the spectral response of a photographic emulsion; this then raises a number of scientific questions about the transfer of energy and charge and about the effects of the various energy levels in the dye molecules. Another type of surface additive results from what is known as chemical sensitization (formation of Ag_2S specks or of Au and Ag compounds of sulfur) and reduction sensitization (which appears to form atomic silver on the surface, but in a way that does not serve as a nucleation site for the latent image). Both the chemical and physical properties of such sensitivity centers are important but still poorly understood.

The problems encountered in trying to understand the highly efficient silver halide photographic emulsion often raise questions of fundamental interest to solid state physics and chemistry. A more detailed summary of ICPS papers dealing with such questions will be available as an ONRL Conference Report.

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University of North Carolina

REPORT ON THE 4th INTERNATIONAL WORKSHOP ON INELASTIC ION-SURFACE COLLISIONS

The 4th International Workshop on Inelastic Ion-Surface Collisions was held in Middlefart, Denmark on 21-24 September 1982. About 70 delegates from 15 nations were in attendance. The workshop focused on several areas of interest: (1) radiationless transitions between an ion and a surface and final charge states, (2) excitation of sputtered atoms, (3) ion-induced secondary and Auger electron emission, (4) ion-induced atomic mixing in solids, (5) electron and photon stimulated desorption, (6) sputtering of massive molecular ions, and (7) anisotropic effects observed during grazing incidence of ions on a surface. A topic of related interest was on the shapes of atoms in gas phase collision studies.

The workshop began with an invited lecture from D.J. Auerbach (IBM, San Jose) on the effects observed when meV neutral atoms of molecules are scattered from surfaces. The probing projectile is usually helium from a supersonic nozzle. The information gained from

the scattering process involves the geometric, vibrational, and electronic structures of the solid surface. The energy loss spectroscopy is usually determined by the time-of-flight method. The interaction time between the projectile and the surface is displayed as a broadening of the time-of-flight spectrum, and the broadening increases as the target temperature increases. Particles trapped in surface potential wells will have a Boltzmann distribution when they finally leak out, and surface phonon dispersion information can be gained from such measurements. The conclusion from the experiments is that meV atomic scattering from surfaces can be separated into two channels: (a) direct inelastic scattering and (b) trapping followed by desorption. The experiments can determine the fraction trapped and characterize the direct channel.

J. Los (FOM Inst. of Amsterdam) discussed resonance charge transfer in atom-metal surface scattering. He considered the yield behavior of ions and neutrals as a metal surface is progressively covered with an alkali metal such as Na or Cs. An interesting effect is the shift of the Fermi level due to Cs coverage, leading to an increase of H^- yield as 10 to 20 keV H^+ ions are scattered from a W (110) target. In this way the resonant electronic atom-metal transitions are investigated by measuring the charge states of the scattered particles. The normal velocity and the work function of the metal substrate are the parameters shown to be most influential.

D.M. Newns (Imperial College, London) gave a theoretical treatment of resonance and Auger processes of charge transfer in ion-atom collisions with a surface. He introduced the concept of a freezing distance in which the probability of charge exchange outside the distance is greatly diminished. Slodzian (Universite Paris-Sud, Orsay) changed the discussion from events on clean, well-defined surfaces to the real, non-ideal surfaces encountered in analytical situations where bombardment conditions are dynamic, i.e., destructive, rather than static. From the enhancement of secondary ion yield due to coverage by oxygen and cesium, Slodzian proposed a bond-breaking mechanism to explain the observed effects.

D.M. Gruen (Argonne National Lab.) reviewed the properties of sputtered excited atoms and went on to describe experiments in which the velocites of metastable states are measured by a laser fluorescence scheme. Metastable states of Zr have velocities 0.5×10^6 cm s^{-1} and show approximately an E^{-2} energy distribution dependence. The Zr results are similar to those found for Ba metastables by M.L. Yu and for Fe atoms by H. Bay. To explain the discrepancy between the low energy metastables and the apparently high energy excited states found by Tsong and Kelly, Gruen presented preliminary computer calculations based on the TRIM code, which showed that the amount of electronic energy transfer, ΔE_e, is proportional to the kinetic energy of the final collision.

N. Anderson (H.C. Oersted Inst., Copenhagen) provided an alternative viewpoint of the collisional physics, where described events occur between ions and atoms in the gas phase and electron density plots of the collision partners provide a clue to the excitation mechanism.

The emphasis of the workshop then changed to the electron emission processes that occur during ion-solid collisions. K.O. Groenveld (Univ. of Frankfurt) reviewed ion-induced electron emission and discussed the mechanism of potential and kinetic ejections. J.A.D. Matthew (Univ. of York) discussed the differences between electron-excited and ion-excited Auger electrons. While the electron-excited Auger energy spectrum generally shows more band-like structure and the ion-excited spectrum exhibits more of an atom-like structure, the distinction is by no means clear-cut. Suggested future experiments such as coincidence measurements of Auger electrons and sputtered secondary ions will be useful to resolve the difference.

H.H. Anderson of the University of Copenhagen lectured on the effect of preferential sputtering of multi-component targets. The preferential sputtering phenomenon was broken down into several operating mechanisms, namely recoil implantation, cascade mixing, diffusion, surface forces (Gibbsian segregation), and radiation-induced segregation. As each of the above mechanisms was switched on, the variation of the sputter yield as a function of concentration was examined in some detail.

Electron-stimulated desorption (ESD) and photon-stimulated desorption (PSD) were reviewed by M.M. Traum (Bell Labs.) and M.L. Knotek (Sandia Labs.). The familiar Menzel, Gomer and Redhead (MGR) model involving Franck-Condon transitions and the Knotek-Feibelman model of core-hole generation were touched upon. Traum then described angle-resolved experiments designed to observe ESD and PSD of O^+, Cl^+, and F^+ from metal surfaces. The ESD and PSD formation of Na excited states from NaCl, Li from LiF, and K from KCl were also mentioned. The reason given for the lack of higher excited states was that the latter coincided with the unfilled conduction band of the solid, and electron tunneling processes essentially formed a non-radiative channel for the excitation. Knotek gave an account of experiments with ESD and PSD of condensed organic compounds on metal surfaces. An interesting observation was that the ESD H^+ yield from silicon monohydride was low due to the strong Si-H bonding and substitution with D had little effect. For silicon dihydride where the bond is weaker, however, H^+ yield was high and the isotope

effect was correspondingly large. In general, the higher the ESD yield on a given surface the larger the isotope effect.

R.D. Macfarlane (Texas A&M Univ.) gave an interesting talk on the sputtering or desorption of massive molecular ions. One of the intriguing features of the energy spectra of the heavy molecular ions (over two-hundred amu) was the Maxwell-Boltzmann behavior whether the bombarding ion was 200 meV Cf or 5 keV Xe. Neither collision cascade nor electronic stopping theory adequately explained the results.

The final invited talk was by H. Winter (Univ. of Munster), who reviewed the different types of anisotropic interactions of fast ions with either tilted carbon foil or solid surfaces at grazing incidence. From the polarization effects and the anisotropic population of sub-levels one can determine atomic hyperfine structure as well as nuclear spin polarization. From grazing incidence work under ultrahigh vacuum conditions, one can observe the influence of the band structure of the solids on the excited states of the reflected particles. The result is totally new and contrasts with previous work under poor vacuum where many emission lines were observed. The situation is somewhat analogous to experiments in sputtering in which results obtained under ultra-high vacuum and clean surface conditions differ strikingly from results obtained under poor vacuum and ill-defined surface conditions.

On the whole the workshop was highly successful, bringing together workers from far ranging fields with the common goal of studying the inelastic effects of particle-solid interactions. The host, Peter Sigmund (Odense Univ.), insured the smooth running of the workshop. A free interchange of ideas and discussion took place among the delegates. Invited talks and many short contributions were presented. The proceedings will be published as a special volume of the journal Physica Scripta. The next workshop in the series will be held at Arizona State University and the chairman will be Peter Williams.

T.S.T. Tsong

Arizona State University

STATISTICS

RELIABILITY WORK AT THE UNIVERSITY OF BRADFORD

Postgraduate work is offered in four broad areas at the Univ. of Bradford, Bradford, UK: Engineering, Life Sciences, Physical Sciences, and Social Sciences. The postgraduate courses and research tend to be interdisciplinary. For example, the MSc course in Polymer Science includes material taught by faculty from the engineering, computing, and textiles departments in addition to the chemistry department. Efforts are made to provide research and course work relevant to the needs of industry, and there is a significant amount of industrial sponsorship for research conducted at the university. It is common for scientists from industry to serve as visiting faculty members, teach seminars, and direct postgraduate research. An Industrial Liaison Office has been established at the university for the purpose of promoting and coordinating industrial involvement in its programs. The university has also established a company, Bradford University Research Limited, which conducts specific research and development projects, carries out feasibility studies, and promotes the use of university facilities, products (such as software and symposia), and patents. Symposia in a wide range of industry-related topics are conducted on the university campus.

One of the engineering postgraduate boards of studies is the Postgraduate School of Studies in Industrial Technology; Dr. A.Z. Keller is chairman of the group. Consistent with the general university effort to interact with industry and to promote inter-disciplinary research, Keller came to Bradford by way of the nuclear power industry; his PhD research was in nuclear physics. Keller and one of his colleagues, Dr. A.R. Kamath, are doing research on a variety of problems related to probabilistic risk assessment. In a recent visit to Bradford, Keller and Kamath told the author about some of their reliability modeling and assessment work. The efforts range from mathematical modeling of failure mechanisms to development of hardware for automatic entry of measurement data into a data base, development of software for use by reliability engineers, and statistical analyses of failure data from various electronic and mechanical systems. In what follows, I summarize a few specific projects being carried out by the Bradford team, beginning with an account of a reliability analysis software package called REGINA (for Reliability Estimation and Graphical Interactive Analysis).

To get an idea of how REGINA might be used, it is instructive to review an application reported by N. Farnworth (Leyland Trucks, UK) and M. Giblin (Univ. of Bradford). ("The Collection and Analysis of Failure Data to Assess the Reliability of Commercial Vehicles," a paper presented at the Safety and Reliability Society Southport Symposium, October 1982.) According to several market surveys commissioned by a group of European commercial vehicle manufacturers, product reliability is the single most important factor leading to customer satisfaction among commercial vehicle operators. The surveys indicate that operators regard reliability to be more important than price, parts availability, service back-up, and fuel consumption, in order of decreasing importance. It is therefore clear that manufacturers

(such as Leyland) must be concerned with the assessment of the reliability of their products and the development of manufacturing methods that meet set reliability goals. Farnworth and Giblin reported on an analysis of data from the market sector for heavyweight articulated (tractor-trailer) trucks. There are two major sources of failure data for such trucks. First, commercial vehicle manufacturers have access to failure data through their warranty claims systems. The system can provide detailed information on failures, but the resulting data have limitations. For example, the warranty system data cover only the manufacturers' own vehicles and relate only to "young" systems, because warranties usually cover only the first year or so of vehicle use. Thus manufacturers often turn to a second source of data, fleet operator's vehicle maintenance records and costing systems. Such data complement the warranty system data because they contain information about the reliability of vehicles made by competing companies on a "whole life" basis. Leyland has developed a computerized data base containing failure data from both sources. It can be accessed via computer terminals, and reliability analyses can be carried out for various market sectors, vehicle models, and types of usage for whole vehicles and major sub-systems. At Leyland, reliability targets are set for the whole vehicle and for major sub-systems. The maximum average number of failures per 100 vehicles is specified at three mileages which correspond to typical half-year (35,000 mi), one-year (70,000 mi), and two-year (140,000 mi) mileages in the UK for heavy trucks. The reliability targets are presented in the form of "Weibull graphs", which give straight line plots of per cent cumulative failure vs log miles. The Weibull distribution is often used in reliability models. It is characterized by its complementary cumulative probability distribution (or "remaining life distribution"). If T denotes the time to failure of the device or system being modeled (or miles to failure of a vehicle), then the probability that failure occurs sometime after time t is, in the Weibull model,

$$(1) \qquad R(t) = P(T > t) = \exp[-(\alpha t)^{\beta}],$$

where $\beta>0$ is the "shape" parameter and $1/\alpha>0$ is the scale parameter. It follows that log. log R(t) is linear in log t, and a coordinate system can be used to fit a line to the plotted observed cumulative percent failure data. This is what Keller and Kamath call the "Weibull Probability Plot". An example for engine life data is shown in Figure 1. At Leyland, the statistical estimation of parameters in the Weibull failure model, using failure data from the data base described above and generation of corresponding Weibull graphs, is carried out by the REGINA package developed by Keller and Kamath.

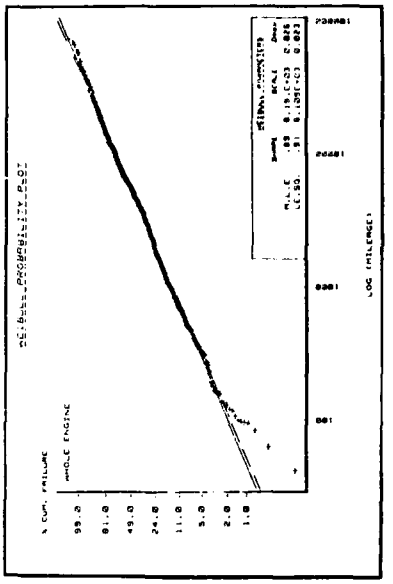

Fig. 1 Weibull plot of truck engine failures.

REGINA is a computer program designed to provide a complete self-contained tool for reliability and maintainability analysis. The package has been used in a wide range of applications by engineers and reliability technicians. The current version is programmed in BASIC and runs on a Hewlett Packard System 45 computer; however, there are plans to produce versions for other machines. The program is menu driven and features user-friendly data input and graphical output. The package contains parameter estimation procedures (maximum likelihood and least squares) for the following distributions: Weibull, exponential, normal, log normal, gamma, and extreme value for complete or censored samples. In addition it contains various statistical test routines for goodness of fit, serial correlation, and hypotheses about parameters. It includes an option for optimizing maintenance, overhaul, or replacement intervals, based on criteria of minimal operational cost per unit time or of maximal availability. The package has been documented and is being made available for purchase through the university company. Inquiries should be sent to Dr. A.R. Kamath, Postgraduate School of Studies in Industrial Technology, University of Bradford, Bradford BD5 7DP, UK.

Keller and Kamath have also been working on what they call "pathological models" for reliability of mechanical systems. Suppose, for example, that the strength of a component decreases with time such that the instantaneous strength $S_L(y) = S_0\phi(y)$, where ϕ is non-increasing and the initial strength is $S_L(0) = S_0$. Let $g(\sigma)$ be the probability density of the distribution of random loads on the component. The component fails at the first time Y, the

load, exceeds the strength, so the probability of failure before time y is

$$1-R^*(y)= \int_{S_0\phi(y)}^{\infty} g(\sigma)d\sigma$$

In particular, if loads are exponential and ϕ is of the form $y^{-\beta}$, then the remaining life distribution is of the form

$$(2) \qquad R^*(y) = 1 - \exp[-(\alpha/y)^{\beta}] = 1 - R(1/y),$$

where R is the Weibull remaining life distribution given in equation (1). It follows that if T is Weibull distributed, Y = 1/T has the distribution given by equation (2); Keller and Kamath therefore call (2) the remaining life distribution characterizing the "inverse Weibull" distribution.

The parameters $\alpha>0$ and $\beta>0$ of this inverse Weibull distribution are analogous to the scale and shape parameters of the Weibull family. The shapes of hazard rate functions $h(t)=-R^{*\prime}(t)/R^*(t)$ for the inverse Weibull can be quite varied. A few examples are shown in Figure 2.

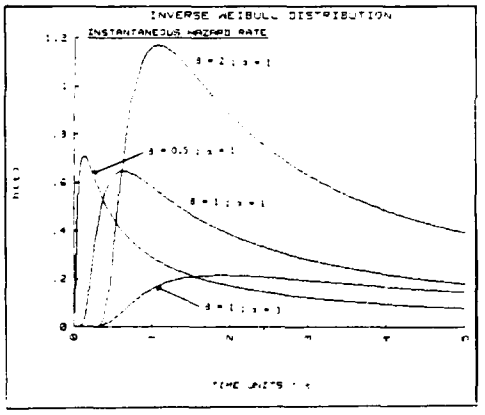

Fig. 2 Hazard rate characteristics of the Inverse Weibull

It is easy to show that $h(t)\to 0$ as $t\to\infty$, and that h increases rapidly to its maximum followed by a gradual decrease. The characteristics are similar to those of the lognormal distribution, so the inverse Weibull is a possible alternative in situations for which lognormal models are considered. The inverse Weibull distribution has no mean (or higher moments).

In a similar way, Keller and Kamath have used simple physical models of failure by corrosion to develop an "inverse exponential distribution" with density function of the form

$$f(t) = (\alpha/t^2)\exp(-\alpha/t) \; ; \; t>0.$$

The reciprocal of an exponential random variab will have this inverse exponential distributior so again the inverse exponential has no momen of order 1 or more. The Bradford researche are now undertaking parametic analyses failure data for various mechanical system using such "inverse" models, to see wheth they can provide better inferences a predictions than the models currently in co mon use.

D.R. Barr

ONR London

NEWS & NOTES

LATTICE DEFECTS -- NATURE'S BEAU SPOTS

Like the beauty spot on a woman's face in long-gone days, it is often the presence of microscopic imperfections in an otherwise perfect lattice that focusses our attention on the properties of ionic crystals. Thus, such diverse and interesting phenomena as electrical conductivity, ion diffusion, plasticity, irradiation coloration, luminescence, and the photographic process all involve the behavior of lattice vacancies, interstitials, impurity ions, and dislocations. The study of such imperfections has led to an ever-deepening understanding, not only of the defects themselves and the technologically important properties they impart, but also of the ionic crystals that provide the host matrix in which the defects act out their roles.

One feature of ionic crystals that makes the study of lattice defect phenomena especially interesting is that most atomic-scale defects effectively are electrically charged. Vacancies, for example, have an effective charge equal to the negative of the charge of the missing ion; dislocations and surfaces are charged because of the presence of ionic "kink" sites. As a result, lattice defects interact with other defects, with photoelectrons, and with the host crystal by means of coulombic, as well as elastic, forces. Thus new properties arise that are not seen, for example, in metallic crystals.

During the week of 30 August-3 September 1982 some 200 scientists assembled at Trinity College, Dublin, for the 4th Europhysical Topical Conference on Lattice Defects in Ionic Crystals. The organizing committee, led by Brian Henderson and John Corish, provided a meeting that was consistently interesting, informative, and pleasant - so much so, in fact, that the attendance at the final session was almost as great as at the beginning of the conference.

Most papers dealt with crystals of the simpler halides and oxides - the prototypical ionic substances. They are the substances that are better understood, are available in

reasonably controlled purities and perfection, and have yielded to theoretical analysis. Only a few papers ventured to the frontier of more complicated materials, but one can anticipate that this wilderness, too, will soon begin to experience a domestication.

Overwhelmingly the research reported at Dublin dealt with point defects, their aggregates, and their interactions with other lattice defects. Few papers dealt with dislocations and most of them focussed on the interactions of line defects with point defects. Two-dimensional imperfections - grain boundaries, crystallographic shear planes, and free surfaces - were also discussed by several authors. The sophistication of modern techniques, both experimental and theoretical, was clearly evident, and the quality and intimacy of the detailed, microscopic knowledge that is emerging from the work is impressive. High-resolution laser techniques, near-picosecond and time-resolved spectroscopy, multiple-resonance spectroscopies, high-resolution microscopies, and modern neutron scattering experiments, for example, make investigations possible that could not have been dreamed of 10 or 15 years ago. And computer simulations, such as the HADES code for point defects, have clearly attained a high level of reliability. One now has confidence not only in their rationalizations of known processes but also in their predictions of new mechanisms and structures.

Many of the papers presented at the Dublin conference, especially those dealing with ionic defects (in contrast to color centers), are summarized in a forthcoming ONR-London Conference Report. The complete proceedings are to be published as a special issue of the journal Radiation Effects.

L. Slifkin

University of North Carolina

FIRST ANNUAL MEETING OF THE BRITISH CRYSTALLOGRAPHIC ASSOCIATION (BCA) 28-31 MARCH 1983, AT ROYAL HOLLOWAY COLLEGE

The inaugural meeting of the BCA was held in April 1982, at the University of Durham. The founders were the crystallography groups of the Royal Society of Chemistry (RSC) and the Institute of Physics (IOP). The new organizational chart proposed for the constituent BCA groups is shown in Figure 1, which resembles a model of a two-dimensional structure. Hopefully, the real BCA structure will be a stable one for the particular benefit of crystallographers who are involved with the study of diffraction effects in the allied fields of biology, chemistry, metallurgy, mineralogy, and physics.

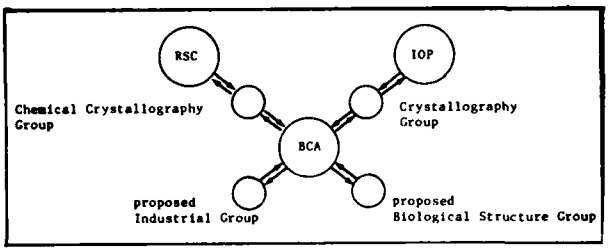

Fig. 1

The BCA is an independent scientific society, governed by the statutes and by-laws adopted in Durham on 6 April 1982. Its council has the following composition:

President	Professor Sir David Phillips FRS
Vice-President	Professor Dorothy C. Hodgkin OM FRS
Secretary	Dr. A.C. Skapski
Treasurer	Professor C.A. Taylor
Ordinary members	Mr. J.W. Harding
	Dr. Olga Kennard
	Professor J. Zussman
Group representatives	Dr. R.H. Fenn (Crystallography Group)
	Dr. R.W.H. Small (Chemical Crystallography Group)
Co-opted members	Dr. B.J. Isherwood
	Dr. A.M. Moore (Editor, Crystallography News)
	Dr. S.C. Wallwork
	Professor A.J.C. Wilson FRS
ex-officio	Professor D.M. Blow FRS (BNCC Chairman)

The BCA has taken over the functions of the United Kingdom Crystallographic Council (UKCC), which dissolved itself in May 1982 in favor of the new organization, and already is the second largest crystallographic association in the world. For further information, contact the Secretary, Dr. A.C. Skapski, Department of Chemistry, Imperial College, SW7 2AY, UK.

Dr. A. Moreton Moore (Department of Physics, Royal Holloway College, Egham, Surrey, TW20 OEX) is editor of BCA Crystallography News. Figure 1 is reprinted from issue 1, June 1982. At the forthcoming meeting planned for the Royal Holloway College, the Industrial Group (IG) and Biological Structure Group (BSG) are to be constituted formally and joined to the organization as shown. That 50 of the 175 delegates at the Durham meeting came from industrial and applied research institutions should insure the establishment of

the IG unit. Because there has never been a scientific society in the UK catering fully to the crystallography of biological molecules, the establishment of the BSG will be a definite step forward for UK crystallographers. In coordination with the planned BCA meeting, Crystallography News has announced that on 25 November 1982 an IOP-sponsored meeting on "Applications of Microprocessors in Crystallography" will be held at the Geological Society, Burlington House, London.

R.W. Armstrong

ONR London

POLYMER RESEARCH FUNDING IN THE UK

The latest issue of the SERC (Science and Engineering Research Council) Bulletin contained two items of interest to polymer scientists and engineers. The Engineering Board has added about £1,000,000 to their Specially Promoted Programs budget for research into polymers with unusual optical and electrical properties. Their applications would be for new kinds of photoelectric, microelectronic, and reprographic devices. Needs have been identified for materials for thin-film microbatteries, new resist coatings for electron and x-ray beam lithography, and photorefractive systems for holographic information storage. In addition, image intensifiers, devices characterized by anisotropic conductance, molecular size devices, and very thin film conductance and switching devices will be studied. Close cooperation between university and industry and a multidisciplinary approach are to be emphasized.

The Polymer Engineering Directorate will change its direction away from wider funding towards more selected, ambitious, and innovative topics. Some areas of future interest are in integrated and relative polymer processing, design, nondestructive testing, and novel composites. Close collaboration with industrial laboratories will be emphasized.

T.J. Reinhart, Jr.

ONR London

FRENCH MATHEMATICIAN AMONG FIELD MEDAL WINNERS

There is no Nobel Prize for mathematics. The story goes that because his wife was the close friend of a Swedish mathematician, Nobel was resentful of the mathematical community and left mathematics out of his award specifications. Perhaps the closest to a "Nobel for Mathematics" is the Fields Medal, which was originated by the Canadian mathematician J.C. Fields in 1936. Every four years at an international congress of mathematics, medal candidates are officially selected. Nominees must be less than 40 years old. This year the congress was scheduled to be held in Warsaw but, because of the situation in Poland, has been postponed until 1983. The 1982 prize winners have been announced as Alain Connes (France), William Thurston (US), and Shing Tung-Yau (US).

Continuing its long traditon of excellence in mathematics, France has had winners in at least half of the 10 Fields Medal awards. Alain Connes's work is in the algebra of operators. Some physicists believe that his work may serve as a basis for a general field theory. Since 1979, Connes has been at l'Institut des Hautes Etudes Scientifiques. The institute is in Bures-sur-Yvette, near Paris, and was established in 1958 as a center for mathematics and theoretical physics. The institute has several permanent professors including two Fields medalists (René Thom and Pierre Diligne of Belgium) on the staff. The Institute director is Jacques Tits, who is also professor at the Collège de France.

J.A. Reed, Jr.

ONR London

Lanchester Theory Study Group

A group of about 40 researchers from various academic institutions and industries in southern England meet quarterly in the London area to discuss combat modeling. They call themselves the "Lanchester Theory Study Group", in honor of F.W. Lanchester, who in 1916 published an account of the use of systems of differential equations to model aircraft battles. A simple example of a Lanchester model of combat is the so-called linear law. Suppose two forces, say Red and Blue, start a battle with R_o and B_o units, respectively. They exchange fire in a one-on-one fashion, and the time rate of change of the forces is approximately represented by the system of equations

$$\frac{dR}{dt} = -\frac{E}{1+E}; \quad \frac{dB}{dt} = -\frac{1}{1+E}$$

The constant E relates to the relative effectiveness of fire on each side, $\frac{dR}{dB} = E$. The solution for the system is linear in t,

$$R(t) = R_o - \frac{E}{1+E}t \quad ; \quad B(t) = B_o - \frac{1}{1+E}t,$$

hence the name linear law. Similar models have been and are being studied; for example, in

1954 J. Engel reported that a solution to the system

$$R'(t) = - p(t) - k_1 B(t); \quad B'(t) = -k_2 R(t)$$

fits actual combat data for the battle of Iwo Jima to a surprising accuracy.

At a recent meeting of the Lanchester Theory Study Group, Mr. Bert Hynd spoke on "The Wartime Work by C. Cunningham". Cunningham developed a sequential device

difference operator, $[\frac{\Delta}{(a)}]^n$, to obtain numerical

solutions of Lanchester models. Apparently one advantage of his approach is that it avoids computations with very large numbers which often appear. Cunningham obtained results that relate the time rate of change in forces to concentration of firepower and vulnerability of the forces. The results give measure of the "maximal" superiority of one side over the other. Following Hynd's presentation, a vigorous discussion took place to relate Cunningham's work to recent Lanchester results.

The Lanchester Theory Study Group is currently preparing a volume containing a collection of about 30 landmark papers in Lanchester Theory. The group has developed a bibliography with nearly 500 entries. The secretary for the group is Dr. Fergus Daly, Faculty of Mathematics, The Open University, Welton Hall, Milton Keynes, MK7 6AA, UK.

D.A. Hay

ONR London

SCORING COUNTRIES FOR ROAD SAFETY

Turkey has one of the worst records in the world for road safety, and Norway and Sweden have among the best. The conclusion comes from a 22-nation survey by the Federation Internationale de l'Automobile in Paris. On the basis of the number of deaths per 100,000 vehicles in 1980, Turkey had 729 whereas Norway and Sweden registered only 29. Comparable figures are 40 for Britain and 42 for Austria, with Portugal, Yugoslavia, and Greece coming in at 232, 201, and 159, respectively.

When the safety index was taken as numbers of persons killed in road accidents as a fraction of the population, Norway was still the winner, and Portugal had the worst score. On that basis, North America was in the middle range with a rating about like France or Belgium. Among all the countries and the several indexes studied, road safety seems to have improved slightly in recent years. As in the comparison of safety records for airlines or other transportation modes there is no univocal "best" scoring method. Some feature can always be cited as unique about a given country's laws or driving conditions. Even more controversial is the effectiveness of strategies for reducing road casualties. Perhaps the Scandinavian road safety figures are about the best that can be expected under present conditions; the sanctions there against drinking drivers are severe, the population is relatively homogenous, educated, and cooperative, and the technical aspects of road engineering and driver displays are carried out well.

N.A. Bond, Jr.

ONR London

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.

OHOLO Biological Conference on Mechanisms of Viral Pathogenesis (From Gene to Pathogen), Zichron Ya'acov, Israel, 20-23 March 83.

Meeting on Synthetic Low Dimensional Conductors and Superconductors, Les Arcs, Bourg St. Maurice, France, 11-18 December 1982.

7th International Conference on Infrared and Millimeter Waves, Univ. of St. Jerome, Marseille, France, 14-18 February 1983.

Conference on Magnetic Resonance Spectroscopy of Liquid Crystals and Biological Membranes, Leeds, UK, 18-20 April 1983.

International Conference on Insulating Films on Semiconductors, INFOS 83, Eindhoven, The Netherlands, 11-13 April 1983.

8th European Symposium on Fluorine Chemistry (ESFC-8), Jerusalem, Israel, 21-26 August 1983.

European Specialist Workshop on Active Microwave Semiconductor Devices, Maidenhead, UK, 4-6 May 1983.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Navy Lab./Org. to be Visited
Prof. J. Latham	Dept. of Pure & Applied Physics, UMIST, Manchester, UK	NPGS, Monterey (29 Nov-3 Dec 1982) NEPRF, Monterey (29 Nov-3 Dec 1982)
Dr. A.J. Lawrance	Dept. of Statistics Univ. of Birmingham, UK	NPGS, Monterey (11-20 Nov 1982,
Dr. R.F.C. Mantoura	Inst. for Marine Environmental Research Plymouth, UK	NOSC, San Diego (6-7 Feb 1983) Univ. of Rhode Island (11 Feb 1983) Woods Hole Oceanographic Institution (9/10 Feb 1983)
Dr. G. Ottaviani	Physics Institute Modena, Italy	NRL (15 November 1982)
LCDR L. Schrier	Head of the Diving Medical Center Royal Netherlands Navy Den Helder, The Netherlands	Naval Diving & Salvage Training Center, Panama City, Florida Naval Experimental Diving Unit, Panama City, Florida Naval Medical Resarch Institute Bethesda, MD National Naval Medical Center Bethesda, MD Naval Base, San Diego, CA (November,December 1982)
Prof. R. Stickler	Institut für Physikalische Chemie-Werkstoffwissenschaft Univ. of Vienna Austria	NRL (29 Nov 1982) NSRDC Annapolis (30 Nov 1982)

ONRL REPORTS

C-1-82 NATO AGARD Conference on "Propagation Effects on ECM-Resistant Systems in Communication and Navigation," by J.M. Goodman

The 30th symposium of the Electromagnetic Wave Propagation Panel of NATO/AGARD was held from 24 to 28 May 1982 in Copenhagen, Denmark. A discussion of the proceedings is contained herein along with appropriate clarifications and personal reflections. The conference dealt with various issues related to the ECM-resistant systems in communications and navigation with special emphasis upon propagation influences. Contributed and review papers covered propagation effects and limitations, system adaptation, and the interaction of specified systems with the environment. The report also describes a concluding round table discussion in general terms.


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