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Science

Notes

Behavioral Sciences 467

Biological Sciences 474

Computer Sciences 483

Material Sciences 494

Mechanics 501

Ocean Sciences 512

Physics 517

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European Science Notes

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September 1987
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Behavioral Sciences

Aggression the Focus of a Recent Conference in Spain William D. Crano 467

Review of
Selected papers presented at the *Fourth* European Conference of the International Society for Research on Aggression, held in April 1987, are reviewed. The topics include playful aggression, glucose and frustration, and aggression and the family; attitudes toward aggression and war; aggression and somatic risk factors; and maternal aggression in rat and men.

Biological Sciences

presentations
Biotechnology Conference Protein Engineering '87, University of Oxford, UK Claire E. Zomzely-Neurath 474

Selected presentations at this major international conference held at the University of Oxford, UK, in April 1987 are reviewed. The topics include theoretical aspects of protein structure, protein structure and dynamics, protein engineering methods, protein engineering stability, protein engineering binding and catalysis, and protein engineering medical and industrial applications.

Second Messengers Signalling Future Areas for Drug Research Claire E. Zomzely-Neurath 479

The conference on second messengers was a 1-day meeting sponsored by the UK's Society of Chemical Industry. Presentations in the various topics are summarized. The topics were: principles of cellular signaling using second messengers, metabolism and function of inositol phosphates, role of C proteins in signal transduction, protein-tyrosine kinases: their role in the control of cell growth, cyclic nucleotides and protein kinases, protein kinase C, and function of the RAS oncogene.

Computer Sciences

Further Developments in Image Processing at University College, London J.F. Blackburn 483

The new cellular logic image processing system, CLIP7, is able to work with less than the full image in the processing of a large image. Other advantages over the previous system include local autonomy of the chip, the ability to easily rotate local conductivity masks, and the flexibility of addressing modes of the local memory.

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- Audible Speech Recognizer--A British
Technology Group Project ; J.F. Blackburn 486

Development is proceeding on a low-cost, high-performance recognition module that must be speaker trained, accommodate a 64-word vocabulary, recognize continuous speech, have high recognition accuracy, and be able to transfer vocabularies rapidly, through an 8-bit bus. Status of the project is reviewed.

- 25th IEEE Conference on Decision
and Control ; Daniel J. Collins 488

Presentations given at this conference, held in December 1986 in Athens, Greece, are reviewed. Topics include robustness and H^∞ methods, applications, the mathematical aspects, nonlinear controls, robotics, and modeling. The conference clearly reflected the state of the art in control and decision theory.

- Artificial Intelligence at Lisbon's
Universidade Nova ; Paul Roman 492

Activities in the Logic-Programming and Artificial Intelligence group and at the Robotics group of the Information Science Department at the Universidade Nova, near Lisbon, Portugal are reviewed. The high quality and quiet approach of the scientists is pointed out.

Material Sciences

- An Exciting Meeting of the
Dielectrics Society Meeting; Robert W. Vest 494

The theme of this year's meeting, held in Cambridge, UK, in April 1987, was dielectric behavior in ordered systems with special reference to ferroelectric and related phenomena. Presentations on relaxor ferroelectrics, other inorganic ferroelectrics, and ferroelectric polymers are reviewed.

- Research on Thick Film Hybrids in Italy (Telettra,
Marelli, and the University of Modena); Robert W. Vest 496

The research on thick film hybrids at two of Italy's industrial laboratories--Telettra Telecomunicazioni and Marelli Autronica--and the University of Modena is reviewed. Cooperation between the universities, with the fundamental research, and the industrial laboratories, with their applied R&D, has helped Italy to be among the world's leaders in the hybrid industry.

Mechanics

- Aerodynamics and Hydrodynamics
Research in Rome ; Eugene F. Brown 501

Aerodynamic and hydrodynamic research at the University of Rome's Department of Mechanics and Aeronautics and at the National Institute for Naval Architecture is discussed, and comment is made on the resources which are available. Attention is drawn to the impact on fluid mechanics research activities of the lack of an Italian Ph.D. program.

Italian Contributions to the
Lambda Formulation, Eugene F. Brown 504

The lambda computational method is an important CFD tool at Italy's University of Bari and the Politecnico Institute of Turin. Research groups at both institutions have made important contributions which have extended the application and improved the accuracy of this method.

Fluid Mechanics Section, Imperial
College, London, S.N.B. Murthy and Eugene F. Brown 508

The interests of the Fluid Mechanics Section at Imperial College is in applied fluid dynamics of internal flows, including flows with heat transfer, combustion, and multiphase content, and in basic research topics arising in the context of applied problems. These activities are reviewed, and the authors observe that the section is very active in research on low-speed, high Reynolds number internal flows with heat transfer and combustion.

Unsteady Flows and Turbulence *at Institut de Mecanique de Lillo,*
at IMFL Daniel J. Collins 510

Selected activities of this institute are reviewed. The author focuses on the aerodynamics group, the industrial fluid mechanics group, and the mechanics of flight group. He concludes that the institute is a small but very competent organization that is doing some excellent research.

Ocean Sciences

An Informal Meeting of British
Ocean Modelers, Jerome Williams 512

Papers presented at this meeting, held in April 1987 at Oxford University, covered several research topics: altimeter data assimilation, diffusion models, waves and mixing, ice models, and El Nino models. Selected papers are reviewed.

Tidal Measurements and Instrumentation--A Seminar
by the UK's Hydrographic Society, Jerome Williams 515

A meeting addressing present tide measuring technology is described. The speakers discussed many aspects of tide measurements, including types of devices used, navigational systems, data storage and analysis, and system accuracy. Present systems were also compared with systems in use 11 years ago when the last similar conference was held.

Physics

Laser Research at the German Aerospace
Research Establishment Laboratories in Stuttgart, Paul Roman 517

The DFVLR center at Stuttgart is heavily involved in laser development, for both military and industrial applications. High-energy gas lasers, novel laser systems (including new CO lasers), RF-excited compact gas lasers, new excimer lasers, recombination XUV lasers, and planned research in tunable, sapphire-based solid-state lasers are highlighted in this review.

Handwritten notes:
2/20/87
517
1/1/87

News and Notes

NATO Advanced Research Workshop on Social and Environmental Psychology	William D. Crano	519
Applied Artificial Intelligence: An International Journal	William D. Crano	520
New Spanish Journal of Social Psychology	William D. Crano	520
Basic Research in Artificial Intelligence at Berlin's Technical University	Paul Roman	520
The Launching of BRAIN in Europe	Paul Roman	522
Fluid Mechanics--An Evolutionary Approach	Eugene F. Brown	522
Computational Fluid Dynamics at the Politechnic Institute of Milan	Eugene F. Brown	525
Workshop to Reconcile Research Differences on Radar Imagery of Ocean Surface Features	Gaspar R. Valenzuela	526
New Journal on Electromagnetic Waves and Applications	David K. Cheng	528
Siemens Ready to Supply High-Power Semiconductor Laser Arrays	Paul Roman	528
A New Center for Electronics Materials Research in England	Paul Roman	528
European Geophysical Society--XII General Assembly	John Simpson	529
ONRL Cosponsored Conferences		530
ONRL Reports		530
Behavioral Sciences		
Biological Sciences		
Computer Sciences		
Material Sciences		
Mechanics		
Multidiscipline		
Overseas Travelers		532
Chemistry		
Electronic Engineering		
Oceanography		
Physics		
Space Science		
Reports on European Science and Technology From Other Commands		533
Aeronautics		
Applied Electronics		
Chemistry		
Life and Behavioral Sciences		
Material Sciences		
Physics		
Technology Roundup--Italy		536
Embassy Notes from West Germany		537
Science Newsbriefs		537
Military Applications Summary Bulletins		538

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Behavioral Sciences

AGGRESSION THE FOCUS OF A RECENT CONFERENCE IN SPAIN

by William Crano. Dr. Crano is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from Texas A&M University, where he is a Professor of Psychology.

The Fourth European Conference of the International Society for Research on Aggression was held at the La Rabida Conference Center, Huelva, Spain, from 20 through 24 April 1987. Organized by the Department of Psychobiology of the University of Seville, this conference drew participants from all of the nations of Western Europe, the Scandinavian countries, some of the Eastern Block nations, the Middle East, Canada, and the US. The range of issues addressed in the conference complemented the geographical diversity of its participants. Studies ranging from the influence of inhibitory neurotransmitters, Gaba and Serotonin, on aggression in cats to the social, attitudinal, and personological factors that predispose people to perform acts of terrorism were discussed.

Based on past experience, we might expect that the diversity of substantive specializations in evidence would mitigate against a successful conference. Clinical psychologists usually do not have much to say to psychobiologists, etho-behaviorists often do not behave well in the company of pure laboratory researchers, and communication specialists do not communicate well with pharmacologists and neurophysiologists. This is not necessarily to suggest a lack of respect of one camp for the work of the other, but rather to acknowledge that the assumptions, research techniques, and basic questions of the various groups do not always intersect in obvious ways. The consequent lack of contact often attenuates the quality of interaction.

Contrary to past experience, however, this conference worked--it worked because researchers from all of the various specializations were willing to suspend, at least momentarily, their own particular view of what is and what is not right and important, and to enter into a scientific dialogue with those from fields far removed from their own. The common thread that linked the entire

discourse was the quest for a more precise understanding of the phenomenon of aggression, in all its varied forms. If nothing else, the participants at this conference learned to appreciate, perhaps even value, the research efforts of scientists from subdisciplines very different from their own.

The richness of this conference would be difficult to distill in a short presentation, and this is not my intention. Two published works are planned to issue from this meeting, and in combination these will provide a good overview of the work discussed at La Rabida. The first of these documents is already available in the form of a short book of abstracts, edited by J. Martin Ramirez of the University of Seville's Department of Psychobiology (cf. Ramirez, 1987). The second publication will appear in a special issue of the *International Journal of Neuroscience*. This publication will contain selected (neuroscience) papers from the conference, and may be ordered from Gordon and Breach Science Publishers, Marketing Department, PO Box 786 Cooper Station, New York, New York 10276. (The cost of the proceedings is \$15.) In addition to the published reports, I also reproduce an abbreviated version of the scientific program (Table 1, overleaf). For the remainder of this brief article, I will discuss some of the papers that (1) struck me as particularly interesting, and (2) that I was able to attend. This latter criterion was sometimes a difficult one, in that it often necessitated a painful choice between equally appealing alternatives.

Plenary Sessions: Some Representative Presentations

Two of the most impressive presentations were given by researchers from very divergent ends of the substantive spectrum of aggression. At the physiological border was the work of Paul Mandel (Centre Neurochimie CNRS, Strasbourg, France), a member of the French National Academy, who summarized more than a decade's work on the neurochemistry of inhibitory neurotransmission in aggressive behavior in rats. Mandel's talk, in addition to providing considerable information on the topic, was a demonstration of the way that scientific knowledge accumulates. In his presentation, Mandel traced the development of his work with rats, with particular emphasis on the role of Gaba, a neuroinhibitor. Carefully grounding his hypotheses on the basis of his prior findings, Mandel, through selective breeding created animals who either were very aggressive or very nonaggressive. He then determined the effects of a number of environmental

Table 1
Abbreviated Listing of Speakers
and Topics

I. Plenary Sessions: Speakers and Topics

- J.M. Delgado. Social Hierarchy and Brain Cycles
K. Arooma. Victimization of Inhibitory Neurotransmission in Aggressive Behavior
P. Mandel. Involvement of Inhibitory Neurotransmission in Aggressive Behavior
L. Eron. The Role of Family and Culture as Mediators in the Relations Between TV Violence and Aggressive Behavior

II. Symposia: Chairpersons and Brief Descriptions

- R. Queraltó. Aggression and Peace Research: General Issues
L. Pulkkinen. Aggression in Children
J. Groebel. The Origins and Conditions of Terrorism
R. Blanchard. Ethological Techniques in Aggression Research
A. Franczek. Attitudes Toward Aggression
E. Fonberg. Dominance, Aggression, and Predation
K.A. Miczek. Ethopharmacological Analysis in Aggression
S. Parmigiani. Maternal Aggression
K. Bjorkquist. Aggression in Adolescents and Adults
M. Linnoila. Clinical Aspects of Aggressive Behavior
R. Wahlstrom. Cross-cultural Studies of the Image of the Enemy

stressors on their behavior, and on Gaba and Serotonin production. It is impossible to detail Mandel's very packed presentation, but it is likely that his work will feature prominently in the special issue of the *International Journal of Neuroscience*, noted above.

At the other end of the aggression's substantive scientific spectrum was the work of Leonard Eron (University of Illinois-Chicago), president of the International Society for Research on Aggression. Eron, too, took an historical perspective in discussing his work on the effects of the mass media, particularly television, on aggression in children (and later in adults, after these same children had grown). In an impressive longitudinal investigation, Eron followed his subjects over a span of 22 years. He found a relation between peer ratings of children's aggressiveness at age 8 and the mean number of criminal convictions of these same individuals 22 years later. In addition, boys' preferences for violent television programs (at 8 years) was related to the seriousness of criminal convictions at age 30.

Of course, the absolute frequency of criminal activity and subsequent conviction was not great. As such, correlating either of these two variables with earlier television preferences is bound to result in an attenuated correlation coefficient. Restricting the range of variability of one or both variables when calculating a correlation coefficient will always have this effect. Even if this

were not the case, however, and the correlation between childhood TV preferences and later criminal activity were very strong, the causal interpretation of this relationship would have to be approached with extreme caution. This is so because it is conceivable that both preference for TV violence (in childhood) and adult criminality are coeffects of a more general, perhaps genetically determined, predisposition toward aggressivity. Be that as it may, the pictures of the preference-aggression relationships are extremely intriguing, as shown in Figures 1 and 2, which have been drawn from results reported by Huesmann (1986), a co-worker of Eron's. More complete details of this general line of research is available in a recent issue of the *Journal of Social Issues*, Volume 42, No. 3 (1986), edited by L.R. Huesmann and N.M. Malamuth.

Selected Symposia

Playful Aggression. Some fascinating research on aggression in children was discussed in a session led by Lea Pulkkinen (University of Jyväskylä, Finland). In a naturalistic observational study, G. Haug-Schnabel (University of Freiburg, West Germany) observed three-person groups of kindergarten children engage in "playful" aggression. Playful aggression is a form of role playing, in which the actors assume various aggressive roles, but only to participate in and to enjoy the game. This type of "aggression" does not have as its object the hurting of another; rather, as described, it is a special type of interactive social behavior. Children playing "cowboys and indians" or, more recently, the "A-team" or "Rambo," provide good examples of such behavior.

The research disclosed that playful aggression maintained a daily rhythm, or pattern, in the school, with the most intense behaviors occurring typically between 45-75 minutes after arrival at the school, or after lunch break. The aggression appeared to serve many functional purposes. For example, if the aggressive session was brought to a successful conclusion (i.e., the "bad guys" were all put in jail, or worse), the group typically stayed together, and began new activities as a group--the playful aggression, that is, served to strengthen group bonds. This result brings to mind Sherif's classic "robbers' cave" experiment (Sherif et al., 1954; Sherif, Sherif, and Nebergall, 1965). At times, the playful aggression was used to offset the initiation of real aggression; through playful aggression, a child could turn another's hostility into a game into

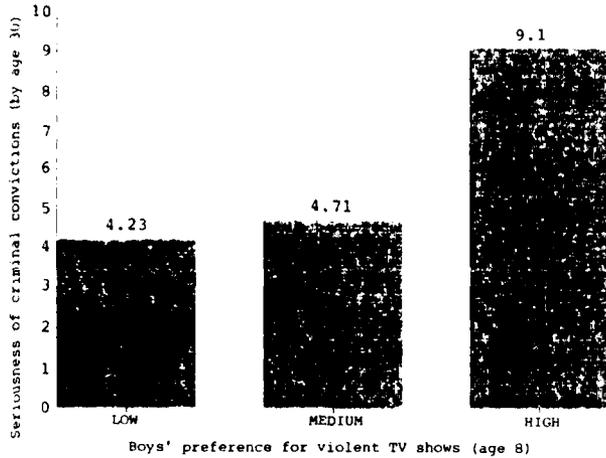


Figure 1. Relation between aggression in school (peer ratings) and criminal behavior 22 years later (adapted from Huesmann, 1986).

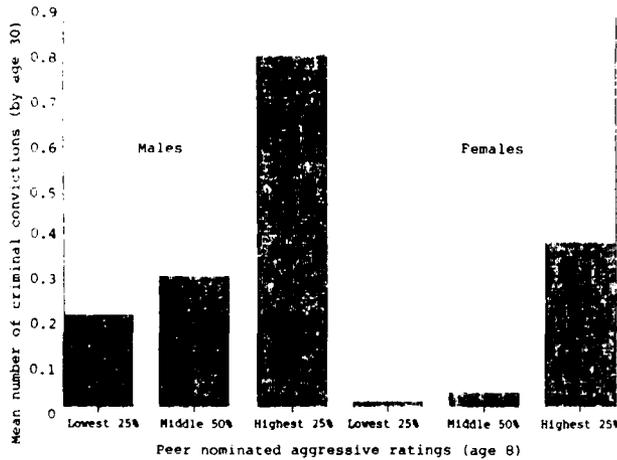


Figure 2. Relation between boys' preferences for violent TV shows (age 8) and the seriousness of criminal convictions at age 30 (adapted from Huesmann, 1986).

which they both could enter, and both enjoy. Factors such as age of children, group size, and adult interference all have implications for the initiation and outcome of playful aggression.

The very interesting implication of this research is that the occurrence of aggressive play should not necessarily be viewed negatively by the controlling adult. As Haug-Schnable has shown in this careful study, role-played aggression can serve a number of group facilitating functions, and its disruption by well-intentioned parents or teachers may at times do more harm than good.

Of course, it remains to be seen if the findings reported in this presentation will generalize to other situations, other samples, and other cultures. On some of the measures this level of generalization seems unlikely. The rhythmic pattern or timing of the playful aggression, for example, would appear to be situation specific, depending upon the patterns of rest and instruction developed by the particular classroom teacher. However, based on experience, that all children play aggressive games seems a good bet, and Haug-Schnable's hypotheses regarding the functional aspect of these games seems reasonable and certainly worthy of further examination.

Glucose and Frustration. In this same session was a discussion of the role of sugar on children's reactions to frustration (typically, aggression). David Benton (University College of Swansea, UK) began with three broadly accepted truisms in this area of research: that too much glucose for children can cause (1) aggression, (2) reactive hypoglycemia, and (3) obesity. He then effectively demolished the scientific basis for the first two of these propositions, while granting that too much sugar can, indeed, make one fat.

The mechanisms thought to control the functional relationship between sugar and aggression are allergic reaction, swings in blood glucose level, or susceptibility to heavy metals, brought about by the sugar refinement process, which removes trace elements and thereby increases the user's susceptibility. The literature on which these hypotheses are based is amazingly thin. Indeed, much of the work relating diet and aggression (or crime) is based on one-shot case studies that rigorous social science has rejected since before the time of Campbell and Stanley's classic discussion of research methodology, nearly a quarter-century ago (Campbell & Stanley, 1963).

Studies of hyperactivity suffer from similar methodological problems. Many of the findings relating sugar intake to hyperactivity are based either on uncontrolled case studies, with no experimental manipulation, or on correlational methodologies, where the cause-effect relationship is almost always in doubt. Those studies that have used appropriate experimental methodologies, with random assignment to experimental and control groups, placebo control conditions, etc., have shown huge placebo effects, but very little evidence for a relationship between hyperactivity and sugar intake. Indeed, Benton's own meta-analysis of this literature suggests either that sugar has nothing to do with hyperactivity, or that it actually *decreases* activity, which is

directly contrary to the sugar-causes-hyperactivity truism that many of us have accepted over the years.

Benton's research on the role of sugar in reactive hypoglycemia is equally nonsupportive of the typical truism, but it has produced some fascinating results in its own right. In this research, children were given either a glucose drink or an artificially sweetened placebo at the afternoon break in their schools. Experimental tests of reaction time showed that the glucose group was faster (i.e., had shorter reaction latencies) than the controls. Using a video game that was devised in such a way that it could not be beaten (a frustrating task for most children) revealed that the glucose-treated children concentrated harder, were less fidgety, showed fewer signs of frustration, and talked less with their peers. These results appear quite contrary to the usual expectations. However, when the test was delayed for a few hours after sugar ingestion, the entire pattern of results was reversed.

These results suggest that it is not the absolute amount of ingested sugar that matters, but rather the variation in the blood glucose level, from very high levels to normal, or perhaps below-normal levels, that make for behavioral difficulties. For example, it is possible that most of the sample started with relatively low levels of blood sugar. The treated group would have experienced a rapid boost in the level after ingesting the sugar-laced drink, while the placebo group would be maintained at their low level.

However, the effect of the experimental treatment would have been short term. Immediate testing would have revealed positive effects of the enhanced glucose level (from below normal to normal, or above normal levels). Two hours later, however, the blood sugar level would have returned, more or less, to where it had been. It is possible that the rapid swing from low to high and then back to low blood glucose level was responsible for the reversal of the initial results that Benton reported. This explanation could have been tested very precisely if measures of blood glucose had been included in the research. However, given the nature of the research setting, the age of the subjects, etc., this was not feasible. As such, an explanation of hyperactivity based on variations in blood glucose must remain tentative. This is especially to be stressed since the absolute magnitude of Benton's results was far from overwhelming and, as Benton himself observed, his findings could not bear the weight of a theory of childhood hyperactivity or aggres-

sivity based on variations in blood sugar alone.

Aggression and the Family. The final study from this session to be discussed was presented by the panel's coordinator, Lea Pulkkinen. This research clearly demonstrates the contribution that the social sciences can make to understanding crucial aspects of human behavior, if the research is undertaken with sufficient care, rigor, and doggedness. In this study, 369 8-year old Finnish children were studied in a longitudinal investigation carried over nearly 20 years. At the first phase of the study, the children completed various personal and socio-behavioral inventories, and were rated by peers and parents. Factor analysis of this mass of data revealed that two orthogonal bipolar factors accounted for 70 percent of the variance of the children's social behavior. The first factor was defined by aggression and disobedience at one pole, and by submissiveness, kindness, and reflectiveness at the other. The second factor was characterized by variations in anxiety. One end of this factor was anchored by such traits as fearfulness and anxiety, the other by cooperativeness and helpfulness. Living examples of the possibilities formed by the combinations of these two dimensions were readily in evidence in Pulkkinen's sample.

Six years after the initial canvas, 96 percent of the original population was reconstituted and retested. The stability of the earlier descriptions of children's social behavior was remarkable. In addition, there was a strong relationship between the various categories developed on the basis of the survey of children at 8 years of age and their adjustment to school. Those who were defined as extreme on either the aggression or the anxiety dimensions were much more likely to misbehave at school, to have greater rates of truancy, and to have begun drinking. Children who scored high on *both* aggression and anxiety dimensions at 8 years of age were much more likely to have criminal records for drunkenness, drunk driving, and violent offenses at 26 years of age than were any of the other children.

Semistructured interviews of these children at age 16 had revealed that their lives differed markedly from those of the other children in the sample. Their living arrangements were less stable, characterized by working mothers and frequently changing day-care arrangements, many moves, and an authoritarian family atmosphere, with a heavy emphasis on corporal punishment. If the recipe for producing a juvenile delinquent seems clear on the basis of Pulkkinen's

research--create an unstable, authoritarian, physically punishing atmosphere, with frequent changes in living arrangements--then the recipe for producing a productive, well-adjusted individual also is clear.

The value of this research is not only that it tells us much about the factors that matter in the socialization of children into the society, but also that it serves as a model of what research on issues of this type can produce. Its implications for future social interventions are clear. If we can identify children as young as 8 years of age as being at risk then it behooves us to try to alleviate such a risk. Certainly this would be so if the susceptibility involved a possible fatal disease. Who is to say that a future of drunkenness, violence, and jail terms is any less damaging than future physical debilitation?

Pulkkinen's research also produced another important "instructional" element, which is especially relevant to those responsible for the support of research. It is not news that social research is expensive--and longitudinal social research is even more expensive. Publicly funded research-support organizations in the US often appear reluctant to enter into long-term arrangements to finance research activities of this type. In some ways, this reluctance is reasonable. Current demands almost always outweigh current resources. To support one longitudinal study well might obviate the possibility of funding other valuable, short-term, projects over the entire length of the one extended project that was supported. However, the kinds of issues addressed in research of the kind undertaken by Pulkkinen cannot be accomplished with cross-sectional research, and the value of research of this type is undeniable. Indeed, some of the most important findings produced by the social sciences have been the results of (expensive) longitudinal research. The issue of support is crucial. The funding dilemma is one with which responsible directors of research support organizations *must* grapple if a scientifically satisfactory resolution is to be achieved. It is hoped that the decisions reached will not be based on the simple expedient of "pleasing most of the people most of the time."

Attitudes Toward Aggression and War

An interesting session focused on a cross-cultural collaborative effort to assess young people's attitudes toward nuclear war and the nuclear superpowers was chaired by Adam Fraczek of the Polish Academy of Science. The researchers

discussing their work in this particular symposium made use of student-respondents from Spain, Hungary, Nicaragua, Mexico, and the US. All respondents in the various studies answered a 19-item questionnaire designed by R. Johnson of Ramapo College (Mahwah, New Jersey). The findings were somewhat predictable, but nonetheless interesting and worthy of discussion. The issues assessed were concerned with respondents' perceptions of the inevitability of nuclear war, the chances of surviving it, and the frequency with which nuclear topics were discussed with parents and friends. In addition, issues tapped perceptions regarding military spending, and attitudes toward the postures of the US and the USSR with respect to the arms race.

Across all nations, respondents admitted that they had little personal knowledge of nuclear issues and did not (with the exception of the Nicaraguan students) discuss the issue often with friends or parents. However, the majority of respondents from all countries surveyed saw the US stronger militarily than the USSR, less interested in disarmament, and (with the exception of the US students) more likely to start a nuclear war. Deployment of missiles in Europe was seen by the European students as providing more threat than protection to the occupants of the affected countries. Between one-third to one-half of the respondents saw nuclear war as an inevitability, and estimated their chances of survival from 15-30 percent.

Despite this bleak set of personal survival estimates, almost all respondents said that nuclear issues had little effect on their immediate plans, and the vast majority, across all nations, had done little to try to influence the course of such events. This apparent inconsistency between self-interest and action can be understood in light of a final result, namely that almost none of the respondents felt that they could do anything to influence the arms race, or the likelihood of a nuclear conflagration.

Attitudes and perceptions of this type, if issuing from students of Eastern bloc countries, would not be surprising. However, when the US is viewed in such negative terms by the intelligencia and future leaders of our western allies, it is clear that we are not presenting our case effectively. It is relatively easy to become complacent about findings of this nature. Indeed, in almost every land I have visited, the same balm is applied, in the form of an aphorism that varies from country to country by only a few words: "A person who is not a leftist at age 20 has no heart; a person who is a

leftist at age 30 has no brain." This formula does indeed seem to describe the common case. But it is not clear why perceptions of the US should be so negative among the educated youth of Europe. To be sure, there may be times when such opinions are justified, on some issues. But this should not be the general case. It is clear that we are not presenting our position as well as we might, and this failure is puzzling in light of the fact that: (1) research on communication and persuasion in the US is as good, usually better, than that produced anywhere else; and (2) if applied appropriately, the negative and often misguided impression of the US would be attenuated considerably among our friends in the West. Given these two observations, the current state of affairs invites critical scrutiny.

Aggression and Somatic Risk Factors

The relationship between Type A behavior and coronary heart disease has been studied extensively for many years. In the initial research, the diagnosis of Type A behavior pattern (characterized by a somewhat aggressive, impatient, hyperactive, short tempered, and generally "rushed" approach to life in general) appeared to be associated with later somatic difficulties (Jenkins, 1971, 1976). Research conducted at the University of Helsinki has attempted to capitalize upon these findings, and to extend them into the realm of childhood. There is some evidence that coronary heart disease begins in childhood. If this is so, then it might prove useful to determine the role of Type A behavior in the early etiology of coronary heart disease. Are "Type A children" more at risk for heart disease than those who are not Type A? To begin to address this question, Liisa Keltikangas-Jarvinen (University of Helsinki, Finland) randomly selected 208 healthy adolescents and young adults for study, approximately equally divided with respect to gender (the sample included 78 12-year-olds, 67 15-year-olds, and 63 18-year-olds). Somatic and psychological features of these subjects were assessed. The somatic risk factors collected included systolic and diastolic blood pressure, total serum cholesterol, HDL-cholesterol, and LDL-cholesterol. The psychological measures employed the Jenkins Activity Survey to assess Type A behavior, a measure of the frequency and quality of the children's emotional expressions, and an assessment of their behavioral coping strategies.

The results that Keltikangas-Jarvinen obtained in this study were very interesting, and potentially of great practical and theoretical importance.

There was a strong positive relationship between aggression and the somatic risk factors of coronary heart disease among the females in every age group. Type A behavior, too, was correlated with aggression--but not with the coronary heart disease risk factors. Among the males, however, there was a *negative* relationship between the Type A score and the somatic risk factors. Aggressiveness in boys was *not* related to risk of coronary heart disease, but it did correlate with Type A behavior, and with constructive coping strategies.

These results point to an interaction of sex and aggression (on risk of coronary heart disease) in childhood that might have important implications. The data suggest that for boys (at least, for boys in Finland), aggression is not necessarily a negative, coronary heart disease risk-inducing behavior. Indeed, the data suggest that aggressiveness might actually serve to decrease somatic risk factors for coronary heart disease. Whether this relationship is maintained into adulthood is anyone's guess, but the fact that it was found in a carefully done survey certainly suggests the potential value of follow-up investigations, both in Finland and other countries as well.

The more "standard" relationships found in the female sample, and the strong levels of statistical significance found throughout the study, give some reassurance that the measures employed were of reasonable psychometric quality. The variation in male-female results also suggests that the meaning of aggression might differ as a function of sex. For girls, Type A behavior might act as an initial predisposing factor for aggressive behavior which, given societal constraints and (negative) evaluations, might in turn result in elevation of coronary heart disease somatic risk factors. Girls placed in a conflict between a pervasive behavioral pattern and the norms of the society might be put at greater risk for chronic heart disease, and a host of other somatic complaints as well. For boys, however, society is more willing to condone (in some situations, even applaud) aggression. As such, it is not likely that aggression, per se, will result in the kinds of conflicts that might give rise to a psychologically induced somatic predisposition to coronary heart disease.

A good test of these possibilities could be carried out by repeating the Keltikangas-Jarvinen study in a developed western society in which aggression in young boys was not only strongly proscribed, but also strongly counternormative or, alternatively, in a society in

which aggression in girls was given at least tacit approval. Unfortunately, the venue for this proposed study does not immediately suggest itself, but this should not deter further investigation of the theoretical possibilities that might help to integrate the interesting results from Finland.

Maternal Aggression in Rat and Man

After giving birth, rat mothers, and apparently other mammalian mothers as well, become more aggressive toward animals of the same species (conspecifics). The selection/survival value of this tendency is obvious, but the neurological and social mechanisms involved in it are not. This issue was addressed in an interesting session chaired by Stefano Parmigiani (University of Parma, Italy), who also contributed two papers to it. Parmigiani begins with the observation that most research on human and animal aggression has been based on the responses of males. Only recently has female aggression been studied, largely in terms of maternal aggression. Maternal aggression is an interesting topic of study because, according to Parmigiani, the attempts of the mother to defend her offspring are rarely successful--yet the behavior persists.

In a well-done experiment carried out in a naturalistic but carefully controlled setting, Parmigiani tested the widely accepted proposition that the unritualized defensive form of maternal attack against virgin male conspecific intruders (vs. the more ritualized offensive attack against female intruders) was undertaken as a deterrent to infanticide. If this were the case, he argued, then (1) naive primiparous lactating females would show clearly different patterns of fighting against male and female intruders, and (2) would be more likely to attack males than females when faced simultaneously with conspecific intruders of both sexes. Results confirmed the predictions: indeed, in the case of multiple intruders, only the males were attacked. This would appear reasonable, since the male intruders almost always committed infanticide, and the females almost never.

Interestingly, the same proportions of male infanticide occurred whether or not the mother was present--her presence, and consequent attack, merely delayed the inevitable. From this, Parmigiani concludes that the counter-infanticide hypothesis of maternal aggression is oversimplified. Aggression in lactating females cannot be viewed solely as a counterstrategy to infanticide, since it is too costly, and too frequently unsuccessful. Rather, maternal aggression might be

viewed as the outcome of numerous causes, only one of them being a counterstrategy to infanticide. Based upon the resource-holding potential hypothesis, Parmigiani proposes that maternal aggression functions as a female choice strategy to select good male genes, and therefore as an expression of (Darwinian) selection.

The neural mechanisms involved in maternal aggression were investigated by Stefan Hansen of Sweden's University of Göteborg. Hansen began with the usual observation that mammalian mothers commonly were extremely aggressive toward conspecifics. However, removal of the litter markedly reduces maternal aggression. From these facts, we can deduce that the litter somehow induces aggressiveness in the mother. How does this occur? Hansen hypothesized that aggressiveness might somehow be associated with nursing. Being a neurophysiologist, he searched for a section of the brain that was implicated in nursing behavior, and settled upon a specific site--the perpendicular area--that is a central component of the milk producing-delivery system. Hansen argued that if his hunch were correct, then interfering with this site would attenuate maternal aggression even if the litter were not removed. His hypothesis was confirmed; bilateral lesions at the critical region 8-days postpartum effectively eliminated all conspecific maternal aggression.

Do these results have anything to do with aggressive behavior in human mothers? There is a great paucity of research in this area, but a paper by de Luis, Llorca, and Ledesma-Jimeno (Department of Psychiatry, Hospital Clinico, Salamanca, Spain) in this symposium has provided some intriguing insights. The investigators administered a translated version of the Buss-Durkee (1957) aggression inventory, and two other indices of quantity and direction of aggression, to 36 women at 4 and 45 days postpartum. Comparing these responses with those of 598 women drawn from the population, the researchers found that global aggression at both measurement periods was substantially higher in the puerperal group. There is much to complain about in this study--the lack of a good comparison group is the most obvious problem. It is conceivable that anyone having experienced trauma and hospitalization would score high on a test of hostility, independent of the cause (which in this instance--labor and delivery--was viewed as crucial). A "sham operation" control group, so common in much psychophysiological research, however, would have proved somewhat difficult in the present instance. Nonetheless, despite the methodological shortcomings, the research of

de Luis, Llorca, and Ledesma-Jimeno is intriguing. In light of Hansen's study, it would have been very interesting to know which of the new mothers were nursing their children, and whether this group obtained higher (as would be predicted) or lower scores on the aggression indices that were administered.

Conclusions

The study of aggression can take many forms. Research can range from psychophysiological investigations of the neural pathways activated in maternal aggression in rats, to the ethnographic account of a blood feud carried over 20 generations, and the societal dynamics that support such an ongoing catastrophe. It is clear that there is a tremendous investment of energy in the study of human aggression, but this investment pales when contrasted with that devoted to research on subhuman species. The present conference was valuable because it provided a forum for many of the different concerns, approaches, and subject populations represented in this multifaceted area of research. And more than this, it provided the opportunity for representatives of these various research camps to interact, and to learn from one another.

Substantively, the work presented in the various symposia and plenary addresses was first rate. Much outstanding work is being done in this field, with the advantage, perhaps, being on the side of those studying aggression in subhuman species. This is reasonable, given the more ready availability of research subjects, and the ease with which these subjects may be manipulated. If such research is to have implications for human behavior, however, it would seem reasonable that more comparative studies involving human respondents be undertaken. It is my hope that future meetings of this society, and others focused on the fascinating area of aggression, will place more emphasis on the issue of the relevance of animal models of aggression for the infinitely more complex problem of aggression in man.

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6/15/87

Biological Sciences

BIOTECHNOLOGY CONFERENCE: PROTEIN ENGINEERING '87

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1988 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Introduction

This major international conference, Protein Engineering '87, took place at the University of Oxford, UK, from 5 through 8 April, 1987. About 450 scientists from 12 European countries as well as the UK, Israel, Japan, US, Canada, Australia, and Eastern European countries (USSR and Hungary) attended the conference. About 30 percent of the participants represented industrial organizations with the balance from academic institutions.

The conference was divided into six symposia sessions on the following topics:

- Theoretical aspects of protein structure
- Protein structure and dynamics
- Protein engineering--methods
- Protein engineering--stability
- Protein engineering--binding and catalysis
- Protein engineering--medical and industrial applications.

There were also poster sessions comprising 107 posters as well as a trade exhibition.

Protein engineering requires a multidisciplinary approach, as shown in Figure 1. Among the protein engineer's objectives are the investigation of those principles which govern structure, the determination of the mechanisms through which particular functions are expressed, and the testing of these principles by introducing site-specific alterations and then evaluating any changes in structural or functional properties. Ultimately, protein engineering has the potential to be a source of novel proteins with novel applications in technology, medicine, and industry.

A great deal of interesting and informative material was presented at the conference. Thus, summaries of only a few selected presentations can be given in this short report. A more detailed summary is available in ONRL Report 7-019-C.

Unfortunately, no proceedings of this conference will be published, according to A.R. Rees, organizer of the meeting. Abstracts of some of the presentations will, however, be published within the next few months in an issue of the journal *Protein Engineering*.

Theoretical Aspects of Protein Structure
Protein folds and protein sequences were discussed by C. Clothia (MRC Labora-

tory of Molecular Biology, Cambridge, UK). He emphasized that the successful prediction of the structure of a protein from its sequence, using the known structure of an homologous protein is of great importance for protein engineering. It is also important for testing theories or models for the sequence-dependent aspects of protein conformation. Clothia reviewed the results he and his group have obtained in cases where (1) the proteins have similar folds but very different sequences, (2) the proteins have low to moderate sequence identities, and (3) the proteins have high sequence identities. He stated that, essentially, the major response of proteins to mutation, whether by natural evolution or experimental mutagenesis is a conformational change and that functional restraints determine which of the conformational changes are accepted.

Modeling of protein structure using data bases was discussed by M.J.E. Sternberg (Department of Crystallography, Birbeck College, London, UK). The known protein structures have been organized in a relational data base that stores the Brookhaven coordinates and computer-derived conformational features such as secondary structure, dihedral angles, and solvent accessibility. The relational data base enables rapid interrogation of features. Applications include the selection of loop conformations for predicting unknown structures based on the x-ray coordinates of an homologous molecule and also to obtain conformation features (i.e., disulfide bridges) for modeling the consequences of site-specific mutations. The protein sequence data base can be used to obtain a multiple alignment of homologous sequences. The combined information from all the sequences can be used to improve secondary structure prediction by 10 percent and to locate probable active site residues in protein families.

A report on the structure, design, and modification of loop regions in proteins was presented by J.M. Thornton (Birbeck College, University of London, UK). In proteins, the loop regions connecting the secondary structures comprise about 30 percent of the structure. The loop regions are on the surface of the protein, and are often flexible. Since insertions and deletions in homologous sequences usually occur in the loop regions, it is expected that engineered mutations will be most easily tolerated in the loop regions without destroying the three-dimensional structure, according to Thornton. Detailed analysis of the conformations of loop regions in proteins of known structure by Thornton and her group has revealed that for short loops, there are structural families with

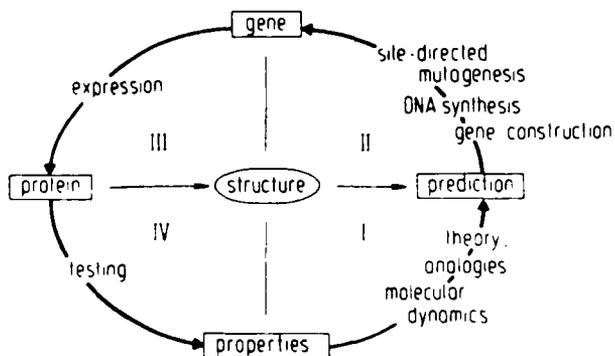


Figure 1. Protein engineering cycle.

specific protein sequence patterns. Such patterns can be used to guide the choice of sequences in novel protein design or in site-directed mutagenesis experiments. Loops are widely involved in recognition between molecules, such as antigen-antibody interactions and protein-receptor recognition. Peptides, excised from loop regions, can be used to elicit an immune response against the native protein.

The topic of messenger RNA (mRNA) translation and protein folding *in vivo* was discussed by J.C. Swaffield (Biotechnology Unit, Institute of Genetics, University of Glasgow, UK). Many highly expressed genes from *Saccharomyces cerevisiae* (yeast) show a strong bias in their choice of codons for the 20 amino acids. This codon bias correlates strongly with the relative abundance of the iso-accepting transfer RNA's (tRNA). The set of preferred codons varies between organisms, according to Swaffield. When "rarely used" codons are clustered within a gene, a pause in the rate of translation is predicted that would result in the accumulation of nascent polypeptide chains of a discrete length. Since proteins are synthesized from the N-terminus, and initial folding reactions probably occur before translation is completed, Swaffield believes that translational pauses possibly influence the folding of some proteins by allowing regions of the growing polypeptide chain to fold correctly before C-terminal regions are synthesized. According to Swaffield, a major problem in relating potential translational pauses to protein folding is the lack of knowledge about the tertiary/quaternary structures of many proteins for which the gene sequence is available. However, there is a tight correlation between the presence of potential translational pauses and the interdomain regions of the *arom* multifunctional enzyme in *Saccharomyces cerevisiae*. According to Swaffield, potential translational pauses have been observed in the genes for other multifunctional enzymes in yeast (e.g., TRP3, TRP5), but in these cases the pauses do not seem to lie in interdomain regions.

Protein Structure, Stability, and Dynamics

Proteins are well designed for their functions. They may be rigid or flexible to various degrees as required for optimal performance. Flexibility at the level of amino acid side-chains occurs universally and may be important for some functions. Large-scale flexibility where large parts of a protein rearrange or move coherently are particularly interesting; this was discussed by R. Huber (Max Planck Institute for Biochemistry,

Martinsried [Munich], West Germany). Huber and his group have carried out extensive research on the flexibility and rigidity requirements for functions of proteins and protein-pigment complexes.

Huber and his group have found that it is possible to differentiate between different categories of flexibility, order-disorder transitions of domains, and domain motions. The domains may be flexibly linked to allow rather unrestricted motion or the motion may be constrained to certain modes by hinges. The connecting segments and the hinges show characteristic structural features. The following examples presented by Huber illustrate various aspects. Small proteinase inhibitors are essentially rigid molecules and provide tight complementary binding to their cognate protease. The large plasma inhibitors, however, exhibit large conformational changes upon interaction with proteases, probably for regulatory purposes.

Huber and his group found that the pancreatic serine proteases exhibit a disorder-order transition of their active domain between proenzyme and enzyme forms as a means of regulating enzymic activity. Immunoglobulins show rather unrestricted and also hinged domains in different parts of the molecule, probably to allow cross-linking of antigens. According to Huber, citrate synthetase adopts open and closed forms by a hinged domain motion to bind substrates and release products and to perform the catalytic condensation reaction, respectively.

The topic of denaturation and renaturation of modified lysozymes was discussed by T. Imoto (Faculty of Pharmaceutical Science, Kyushu University, Fukuoka, Japan). Lysozyme was variously modified and the stabilities of the derivatives were determined with thermal denaturation experiments by Imoto and his group. The contributions of salt bridges, hydrophobic interaction and cross-linkage were also evaluated as well as stabilities against proteolysis.

Imoto reported that for stability against proteolysis, it was important to depress the rate of unfolding--i.e., to stabilize native conformation. He stated that, as a rule, salt bridges and hydrophobic interactions stabilize native conformation and cross-linkages destabilize denatured conformation. However, cross-linkages are apt to introduce strain in native conformation and only suitable lengths of cross-linkages can stabilize protein. The stabilization was shown to be generally effective at improving functionality of proteins. Regeneration of disulphide bridges was examined by employing several chemically cross-linked lysozymes. The derivative cross-linked

between Lys-13 and Leu-129 showed a 2.3 times accelerated regeneration rate compared with that of unmodified lysozyme. Mutation of Ala-31 to Val completely hindered the regeneration of lysozyme into active conformation. According to Imoto, such a minor mutation can lead to critical damage in the folding of proteins, which is an indispensable process in the genetic engineering of proteins.

Protein Engineering: Methods

The use of synthetic oligonucleotides in methods of site-directed mutagenesis, particularly with regard to the needs of protein engineering, was reviewed by M.J. Gait (MRC Laboratory of Molecular Biology, Cambridge, UK). The methods include the use of (1) mismatched oligonucleotide primers to direct single or multiple mutations, deletions, or insertions on single-stranded DNA templates; (2) fully matched oligonucleotide primers in error-forcing repair synthesis; (3) total synthesis of genes; and (4) cassette mutagenesis. The first two methods were used to effect single amino acid changes in the enzyme T4 ligase. For example, substitution of Lys-99 (the site of covalent adenylation in the first step of the enzyme mechanism) by Asn or His leads to inactivity in adenylation as well as in the joining reaction, whereas an Arg-99 mutant retains activity. A total synthesis approach was used by Gait and his group to construct the gene for bovine caltrin (seminal plasmin), a 47-amino-acid protein with antifertility and antibacterial activity. The gene has been expressed in *E. coli* as several different fusion proteins with a view to production of caltrin for structural and mutagenesis studies.

The molecular modeling of antibody combining sites was discussed by J.C. Cheetham (Laboratory of Molecular Biophysics, University of Oxford, UK). The lack of detailed structural information on the nature of antibody combining sites, particularly in the complex environment with antigen, has resulted in the widespread application of modeling techniques to the study of the antigen-antibody reaction. An understanding of the specific interactions between antibody and antigen is fundamentally important if one hopes to design antibodies with a given specificity and affinity for a particular antigen, according to Cheetham. The latter is perhaps the ultimate goal for such studies, and is of immense importance in clinical application.

Cheetham and her group have carried out the modeling of a monoclonal antibody (Mab) called Gloop2 (class IgG), on the basis of DNA sequence information and a structural data base of known immunoglob-

ulin structures. Their studies have yielded a preliminary model for the structure of the "anti-loop" binding site. Prediction of the effects of single and double mutations engineered with the antibody combining site were compared directly with experimental results by Cheetham and her group. The results point to important considerations for the design of future mutagenesis experiments.

The particularly well-studied antibody combining site of McPC603 (phosphorylcholine binding antibody) is being used by R. Glockshuber (Gene Center of the University of Munich, Martinsried (Munich), West Germany) and his group as a model system for quantitatively investigating factors that contribute to efficient hapten binding, and subunit interactions. These investigators are also studying the potential of stabilizing a transition state through the controlled modification of the protein. They are attempting to delineate protein contributions to catalysis by making an almost-catalyst (a transition state-binding antibody) perform a suitable hydrolysis reaction.

Studies of protein engineering starting from an immunoglobulin variable domain were presented by H.J. Fritz (Max Planck Institute for Biochemistry, Martinsried). The three-dimensional architecture of several immunoglobulins is known, among them dimers of light chain variable domain. Such material was isolated from the urine of patients suffering from Bence-Jones disease. Fritz and his group chose one such variable domain (REI-V) as the starting point of a protein engineering project. A gene for REI-V was chemically synthesized by a combination of known and newly developed techniques. Work currently in progress by Fritz and his group includes (1) expression of the synthetic gene in bacterial hosts, (2) oligonucleotide-directed mutagenesis of the REI-V gene to obtain structurally predetermined variants of the protein, and (3) protein-chemical characterization of REI-V and its constructed variants.

A study of the sequence-specific interaction of the cyclic AMP receptor protein (CRP) with DNA was reported by M.E. Gent (Department of Biochemistry and Applied Molecular Biology, University of Manchester, UK). Mutants in the DNA-binding helix F of the CRP were constructed by site-directed mutagenesis. Mutants in a synthetic DNA site derived from the sequence in the *lac* regulatory region were also constructed. The effect of these selected amino acid and nucleotide substitutions on CRP-mediated binding was studied. It was shown that Arg-180 in helix F is crucial for the specific

interaction of CRP with DNA whereas Arg-185 and Lys-188 are not involved in specific complex formations. Substitutions of adenine (A) and guanine (G) at position 2, and G at position 5, in the DNA recognition sequence T₁ G₂ T₃ G₄ A₅ both abolish specific binding of a wild-type CRP protein.

A report on evolution guidance for the engineering of alcohol dehydrogenase (ADH) and ribonuclease (RNase) was presented by E.G. Weinhold (Laboratory for Organic Chemistry, Institute for Biotechnology Research, Zürich, Switzerland). The evolution of proteins represents (in part) natural selection engineering of a protein to be suitable for different environments, and (in part) the nonfunctional drift of the protein's structure. According to Weinhold, some of the information drawn from the recent evolutionary history of a protein, deduced by sequence comparisons of homologous proteins, may assist the biochemist seeking to alter the protein's structure to achieve desired properties. This approach was tested by Weinhold and his group on two proteins: ADH and mammalian RNase. Several mutants were chosen by comparison of homologous dehydrogenases from yeast and other organisms. A specific example is the change of Arg-211 to Thr. The residue, in a helix remote from the active site, would not be selected for mutagenesis based on a simple inspection of crystal structure, according to Weinhold. Yet its alteration was found to effect cofactor binding predictably. In RNase, alterations were introduced into a synthetic gene expressed in *E. coli*. Changes at positions 35 (Leu to Met) and 19 (Ala to Ser) recreate a ribonuclease from a now extinct organism, the precursor of modern bovovoids.

Protein Engineering: Medical and Industrial Applications

The topic of making therapeutic proteins by directed mutagenesis was reviewed by T. Harris (Celltech Ltd., Slough, UK). There are now many classes of proteins which are being synthesized in *E. coli*, yeast, or mammalian cells from cloned DNA. These proteins include hormones, blood proteins, enzymes, inhibitors, and antibodies. Using techniques of site-directed mutagenesis it is possible to change single amino acids in these proteins to make novel molecules with altered characteristics. Some examples are interleukin-2 and α_1 -antiprotease. The domain structure of many large eukaryotic proteins is often reflected in the genome by the arrangements of the exons and introns making up the gene. As the domains probably fold independently during synthesis it has been

possible to change the domain structure of several proteins without destroying specificity of enzymatic activity and conferring novel functions to the hybrid. This is done by manipulating cloned genes or complementary DNA (cDNA) using naturally occurring or introduced restriction sites and oligonucleotides and expressing the chimeras in mammalian cells. Interferons and the plasminogen activators have been altered in this way, but antibodies provide the best paradigm.

The applications of protein engineering to human α_1 -antitrypsin and HIV envelope protein were described by J.M. Lecocq (Transgene SA, Strasbourg, France). The application of protein engineering in the pharmaceutical industry is becoming increasingly important. Lecocq presented two examples of the high potential of this new technology:

1. Human α_1 -antitrypsin analogs. The primary function of α_1 -antitrypsin is the inhibition of neutrophil elastase. An α_1 -antitrypsin deficiency results in lung emphysema. Moreover, the α_1 -antitrypsin from lungs of heavy smokers is inactivated due to the oxidation of the methionine (Met) residues at the active site. A (Met-358 to Val-358) α_1 -antitrypsin analogue which remains fully active as an elastase inhibitor but which is also resistant to oxidative inactivation was constructed by Lecocq and coworkers and characterized. The inhibition of the clotting pathway by other analogues with modified residues in the active site has also been studied by these investigators.

2. HIV envelope protein. The envelope glycoprotein (env) represents the major antigen at the surface of HIV viral particles, and efforts to produce a vaccine against AIDS have centered on this protein. Lecocq and his group have constructed a recombinant vaccinia virus expressing the HIV envelope protein. In infected tissue culture cells, the envelope precursor (gp160) is efficiently cleaved to two components, an extracellular one (gp120) and a transmembrane segment (gp41). Lecocq has observed that gp120 is rapidly shed from the cell surface, thus offering an explanation for the low immunogenicity of the envelope protein. In order to enhance immunogenicity of the envelope protein, Lecocq and his group have genetically engineered new variants which are now being checked.

The production of monomeric insulins by protein engineering was reported by J. Brange (Novo Research Institute, Bagsvaerd, Denmark). Insulin associates above physiological concentrations of 10^{-10} M into dimers and hexamers. This strong tendency to self-assembly has numerous

advantages in relation to the events following biosynthesis in the beta cell of the pancreas, but does not necessarily represent useful properties for the therapeutic formulation and clinical use of insulin, according to Brange. Therefore, Brange and his group applied protein engineering to the hormone (insulin) with the aim of counteracting self-association and changing its physicochemical properties. Substitutions were performed at five different residues (B9, B12, B26, B27, and B28) by oligonucleotide-directed mutagenesis or by total gene synthesis. The insulin analogs were produced by fermentation of single-chain precursors in yeast followed by semisynthetic conversion into the respective mutants. Brange and his group found that mutation of B12-Val to Ileu, B26-Tyr to Glu, or B-27-Thr to Glu gave a partial reduction of the association tendency whereas a single mutation of B9-Ser to Asp, B12-Val to Glu, or B28-Pro to Glu resulted in analogs which remained essentially monomeric even above millimolar concentrations. Molecular modeling by Brange and his group has revealed that electrostatic effects probably are the main explanation for the observed prevention of the association, but steric hindrance also accounts, in some cases, for the weakened self-assembly. Thus, monomeric insulins can be obtained by a single mutation in the monomer-monomer interface of the insulin dimer.

Conclusion

This informative and intensive conference on the new and rapidly developing area of protein engineering covered many of the protein-based aspects of this subject as well as some of the sophisticated molecular biological techniques needed to make and express mutant proteins. In addition, the concept of making defined mutations in proteins to probe ligand binding and protein structure-function relationships was also covered. It is evident that the prospect for applications of recombinant DNA techniques in the study and use of enzyme catalysis and protein-protein interactions has been radically changed in the past few years. Protein engineering has also become an area of top priority for industrial organizations--in particular, the pharmaceutical industry. Some applications to commercial products were also presented.

6/27/87

SECOND MESSENGERS SIGNALLING FUTURE AREAS FOR DRUG RESEARCH

by Claire E. Zomzely-Neurath.

Introduction

A 1-day conference on the very timely topic of second messengers was sponsored by the Society of Chemical Industry (SCI). The conference took place on 7 May 1987 at the headquarters building of the SCI in London, UK. Of the 145 participants, 70 percent represented industrial organizations and 30 percent academic institutions. Most of the attendees were from the UK; however, there were a few from Sweden, France, Belgium, Italy, West Germany, and the US.

The topics covered at this conference were:

- Principles of cellular signaling using second messengers
- Metabolism and function of inositol phosphates
- Role of G proteins in signal transduction
- Protein tyrosine kinases: Their role in the control of cell growth
- Cyclic nucleotides and protein kinases
- Protein kinase C
- Function of the RAS oncogene.

A summary of the above topics presented at this SCI-sponsored conference is given in this report.

Principles of Cellular Signaling Using Second Messengers

An excellent review of this topic was presented by R.H. Michell (Department of Biochemistry, University of Birmingham, UK). Michell pointed out that cells are constantly responding to chemical changes in the extracellular environment--for example, in the concentrations of neurotransmitters; peptide hormones and growth factors; ions and metabolites; lipid factors such as prostaglandins, leukotrienes, and platelet activating factor; or antigens. Many of these agents fail to cross the barrier of the plasma membrane, so they must be recognized by highly selective cell-surface receptors which, in their turn, transmit into the cell interior the message that they have been activated.

In the mid-1950's, Earl Sutherland and his colleagues discovered that some receptors cause activation of adenylate cyclase, with the resulting rise in intracellular cyclic AMP serving as a 'second messenger' that activates a protein kinase. We now know that adenylate cyclase is activated by some receptors and inhibited by others, and that two GTP-dependent proteins (Gi [inhibitory] and Gs [stimulatory]) serve as transducers which

transmit information from activated receptors to adenylate cyclase.

Cyclic GMP was discovered soon after cyclic AMP, but its cellular role proved much more difficult to understand. There is now evidence that receptors for atrial natriuretic factor activate a membrane-bound guanylate cyclase, also that cyclic GMP may be a feedback regulator that limits smooth muscle contraction and platelet activation in response to a variety of stimuli.

A second large family of receptors regulates the hydrolysis of a membrane phospholipid, phosphatidylinositol 4,5-bisphosphate (PtdIns4,5P2), to 1,2-diacylglycerol (1,2-DG) and inositol 1,4,5-triphosphate (Ins1,4,5P3). Receptors control the enzyme that catalyzes this reaction through one or more GTP-dependent transducing proteins (designated 'Gp'): candidate Gp's include the 21 kDa proteins encoded by the *ras* family of (proto)oncogenes. Both of the products of PtdIns4,5P2 hydrolysis serve as second messengers. 1,2-DG activates protein kinase C, and Ins1,4,5P3 causes the release of stored calcium from an intracellular membrane-enclosed store. In addition, Ins1,4,5P3 is: (1) dephosphorylated to Ins1,4P2 and thus inactivated; and (2) converted sequentially to Ins1,3,4,5P4, Ins1,3,4P3 and another InsP4 (probably Ins1,3,4,6P4). The biological significance of the latter pathway is still unknown, but Michell thinks that it might be involved in the regulation of the long-term behavior of the cell (for example, proliferation vs. differentiation).

Recent studies have suggested that at least some of the actions of insulin are mediated by a water-soluble second messenger, and that this is produced by hydrolysis of another membrane phospholipid, a phosphatidylinositol glycan. However, according to Michell, confirmation of this mechanism must await the elucidation of the structure of this phosphoinositol glycan "second messenger."

Metabolism and Function of Inositol Phosphates

This topic was discussed by R.F. Irvine (Department of Biochemistry, Institute of Animal Physiology, Cambridge, UK). Irvine emphasized that as more investigators study it, in more tissues, the metabolism of inositol phosphates in animal tissues becomes increasingly complex. There are two routes of catabolism of Ins(1,4,5)P3, one by dephosphorylation to Ins(1,4)P2 and the other by phosphorylation to Ins(1,2,4,5)P3 (which is then dephosphorylated to Ins(1,2,4)P3). The further catabolism of Ins(1,3,4)P3 is probably complex, according to Irvine, as

both Ins(1,3)P2 and Ins(3,4)P2 have been found and the routes by which either of these are catabolized is not known. Furthermore, Ins(1,4)P2 also can be hydrolyzed by two routes (i.e., Ins(1)P or Ins(4)P can be formed), and these pathways may differ in lithium sensitivity. Overlaying this, at least if tissues are radiolabeled for long periods, is the appearance of Ins(1,3,4,5,6)P5 and InsP6, which are probably formed directly by phosphorylation from inositol using InsP1-4 intermediates distinct from those in the Ins(1,4,5)P3 metabolism story.

According to Irvine all the above information is very trying for the biochemist, but very enheartening for the pharmacologist. The reasons are that the greater the complexity, the greater the likelihood of heterogeneity and tissue differences, and hence the greater room for manoeuvre in possible postreceptor pharmacology. Irvine stated that, therefore, the ensuing years are likely to be filled by a much more detailed mapping of these pathways in different tissues, and a rational approach to their manipulation; however, it is first necessary to clear up functions.

The function of Ins(1,4,5)P3 is to mobilize calcium from the endoplasmic reticulum. So far, that is its only known function although more may emerge. Ins(1,3,4,5)P4 definitely has a function because of its potent and specific biological effects. The evidence is consistent with its playing a role in calcium homeostasis at the plasma membrane, but more direct evidence for this is required, according to Irvine. Ins(1,3,4)P3 can mobilize calcium, but only at high concentrations, and also has some effects on membrane potential in neuroblastoma cell line. Whether these are important *in vivo* is not known. The function of any other inositol phosphates, especially InsP5 and InsP6 in cells other than avian erythrocytes, is not known as yet. However, their metabolism can change quickly on cell stimulation, and cells are not making them without a reason, so the knowledge about their function may be quite important. Irvine thinks that inositol phosphates are still in their early childhood as regards function, and infancy as regards metabolism. Thus, much more basic information is required before drug treatment affecting these second messengers can be viable.

Protein Tyrosine Kinases

The role of protein tyrosine kinases in the control of cell growth and transformation was discussed by C. Picton (Mammalian Biochemistry Department, Glaxo Group Research Ltd., Greenford, UK). Since the discovery that viral oncogenes

such as v-src were originally of cellular origin, these cellular oncogenes or proto-oncogenes have become an increasing area of investigation. Picton stated that it has become clear that the cellular genome comprises some genes that are not only involved in the proliferation of normal animal cells but can assume malignant roles when activated at inappropriate times, or if excess amounts of the gene product are expressed. The designation of functions for the products of these cellular oncogenes has led to an understanding of how a single protein can have the pleiotropic effects necessary for cell growth or transformation.

The exact mechanism by which the controlled growth of cells is brought about by proto-oncogenes is not understood, according to Picton. However, in the case of oncogenes encoding protein tyrosine kinases it is thought to involve covalent modification of specific and important intracellular targets involved in the pathways essential for cell growth.

Protein tyrosine kinases form a family of enzymes which are implicated in the control of cell proliferation. Some have been identified as cell surface receptors for polypeptide growth factors and appear to be involved in their signal transduction while others have as yet unidentified functions. Tyrosine kinases are not only involved in the normal function of a cell, but lesions in this regulated process at the growth factor receptor level may, in Picton's opinion, be responsible for the uncontrolled growth of cancer cells. He thinks that the growing family of tyrosine kinases and their implied involvement in the disease states of cell proliferation suggest a common mechanism for regulation of cell growth by the specific actions of different polypeptide growth factors.

Cyclic Nucleotides and Protein Kinases

An overview of the topic of cyclic nucleotides was presented by P.J. England (Department of Cellular Pharmacology, Smith, Kline & French Ltd., The Frythe, Welwyn, UK). Two cyclic nucleotides, cyclic AMP and cyclic GMP, are known to have well-defined roles in the control of cell function. There are many parallels in the formation, mode of action, and breakdown of these two nucleotides, although each nucleotide appears to have a distinct role in many cells.

Cyclic AMP and GMP are produced in the cell by adenylate and guanylate cyclase respectively. Adenylate cyclase is an extremely well-studied plasma membrane complex comprising several different hormone-binding proteins (receptors), at least two different GTP-binding complexes, and a catalytic unit responsible

for the actual synthesis of cyclic AMP. The receptors have provided classical pharmacological targets for drug interactions, with great success in beta blockers and H₂-antagonists. The two GTP-binding complexes (N₅ and N₁) are coupled to excitatory and inhibitory receptors respectively, and can be activated by ADP-ribosylation catalyzed by appropriate bacterial toxins. The catalytic subunit can be activated directly by at least one pharmacologically useful agent, the diterpene, forskolin.

Guanylate cyclase has been much less well studied. There are two distinct enzymes, one soluble and one membrane bound. However, the precise roles of these are not understood. Agents which activate guanylate cyclase and increase cyclic GMP in cells include acetylcholine, endothelial-derived relaxant factor, a wide range of nitro-containing compounds (for example, nitroprusside) and many compounds capable of free-radical generation. A number of acute smooth-muscle relaxants in current use have as their main (or sole) mechanism of action, the activation of guanylate cyclase.

The only known mode of action of cyclic AMP in eukaryotic cells is the activation of cyclic AMP-dependent protein kinase (cAMP-PrK), which catalyzes the transfer of the γ -phosphate of ATP to serine or threonine residues in target proteins (protein phosphorylation). These phosphorylations cause conformational changes in the proteins, resulting in alterations in their activity or function as, for example, in activation or inhibition of enzyme activity, changes in affinity for regulators, etc. Increases in cyclic AMP induced by activation of adenylate cyclase therefore ultimately result in the modification of target proteins to bring about the action of hormones in the cell. Specificity of response may occur because of restriction of particular target proteins to certain tissues. In addition, there is evidence that within a single cell there is compartmentation of the cyclic AMP generation, transduction, and target and removal proteins, such that different effects may be brought about by selective modulation of the appropriate compartment. The target proteins are phosphorylated by a group of phosphoprotein phosphatases, the control of which are less understood than the kinases. The major control of protein phosphorylation appears to be via the kinases, with the phosphatases having a role predominantly in the termination of hormonal effects.

Cyclic GMP also mediates at least some of its effects by activation of a cyclic GMP-dependent protein kinase (cGMP-PrK) in an analogous manner to

cyclic AMP. There is a high degree of homology between cAMP-PrK and cGMP-PrK, although some differences in phosphorylated target proteins exist. At present, it is not completely clear how cyclic AMP and cyclic GMP can cause quite different effects in the same cell.

Cyclic AMP and cyclic GMP are destroyed and hormone signals terminated by the action of cyclic nucleotide phosphodiesterases (PDE's). At least six different PDE isoenzymes are known, with any one cell probably containing a minimum of three of these. Each isoenzyme has different kinetic constants for cyclic AMP and cyclic GMP, with some of the isoenzymes being essentially selective for either cyclic AMP or cyclic GMP, whereas others will hydrolyze both nucleotides at rates physiologically significant. In addition, some of the isoenzymes also exhibit allosteric regulation. A wide range of inhibitors of PDE isoenzymes are known, with isoenzyme selective and non-selective compounds being available. Several of these are being developed as potential inotropes, antihypertensives, antithrombolytics or antidepressants not only by Glaxo but many other pharmaceutical companies as there inhibitors represent a potential high volume of sales.

Protein Kinase C

Studies of Protein kinase C (PKC) were reported by P.J. Parker (Ludwig Institute of Cancer Research, London, UK). PKC is one of a large superfamily of proteins responsible for the regulation of cellular processes. The enzyme is defined as a calcium and phospholipid-dependent protein kinase. *In vivo* the production of the second messenger diacylglycerol is critically involved in permitting the activation of PKC as physiological calcium, an effect that can be mimicked by biologically active phorbol esters and certain other tumor promoters. Ludwig and his group have carried out partial sequence analysis and complementary DNA (cDNA) cloning of PKC and showed that the operationally defined PKC does, in fact, represent a family of highly related polypeptides. In man, there are at least three distinct PKC genes that have been mapped to chromosomes--i.e., 1 (α), 16 (β), and 19 (γ). These three genes generate at least four protein products including β_1 and β_2 that are produced by differential splicing of the beta gene messenger RNA (mRNA). The mRNA species for PKC α , β , and γ are differentially expressed although as yet no clear pattern of expression has emerged, according to Parker, to suggest particular physiological roles for these related but distinct enzymes. Structural analysis of these proteins has allowed an investiga-

tion into the domain structure of the PKC polypeptide through both biochemical and immunological studies. Reagents raised to the PKC protein by Parker and his group are being used to develop an understanding of the expression and behavior of the polypeptide *in vivo*. It is hoped that these studies will provide an insight into the workings of this subfamily of kinases.

Function of the RAS Oncogene

The three human *ras* oncogenes encode 21,000 dalton proteins (p21) which are expressed in most if not all normal cells. Point mutations have been detected in these genes in about 20 percent of human cancers, and in these tumor cells, a mutant p21 protein with a single amino acid alteration is expressed. It is believed that the presence of the mutant protein is a major contributor to the transformed phenotype of these cells. A. Hall (Institute of Cancer Research, Chester Beatty Laboratory, London, UK) and his group are working on trying to understand the biochemical role of the normal *ras* proteins and the mechanism by which mutant proteins transform cells. The proteins have been shown to bind GTP/GDP and to have an intrinsic GTPase activity. This has led to speculation that the proteins function as G proteins involved in signal transduction. Hall and his group have recently obtained some evidence for this hypothesis and have shown that the normal *ras* proteins are capable of coupling certain growth factor receptors to the breakdown of phosphoinositides in the membrane. Currently these investigators are carrying out experiments to determine if this observed coupling is a direct or secondary effect of p21 *ras* action.

Role of G-Proteins in Signal Transduction

Cell surface receptors fall into two general groupings, those that have the built-in capacity to generate an intracellular signal themselves--for example, the ion channel of the nicotinic acetylcholine receptor--and those that persuade other proteins in the membrane to do it for them. A classic example of the system would be the action of the glucagon receptor to stimulate adenylate cyclase to produce the intracellular second messenger, cyclic AMP. There is now a growing body of evidence which suggests that all those receptors which have to stimulate an "effector" protein to generate an intracellular second messenger do so via "go-between" proteins. These are the guanine nucleotide regulatory proteins (G-proteins). Studies of the G-proteins were reported by M. Hall (University of Glasgow, UK). The original identification

of the G-proteins utilized the adenylate cyclase system which is under dual control by the stimulatory (Gs) and inhibitory (Gi) species. However, Hall and his group as well as others have shown that actually a wide family of such G-proteins exists. The majority have a heterotrimeric structure, expressing an alpha subunit capable of binding GTP as well as interacting with effector and receptor systems. It appears that G-proteins may be regulators of ion channel function and that channels whose permeability mechanism can be altered by a G-protein-mediated process may be more the rule than the exception.

Conclusion

It was evident from the presentations at this conference that much progress has been made in our knowledge about second messengers. In particular, research on the inositol phosphates indicates that there is a great potential for drug intervention in the control of cell function in abnormal states. The predominance of participants from industrial organizations at this conference is indicative of the interest of industry in potential products. In addition, it was also evident that much research is already being carried out in the area of second messengers by commercial organizations. However, there is still much basic research that has to be done to elucidate the functions of some of these second messengers. Indeed, it is likely that continuing research will reveal additional new second messengers.

6/27/87

Computer Sciences

FURTHER DEVELOPMENTS IN IMAGE PROCESSING AT UNIVERSITY COLLEGE, LONDON

by J.F. Blackburn. Dr. Blackburn is the London representative of the Commerce Department for industrial assessment in computer science and telecommunications.

Introduction

Cellular logic image processing (CLIP4), discussed in last month's issue of *European Science Notes* (ESN 41-8:422-425 [1987]), has proven useful in applications in, for example, tomographic reconstruction, electrophoresis gel analy-

sis, and lay planning (positioning of pattern pieces on cloth) in the manufacture of clothing.

After several years of operation of CLIP4 University College has decided to develop an improved system for pixel resolution and a better mode of control for an assembly of many processors. About 64 CLIP4 processing units can be implemented on a single VLSI chip. However, there are a number of applications that require 512x512 pixel resolution, and for one-to-one correspondence between pixels and processing units 262,144 such units would be required. Some applications may use images several thousand pixels square, leading to millions of processing units for a one-to-one correspondence.

CLIP4 is a SIMD (single instruction, multiple data) machine. It will be necessary for the new system to allow each processor in the assembly to operate to some degree independently of the others, leading to a multiple instruction, multiple data (MIMD) machine.

In order to keep the number of processing units within acceptable limits, the block of array processors can move to successive subareas of the data array and perform the same processing on each. However, a means has to be found to ensure that the appropriate exchange of signals between subareas is handled. Also, each processor must deal with data from a number of pixels, which will require increased local storage.

Five strategies for meeting these requirements are:

1. Software scanning. Propagation signals which are to be passed between neighboring subareas are stored at the edge locations of planes of local storage and are shifted across the array as required. This scheme uses an excessive amount of time and local data storage.

2. Overlapping scans. This concept assumes that the objects to be processed are no larger than some defined fraction (often half) of the array size and avoids the interconnection requirement by assuring coverage of such objects by a coherent block of the array. The maximum size of objects is fixed and the scanning time is longer than would otherwise be necessary.

3. Two-dimensional scanning with edge stores. The special-purpose edge stores which are required along each edge of the array demand additional hardware; also, a problem arises at corner points of the array, concerning two possible sources for propagation impact.

4. One-dimensional scanning with edge stores. The implementation of this

scanning strategy is simpler than for the two-dimensional scanning because propagation signals are all of the same type and are dealt with in the same manner. Furthermore, there is no need to consider the corner problem. The disadvantage is that the flexibility of choosing the area over which scanning can usefully take place is substantially reduced.

5. Noncontiguous segmentation. In this method the array of processors does not deal with a contiguous block of pixels. The concept is further complicated by the introduction of offset processor/memory architecture.

The CLIP7 Project Specification

The aims of this project are:

- To design a machine of sufficient power to process high-resolution (512×512 pixel) images at rates comparable to the CLIP4 processing of 96×96 pixel images
- To study the use of more individual processor autonomy in processors
- To investigate alternative system architectures, particularly three-dimensional structures having novel connectivity nets.

The procedure to be followed is:

- To devise a new LSI custom chip which can be used at all stages of the project
- To devise a system architecture giving priority to the first two project aims
- To construct small-scale pilot systems for any subsequent machines.

The following specifications were used to guide the design of both system and processor chip.

- Data area: 512×512 pixels
- Data source: 625-line TV camera
- Operating speed: same as CLIP4
- Processor array: 512×4 processors
- Processor: Custom LSI
- Local data store: 16-265 bytes/pixel
400-ns access-time RAM
- Backup data store: 1000 8-bit images
65-ms access-time/image.

The CLIP7 Chip

- Technology: 5- μ m complementary metal oxide semiconductor (CMOS)
- Active devices/chip: 5000
- Die size: 4.5×5.0 mm
- Package: 64 pin
- Clock frequency: 5 MHz
- Power consumption: 0.75 W
- Processors/chip: 1
- Architecture: 16-bit arithmetic logic unit (ALU), multimode shifter, 8-bit parallel data accesses, serial connec-

tion to eight neighbors, 16-bit local condition register, separate local data store.

The first data path section includes a 16-bit ALU having 18 functions (16 Boolean, add, and subtract) operating on two inputs. The first input is derived from a 16-bit shift register. This register has left or right direction of shift, 16-bit arithmetic shift, 16-bit logical shift, and 8-bit logical rotate modes. It also has an external data input, usable in both left and right modes. The second ALU input can be derived from any one of five 16-bit registers. The ALU data output may be put in any of three registers or the bidirectional RAM access port. Data may be input to the system by way of the RAM port or the D (data) register and may be loaded to either the S (shift) or C register.

The other section of the data path is for connections with neighboring processors. Data from the ALU outputs, D register, or the RAM port may be loaded to the 9-bit N-out register. In the planar array of processors data is passed bit-serially to the neighbors, N-in registers. On each chip these registers, a 64-to 8-line multiplexer, and a binary gate form an input matrix. The 8-bit output of the multiplexer and the 1-bit output of the binary gate form two further alternative inputs to the ALU, (Figure 1). The register labelled MDR in the figure stores the direction of the multiplexer control at the time the S register is loaded. The 3-bit output of the register can provide an alternative source for the loading of S, C, D and the RAM port.

The CLIP7 chip may be driven by externally imposed control, or by a combination of external and internal functions. The choice is determined by the state of the "use CC" control pin. All operations of the circuit are synchronous with the 5-MHz clock. Internal control is achieved by the C and MDR registers. The contents of these registers can affect a number of processor operations (details included in Fountain and Duff, 1986).

The CLIP7 System

The CLIP7 system (Figure 2) is primarily arranged to handle a 512×512 by 8-bit image format. Its main components are:

- Host. A high-powered general purpose computer running, under the UNIX system, all necessary user software including editors, assemblers, and compilers.
- Controller. An interface between host processor and microbus and databus,

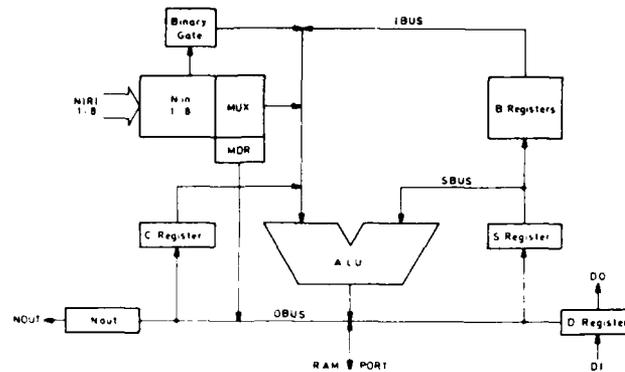


Figure 1. Data paths for the CLIP7 system.

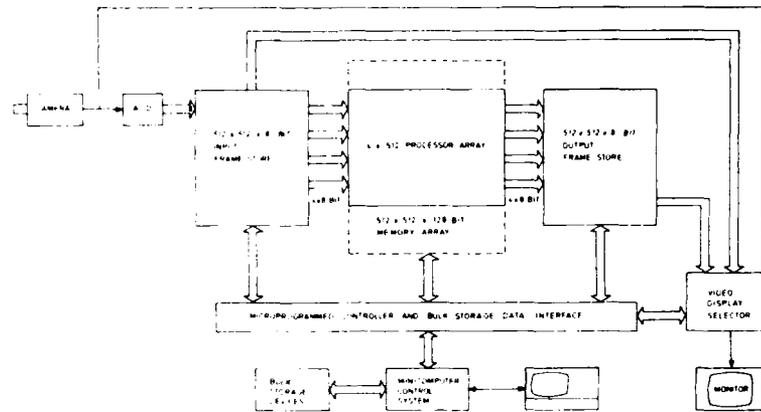


Figure 2. The CLIP7 system.

- allowing microcoded control of all modules interfaced to these buses.
- Databus. A 32-bit tristate bus running at 5 MHz.
 - Microbus. An expandable microcontrol bus having initially 128 lines.
 - Data I/O. A structure including frame-stores, data counters, host/array data interface, and image capture and display facilities.
 - Processor array. An array of 512×4 CLIP7 processors, together with appropriate edge stores permitting scanning of the array in both vertical directions.
 - Local storage array. An array of high-density static RAM's configured as 512×512 by n bytes, where n is between 64 and 1024 depending on the stage of system development.
 - Array gate. An overall gate structure having a variety of functions including overall OR, position of source, send to specific destination, and overall broadcast.

A number of features of CLIP7 described in the following paragraphs give

it much more flexibility than CLIP4, a strictly SIMD machine.

The array consists of a strip of 512×4 processors which may be used to scan the 512×512 pixel data area. The user may determine the size of the data area to be scanned by storing data from every fourth pixel (vertically) in the block of RAM to which each processor has access. In order to perform a given operation over a 512×512 pixel image, each processor must function 128 times. In CLIP7 each pixel of data will be provided with 64 to 1024 bytes of storage (dependent on the state of system development) so that each processor has access to 8- to 128-k bytes of storage. Three points follow from the above arrangement. First, a scan is possible over a smaller, or larger, vertical dimension than the usual 512 pixels and thus to vary the amount of local storage available per pixel. For example, if the chosen scan area is 512×128 pixels, the amount of local storage available per pixel is quadrupled. Second, a block of the RAM available to each processor may be assigned as an overwriteable or reaccessible workspace.

For example, if each pixel normally has available 64 bytes of RAM (8-k bytes per processor) then a workspace of 128 bytes can be assigned to the processor, while the amount of storage available per pixel is reduced to 63 bytes. Third, by manipulation of the RAM addresses both apparent and actual shifting of data in the vertical direction can be achieved at high speed.

The CLIP7 array gate provides an overall OR function of processor outputs, mainly to detect the "array clear" condition. Also, it allows the position of the first (top-leftmost) nonzero array point to be read directly and its data value to be retrieved directly. Also, a value can be passed from the controller to any specified processor in the array. Finally, a constant can be broadcast to all processors in the array simultaneously. During a scan of an image, the array clear/not-clear output can be used to pinpoint (via control registers) those points in the scan where a relevant image property began and ended. Used with the properties of the gate structure, these control registers can yield position information about the array for use in subsequent operations or by the host computer.

The data capture system is a monochrome CCTV running in the interlaced mode (40-ms per full-frame capture time), high-speed 8-bit A/D converter and input framestore. All data transfer in the I/O system is 8-bit data.

Data transfers between array and host are handled by an interface which is another framestore with image size predefined at 512x512 bytes.

The host processor provides the environment for all system software including editors, compilers, and subroutine libraries, with UNIX as the preferred operating system. Programs using standard subroutines are written in image processing C (IPC), and the great majority of CLIP4 programs will run on CLIP7.

The host processor also drives the CLIP7 system by passing appropriate instructions to the CLIP7 control unit and receiving from it status information, data, and interrupts.

The CLIP7 control unit consists of a microprogram sequencer and the microprogrammed controller. The sequencer generates the control signals by sequential access to a large, writable microcode instruction store. The sequencer controller includes a 32-word stack and two 8-bit counters which are used to control microcode loops and may be reconfigured as a simple 16-bit counter.

The system controller is a host computer interface and the generator of the instruction operand-dependent control

signals such as RAM addresses and direction selections. It includes a block of memory of up to 64-k words, sets of array control registers, databus control registers, host interface registers, and a microprogrammable processor which includes 32 registers, an accumulator, a status register, and an ALU.

Because of the scanned nature of CLIP7, the average instruction execution time is relatively long, which allows preprocessing of the instruction queue before execution to be performed without undue overhead. This preprocessing incorporates instruction format verification, including checking the number and type of operands supplied with the instruction, and memory management of the operands if required. Memory management allows virtual addressing of up to a billion segments, where a segment may be of any size from 1 byte to 3.2 bytes.

Comments

Perhaps the main advantage of CLIP7 over its predecessor CLIP4 is the ability of CLIP7 to work with less than the full image in the processing of a large image. Other advantages of the system include the local autonomy of the chip, the ability to easily rotate local connectivity masks, and the flexibility of the addressing modes of the local memory.

The performance of the system in its primary function of manipulating images promises to be good once completed programs have been investigated and exploited. CLIP4 is currently believed to be the fastest image processing system in use. CLIP7 will overcome several significant shortcomings in CLIP4 and may prove to be substantially faster; certainly it will have greater flexibility and versatility.

Reference

Fountain, T., and M.J.B. Duff, *Cellular Logic Image Processing*, (Academic Press Inc: London, 1986).

6/23/87

AUDIBLE SPEECH RECOGNIZER-A BRITISH TECHNOLOGY GROUP PROJECT

by J.F. Blackburn.

Introduction

The British Technology Group (BTG) is a self-financing public organization that licenses new scientific and engineering products to industry and provides finance for the development of new technology.

Project Audible Speech Recogniser (ASR) is devoted to the development of a

low-cost, high-performance speech recognition module with the following specifications:

- The equipment must be speaker trained.
- A 64-word active vocabulary is to be accommodated.
- Continuous speech is to be recognized.
- High recognition accuracy is required.
- Vocabularies must be rapidly transferable through an 8-bit bus.

The project is actually under development by PA Technology under BTG sponsorship. BTG now wishes to commercialize UK Government research in speech recognition. BTG expects to be able to offer a sale price of about \$1000 per unit in an interim development phase in which a board-level design can be used with an IBM personal computer or equivalent. This intermediate phase in development is expected to generate commercial interest, to build market opportunity, and develop applications. BTG will offer licenses to the board design including access to proprietary very large scale integration (VLSI) design.

Algorithms

The algorithms used in the module are based on a process called Hidden Markov Modeling (HMM). The essential feature of this process is that speech is described in terms of a stochastic (conjectural) system and this provides for much improved modeling of the statistical variability of speech, leading to improved recognition performance. The method also offers economy of computing.

The main advance made by PA Technology has been the augmentation of the techniques for isolated word recognition with more powerful techniques to provide continuous speech recognition--that is, without pauses required between words.

Hardware

Figure 1 shows the structure of the recognizer. The front end does the contouring and analysis of the speech signal. The signal is filtered and pre-emphasis is applied. The filtering is followed by 12-bit analog-to-digital conversion and the signal is analyzed by a channel bank filter (Figure 2).

The outputs of the filters are integrated and sampled at the frame rate to provide feature vectors.

When the module is being trained by a speaker, the feature vectors associated with repeated examples of each vocabulary utterance are analyzed and a statistical model is built in Hidden Markov Modeling form. The model is then stored in random

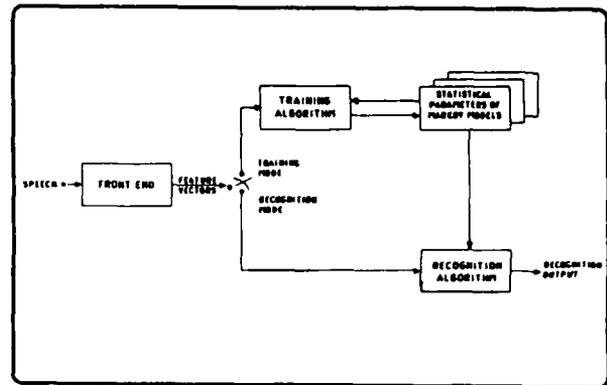


Figure 1. Structure of the speech recognizer.

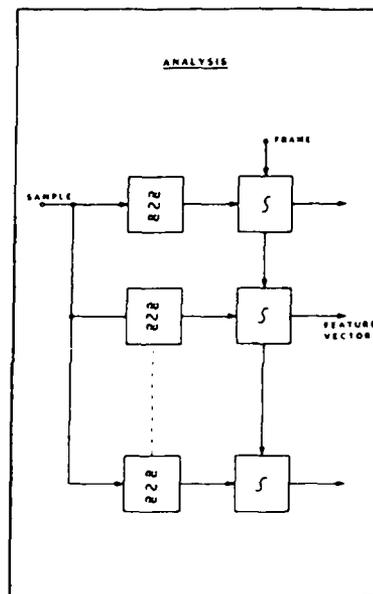


Figure 2. Channel bank filter.

access memory and the process is repeated until the desired vocabulary is trained. Typically each utterance is repeated about six times before the learning is achieved.

During use, the feature vectors of utterances are processed by the recognition algorithm and a measure of likelihood that a given sequence of feature vectors was produced by a given utterance model is generated for every utterance in the complete vocabulary. The most likely is the one selected. The process of generating the likelihood measure is based on the Viturbi pattern matching algorithm, an established mathematical principle. The current implementation is shown in outline in Figure 3.

The key to the computational efficiency of the system is the way in which

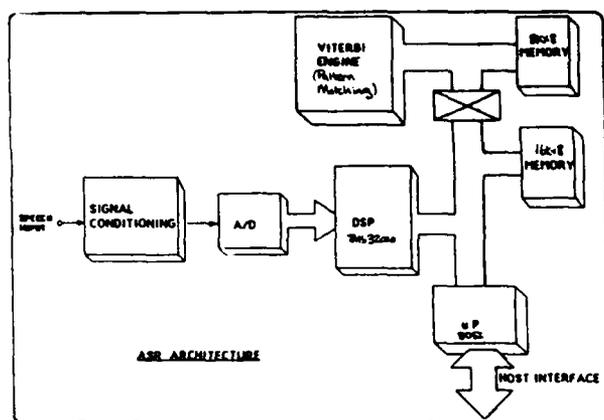


Figure 3. Current implementation of the recognizer.

the three key processors co-operate in the execution of the algorithm, especially during recognition, when the continuous speech feature demands real-time processing. The DSP process (Figure 3) is responsible for generating the feature vectors and a set of distance vectors. The Viterbi engine does the matching using the Viterbi pattern-matching algorithm. The 8052 executive microprocessor completes the recognition process and controls the whole system and interface, as well as carrying out the major part of the training.

Very Large Scale Integration (VLSI)

The use of a dedicated unit, the Viterbi Engine, for pattern matching greatly increases the computational efficiency of the module. The current technology demonstrators use a discrete implementation of the Viterbi Engine, but a VLSI version could be achieved within a gate array of about 3000 gates. The next version of the demonstrator will incorporate an advanced pattern matcher with a number of enhancements to improve recognition performance and expand the ancillary applications for which the device may be used. However, the product will be a modest cell-based or gate array design of the order of 6-10 thousand gates. The devices are expected to be microprogrammable, which will allow improved flexibility and enable further algorithm enhancement.

Comments

Based on the demonstration I saw at BTG it appears that the training process is critical. When a speaker is establishing his dictionary of utterances in the system it is important that his speaking manner and style is consistent.

It is also important that this consistency continue when using the device. Otherwise the system is prone to error.

However, the design of the ASR is such that further enhancements can be readily accommodated as speech research progresses to give improved performance. The design is not unduly constrained by rigidly implemented procedures.

According to the designers the recognizer will offer in the future:

- The capacity for upgrading of current algorithms by installing new versions of software only.
- The potential for use in speaker-independent speech recognition applications by using modified versions of the current speaker-dependent algorithms.
- The potential for use in speaker verification applications by further adaptation of the speech recognition algorithms.

6/23/87

25th IEEE CONFERENCE ON DECISION AND CONTROL

by Daniel J. Collins. Dr. Collins is the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

The 25th IEEE Conference on Decision and Control (CDC) was held in Athens, Greece, from 10 through 12 December 1986. Some 578 papers were organized into 74 technical sessions with 12 sessions running in parallel at any given time. The conference involved authors from 37 countries. It was the first time that this typically American conference has been held in a European country. Showing a difference in style, if not in substance, the American and European concepts of time were combined so that plenary sessions began at 8:00 in the morning and some of the technical sessions finished at 7:30 in the evening.

Some idea of the breath of the conference can be obtained from Figure 1, which lists the titles of the different sessions. It was clearly impossible for me to attend all the sessions and it would, indeed, be difficult to characterize completely the entire conference. While the conference might be looked upon as a

		1	2	3	4	5	6	7	8	9	10	11	12
DAY	TIME ROOM	BALLROOM I	BALLROOM II	BALLROOM III	EPSILON I	EPSILON II	EPSILON III	OMEGA	LAMBDA	VIP LOUNGE	THETA	SIGMA	DELTA
WEDNESDAY	8 30 9 15	BALLROOM PLENARY I—J B CRUZ JR											
	9 45 WA	Robust Control System Design	Modeling and Control of Electrical Machine Systems I	Advanced Robotic Mechanisms	Pole Placement Regulators	Singular Stochastic Control	Distributed Parameter Systems	Stochastic Space-Time Modeling and Estimation	Advances in Nonlinear Control Theory	Distributed Detection and Estimation	Optimal Control and Management Science/Economics Applications	Detection and Identification	Variable Structure Control Systems
	3 30 WP	Robust Control Theory Applications and Future Directions	Modeling and Control of Electrical Machine Systems II	Robust and Sensor-Based Control of Robots	Robust Adaptive Control	Deterministic and Stochastic Optimal Control	Parameterization Problems	Numerical Analysis and Algorithms for Control	Nonlinear Systems I	Open Problems and New Directions in Distributed Computing and Control	Decision and Expert Systems	Aerospace Control	Multivariable Feedback Control
THURSDAY	8 00- 8 45	BALLROOM PLENARY II—J L LIONS											
	9 15 TA	Robustness Analysis Methods	Modeling Issues in Dynamical Systems	Computer Integrated Manufacturing in ESPRIT	Adaptive Control	Decentralized and Hierarchical Control	Time-Delay Systems	Algorithms in Signal Processing and Estimation	Controllability and Observability of Nonlinear Systems	Control of Queueing Systems	Modeling and Control of Macroeconomic Systems	Estimation and Fault Tolerance	Model and Order Reduction
	3 00 TP	Discrete Control	Micro-processor-Based Control	Analysis and Control of Flexible Manipulators	Chaos and Complex Dynamics in Control Systems	Decentralized Control	Large-Scale Power Systems Achievements and Prospects	Intelligent Control Schemes and Systems	Algebraic and Geometric Methods in the Study of System Structure	Design Control and Performance of Communication Networks	Decision Theory and Applications in China Recent Progress	Recent Singular Perturbation Methods in Control	Optimal Periodic Control and Periodic Systems Analysis
	9 15	CONFERENCE BANQUET											
FRIDAY	8 00- 8 45	BALLROOM PLENARY III—E D JENSEN											
	9 15 FA	Control and Stabilization of Systems with Parametric Uncertainty	Universal Coding and Estimation	Applications and Systems Design	Self-Tuning Control	Failure Detection and Isolation	Computational Methods and Discrete Systems	System Identification I	Viscosity Solutions in Optimal Control and Differential Games	Scheduling in Flexible Manufacturing Systems	Decision and Control in Operations Research	Estimation and Tracking	Linear Control
	3 00 FP	H [∞] Methods in Control System Design	Optimization and Mathematical Programming	Robot Modeling and Control	Stochastic Adaptive Control	Mathematical Methods in Systems and Control Theory	Deterministic Optimal Control	System Identification II	Nonlinear Systems II	Access and Routing in Communication Networks	Markov Decision Theory and Its Applications	Multi-Dimensional Systems	Linear Systems and Control

Figure 1. Program schedule.

summary of the state of the art of control theory as of that date, it was, in effect, a series of simultaneous, specialized conferences. This is particularly evident if one considers the vertical columns (simultaneous sessions) in Figure 1. Thus the first column (with the possible exception of the session on discrete control on each of the days) becomes a conference in which about 37 papers devoted to robustness and H^∞ methods were given. In the second column there were 16 papers on modeling and control, while in the third column there were 37 papers, essentially devoted to robotic mechanisms, manipulators, and controllers. Column 8 represents 4 half-days on nonlinear control and nonlinear systems which comprised 36 papers. This method of viewing the conference is convenient but it can also be misleading since papers on nonlinear control, robotics, modeling, etc, are also contained in other sessions scattered through the proceedings. Never-

theless I am going to use this vertical format as a vehicle for highlighting the European contributions to the conference. The American contributions to the conference were clearly substantial and in some areas dominate but I expect that this work will appear later in publications in the US.

Robustness and H^∞ Methods

Of the 37 papers on robustness and H^∞ methods (many of which I attended) only 10 were from European countries and of these, six were from the UK. Other countries represented were China, Australia, and Canada, but in sheer weight of numbers the American contribution (21) dominated this area of the conference. Modern robustness analysis is a reasonably complex mathematical subject so there were several papers of a tutorial nature which outlined problem areas and past progress. P. Dorato (University of New Mexico, Albuquerque) gave an

interesting historical review of recent results in robust control. While M.G. Safonov (University of Southern California, Los Angeles) discussed further directions in L_∞ robust control with a brief survey of the state of the art and its shortcomings.

Applications

The European contributions can be roughly divided into two groups. In the first group, H^∞ or robustness design methods were applied to some complex but practical controller designs. The second group of papers examined special problems from a more strictly mathematical viewpoint and developed bounds and existence theorems. In the first group, I. Postlethwaite and coworkers (University of Oxford, UK) reported on the application of H^∞ optimization design to industrial controllers. In their short paper, the case of a full-authority flight control of a high-performance helicopter was investigated. Essentially the analysis was directed at determining the usefulness of H^∞ design for industrial application. The full program of investigation will include pitch axis control of an unstable aircraft, package boiler control, and reactor and powerplant control. The report on the helicopter analysis contained brief comments on the design procedure, the helicopter control problem, and the controller design. Response curves for vertical and lateral motion were given. The final controller had 59 states as compared to 22 for the plant plus weights. The authors stated that the controller could be reduced to 18 states. They further concluded that the H^∞ approach provided a good design for a complex plant. In this type of analysis, comparisons with a classical design, which would have considerably fewer states, might be most helpful.

J.H. Xu and M. Mansour (Swiss Federal Institute of Technology), in perhaps one of the more interesting papers, presented a new synthesis method for the design of H^∞ single-input single-output (SISO) robust controllers which optimize the excess stability margin and ensure asymptotic regulation and disturbance rejection. Xu and Mansour proposed a new technique of "jw-axis shifting," in which there are no constraints on the poles and zeros of the plant. Two simple problems were solved to show the advantages of the technique. Current work is directed at the extension of the technique to multi-input multioutput (MIMO) systems.

M.R. Katebi, M.J. Grimble and J. Byrne (University of Strathclyde, Glasgow, UK) considered the disturbance rejection robustness of LQG controllers applied to fin stabilization of ship

rolling motion. A discrete model with the usual cost function was considered but the weighting functions were permitted to be dynamical. This permits the introduction of integral action and the modification of the robustness of the design in different frequency domains. The technique is a good candidate for self-tuning applications. For SISO systems a trial and error procedure is used in shaping the sensitivity plots. The paper's detailed analysis of the fin-stabilized ship was most helpful in illustrating the technique.

The Mathematical Aspects

In the second group of papers, which were perhaps of a more mathematical nature than the first, that by K. Glover, J. Lam, and J.R. Partington (Cambridge University, UK) was of fundamental importance. Consideration was given to balanced realization and Hankel-norm approximation of systems involving delays. Approximation of the transfer function $G(s) e^{-st}$ was obtained by means of the singular values σ_i of its Hankel operator. It was shown how to calculate the σ_i and the corresponding Schmidt vectors for this class of transfer functions.

The aim of the paper by D.J.N. Limebeer and G. Halikias was to analyze the effect of pole-zero cancelations in H^∞ problems of the second kind (characterized by one of the off-diagonal blocks of P_{12} or P_{21} being nonsquare). This is an extension of some previous work to be reported in the *Siam Journal of Control*. It was shown that if the McMillan degree of $P(s)$ is n then there is always an H^∞ -optimal controller of degree no more than $2n-1$. The authors also believe that the analysis might yield insight for the improving of H^∞ software.

D.H. Owens and G.S. Hong (University of Strathclyde and University of Sheffield) developed frequency domain stability conditions for a Smith Predictor-like control scheme for multirate sampled data control schemes using a contraction mapping theorem in l_2 .

The paper by D.P. Goodal and E.P. Ryan (University of Gloucester and University of Bath) dealt with controlled differential inclusions and stabilization of uncertain systems.

The papers I have not discussed developed theorems and the necessary and sufficient conditions related to robustness stability. It is clear from the foregoing that the principal actors on the European scene in the area of robustness (as far as this conference is concerned) are in the UK.

Nonlinear Controls

In the nonlinear controls area (column 8 of Figure 1), out of the total of

36 papers only 11 were from the US while 24 were of European origin. This essentially reverses the ordering observed in the area of robustness. There was a relatively large contribution from Italy in the nonlinear mechanics aspects. Most of the papers in the nonlinear sessions were from mathematics or informatics departments. Few of the presentations concerned actual control problems dealing with applications. The main concern was the mathematical characterization of certain classes of nonlinearities.

The remarks by M. Fliess (Laboratoire des Signaux et Systemes, Plateau du Moulon, France) on the invertibility of nonlinear systems was an outline of the contents, with some modifications, of two of his papers in *Systems and Control Letters*. He solved the long-standing problem of the inverting of a nonlinear input-output system by employing differential algebra. This results in a simple characterization of left and right invertibility. The invertibility rests on an invariant integer which, in the case of constant linear systems, is the rank of the transfer matrix. For control-linear systems he presented an algorithm for calculating this integer.

In another paper, Fliess showed the fruitfulness of this approach by using difference algebra to develop an observability canonical form for a discrete-time nonlinear system. From this development it is straightforward to show how to reconstruct the state from the output and control. The viewpoint is also valid for continuous time systems but requires the derivatives of the output, which are difficult to measure. In this latter case one is led to an asymptotic observer, the theory of which is presently being considered by Fliess. Fliess further indicated that the analysis has some interesting implications on the decoupling of nonlinear control systems.

Using differential geometric methods, Nijmeijer and W. Respondek (Twente University of Technology, the Netherlands) determined in an analytic fashion whether or not one can achieve input-output decoupling of a nonlinear system by means of dynamic precompensation. For a two-input and two-output system, necessary and sufficient conditions can be formulated and proved geometrically. A helpful example of this latter system was given.

A. Isidori et al., in a paper published while he was a visiting professor at Arizona State (permanent address: University of Rome, "La Sapienza"), considered a sufficient condition for full linearization via dynamic feedback. Any square invertible nonlinear system whose inverse is "state-free" can be turned

into a controllable and observable fully linear system by means of dynamic-state feedback and coordinate transformations. A system inverse is considered state-free if the input at time t can be expressed as a function of the output at time t and a finite number of its derivatives. It is worthwhile here to go into some detail with this paper since it was an excellent presentation and illustrated the general type of paper published at the conference in the nonlinear area. The basic nonlinear system is:

$$\begin{aligned}\dot{x} &= f(x) + g(x)u \\ y &= h(x)\end{aligned}$$

Where x is the state, u the control, and y the output; $f(x)$, $g(x)$, and $h(x)$ are nonlinear functions.

The system is considered to have the same number of inputs and outputs.

By means of a dynamic-state feedback compensator, given by:

$$\begin{aligned}\dot{\xi} &= a(\xi, x) + b(\xi, x)v \\ u &= c(\xi, x) + d(\xi, x)v\end{aligned}$$

and with a coordinate transformation

$$z = g(\xi, x)$$

One then obtains the final fully linear system given in the standard form as:

$$\begin{aligned}\dot{z} &= Az + Bv \\ y &= Cz\end{aligned}$$

The basic problem with this decoupling procedure is to identify those systems in which one does not induce unobservable parts. The paper went on to show that the correct systems to consider are those with "state-free" inverses. The paper also contained a helpful example illustrating the technique.

Robotics

Another area in which there was a strong European representation was that of robotics. This correlates with many of my visits to control institutes in Europe where I have found strong interest in this field. There were 37 papers in the robotics area (column three, Figure 1) of which 18 were from Europe and 12 from America. Several of the papers considered robots with flexible arms, and there were a series of papers devoted to the development of software used in the control and coordination of robotic machines.

Modeling

The last topic that I will cover is that of the modeling issues in dynamic

systems. In particular, I would like to point out the work of two individuals. L. Ljung (Linköping University, Sweden) discussed how to build models that for prescribed constraints are of optimal quality. For a broad class of identification methods in the predictive error family, the optimal choice of the design variables can be given in an explicit form. His discussion was limited to linear models and focused on the design variables that are available for the estimation of the transfer function. He made use of some recently developed asymptotic expressions for the bias and variance of the transfer function.

In a short paper, J.C. Willems (Mathematics Institute, Groningen, the Netherlands) outlined the main points of an extensive series of papers that are appearing in *Automatica*. The approach is not stochastic and consists of defining a complexity level space, C, and another space, E, which is called the misfit level space. Mappings of the model set M onto C and of the measurement set Z onto the misfit space are included in the procedure for approximating the modeling. Intuitively one desires a model of low complexity and of small misfit. With Willems' formal framework it is possible to define modeling with maximal tolerated misfit modeling, with maximal admissible complexity, and exact modeling. Willems further developed conditions for determining the optimal approximate modeling. This paper cast a sharp light on the interesting contrast between the stochastic and the deterministic approach to modeling.

Summary

There is no doubt that the 25th CDC conference reflected the state of the art in control and decision theory. It was an excellent meeting although perhaps too inclusive. The conference proceedings, which comprises three volumes weighing 5.3 kg, are available. Copies may be ordered from the IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

6/15/87

ARTIFICIAL INTELLIGENCE AT LISBON'S UNIVERSIDADE NOVA

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Re-

search's London Branch Office. He is on assignment until September 1988.

Introduction

The 2-year old building of the Information Science Department of the Science and Technology Faculty, Universidade Nova ("New University" of Lisbon, founded in 1972) at Quinta da Torre--some 15 km Southwest of Lisbon on the Atlantic Coast--houses two fine groups working in the area of artificial intelligence (AI). They are: the group of Logic-Programming and Artificial Intelligence (Director: Professor M. Pereira) and the Robotics group (Director: Professor A. Steiger-Garção). Both groups share extensive and dedicated basic computing facilities which include several VAX computers, a Zilog system, VAX work stations (including CAD/CAM, graphic facilities), about a dozen Sperry PC's, 10 Mackintosh Plus PC's (all these integrated by an Ethernet network), and several laser printers. About 50 percent of the fiscal support for the AI work comes from the university, which puts high priority on this research; the rest is sponsored, amongst others, by the Ministry of Industry and Energy, the National Board of Scientific and Technological Research, the National Institute for Scientific Research, the Luso-American Foundation for Development, and the European ESPRIT program. A special feature of external support by means of "in kind" mechanisms is the consortium-membership of the groups in various computer-company support systems, including Apple, Digital, Westinghouse, and Unisys. I found the AI activities well balanced, well supported, and the scientists confident of the future. A summary follows.

The Logic-Programming and AI Group

This group, now consisting of about 20 members (including several research students and even a few undergraduates), began activities in 1978. Its main activities have been in the area of logic programming and development of advanced software tools for AI. Overwhelming emphasis is given to basic research and integration of different projects into a dynamical environment of tools and systems. Yet, an eye is kept on short-term practical applications also. The reputation of the group is reflected by the fact that it is editing the *Logic Programming Newsletter*, the official newsletter of the worldwide Association for Logic Programming. It also organized two international workshops in Portugal. Current research areas are as follows:

Extended Logic Programming Language and Environment. Work is directed toward

a set of suitable extensions of current computational models, so as to accommodate for concurrency and distributed execution. In addition, a powerful programming environment is explored that will allow for fast prototyping and for programming through extensions of the environment. In particular, the full-blown logic programming environment will include a generic browser, a generic text editor, static and dynamics modules, type-handling facilities, debuggers, and graphical interfaces.

Distributed Knowledge Bases. Expedient creation, maintenance, and query of knowledge bases, distributed across several different computers is the project's goal. The definition and an intermediate semantic representation-language for expressing knowledge inside a system, suitable for relevant operations on that knowledge, has already progressed to an advanced stage. Also, a deduction mechanism for extracting answers to queries in not only an efficient but also in a flexible way, is under development. (This mechanism uses types and prototypes.)

Natural Language Interfaces. A translator is being built that translates natural language to the intermediate representation language (developed in the preceding project). This translator has a modular structure which supports different languages (presently: Portuguese and English), it deals separately with syntax and semantics, and it separates general semantics from application-dependent semantics. It can handle not only queries but also assertions and imperatives. Another subproject consists in the construction of a translator from the internal representation to natural language, sharing the characteristics of the just described translator. In addition, a module is being built that can handle sustained coherent dialogues. It will feature mixed initiative, interruptibility, and maintenance of context and focus of attention. Finally, good progress has already been made in the development of a menu-driven/free-typing graphical interface for easing the tasks of developing (and of learning to use) a particular natural language system.

Improved Diagnosis and Explanations in Prolog. This project (which the researchers call "Rational Methodology") will lead quickly to a high-power logic-program debugger. More ambitious is the subproject leading to a general fault-finder. Given a simulator of any artifact, the fault-finder will conduct a "testing agent" to find faults in the artifact. It will be a special program debugger, where the program being debugged is the simulator of the artifact. It will incorporate domain-independent

fault-finding strategies; powerful facilities for modeling artifacts, allowing the use of logic grammars and subprograms in other programming languages; and it will envisage integration with CAD. Expert heuristics and learning from experience will be accommodated in the fault-finder. It will also lead to the automatic generation of troubleshooting manuals, and it will be able to explain its testing decisions and diagnostic conclusions. Finally, a third subproject is aimed at constructing a general explanation toolkit, consisting of program interpreters which are used by the fault-finder.

The Robotics Group

This unit is a very interdisciplinary enterprise. Apart from other groups in the Informatics Department, it uses experts from the Department of Mechanics and even from the Department of Applied Social Sciences. It "feeds" into UNINOVA, the Portuguese Institute for the Development of New Technologies, which is a joint venture of the Universidade Nova's Faculty of Science and Technology, several governmental organizations, and about 25 private companies.

The Robotics Group has about 30 members. While it has some hardware facilities and equipment, 80 percent of its activities are in the AI area.

Current research may be characterized as follows:

- Sensors and perception (integrated sensorial models combining visual, tactile, acoustic, etc. inputs; knowledge-based perception; laser metrology; integration of perception with CAD/CAM)
- Autonomous decision making (task level programming; general architecture, planners, execution supervision, knowledge architecture; explicit programming; simulation)
- Distributed systems (multiprocessor architecture; communications module for a distributed system)
- Intelligent manipulator (conception and development of a knowledge-based hydraulic manipulator; development of a conveyor; compliance systems)
- Social implications (conditions and social circumstances for introducing robotics into industry; evaluation of social effects of robotization).

Concluding Remarks

Even though I am not an expert in AI, I found both the breadth and depth of the work done at the two AI groups of the Informatics Department quite remarkable. I noted the large proportion of gifted, sincere, disciplined, and confident young

scientists in both groups I visited. Unlike some groups in AI that I have visited, these people were not out to "sell their line". I did not meet at this institution the customary overpowering jargon of AI. I listened with much respect to the self-critical views of the scientists who, despite their dynamic involvement, still find it appropriate to question the validity and the directions currently taken by AI work. In fact, they seemed to be worried that an "overselling" is in the making that might discredit AI, as it already did in the 1960's.

8/24/87

Material Sciences

AN EXCITING MEETING OF THE DIELECTRICS SOCIETY

by Robert W. Vest. Dr. Vest is the Liaison Scientist for Electronic Ceramics and Materials in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave from Purdue University, where he is Turner Professor of Engineering in the School of Materials Engineering and in the School of Electrical Engineering.

Introduction

The 1987 meeting of the Dielectrics Society was held 7 through 9 April at Queens College-University of Cambridge, UK, and was attended by 75 scientists from 16 countries. The theme for this year's meeting was dielectric behavior in ordered systems with special reference to ferroelectric and related phenomena. There were four invited, 17 contributed, and 22 poster papers presented, and these can be divided into three main subject areas: relaxor ferroelectrics; other inorganic ferroelectrics; and ferroelectric polymers. A proceedings will be published, hopefully in 1987, as a special issue of the journal, *Ferroelectrics*. However, some of the invited speakers (e.g., Cross and Gunter) did not intend to submit manuscripts, and eight additional papers had not been turned in at the close of the conference. I will give a brief review of highlights from selected papers in the three general areas covered by the conference, starting with

one of the most exciting events I have ever seen at a technical conference.

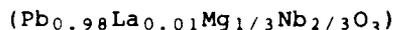
Relaxor Ferroelectrics

In the first paper of the conference, Professor L.E. Cross (Pennsylvania State University) reviewed the research from his laboratory over the last several years on the dielectric behavior of complex relaxor ferroelectrics, such as PMN ($\text{PbMg}_{1/3}\text{Nb}_{2/3}\text{O}_3$), BSN ($\text{Ba}_x\text{Sr}_{1-x}\text{Nb}_2\text{O}_6$), and PST ($\text{PbSc}_{1/3}\text{Ta}_{2/3}\text{O}_3$). These are materials that show an interesting combination of ferroelectric properties with strong dielectric dispersion at low frequencies. Professor Cross suggested a model in which the local heterogeneity in cation distribution gives rise to local variations in the ferroelectric Curie temperature and thus to a range of temperatures over which nanoscale (10-20 nm) polar regions coexist with the high permittivity paraelectric phase. In the second paper, Dr. C.A. Randall (University of Essex, UK) discussed microstructure studies of several relaxor materials including PST using a cold-stage transmission electron microscope. He found that annealing PST increased the translational symmetry by ordering the B-site cations to give an F-centered $2a_0 \times 2a_0 \times 2a_0$ superlattice. By imaging with an F-type superlattice diffraction spot, he revealed the presence of polar microdomains in ferroelectric PST within the "normal" ferroelectric macrodomains. Annealing the samples increased the size of the domains from ~20 nm to 100 nm. The nature and size of the domains observed in Randall's experimental study were identical to those predicted by Cross to account for his dielectric measurements. This was the first time I have ever seen a theory proposed in one technical paper and confirmed by experimental results presented in the following paper when the two were from different laboratories in different countries and working independently of each other.

The relaxor ferroelectrics are extremely interesting from both a theoretical and applications point of view. They have very high dielectric constants but show cubic symmetry to x-rays and exhibit no birefringence. The spontaneous polarization (P_s) does not decrease sharply at the Curie temperature (T_c), but rather decreases slowly over a temperature range and finally goes to zero at T_c . However, Cross presented results of thermal expansion and optical refractive index measurements over a wide temperature range for several relaxor compositions that showed the occurrence of large values of RMS polarization ($\overline{P_s^2}$)^{1/2} persisting to temperatures well above T_c . Cross also presented new results with the lead

barium niobates ($\text{Pb}_x\text{Ba}_{1-x}\text{Nb}_2\text{O}_6$), which are ferroelectrics with the tungsten bronze structure. For compositions on either side of the morphotropic boundary between orthorhombic and tetragonal ferroelectric phases, different components of the dielectric constant showed strong dispersion at low temperatures. He proposed an explanation for these phenomena which again invoked differences between local and global symmetry in these relaxor compositions. It will be interesting to see how long before this prediction is also confirmed by direct microstructure observations.

Dr. R. W. Whatmore (Plessey Research Caswell, UK) discussed the use of the relaxor PMN as the sensing material for thermal IR detectors. Some of the advantages of PMN over more traditional ferroelectrics (e.g., modified $\text{PbZr}_x\text{Ti}_{1-x}\text{O}_3$) is the ease with which the Curie temperature can be adjusted; T_c can be increased by additions of PbTiO_3 and decreased by additions La_2O_3 . Certain compositions gave pyroelectric coefficients which were two to four times higher than the more normal pyroelectric materials. One composition of particular interest was dubbed PLOIMN:



A theoretical study of dielectric dispersion and lattice dynamics was reported by Dr. M.D. Fontana (University of Metz, France). His goal was to explain the strong frequency dependence of the dielectric permittivity in various relaxors where large discrepancies are found between the permittivity calculated from phonon frequencies via the Lyddane-Sachs-Teller relation and experimental data at lower frequencies. Fontana showed that for a strongly anharmonic lattice, the Lyddane-Sachs-Teller relation is always valid, but the critical (soft) phonon frequency is no longer the pole of the imaginary part of the dielectric constant. Using this approach he showed reasonable agreement between theory and experiment in the low-frequency spectrum.

Dr. T.R. Shrout (Pennsylvania State University) reported studies on the effect of grain size on properties of PMN. For samples with grain sizes from 1-8 μm , he found large variations but no direct correlation between the magnitude of the dielectric constant at the Curie temperature and grain size. However, when he calculated the diffuseness of the transformation in the different grain size PMN samples, he found that there was no grain size dependence for samples with the same diffuseness. The diffuseness is determined from the slope of a plot of the dielectric susceptibility versus the square of the temperature.

Other Inorganic Ferroelectrics

Dr. Peter Gunter (ETH Hönggerberg, Switzerland) gave an excellent review paper of nonlinear optical effects in photorefractive crystals and their applications in phase conjugate optics, image processing, and real-time holography, but did not present any theoretical or experimental studies which had not previously been published. Gunter did, however, conclude his review paper by stating his opinion of the principal needs in the field. These are: (1) the growth of high-purity homogeneous crystals with large electro-optic coefficients and high photoconductivity; (2) identification of the photorefractive centers in these crystals; (3) determination of the influence of oxidation-reduction processes on the nonlinear optic effects; and (4) the development of new materials for the IR and UV portions of the spectrum.

Dr. G. Arlt (Aachen Technical University, West Germany) gave an excellent review of the role of domain walls on the properties of ferroelectric ceramics, and then presented new results from his laboratory in two poster papers. His current work is primarily aimed at determining the influence of various dopants on the dielectric properties of $\text{PbZr}_x\text{Ti}_{1-x}\text{O}_3$ (PZT) and BaTiO_3 ceramics. His results showed that BaTiO_3 ceramics with small additions of chromium had a strong time-dependent internal bias, which he described as a domain stabilizing volume effect and interpreted its time-dependent behavior as a relaxing orientation of dipoles consisting of chromium ions on titanium sites and oxygen vacancies. His research on the pinning of domain wall motion in PZT by various dopants was interpreted on a phenomenological model based on a vibrating domain wall in an electric and mechanic stress field. This allowed him to separate the 90° domain wall contributions from the total effects. The model holds for the dielectric, piezoelectric, and elastic constants if losses other than domain wall motion are negligible.

Ceramics with a very nonuniform polarization distribution in the direction parallel to the polar axis were discussed by Dr. Sidney Lang (Ben-Gurion University of the Negev, Israel). PZT ceramics with a large Zr/Ti ratio and a high Sn content were poled under a variety of conditions to produce deliberately nonuniform polarization distributions, and the laser intensity modulation method (LIMM) was used to determine the distribution. It was found that the presence of space charge leaves a permanent record of the sign of the original poling field (relative to ground potential). The results presented were preliminary ones from an ongoing

study, but L IMM was shown to be a powerful technique to determine polarization distribution in a quantitative and non-destructive manner.

A new concept in the use of ferroelectrics for IR detection was discussed by Dr. R. H. Whatmore (Plessey Research Caswell, UK). If the ferroelectric material is used in the region of T_c with an applied electrical bias field to generate and maintain an electric displacement (D), the strong temperature dependence of the dielectric constant creates a corresponding change in D which appears as an induced pyroelectric effect. The application of this effect in "dielectric bolometer" IR detectors using PMN or BST was very promising. The materials gave results indicative of a high induced polarization, a low dielectric loss, and a high pyroelectric coefficient. This approach is quite interesting for IR detection.

Ferroelectric Polymers

There were eight oral presentations and eight poster papers dealing with ferroelectric polymers, which is an indication of the high level of interest in these materials. However, this reporter does not feel qualified to comment on the technical aspects of the work presented. Most of the papers dealt with poly(vinylidene fluoride) [PVDF] or copolymers of PVDF with tetrafluoroethylene or similar materials. It was interesting that during an extensive discussion among researchers in the field, their conclusion was that PVDF is unique. It consists of a polar crystalline phase in an amorphous phase above the glass transition temperature at room temperature, a situation which gives a very high compliance. Secondly, the polar phase gives the material a reasonably high dielectric constant. These properties which make PVDF attractive for applications such as sonar transducers are not known in any other system, and the synthetic organic chemists in the audience felt it unlikely that any other similar system could be produced.

A fascinating new method for poling PVDF was discussed by Dr. G.M. Sessler (Technical University Darmstadt, West Germany). He used an electron beam to implant a space charge region within a film of PVDF, and the location of the space charge region could be varied by varying the beam energy. This internal space charge region produced poling in the region of the PVDF film between it and the bottom electrode while leaving the region above the space charge non-polarized. This resulted in a film with monomorph characteristics, that is, $e_{33}=0$ in the region penetrated by electrons and large e_{33} values in the nonirradiated

region. Such structures have never been produced in inorganic piezoelectric materials.

Summary

This relatively small meeting of the Dielectrics Society attracted some of the top research scientists from around the world, and provided a very stimulating forum for discussion of new developments both theoretical and experimental; it was just the right size. By far the most exciting part of the conference was the experimental confirmation by Randell from the UK of the predictions of Cross from the US concerning microdomains in relaxor ferroelectrics.

There were extensive discussions concerning why some ferroelectric materials age while others do not; a multitude of possibilities were suggested but no consensus was arrived at. This is an area that still needs extensive basic research and many new ideas were generated at this meeting. All in all, it was an extremely successful conference.

6/24/87

RESEARCH ON THICK FILM HYBRIDS IN ITALY (TELETTRA, MARELLI, AND THE UNIVERSITY OF MODENA)

by Robert W. Vest.

Introduction

The microelectronics industry has been one of the leaders of the rapid economic growth in Italy during the past several years. I had the opportunity to visit two of the major industrial laboratories (Marelli Autronica, and Telettra) and the leading university (Modena) involved in research on thick film hybrid microelectronics. Italy was host of the most recent biannual European Hybrid Microelectronics Conference, which was held in Stresa in May 1985. Four of the seven members of the steering committee which organized that highly successful conference were from the three locations I visited in April, 1987.

Telettra Telecomunicazioni

Telettra, the Fiat Group company operating in the telecommunication systems sector, has achieved a leading position on the international market with two-thirds of its production sold to more than 60 different countries outside of Italy. From 20 plants located all over the world, Telettra had 1986 sales of

near \$500 million, which represents an increase by a factor of more than two during the last 3 years. From their total staff of 8,000 people 5,000 are in Italy and half of those are at the Vimercate facility near Milan.

The Components and Technology Division has activities in printed circuit boards, CAD/CAM, materials analysis, surface acoustic wave and quartz resonators, gallium arsenide microwave components, and optoelectronic devices in addition to hybrid circuits and packaging, which were the two areas that the research and development people I visited were involved in. I presented a seminar to this group on some of our basic research at Purdue on microstructure development in thick film resistors, and the scientists and engineers that attended the seminar showed intense interest--there were 2 hours of questions after I completed the seminar. Dr. Salvatore Iannazzo, Research and Development Manager of the Components and Technology Division, explained that his scientists are extremely interested in fundamental research on thick films, but that they get very little opportunity to do such work because business is so good that urgent development projects consume all of their time. He is trying to hire more people so that his researchers can undertake more long-range projects.

The only long-range project underway at the present time is a study by G. Castelli and G. Lovati of the integration of polymer thick films (PTF) with printed circuit board (PCB) technology. Polymer thick films have been widely used for several years in low-cost consumer electronics, but the technology has not been extended to the high-reliability circuits needed for telecommunications. The mature PCB technology leads to circuits with low track resistance, good solderability, and good insulation, but suffers by comparison to thin and thick film hybrids in circuit density and reliability. The purpose of this research program is to determine if some combination of PTF and PCB technologies can be beneficial for any circuits required in the telecommunications field. All of the PTF inks that they are using are proprietary formulations but they do say what the general nature of them is. For example, the conductive PTF's are phenolic based, that is, thermosetting polymers which cross-link when the solvent is removed during the curing step; the functional phase (e.g., silver) ends up within the cross-linked polymeric binder. The dielectric PTF's are epoxy based.

The PTF conductive films were found to have a resistance about 40 times higher than that of the electrolytic copper

used in PCB's. This high resistance places a lower limit on the widths of conductor lines for a given current carrying-capacity and must be taken into account in the design rules. The design rules for line width and line spacings of PTF were found to be essentially the same as the traditional rules of thick film technology. The contact resistance between the PTF conductor and the PCB copper was found to be sufficiently low provided that there was a minimum of 0.5 mm overlap. When studying printed-through-holes, it was determined that the average resistance of the hole was quite low (about 4 mohm) and remained stable after 100 thermal shocks. This good performance was shown to be a consequence of the compatibility of the substrate and the PTF conductive material; both were polymers and had similar coefficients of thermal expansion.

The dielectric PTF's evaluated had dielectric constants of about 5, which was good, but the loss factors, which were not good, varied from 1-10 percent depending upon the epoxy base of the formulation. The environmental stability of the PTF dielectrics was found to be rather good: the insulation resistance generally remained above 10^{11} ohm and the dielectric constants were unchanged after the 85°C/85-percent relative humidity test, and the loss factors were either unchanged or improved after 1000 hours of the 85/85 conditions.

At this point in their research, the PTF technology looks rather attractive although the materials costs are high. Even with the present materials costs, the PTF/PCB combination is economical during the prototyping and development steps as an engineering aid, and in production for low-cost, low interconnection density multilayers. The real impact of this approach is anticipated when solderable copper conductive pastes and reliable resistive pastes are developed for PTF.

Marelli Autronica

The Magneti Marelli Group of 17 companies covers all areas of the automobile components market. The group is organized into six sectors, one of which is Electronics, where Marelli Autronica is responsible for the development and production of components for engine and mechanical electronic control. With 1986 sales of approximately \$50 million, Marelli, at their production facility in Pavia, is the largest manufacturer of thick film hybrid microcircuits in Italy. They anticipate that their sales of electronic engine control systems and sensors will double within the next 2-3 years because they believe that by 1992 all of

Europe will have automobile pollution requirements similar to the 1983 United States standards.

Of the 550 employees, 155 are engaged in research and development, and their Pavia laboratories are very well equipped. The five major R&D projects currently underway are:

1. Surface Mount Technology. Marelli is suspicious of surface mount technology (SMT) because they question whether or not they can maintain the reliability required in the hostile environment of under-the-hood electronics, but the potential economic considerations of computer-controlled manufacturing with SMT are sufficiently great that this technology is being seriously evaluated.

2. Copper Thick Film Technology. They are not currently producing any copper thick film hybrids, but they have a group conducting research in this area because they foresee that the requirements for high-speed circuits may require switching to copper.

3. Die Bonding. Marelli does not have a silicon foundry, and they are currently buying their chips with pads bonded on. They do not foresee producing their own silicon chips, but they would like to develop their capabilities for die bonding so that they have more flexibility in how the chips are mounted on different hybrids.

4. Wire Bonding. Bond pads on the thick film conductors are used on all of the hybrids currently in production when it is required to bond wires either from a chip or to a package terminal. For economic reasons they would like to eliminate the bond pads because they require additional printing and firing steps during production.

- 5 Sensors. This is Marelli's main research area and will be discussed in some detail.

The major emphasis of the research is on pressure sensors. Two of the products currently being produced at the Pavia facility are thick film pressure sensors, one with a range of 0-2 bar and the other with a range of 0-200 bar. The thick film pressure gauge is based on the piezoresistive response (relative change of resistance, $\Delta R/R$, versus the strain, e , resulting from an applied stress). The sensitivity is characterized in terms of gauge factors ($GF = \Delta R/R/e$) which range in value from 2 to 18 depending on the composition and resistivity of the thick film resistors. One particular feature of thick film resistors, as opposed to either metal or semiconductor strain gauges, is the fact that R increases in tension either if the strain is applied

parallel or perpendicular to the current flow--that is, both longitudinal (GF_l) and transverse (GF_t) gauge factors are positive. The typical difference between GF_l and GF_t is only a few units, suggesting an isotropic electrical transport.

A schematic of the pressure sensor currently in production at Marelli as part of the engine control system is shown in Figure 1. The sensing element is a 96-percent alumina circular edge-clamped diaphragm (thickness, t ; diameter, $2r$) on which four thick film resistors are printed and fired and interconnected in a Wheatstone bridge configuration (Figure 1). Clamping is obtained by glass-ceramic (solder glass) bonding of the disc to an alumina ring (for relative pressure measurements) or to a thick alumina base plate (evacuated for absolute pressure measurements). The strains in the diaphragm assume maximum values (both radial and tangential strains) at the center and (radial strains) at the edges; these maxima are directly proportional to the r/t ratio. Consequently, this latter figure can be varied according to the desired value of full-scale pressure within the known bounds of elastic limit, fracture limit, and fragility of the alumina diaphragm. Following these criteria, capsules with 3- to 4-cm-diameter diaphragms for 1- to 2-bar full-scale ranges are built. The position and orientation of the two resistors near the center and the two at the edges maximize the device sensitivity and take into account the positive value of both the GF_l and GF_t .

Comparing thick film pressure gauges with those based on piezoresistance changes in silicon (e.g., the type made by Delco Electronics and used in all GM cars in the US), the thick film gauges have better thermal stability because they have a lower temperature coefficient of resistance (TCR) and temperature coefficient of gauge factor. This makes the sensor electronics more simple because less temperature compensation is required for the thick film gauge. In addition, the processing is easier for the thick film gauge and the handling of the capsules is easier.

One current research project at Marelli involves studies to produce multi-layer substrate pressure sensors, which should result in higher reliability and lower cost fabrication. Instead of using a solder glass seal as shown in Figure 1, they are fabricating the cells by laminating three layers of prepunched green tape sheets and firing this laminate to produce the required sensor geometry. This research is at the leading edge of what can be accomplished with ceramic

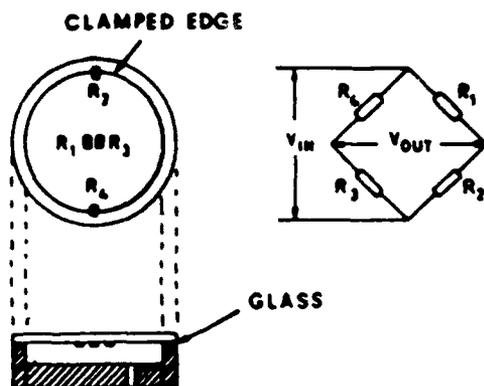


Figure 1. Thick-film pressure gauge.

multilayer technology, because the diaphragm layer must be $100 \pm 10 \mu\text{m}$ and the total thickness of the three layers must be $1 \text{ mm} \pm 50 \mu\text{m}$. At the present time, the four sensing resistors must be printed and fired on top of the diaphragm after the multilayer ceramic has been fired, which limits the design flexibility. It would be desirable in some cases to be able to print the resistors on the bottom of the green tape diaphragm and co-fire them with the ceramics, and this approach is under investigation.

Another major research project related to the present pressure gauge involves studies to increase the gauge factor of the thick film resistors. This work is based on a model recently proposed by Dr. Roberto Del'Acqua of Marelli (Del'Acqua, 1987) in which he assumes that the microstructure of the thick film resistors consists of conducting oxide particles in a glass matrix with three types of behavior: (1) some of the grains are connected by ohmic contacts; (2) other grains have very small contacts and the charge transport is limited by constriction resistance, and (3) some grains are separated from other grains by a very high resistance glass film. He visualizes conduction within this network as a percolation of the electrons always searching for the less resistive path. This model gives the resistivity ρ as a function of temperature T by:

$$\rho = \rho_0 T^{\frac{1}{2}} \exp \left(\frac{T_0}{T} \right)^{\frac{1}{2}} \quad (1)$$

where T_0 is a characteristic temperature which depends of the structure and ρ_0 is a temperature independent constant. The resulting TCR:

$$\text{TCR} = \frac{1}{\rho} \frac{d\rho}{dT} = \frac{1}{2T} \left[1 - \frac{1}{2} \left(\frac{T_0}{T} \right)^{\frac{1}{2}} \right] \quad (2)$$

The TCR becomes 0 at a temperature $T = T_0/16$, being negative at low temperatures and positive at high temperatures. The inversion of the TCR at a temperature around ambient is a typical property of high GF thick film materials. Therefore, the temperature-resistance behavior is the primary screening tool used in searching for new thick film resistor compositions with higher gauge factors.

Yet another research project on thick film pressure sensors is attempting to extend the range to very high pressures--for example, 0-2000 bars--so that they can be used to measure cylinder pressures directly or the pressures in diesel fuel injection systems. This research, under the direction of Dr. Luciano Benini, uses the change in resistance due to the change in volume of a thick film resistor when subjected to an isostatic pressure P . Empirically, they have found that the resistance follows a linear relation:

$$R = R_0(1-cP) \quad (3)$$

For one resistor system ($R_0 = 10 \text{ ohm}$) under study they have shown that Equation 3 holds over the pressure range 0 to 2000 bar with $c = 3 \times 10^{-5} \text{ bar}^{-1}$. The major unsolved problem involves changes in R_0 after extended time at high pressures. So far they have not been able to determine any changes in the microstructure of the thick film resistors that may be responsible for changes in resistance after exposure to very high pressures.

University of Modena

The research group in the Department of Physics, led by Professors Maria Prudenziati and Bruno Morton, has been very active in research on thick films for over 10 years. Most of their early work involved the development of models for charge transport in thick film resistors. Their work through 1983 is summarized in two publications (Prudenziati et al., 1983, and Prudenziati, 1983), the first being a more complete summary whereas the second is more easily accessible. Their basic model considers the electrical conductivity of neighboring grains of metal oxide separated by a glassy layer. The conduction process is assumed to be due to direct tunneling of electrons between particles through the nonideal barrier provided by the intergranular material. Deviations from the ideal condition for tunneling barriers in thick film resistors was assumed to arise from two effects: (1) the small size of the grains which implies that a small but not negligible energy is required to add or remove one electron from these particles, and (2) the presence of impurities and

defects in the intergranular material which act as resonant centers for tunneling processes and affect the transmission probability.

Their model differs from others which had been proposed in the literature in that it completely neglects the resistance of the metal oxide grains in series with the resistance of the barrier, but it explicitly considers the temperature dependence of the barrier widths and barrier heights. They achieved reasonably good agreement between their theoretical equation and various sets of experimental data on temperature dependence of resistance, but their model involves five adjustable parameters. Almost any set of experimental data can be fit to an equation with five adjustable parameters, and this shortcoming has been recognized by the Modena group.

They have stopped work on theoretical modeling and have been concentrating on experimental studies of microstructure in the thick film resistors in order to move toward a more realistic model with fewer adjustable parameters. The shift in emphasis from theoretical to experimental studies was influenced by both scientific and financial considerations. The funding sources available to them in recent years have been those for which the sponsors are interested in practical applications of the research results.

Since 1983 they have broadened their interests in thick film technology to include conductors, and have done some good research on application of aluminum-based inks as back-surface metalization of solar cells (Sardi, et al., 1984), and some basic research on the development of microstructure and its relationship to performance of Pd/Ag thick film conductors (Prudenziati, et al., 1985). Their work with thick film conductors and their previous research on theoretical aspects of thick film resistor transport led them into studies of the interaction of thick film resistors with terminations of various metals. The resistivity was studied as a function of resistor length and temperature, and microstructural studies of the interfacial region between the resistor and conductor were carried out. The results showed (Prudenziati, et al, 1986) that bismuth, a common component in these termination materials, was primarily responsible for the interactions. Bismuth was shown to have a high diffusivity and a high solubility in the glass of the resistor.

In order to expand their data base on thick film resistors for future theoretical modeling research, they have recently undertaken studies of the flicker (1/f) noise in thick film resistors as related to the microstructure. They have

been preparing thick film resistors at different stages of microstructure development by changing the peak firing temperature, and are measuring the power spectral density as a function of frequency, measuring temperature and firing temperature in addition to sheet resistances and TCR's. They found that the microstructure of the films strongly affected the level of flicker noise, but had only a minor influence on the temperature and frequency dependence of the noise. They related the stable temperature and frequency dependence to the exchange of charge carriers with localized states having a broad distribution of energy and whose position remains unchanged while the population and concentration are varied by changing the firing temperature. They related the high level of 1/f noise observed in samples fired below 750°C to the presence of different degrees of oxidation-reduction reactions of the $\text{Bi}_2\text{Ru}_2\text{O}_7$ grains. They suggested that at higher firing temperatures the effects of doping of the glass in the intergranular barrier regions helped the electron transfer and so reduced the current fluctuations, while the partial crystallization of the glass matrix may be in competition by serving as a source of additional scattering of the charge carriers. They found that the conventional firing temperature of 850°C gave the minimum of 1/f noise.

One of the major research thrusts at the present time involves studies related to thick film sensors. Some of this work, particularly research on pressure sensors, grew out of their earlier studies of the strain sensitivity of thick film resistors which was conducted primarily to assist in developing theoretical models for charge transport. The basic research conducted by this group was a major contributing factor to the successful development of the thick film pressure gauge by Marelli Autronica. A review of the present status of their piezoresistive studies with thick film resistors has been recently published (Prudenziati and Morton, 1986).

They are currently studying relationships between firing temperature, microstructure, and gauge factor. The gauge factor of typical thick film resistors will change by 50 percent as the firing temperature is varied from 700 to 950°C. They have determined that a low gauge factor is always associated with a stable resistor, but that resistors having a high gauge factor may or may not be stable. The origins of this puzzling behavior is under investigation. Another part of this study currently in progress involves measurements of the sheet resistance as a function of firing

temperature. They have determined that as the firing temperature increases, the room temperature sheet resistance decreases, passes through a minimum, increases to a maximum, and then decreases to a more or less stable value for the highest firing temperatures. Attempts to correlate this electrical behavior with the microstructure of the resistors at the different firing temperatures are currently underway.

The group at Modena started research 10 years ago on thick film resistors from a physicist's point of view, and developed very elaborate mathematical models based on extremely simple physical models. They have since come to realize that thick films are very complex systems, and that simple physical models (e.g., a single tunneling barrier between grains of conducting oxide in a thick film resistor) cannot be representative of the very complex structures that have been observed experimentally. They are currently taking a much more realistic approach; that is, they are becoming more like engineers than physicists. They still hope to return to the theoretical modeling when they have developed a sufficient level of understanding of the structure of the materials being modeled. Whether or not this happens remains to be seen, but the current direction of their research is helping to build the data base that is required if the problem is ever to be reduced to a quantitative model which incorporates theory compatible with all experimental observations.

Summary

The Italians have been able to develop a workable relationship to utilize fundamental research in the universities and applied research and development in the industrial laboratories, and this has led to a number of thick film hybrid microcircuits currently in production. They are now building on this success, and more interactions between industry and the universities are evolving. Many more technical papers in the hybrid field are coauthored by industrial and university personnel in Italy than is true in the US. This cooperation has helped the hybrid industry in Italy to become the equal of that in the US in most areas, and more advanced in some, e.g., thick film sensors. They are currently challenging not only the US but also Japan and the rest of Western Europe in hybrid microelectronics.

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6/24/87

Mechanics

AERODYNAMICS AND HYDRODYNAMICS RESEARCH IN ROME

by Eugene F. Brown. Dr. Brown is the Liaison Scientist for Fluid Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1987 from the Virginia Polytechnic Institute and State University, where he is a Professor of Mechanical Engineering.

Introduction

During a recent visit to Rome I had the opportunity to discuss aerodynamics research activities in the Department of Mechanics and Aeronautics at the University of Rome and hydrodynamics research at INSEAN, the National Institute for Naval Architecture which, although supported by the Ministry of Defense, has important connections with the University of Rome.

University of Rome

The University of Rome is the largest university in Italy, with more than 150,000 students. This enormous enrollment is a direct result of Italy's open admission policy in which any student either from Italy or abroad possessing a high school diploma is accepted. There are no entrance examinations nor is there any attempt to balance the enrollment between the various departments at the university.

The process of consolidation from institutes into departments which has been taking place over the past few years at Italian universities is virtually complete at the University of Rome. The Department of Mechanics and Aeronautics was formed approximately 5 years ago and resulted from a consolidation of the separate institutes of Applied Mechanics, Turbomachinery, Propulsion, and Aeronautics. My host during my visit to the department was Professor F. Sabetta, who heads the fluid mechanics activities, which account for approximately 15 staff, including six full professors, four associate professors, and five researchers.

The department has a local UNIVAC system and is on the IBM network, which allows them to connect with the Italian National Science Foundation (CNR) computers in Bologna. These facilities are augmented by an AT/370 microcomputer which emulates the IBM 4381 which, in turn, serves as the front end for the CRAY 1 in Bologna. This allows them to debug their CRAY-destined programs locally as well as to do local pre- and post-processing.

As at the University of Bari and the Polytechnic Institute of Turin, work has recently been done on Moretti's lambda formulation (see following article). A particularly interesting piece of work is the application of the lambda formulation to two-dimensional, nonequilibrium, chemically reacting flows. In these calculations (Letini and Onofri, 1987), a novel approach is used in which the dependent variables can be considered as an extension of the concept of the Riemann variables to chemically reacting flows. The computational efficiency of this scheme results from the realization that the energy and species concentration equations can be solved independently from the equations for the bi-characteristics. For additional computational economy, the species continuity equations are solved in their steady form by an implicit scheme in order to overcome the numerical stiffness inherent in the equations. Using an 8-step reaction model, the problem of hydrogen/oxygen combustion in the throat of a convergent-divergent nozzle was solved. Approximately 60 time-steps

were required in order to get a converged solution. The results appear to be reasonable; however, no comparison with experimental data was made.

Work is also being done on the solution of the vorticity/velocity formulation of the Navier-Stokes equations. In a report by Guj and Stella (1986), an alternating direction implicit (ADI) calculation of a driven cavity and a backward facing step problem are described. Although good agreement was shown with other numerical studies of the driven cavity problem, the calculations predict a separation region larger than that experimentally observed. This appeared to be a systematic error independent of the value of the Reynolds number. The results for the backward facing step problem agreed much better with the experiment. The position and dimension of the primary and secondary reattachment regions were both well predicted by the calculations.

For the calculation of problems where there is a significant distortion of the free surface, the use of the boundary element equation (Greens function) method has been explored. Using this technique, both the steady and unsteady Navier-Stokes equations have been solved for thermocapillary flows with special application to microgravity conditions. In a related study, using the Greens function method in expanding the velocity potentials in a series of Legendre polynomials, another microgravity problem has been solved, namely that of the free vibrations of a drop in partial contact with a solid support (Strani and Sabetta, 1984).

As experimental activities in fluid mechanics seemed to be a bit of a rarity in southern Italy I was pleased to come across what appeared to be some first-rate laser Doppler anemometry (LDA) work in Sabetta's fluid mechanics laboratory. Not having a specially close connection with the department's theoretical and computational activities it nevertheless included some interesting applications. Experiments on two-phase flows seemed to be a topic of great interest, and the laboratory has developed their own phase-sensitive particle sizing and velocity measuring equipment. Experiments have centered on the use of particle sizes between 50 and 200 microns in diameter. During my visit, particles of a single diameter were being pulled back and forth across the laser beam with a pneumatically controlled driving mechanism to verify the capabilities of their bidirectional velocity measuring system. Although the group constructed the hardware themselves, they are using a data reduction program based on a locally modified version of commercial LDA software. In

addition to studying the flow of solid particles in water, they have done one- and two-component LDA studies of cascade flows using hydrogen bubbles as the seeding medium, measurements in particulate and liquid sprays, and are planning on doing speckle velocimetry studies with a high-power laser system and automatic image processing system which they have recently purchased.

Of direct Navy interest is the investigation of the flow in the wake of a ship's propeller. The experiments were conducted in the Italian Navy's $0.6 \times 0.6 \text{ m}^2$ water tunnel. Using a two-channel reference beam LDA system and a phase sampling procedure, the flow in the near wake was measured with particular attention given to the vortex sheet developed at the trailing edge of the blades, the sudden increment in the axial velocity present in the core of the tip vortex, and the propeller shaft boundary layer (Cenedese et al., 1985).

The abundance of high-quality instrumentation which I saw in the laboratory is a good indication of the generous level of support which fluid mechanics activities are receiving in southern Italy.

INSEAN

Hydrodynamic testing and research are the focus of the National Institute for Naval Architecture (INSEAN) which was founded in 1927. My host during my visit was Dr. U. Bulgarelli. Dr. Bulgarelli is a member of a small team of researchers which has recently been added to the institute to provide a computational capability to what had previously been a ship testing facility. Dr. Bulgarelli's interests, which are in the area of boundary element methods for free-surface problems and vector potential methods, should provide a very useful nucleus around which such an expertise can be developed. The current slump in the shipping business has brought about a sharp reduction in the requirements for traditional ship resistance, sea-keeping, and propeller wake testing, and Dr. Bulgarelli's activities are part of a multimillion dollar effort on the part of the Italian government to diversify the institute. The near-term computational objectives include the development of a boundary element solution for rudder wakes including a three-dimensional calculation of the deformation of the surface.

The intention is clearly to develop a computational capability on a par with the institute's quite impressive experimental facilities. These facilities include a 500-m-long, 14-m-wide, 7-m-deep towing tank with a 15-m/s carriage; a 200-m-long, 9-m-wide, 4-m-deep towing

basin with a 10-m/s carriage and wave generating facilities; and a free-surface water channel with a 10-m-long, $3.6 \times 3.2 \text{ m}^2$ test section where the pressure as low as 25 millibars can be created at speeds between 0.5 and 5 m/s. Both towing basins are equipped with a 256-channel data acquisition system in which data is transmitted from the carriage to a VAX 11/750 in the control room by means of a laser down-link, which was developed and built in their exceptionally well-equipped electronics laboratory. At the time of my visit, a 5-m-long submarine model was being mounted in a horizontal position on a sting in the large towing tank for wake measurements which were to be made with a rotatable Pitot rake located in the submarine tail.

New instrumentation is being planned for the water channel. This includes the purchase of an \$800 million (\$600,000) three-dimensional LDV system with immersible fiber optics and the purchase of sound measuring equipment so that studies of appendage and propeller noise can be made. At present, studies are being conducted in the tunnel with borrowed equipment in order to assess the level of the background noise.

Conclusion

The strength of the fluid mechanics research programs at the University of Rome (aside from INSEAN) appeared to be in the theoretical and computational rather than the experimental areas. The faculty members whom I met were young and energetic and had access through various in-house dedicated computers and a well-developed networking system to computer centers throughout Italy as well as in the US.

Several of the faculty members with whom I spoke indicated to me that their research activities suffered from the fact that Italy lacks a Ph.D. program. This means that in contrast with other European nations, where the existence of nationally recognized Ph.D. programs produces large numbers of well-trained people available to assist faculty members in carrying out their research programs, in Italy the number of such individuals is very limited. This contributes to the current dilemma in which plentiful funds are available to carry out the research but not enough people are available to do the work. To some extent this problem may be addressed by the new Ph.D. program which has been introduced. There are some signs, however, that it may take many years before such a program is firmly established and the value of the degree becomes appreciated in both academic and industrial circles. If it is successful it will greatly increase the numbers of

scientific staff with advanced research training, and will greatly benefit Italy's currently understaffed fluid mechanics research activities.

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4/10/87

ITALIAN CONTRIBUTIONS TO THE LAMBDA FORMULATION

by Eugene F. Brown.

The lambda formulation was developed by Professor Gino Moretti at the Brooklyn Polytechnic Institute (US) in the mid-1970's (Moretti, 1979) as an alternative to conventional finite difference methods or the solution of the Euler equations, the equations of inviscid compressible flow. Members of the faculty of the Institute of Turbomachinery and Energetics at the University of Bari and the Department of Aeronautical and Space Engineering at the Polytechnic Institute of Turin in Italy worked with Professor Moretti in the US in the 1970's and carried back to Italy an interest in conducting further research on the use of the lambda formulation.

The University of Bari

Recently, I visited the Institute of Turbomachinery and Energetics in Bari, a city of approximately 500,000 located approximately 200 miles southeast of Naples on the Adriatic coast.

The Institute of Turbomachinery and Energetics was founded (approximately 30 years ago) at the same time as the Department of Mechanical Engineering, in which the faculty of the Institute do their teaching. The University, founded around the turn of the century, has grown to the third largest in southern Italy after Rome and Naples and presently has a student population of approximately 50,000.

My host during my visit was Professor M. Napolitano, who has been a member of the faculty since 1973. Napolitano, who received his Ph.D. from the University of Cincinnati, like several of his colleagues with whom I spoke, has excellent research connections in the US. For example, this year he spent the spring quarter in the Department of Aerospace and Ocean Engineering at the Virginia Polytechnic Institute and State University in Blacksburg, Virginia, and he has spent varying lengths of time at the University of Cincinnati, the Flight Dynamics Laboratory of the Wright Patterson Air Force Base, the Research Center for Scientific Computation at Yale University, and the Institute for Computer Applications in Science and Engineering (ICASE) at NASA-Langley.

At Bari, and in all of Italy, doctoral candidates in engineering play no role in university research programs since, until this year, the Ph.D. was not granted. After their first engineering degree--a nominal 5-year program, but on the average amounting to 7½ years (allowing for 1 year of military service)--students are granted the degree of Doctorate in Engineering and either leave the university to pursue a career in industry or seek one of the relatively few university research assistant positions. This year the first graduates were produced from an experimental Ph.D. program; however, such matters as the composition of the national examining committee, the marketability of the candidates, and even the year in which the diplomas will be conferred remains uncertain. With so much left undecided, the Ph.D. program must be regarded as *highly* experimental. In addition, the stipends from the Ph.D. program have been set at a low level relative to those for industrial and academic positions. This is not a strong incentive for students to enter the program. Considering all these factors, doctoral candidates in engineering are unlikely to play an important role in the engineering

research programs of Italian universities for some time to come.

The Institute's vigorous and extensive computational fluid dynamics CFD research program is carried out by four professors and two research assistants whose activities are largely supported by grants from the Italian National Research Council (CNR) and the Ministry of Education (MPI). Napolitano reported that funds to support the Institute's activities are plentiful and reasonably easy to obtain.

Most of the calculations are performed on a dedicated HP9000 minicomputer purchased with CNR and MPI funds. For computations requiring more speed than offered by the HP9000, time on a Cray 1 in Bologna is available through the CNR.

Recent Lambda Method Improvements.

Work on the lambda-scheme is being conducted by Napolitano and Professor Dadone, who worked with Moretti in the 1970's. Separately and in collaboration they have been responsible (along with their colleagues at the Politechnic Istituto of Turin) for significant contributions to the method.

Although the classical lambda methodology uses characteristics-type variables and thus enjoys the intrinsic accuracy and robustness of the classical method of characteristics, it is a non-conservative formulation and thus special localized treatments must be introduced in regions where shocks appear. Shock capturing and shock fitting are two methods for overcoming this difficulty. However, until recently, unresolved problems arose in their application.

In the case of shock capturing, a failure to properly simulate the response to variations in the free-stream conditions was observed. To overcome this problem, Dadone and Magi (1986), introduced a quasi-conservative lambda formulation. In this approach, terms borrowed from flux vector methods were introduced in order to restore the correct subsonic/supersonic coupling in regions where embedded shocks occur.

The difficulty with using shock-fitting is that the final shock position is subject to small oscillations and very small time steps are required in the vicinity of the shock in order to stabilize the calculations. Although many would regard the reduced time steps as being an acceptable procedure for engineering purposes, Dadone regarded it as a sign of inherent incompatibility in the shock fitting procedure. In yet unpublished work, Dadone discovered that a stable shock position could be produced if an extrapolation procedure using several upstream points was used to establish the

shock conditions (instead of using only the conditions at the point immediately preceding the shock), and if, in addition, sonic conditions were enforced at the shock tip. Dadone expressed considerable satisfaction in having at last produced a rigorously satisfactory shock fitting procedure. In fact he has been so impressed with his experience with the two-dimensional calculations which he has made that he plans to abandon his previous quasi-conservative shock capturing technique and use the new shock fitting procedure in all of his subsequent work. This includes the development of a three dimensional transonic code which he hopes to begin in the next few months.

Another improvement was the introduction of implicit integration methods which allow for faster convergence to steady state. The integration scheme employs a first-order upwind difference and has the important feature that second-order accuracy is recovered at steady state. This is a result of the manner of which the right-hand-side of the governing equations is differenced and a result of the use of the Beam-Warming (δ) formulation of the problem. Both alternating direction implicit (ADI) and line Gauss-Seidel numerical integration schemes have been used. Further information can be found in Dadone and Napolitano (1985) and Fortunato and Napolitano (1986).

The Perturbative Lambda Approach.

Dadone found that increased accuracy in stagnation point flows could be obtained if the incompressible solutions were used as the computational grid for solving compressible flow problems (Dadone and Napolitano, 1985). In addition, perturbation variables amounting to the differences between the usual characteristic (Riemann) variables and those corresponding to incompressible flow were used. In this way the geometry-induced gradients are accounted for by the incompressible flow solution, and corrections due to the compressibility can be accurately accounted for, even with a very coarse mesh.

Using a combination of the quasi-conservative and perturbative lambda approaches Dadone (1986) performed calculations for the transonic flow over a circular cylinder, a NACA 0012 airfoil, and a Korn airfoil. In his attempt to simulate the flow over a circular cylinder at a Mach number of 0.5, the results showed, much to Dadone's surprise, an unresolvable unsteadiness when the flow over the entire cylinder was calculated. (This contrasts with previous calculations which Dadone had made for the half-cylinder in which a steady result was produced.) Many numerical experiments

convinced Dadone that this unsteadiness is produced by round-off errors which initially appear as a mild asymmetry in the position of the shock wave on the bottom and top of the cylinder. Eventually this asymmetry becomes amplified by the feedback mechanism provided by the region of separated flow downstream of the shock until the large-scale unsteadiness discovered in the calculations is produced. Dadone believes that such unsteadiness is an inherent feature of *all* inviscid separated flow problems whether the results are obtained by computation or experiment.

For some time now, Napolitano has been involved in the development of procedures for solving the Navier-Stokes equations for laminar incompressible flow. He uses the velocity-stream function formulation in generalized curvilinear coordinates and a discretization procedure similar to that used for the lambda formulation in which second order accuracy is recovered at convergence. To solve the resulting algebraic equations, Napolitano at first employed an alternating direction implicit (ADI) technique; however, some subsequent experience with the calculation of two-dimensional natural convection problems seemed to suggest that improved results could be expected if a block-line Gauss-Seidel (LGS) method were used instead (Napolitano and Quartapelle, 1985). Consequently, in all of his subsequent work Napolitano has used the LGS procedure. The advantages of the LGS method are clearly demonstrated in Napolitano and Walters (1986), in which calculations in an expanding channel are shown at Reynolds numbers as high as 10^{15} . (In contrast, when the ADI approach was used, Napolitano found that the convergence of the calculations deteriorated rapidly for Reynolds numbers greater than 100 and for Reynolds numbers greater than 10^4 a solution could not be obtained.) In addition, for the 10^{15} Reynolds number case the final time step was as high as 10^{21} , which provides convincing demonstration of the unconditional stability of the method.

Napolitano's most recent work involves the implementation of a multigrid strategy to his LGS Navier-Stokes solver. The results were somewhat mixed. For low Reynolds number problems the multigrid strategy performed well; however, at higher Reynolds numbers the extrapolation, based on minimum residual concepts which had been found to provide beneficial results at lower Reynolds numbers, actually retarded the convergence. In addition, some difficulties were encountered for highly stretched grids. Obviously, for high Reynolds numbers and

for highly nonuniform grids more work remains to be done.

The Polytechnic Institute of Turin

Work on the lambda formulation is also being carried out at the University of Turin. The work, centered in the Department of Aeronautical and Space Engineering, is being conducted by Professor M. Pandolfi and Professor L. Zannetti. Professor Pandolfi, who served as my host during my visit, worked with Professor Moretti in 1970-71, as did Professor Zannetti a short time later. Their work on the lambda formulation is well coordinated with that at the University of Bari, and, in fact, Napolitano and Pandolfi have written a number of papers together. Some interesting new applications of the lambda formulation being pursued by Pandolfi include the solution of supersonic flow over cones at high angles of attack and the solution of hypersonic blunt-body reentry flows.

Pandolfi's approach to the supersonic cone calculations, unlike his more recent hypersonic flow work, employs the steady form of the Euler equations rather than the time-dependent (unsteady) form, and thus the solution is marched in space rather than in time. In these calculations Pandolfi uses shock fitting to handle the bow shock and shock capturing (based on flux difference splitting and not unlike the quasi-conservative approach used by Dadone) to handle the cross-flow shock on the surface of the cone. Unlike Dadone, however, Pandolfi is convinced that shock fitting procedures are only practical in regions (such as the bow shock) where the flow is geometrically simple. By using the nonconservative lambda formulation in regions of smooth flow and conservative flux difference splitting to capture the shocks, Pandolfi believes he has combined the best features of both methods--the lambda scheme offers simple, fast, and reliable results in the region of smooth flow while flux difference splitting offers accurate and sharp resolution of shocks where discontinuities appear.

The geometry which Pandolfi is using corresponds with that previously studied by Marconi (1984) and consists of a 10-degree cone at a Mach number of 2.0. The calculations, although carried out on a relatively coarse (36×72) grid, show a surprising richness of detail (see Figure 1). As the incidence increases from zero to 10, and eventually to 25 degrees, a spiral vortex appears on the leeward side of the cone--a vortex produced by the cross-flow shock which gradually grows and eventually engulfs the entropy singularity. Pandolfi is justifiably proud of his results and regards their

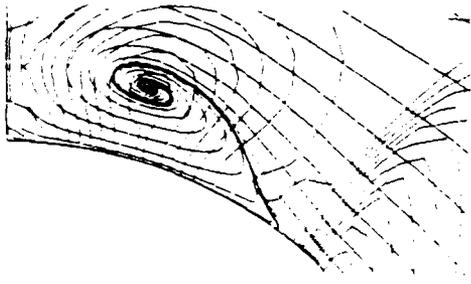


Figure 1. Details of the streamline pattern of the flow over a 10° cone at 25° incidence at a Mach number of 2.0.

excellent agreement with Marconi's results (obtained by using shock fitting) as providing conclusive validation of his technique.

Hypersonic Calculations. Pandolfi's work in the hypersonics area is only 6 months old and is being done with support provided by Avions Marcel Dassault/Bréguet Aviation (AMD/BA), which has the aerodynamic design responsibility for HERMES, the European earth orbiter. The work is also connected with various related activities being undertaken in the context of EUREKA, the European high-technology research initiative.

Pandolfi is attempting to simulate hypersonic flow about a bluff body under atmospheric reentry conditions. AMD/BA is particularly interested in the influence which the reactive nature of the flow will have on the geometry and position of the bow shock. For these calculations Pandolfi uses the unsteady form of the lambda method and is in the process of calculating Mach 20 flow about a sphere with a 5-species chemistry model borrowed from the work of Rakich (Rakich et al., 1982). Special problems arise in the vicinity of shocks where, despite the conditions in the remainder of the flow, a nonequilibrium situation is present. Extremely fine grids are required in order to provide sufficient resolution in the shock region if standard shock capturing methods are used. Pandolfi has discovered, however, that if the chemistry is handled in the spirit of a shock fitting procedure that the mesh spacing requirements can be considerably relaxed. This, however, requires an a priori assessment of the extent of the reaction which occurs in the shock. To aid in making such an assessment, he has developed a one-dimensional shock-wave simulation from which, for various Mach numbers and pressures, he has obtained information on the extent of the reaction which

can be expected. This, in turn, he introduces in tabular form into his bluff body calculations. Quite properly, Pandolfi interprets this as a generalization of the shock fitting procedure in which the Rankine-Hugoniot relationships are supplemented by the nonequilibrium chemical conditions provided by the tabular reaction data.

In regions away from the shock where equilibrium chemical conditions exist, Pandolfi has introduced an implicit formulation of the lambda scheme to accelerate the convergence of the calculations. This avoids the so-called "stiffness" problem which arises because of the shortness of the chemical time scales compared with the convective time scales. During my visit he was in the process of completing his calculations for a 200 K static temperature test case. It is difficult to judge the accuracy of such calculations, however. Much of the atmospheric reentry data is classified and therefore Pandolfi has little experimental data with which to compare his calculations.

Unlike Napolitano at the University of Bari, Pandolfi receives only a small portion of his funding from the Italian government. Most of his research is funded through industrial contracts. He has extremely good contacts with the gas turbine division of FIAT for which he has performed transonic turbomachinery calculations for a number of years and with Aeritalia, the Italian aircraft manufacturer. In addition he receives funding through AMD/BA as a consequence of Italy's support of the HERMES project and funds from EUREKA through its AEROTAP supersonic and hypersonic commercial transport program. Pandolfi said that industrial support, particularly Italian industrial support, of engineering research activities in Italy was a welcome change from what had in the past appeared to be a preference for buying its technology abroad.

He made the interesting comment that whenever possible he makes use of his research funding to support international travel by the members of his research team. He said that travel was his single most important research expenditure. Without such travel, he claimed, he and his colleagues would be cut off in a competitive sense from the rest of the world in less than 6 months!

Conclusion

An important CFD tool at the University of Bari and the Politecnico Institute of Turin is the lambda method originally devised by Professor Moretti. Both research groups have made important contributions which have extended the

application and improved the accuracy of this interesting computational method. Each group has found adequate sources of financial support, although the industrial connections of the Politecnico Institute of Turin appear to be a bit better than those in Bari, undoubtedly due in great measure to the fact that the center of the Italian aerospace industry is much closer to Turin than it is to Bari. Each group has close scientific connections with the rest of Europe and the US. Among the projects now underway which should be of interest to the US fluid mechanics community are the improvement in the use of the lambda scheme for multidimensional, shock-containing flows and the use of the lambda scheme for hypersonic reentry problems.

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7/06/87

FLUID MECHANICS SECTION, IMPERIAL COLLEGE LONDON

by Professor S.N.B. Murthy and Eugene F. Brown. Professor Murthy is a professor in the Thermal Sciences and Propulsion Center of the School of Mechanical Engineering at Purdue University in West Lafayette, Indiana. He has been an active researcher in the field of combustion for many years and has been involved in many European collaborative research activities.

The Fluid Mechanics Section of the Department of Mechanical Engineering of Imperial College, London, is headed by Professor James H. Whitelaw. On Whitelaw's staff are: Drs. M.M. Gibson, A.D. Gossman, F.C. Lockwood, J.J. McQuirk, and A.M.K. Taylor of the Mechanical Engineering Department, and W.P. Jones of the Chemical Engineering Department. The staff is complemented by several postdoctoral fellows, graduate students, and computer assistants.

Whitelaw's research support comes from the Science and Engineering Research Council, various industrial organizations in the UK, Europe, Africa, and the US, and also various US government agencies, notably the DOD and NASA. In addition, at the present time two staff members are heavily involved in research work sponsored by Rolls Royce plc. Whitelaw and his group are extremely prolific, and the results of their research appear in many contractor reports, journal articles, meeting papers, and invited contributions each year.

Broadly, the interest of Whitelaw's group is in applied fluid dynamics of internal flows, including flows with heat transfer, combustion, and multiphase content, and in basic research topics arising in the context of applied problems. The research topics may be divided into experimental studies including development of diagnostic and measurement tools, generation of benchmark-quality data sets, computational studies, and code development.

The members of Whitelaw's staff seem to participate in different projects under their own initiative and expertise

and are largely responsible for their own technical activities. This is evident in the section's publication record. Considering the reports written in 1985 and 1986, over half have been without Whitelaw as an author. Thus Whitelaw has been successful in building the group, holding it together functionally and financially, and providing a reasonably free environment for independent research. The projects in which Whitelaw has had a direct involvement are internal combustion engines, gas turbines, furnaces, pumps, internal ballistics, and two-phase flow studies. The studies generally involve experiments in internal fluid dynamics and aero-thermo-chemical interactions.

Research Activities

Whitelaw's work in laser velocimetry is well known through his books and publications. Whitelaw's laser velocimetry work has involved engine studies in a steady flow rig and in a single-cylinder engine in which Freon-12 injection was used to simulate the presence of fuel. In these experiments the differences between the results obtained in steady flow rigs and engines were explored.

During the past 3 years Professor Paul A. Libby of the University of California, San Diego (UCSD), La Jolla, California, has been visiting Professor Whitelaw's laboratory for short periods of time. One of the outcomes of this collaboration has been a general assessment of work on premixed combustion, which they, along with S. Sivasegaram, have published in *Progress In Energy and Combustion Science*, 2 (1986). It is a noteworthy summary of available experimental information and models, with some comparisons and projections for the future.

Among the three classes of premixed combustion problems Whitelaw and his colleagues have examined are bluff body stabilized flames in open and confined surroundings. These studies have shed some light on the production of Reynolds stresses, the recirculating mass flow, and the size of the recirculation zone for different forebody shapes and blockage area ratios. This work has been extended to study the correlations of the fluctuations of velocity and temperature in premixed flames. Velocity measurements have been obtained with laser Doppler velocimetry, and temperature measurements have been obtained with digitally compensated bare-wire thermocouples (manufactured from 15- μ platinum and platinum-rhodium wire with a frequency response of a few hundred Hz.) Considerable ingenuity was obviously required to obtain an adequate number of simultaneous samples of velocity and temperature in

order to generate the required moments. In addition to their use in developing and validating various models for premixed combustion calculations, the experiments have been used to examine seeding, thermocouple size, and sampling time requirements for reliable data collection.

For some years, Whitelaw has been engaged in research related to gun barrel wear under support of US Army Research Office. As a part of that study, in-bore velocity measurements have been obtained in the wake of a subsonic, compressed-gas-propelled projectile. Different projectile velocities were used and the wake investigated in each case using laser Doppler anemometry. Measurements have been made as close as 0.5 mm from the tube wall. It is surmised that the boundary layer thickness in the 76.7-mm-diameter tube is of the order of 1.0 mm for a range of centerline velocity values of 2.0 to 15.0 m/s. Velocity fluctuations in the core are found to be larger than those in the boundary layer. It remains to be seen how far these data are of significance in the actual two-phase reactive flow in a gun barrel.

A project that has been carried out over the past 2 or 3 years relates to the occurrence and suppression of oscillations in confined, disk-stabilized flames; the research is being supported by the Office of Naval Research. The vortex shedding frequency of the disk is an important parameter; however, Whitelaw and his associates have concentrated on the duct oscillations, taking into consideration the role of shedding in stable and unstable combustion. In a series of investigations with a straight pipe, a sudden contraction and a smooth contraction with and without baffles, the effect of an upstream contraction or orifice and a downstream resonator section have been examined. The instabilities in a disk-stabilized flame case are found to exist in a small frequency range around 200 Hz and to exhibit coupling with the acoustic oscillations in only a small range of equivalence ratios. The studies provided little information on the shed structures and on their dynamics, however. In addition the central question pertaining to the relation between coherence, if any, in the shed structures, and the enhancement of mixing and the occurrence of duct flow oscillations does not appear to have been resolved. Similar studies have been conducted on the influence of geometric parameters and equivalence ratios on oscillatory behavior of dump combustors under premixed conditions.

Under NASA Lewis sponsorship experimental and modeling studies have been conducted over the past few years on various curved flows. The work has proved

of substantial value at the design level and shown the importance of further investigations on phenomenology associated with the generation of secondary flows and three-dimensional separation in internal flows.

Conclusion

The section is very active in low-speed, high Reynolds number internal flow dynamics with heat transfer and combustion. Other than laser Doppler velocimetry, most of the measurement techniques are conventional, but great ingenuity has been evident in combining and processing data. The research work has been well recognized as in the best traditions of applied thermofluid mechanics.

6/3/87

UNSTEADY FLOWS AND TURBULENCE AT IMFL

by Daniel G. Collins. Dr. Collins is the Principal Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

The Institut de Mécanique des Fluides de Lille (IMFL) has a distinguished history which goes back to 1930. The institute has close connections with the Centre d'Etudes et de Recherches (CERT) in Toulouse and was indeed located there for a while. At present the institute is part of the French research institute ONERA but is semi-independent with its own director. About 37 of the 120 employees are at the professional level and, in addition, there are typically 5 to 10 students working on their theses. There are four operational groups: mechanics of flight, mechanics of structures, aerodynamics, and industrial fluid mechanics (see ESN 40-7:239-24 [1986] for a report on turbulence research at IMFL). My principal host for the visit was Dr. R. Verbrugge, who is head of the mechanics of flight group. I talked to people from each of the other groups except for the one concerned with structures. Verbrugge, in a review of the institutional activities, indicated that about 53 percent of IMFL's work is in applied research, 31 percent in fundamental research, and 16 percent in technical

assistance. A further breakdown in terms of group effort would be about 30 percent mechanics of flight, 30 percent mechanics of structures, 19 percent aerodynamics, and 13 percent industrial fluid mechanics.

Aerodynamics Group

Dr. A. Dymont is the head of the Aerodynamics Group and has also a half-time appointment to the University of Lille. There are seven engineers in the group and three students working on their theses. I had the opportunity to review the recent (November 1986) doctoral thesis by F. Beluche. The study is somewhat classical in that it deals with measurements and calculation of the hydrodynamic wake of a cylinder at right angles to a uniform flow. A vertical water tunnel was used in the experiment and the Reynolds number varied from 140 to 500. Along with detailed flow visualization, the velocity field was determined using both point laser Doppler anemometry (LDA) measurements and particle image velocimetry (PIV).

These measurements are further compared with numerical calculation at a Reynolds number of 210. The work, which is a thesis of high quality and which uses the latest measurement techniques, is a good example of how some fundamental research is being done at IMFL. The application of three-dimensional holographic technique or PIV has been further reported by IMFL's M. Stanislas, who was a member of Beluche's doctoral committee (Stanislas et. al, 1986). Copies of the thesis may be obtained by writing M. Stanislas at IMFL.

The principal emphasis of the fundamental research in the Aerodynamics Group is on unsteady detached flows and on turbulent detached flows. One of the problems that they have recently investigated is that of a flow field produced by an oscillating spoiler. Different aspects of the spoiler problem have become more or less a test case in Europe, and I have found researchers in Denmark and Greece also working on spoilers. Theoretical Navier-Stokes calculations of transonic turbulent boundary layers have been reported on (Degrez and Vandromme, 1985). Further work is reported on turbulence modeling in compressible flow, and some of the current in-process effort is concerned with the structure of wall turbulence.

In the experimental area the group has developed some very effective techniques for determining the structure of an unsteady flow field. One of these techniques uses a 24-spark camera capable of microsecond timing. Thus, with a

single firing of a rifle one can obtain a complete characterization of the muzzle exit flow field. A series of pictures obtained from the camera can generate a better understanding of a time-varying physical phenomena. They have done some cooperative work with the French-German Institute at St. Louis (ISL) using the camera on weapons-firing and have also investigated the effect of weapons-firing on aircraft inlets. Another flow field visualization technique that the group uses is a pulsed ruby laser in order to obtain ultra-high-speed smoke visualization of unsteady flows. The laser light is formed into a laser sheet so that a two-dimensional plane of the flow is illuminated. This approach is quite successful in revealing coherent structure in turbulent flows. The laser light-sheet technique is presently being used in a fundamental doctoral study on the structure of wall turbulence and its development. I was impressed by the fine details revealed by the laser-sheet photos.

Additional facilities available to the group consist of a small supersonic tunnel and a small transonic tunnel, in which some transonic wake reduction studies and drag reduction studies were being conducted when I saw it. Small modification of the boattail of a shell can result in 25- to 50-percent reduction in the transonic drag. This is perhaps not too surprising since the flow is nonlinear. The tunnels are not adequate for reasonable scale flow studies but I do not believe that this is a handicap for IFML since it is a part of ONERA, which has excellent wind tunnel facilities. In addition, on many of the projects IMFL is cooperating or has liaison with other laboratories and industries. Thus, on the inlet problem it is working with Centre d'Essais Aéronautiques de Toulouse (CEAT), Société Nationale d'Etude et Construction de Moteurs d'Aviation (SNECMA), and Avion Marcel Dassault (AMD). Further liaison is maintained with Aerospatiale, ISL, and Etablissement Technique de Bourges (ETBS).

Industrial Fluid Mechanics Group

Mr. P. Bailleux is the head of the Industrial Fluid Mechanics Group, which is a group of nine people--if one counts collaborators. The present major effort (40 percent) is in the computer modeling of surface effect vehicles. This effort is being made in cooperation with Service Technique des Constructions et Armes Navales (STCAN) and Breguet Aviation (BA); the project is not yet finished. The group supports one of the IFML missions, which is to supply technical support and assistance to a variety of industrial concerns in northern France. In

cooperation with Centre National d'Etudes des Télécommunications (CNET) they are investigating different methods of encasing optical fibers. They are working for two private companies on piping and ventilation circuits, and, finally, for Atelier de Fabrication Mécanique de l'Etrat (AFME), Aerospatiale, and Ratier Figeau they are studying wind systems (windmills, etc). Although primarily concerned with technical assistance to French companies, the group has also served as consultant to companies from Peru, Spain, and Canada. It seemed to me that they were a fairly diverse set of investigations for the small number of people involved.

The group is in charge of one of the larger test facilities at the institute--the atmospheric wind tunnel--which has a test section diameter of 2.4 m, test length of 2.4 to 11 m, and a maximum velocity capability from 35 m/s to 70 m/s. The tunnel is used for, among others, studies of atmospheric pollution and diffusion, wind flow patterns over industrial sites, and flow over offshore oil platforms. Finally, some work is being done in the turbomachinery area, mainly with components such as pumps. Obviously, most of the work of this group is in the applied research area, which would result in technical reports.

Mechanics of Flight Group

The Mechanics of Flight Group, headed by Verbrugge, has two large test facilities: a free-flight range for large airplane models and a vertical spin tunnel. One of the Institute specialities, starting in 1938, has been the investigation of the spin behavior of aircraft. The spin facility at IMFL is the only operational one in Europe. The present 4-m-diameter tunnel was built in 1966 and has a maximum vertical velocity of 40 m/s, which can be established in 2 seconds. Some 200 models of aircraft from both France and some 12 other countries have been investigated in the spin facility. The models are instrumented and radio-controlled so that precise studies of controlled exit from spin can be determined. In addition, extensive sensor instrumentation with accelerometers and gyros of the model permits in-flight determination of stability derivatives within the modeling limitations. Motorization of the model is also possible. In 1978 a rotating balance was added to the tunnel which permits experiments with rotational rates of 11 rd/s on a six-component balance. Aerodynamic derivatives such as $C_{m\dot{\alpha}}$ and $C_{n\dot{\beta}}$ can be determined.

The free-flight range is devoted to the catapult launching of large

approximately 3 feet or more) models of aircraft that are fully instrumented. A typical model that I saw was that of the Mirage 2000. The telemetered data enables the determination of the aerodynamic characteristics of the aircraft. High angle of attack data which is sometimes difficult to obtain in a small wind tunnel can be obtained in this fashion. The actively controlled model can also be flown through artificially generated vertical or horizontal turbulence fields. In this way active control devices can be tested. In particular, this is an ideal facility for testing gust alleviation control schemes. This gust alleviation project is in cooperation with Deutsche Forschung und Versuchsanstalt für Luft und Raumfahrt (DFVLR) of Braunschweig, West Germany.

Summary Remarks

IMFL is a small but very competent organization. I was particularly impressed by their experimental expertise in unsteady flow measurements. Some excellent applied aerodynamic research is being accomplished at Lille. Through their doctoral program they are conducting a first-class fundamental research program which has a good interface with university research. Their industrial interaction and relationships with a variety of institutions is also very good. Their knowledge of activities in the US is excellent and, in fact, there is presently a member of the technical staff working at the Naval Research Laboratory in Washington.

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Ocean Sciences

AN INFORMAL MEETING OF BRITISH OCEAN MODELERS

by Jerome Williams. Professor Williams is the Liaison Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until December 1987 from the US Naval Academy, where he is Associate Chairman of the Oceanography Department.

About 60 people jammed the University of Oxford's Townsend Lecture Theater on 9 and 10 April to attend an informal meeting of British ocean modelers. The meeting was sponsored by the National Environmental Research Council (NERC) in an effort to acquaint British modelers with other UK modeling work in progress, since NERC is starting to encourage modeling efforts in Britain by funding a series of modeling projects. Another meeting will be held at the end of April in London to discuss these new projects, but this meeting was the result of a general call to all ocean modelers to come forth and describe their work.

Altimeter Data Assimilation

The first paper, given by David Webb of the Deacon Oceanographic Laboratory (DOL--formerly the Institute of Oceanographic Sciences, Wormley), discussed the assimilation of altimeter data in ocean models. Webb is attempting to utilize altimeter data to calculate deep-ocean circulation. He is mapping a model of the real ocean surface, in space and time dimensions, and treating the water column in terms of various vertical modes in the vertical and Rossby waves in the horizontal. At this time his model does not converge to the assumed real-world values until the passage of between 100 and 1000 days, so in order to generate a more rapid convergence he is using different amounts of bottom friction. He is also attempting to use a backward/forward scheme (using two or three data points over and over again) to allow the use of minimal amounts of altimeter data.

Paula Berry (Imperial College, London) discussed the use of altimeter data in an eddy-resolving model, from which she hopes to infer the lower layer circulation. She discussed the use of infrared rather than real altimeter data. Using wind stress to generate altimeter data, she let her model run then compared

4/14/87

the model with the calculated circulation derived from the previously generated altimeter data. The upper layer reacts immediately, but the lower layer takes about 100 days to reflect upper layer perturbations. From this she concludes that the upper layer is well constrained by the data and that the main features of the lower layer circulation are well predicted within a period of a few months. Altimeter data from two separate altimeters improve the upper layer stream function but this effect is not seen in lower layer predictions. It appears that success in the lower layers is dependent on correct model parameter choice, particularly the magnitude of nonlinear terms such as the wind stress.

Diffusion Models

Looking at ocean thermodynamic equilibrium as a result of the impact of increasing atmospheric CO₂, B. Henderson-Sellers (Salford University) described his attempts at developing box diffusion and convective diffusion models. His models are basically thermodynamic, which start with the heat conservation equation and include the equations of motion with viscous dissipation. He also inputs wind shear, surface energy in the form of solar insolation, and advection--all of which must include interrelationships and feedbacks. It is difficult to justify a global model of this type when regional processes are so different, but these models can work through short or long time scales if a methodology is included to transfer heat below the thermocline. The box model is a two-layer model with a mixed layer and a deep layer, whereas the eddy diffusion model includes eddy diffusion coefficients which must be evaluated. He calculates the global sea-surface temperature change in the last 120 years due to the addition of CO₂ in the atmosphere, a change that has been estimated variously at about 0.1 K. His box model predicts a change of six times this amount, while his diffusion model predicts a change of twice this amount.

Waves and Mixing

With a model using the linearized equations of motion with the Boussinesq approximation, Adrian New (DOL), looked at internal tidal mixing in the Bay of Biscay. In this bay the 200-meter depth contour is very often associated with the minimum sea-surface temperature, as well as high phytoplankton productivity. It is assumed that tidal current instigates internal mixing at the shelf break, generating internal waves. Solving his model for the modes of possible oscillation in a stratified fluid and assuming the frequency is semidiurnal, the amplitudes

were found to be as high as 200 meters. Water particles oscillating in a region of critical bottom slope resonate and send out energy at specific angles which propagates out to sea, bouncing off the bottom and the surface. This particular model, utilizing a turbulence source in a region where the bottom slopes at the critical angle, fits the data remarkably well for both displacements and velocities. The model predicts that the most energetic area is the offshore region in the thermocline. This is what is actually found when measurements are made.

Andrew Willmott (Exeter University) described a model addressing coastally trapped waves driven by deep-ocean dynamics. He assumed that deep-ocean eddies on the continental slope impinge on the bottom to generate Rossby waves. The radiation field associated with a point source of vorticity adjacent to a western boundary allows the excess vorticity to dissipate into a coastally trapped wave. He uses a barotropic model with a step shelf to allow for dissipation of the eddies which results in energy being sent equatorward along the shelf as a coastally trapped wave. Willmott's future plans include looking at the effect of bottom friction in a nonlinear model on these waves.

Rose Wood (Exeter University) discussed a possible generation force for observed long waves in the North Pacific. By assuming a causal effect produced by changes in location of the North Pacific drift, she was able to produce a solution that indicates that this current path diversion could be the source of Rossy waves. This was predicted by Lighthill in 1967, but her model also predicts wave length and direction of wave propagation.

Wolfgang Barkmann from Southampton University discussed the formation of mode water in the Atlantic. He is looking at 18°C water which appears at depths of 200-400 meters and is apparently associated with low potential vorticity. His model includes solar radiation and turbidity based on the Jerlov water types to produce a diurnal pycnocline as a result of solar energy heating of the upper layers. This model is able to produce a monthly variation of the mixed layer depth, qualitatively similar to that found in the Sargasso Sea.

Ice Models

Tom Holt (University of East Anglia) attempted to simulate seasonal sea ice in the Karac Sea. This sea is greatly influenced in its ice formation by river input which seems to correlate with following-year ice formation. Holt used a 1-degree-resolution closed-basin model with 14 levels and also accounted for topography.

He used monthly mean winds to produce surface current, but did not consider the gradient currents produced by river inflow to the sea. An isothermal surface is assumed throughout. The results of the present model do not appear to be very satisfactory, but it is not known whether this is due to a lack of data or basic inaccuracies of the model.

Another model, this one a thermodynamic ice model, was described by Osmond Lee, Scott Polar Research Institute, UK (SPRI). Lee looked at a one-dimensional thermodynamic model with air temperature, specific humidity, cloud cover, solar radiation, and monthly mean wind-speed inputs. He allowed these parameters to vary and assessed a sensitivity of the effect of each on the prediction accuracy of the model. He found that wind speed, cloud cover, and humidity variations had very little effect on the predicted ice thickness. Air temperature, on the other hand, produced a singular effect, especially in summer months when melting occurs. Ice grows slowly and melts quickly, and it melts from the top and freezes from the bottom. This explains the high degree of relationship between air temperature and ice thickness.

El Nino Models

Moving from polar regions to tropical regions, Garry Budin (Oxford University) described a simple coupled ocean atmosphere model to attempt to represent the tropical Pacific basin. His model involves sea-surface temperature-dependent forcing and includes upwelling, wind mixing, and the mixed layer to deep layer temperature differences. Thermocline depth seems to be the key element in this model and as Budin develops it further, he hopes to relate the model to the El Nino Southern Oscillation (ENSO).

Jan VerHarr, Royal Netherlands Meteorological Institute (KNWI), did describe an ENSO model. His model consists of a coupled ocean atmosphere model using a linear atmosphere and a nonlinear ocean with reduced gravity. The atmosphere was assumed to be steady state, since atmospheric time scales are so much shorter than those of the ocean. As an initial state, the ocean was considered to be in equilibrium with the October 1978 wind-stress field. He instituted a perturbation consisting of a patch of wind on the west side of the basin for 30 days and then switched this perturbation off. Four experiments were run with different conditions ranging from completely uncoupled actions between the ocean and the atmosphere to a maximum coupling situation. The stronger coupling increased the vigor of the atmospheric motion, but maximum coupling resulted in a model blowup.

It appeared from these experiments that the amount of air/sea coupling is an area that requires greater study.

The last paper in the meeting addressed another ENSO simulation model and was given by Malcolm MacVean of the UK Meteorological Office. He used two models: a coarse-resolution global circulation model and a fine-resolution model, which he compared. The models, included bottom topography, had constant eddy viscosity, and barotropic flow was assumed in both cases. The Cox code was used on both fine and coarse models so that both models were similar in most respects. The forcing functions used were wind, sea-surface temperature, surface salinity, heat fluxes, and precipitation minus evaporation.

In the coarse model it was found that warmer water took longer to reach the South American coast than it did in the fine model. In addition, currents in the coarse model were markedly smaller--about 1/3 those in the fine model. However, both models appeared to give the same results for the sea-surface temperature pattern and the thermocline slope (defined as thermocline depth divided by horizontal difference).

The most important result of MacVean's study is that the basic process appears to be local heating in conjunction with Ekman layer dynamics. This is modified somewhat by advection and wave propagation. MacVean believes that the major difficulty in obtaining realistic El Nino simulation is in the specification of current forcing--that is, the wind field data. The data sets that are available are not too reliable and they differ for similar times and locations. Until a reliable, reproducible data set becomes available, MacVean feels that El Nino models will not improve very much.

Conclusion

This meeting in Oxford was attended by people from a number of different institutions and, once more, illustrated the fact that a large amount of ocean modeling takes place in other than oceanography departments and institutions. Mathematics departments from a number of different schools were well represented, as were oceanography laboratories and university oceanography departments. The breadth of the range of institutions covered was not complete, so that I would guess that about half of the present modeling work in progress in the UK was represented at this meeting. This is not too surprising, since the meeting was called with very short notice and did not receive very wide publicity. Nevertheless, the meeting showed that there is a fair amount of modeling being done in the

UK, and these models are fairly diverse in their nature.

6/25/87

TIDAL MEASUREMENTS AND INSTRUMENTATION--A SEMINAR BY THE UK'S HYDROGRAPHIC SOCIETY

by Jerome Williams.

The Royal Institution of Chartered Surveyors hosted the Hydrographic Society in its presentation of a seminar on tidal measurements and instrumentation held on 15 April 1987. This meeting was the second in a series to review the state of the art in tide measurement, the first being held 11 years ago.

CDR N. Glenn of the Royal Navy's Hydrographic Department opened the meeting by reminding the assembled group that specific instrumentation should be chosen on the basis of the uses to which the data are to be placed. It is possible, at this time, to get an accuracy of ± 2 cm in water level height routinely and he asked whether it was necessary or even desirable to aim for an accuracy of ± 5 mm, especially with the definition of mean sea level still being somewhat in doubt. As accuracies become greater and greater, the choice of the tide gauge location with respect to amphidromic systems and environmental effects such as humidity become more and more important.

One of the newer technology advances that have come on the scene in the past 11 years is the navigation Global Positioning System (GPS), which utilizes a series of satellites for accurate location. Using GPS, it is now possible to compare heights over lateral distances up to 12,000 miles to a vertical accuracy of $\pm 1-2$ mm per km and a precision of about one-half a part per million. The advantages of GPS include the fact that it is reliable, accurate, not weather dependent, quick, cost-effective, and has extremely high geodetic accuracies. The major disadvantage of this system is that it can be used only at specific times, that is, when the satellites are viewable. In addition, its accuracy depends on the accuracy of the geoid/spheroid separation model, and expensive hardware is required. There are also problems with seasonal ionospheric effects which will result in a small scatter in the data, as well as variations in the mean. The deviation from this absolute accuracy and the actual knowledge of the geoid turn out to be two stumbling blocks in

the use of GPS, but even so, it is still the most accurate system available today.

Ralph Rayner from Wimpol Ltd., Swindon, presented a review of developments in tide gauges since the April 1976 meeting. He started by defining a tide gauge as having four components: the sensor, a means of handling the sensor output, the recording system, and a methodology by which access is gained to the data. Sensors might include the human eye, floats, step gauges, pressure transducers (probably the most common today), acoustic (common in the UK), and electromagnetic including both laser and radar sensors. Sensor outputs in use include both mechanical and electronic types with the electronic outputs being analog, digital, or perhaps even programmable digital. Data logging systems include: analog records, cassette tape, other magnetic media, and solid-state memory components (the most popular at the present time). Data access includes tape reading, interrogations of solid-state memories, telemetry of both coastal and offshore gauges, telemetry from tide gauge networks, and real-time use of the telemetered data. In summary, it appears that major differences between tide gauges in use 11 years ago and those used today are in the sensors, the sensor outputs (now primarily involved with programmable digital electronics), and the data logging systems. The future seems to hold promise of measurements of sea level by satellite (e.g., the satellite altimeter), improvements in data telemetry, and improvements in methods of networking of data from many different tide stations.

D.T. Pugh from the National Environment Research Council (NERC) discussed a Global Sea Level Monitoring Network (GLOSS) which is an attempt to get an international tide data base established. He listed the many uses of sea-level measurements including the provision of a standard for bathymetric charts, tidal predictions, coastal stabilization and management, satellite altimetry comparisons, flood warnings, erosion control, sedimentation control, determination of national boundaries, oceanic circulation studies, climate prediction, upwelling for fisheries management, heat budget calculations, eustatic changes in sea level, and glacier and ice pack melting. Some problems involved with these studies involve the basic questions of how to differentiate between land-level and sea-level changes, and how to relate these to the geoid. Nevertheless, the International Oceanographic Commission (IOC) has approved the concept of GLOSS, and many countries are now starting to become associated with the program. The concept involves a network of tidal stations with

about 1,000-km spacing along coasts and 500-km spacing for ocean islands. Accuracies of ± 1 cm in the vertical and ± 1 minute in time are desired. GLOSS will consist of this global station network; a data collection center for international exchange, including various data banks; the stipulation of standard methods for data analysis; and, lastly, the assistance of training for third-world countries needing help. So far, 45 countries have made the commitment, with India being the major exception. There is no international funding involved, the individual countries must support their own activity.

Roger Scrivens of W. S. Ocean Systems, Haslemere, described the rental market for tide gauges. In describing those tide gauges available for rental he covered the types of portable gauges available commercially. These included: float systems, tide staffs, pressure sensors (the majority of the devices used), time path sensors, and buoy systems. The choice of a particular system apparently depends upon individual preference, ease of setup, length of time to be utilized, and cost involved.

P.J.C. Jonas of Metocean Consultancy Ltd. discussed some of the problems in accuracy resulting from the poor knowledge of datum points around the UK. He said that differences in water depth can result from these inaccurate datum points and also from different methods used for the determination of datum points. Jonas claimed that errors may be as much as 25 percent when these differences are taken into account.

On the other hand, T. Crocker of Valeport Marine Scientific Ltd., Dartmouth, expressed the opinion that most problems in tidal measurement lay in the data analysis area rather than in instrumentation. He said that the error of a typical tide measuring device is about 0.1 percent with a 10-meter water column (± 1 cm). In actuality, it is exceptional when an error that small can actually be recorded, and he thinks an error of 3-10 cm in a 10-meter water column is probably about the best that can be accomplished with present systems.

J.B. Rae of the Proudman Oceanographic Laboratory (formerly Institute of Oceanographic Sciences, Bidston) addressed centralized data collection and monitoring systems for coastal tide gauge measurements. Common methods of data use involve a 15-minute integration period before data are telemetered. There are many requirements to transmit data from the sensor site to some centralized location so that a permanent network of tidal stations feeding into a single analysis center in real time is extremely

desirable. At the present time a telephone link in the UK and a satellite (Meteosat) link from distant stations is utilized. There was some discussion about whether valuable data are lost if the data are integrated over a 15-minute period and the raw data then discarded. Rae indicated that efforts would be made to retain all the data and therefore allow for future data analysis without the 15-minute integration, if that should become necessary.

To end the seminar on tidal measurements, two papers were presented that described low-technology tide-measuring devices utilized in regions where it is difficult to install tide gauges and keep them there for any length of time. The first of these, by M.C. Oberman of Odling-Smee, Oberman and Associates, described a charting project in the Persian gulf. Oberman worked with both a lack of tide data and accurate bathymetric charts for the area. This seems to be typical for most underdeveloped regions of the world.

C.J. Teal and C.B. Waters of Hydraulics Research Ltd., Wallingford, then described a small, portable device to be used in a situation such as that described by Oberman. This portable device includes a bubbler which produces its own gas supply from an electrolysis cell. The unit is much less bulky than the common bubbler system that requires gas bottles, and it is apparently reliable and works quite well for long periods of time.

Conclusion

This very short meeting on tidal measurements was attended by about 50 people, all of them active workers in the field of tidal measurements. In addition, there was an instrument display supported by six different manufacturers or distributors. The instruments shown were tide-measuring devices and some current meters. Since this was not a science meeting but a meeting of those people who actually make measurements and utilize these measurements for routine purposes, the devices displayed and described were not of the most advanced technology, but represented those in actual use at this time. Even so, it was apparent from the papers given that in the last 11 years there have been marked strides in both the accuracy and the reliability of the devices used to measure tides, resulting in much higher quality data available to those who would utilize sea-level information. It appeared that an order of magnitude in accuracy improvement had been accomplished during the past 11 years. It was also sobering to note that even though tide measurements have been made for over 300 years now, in most parts of

the world tidal records are still either very scarce or almost nonexistent.

6/26/87

Physics

LASER RESEARCH AT THE GERMAN AEROSPACE RESEARCH ESTABLISHMENT LABORATORIES IN STUTTGART

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1988.

In 1985 and 1986 I wrote several articles and news items in *ESN* about the optoelectronics research division of the German Aerospace Research Establishment (Deutsche Forschungs-und Versuchsanstalt für Luft und Raumfahrt, DFVLR) located at Oberpfaffenhofen, near Munich. DFVLR is one of the 13 national "large scale-research establishments" of West Germany and has several big centers in other towns as well. In January 1987 I had the privilege to pay a substantial visit to the Energetics Research Center of DFVLR, in Stuttgart, located within the new and beautiful University City in the district of Vaihingen, some 8 miles outside the city center. The center (including a test-station at the nearby site at Hardthausen-Lampoldtshausen) employs about 3,500 people, 70 percent of whom are academics. The Director of the establishment is Professor Dr. C.J. Winter, and there are four institutes under his authority: Technical Physics, Technical Thermodynamics, Physical Chemistry of Combustion, and Chemical Propulsion/Engineering. My visit concerned the Institute for Technical Physics, whose new Director (since September 1986) is Professor Dr. H. Opower, an expert in novel tunable solid-state lasers, and formerly with the crystal growing branch of Heraeus near Munich. His institute here, in turn, has five divisions: Quantum Optics, Electrical Engineering/Discharge Physics, Fluid Mechanics/Plasma Dynamics, Tribology/Materials Science, and High Energy Beam Technology. Fifty-three percent of the Institute's activities in 1986 were concerned with military lasers, 25 percent with commercial lasers, and 11 percent

each with tribology and with materials science. In this article, I focus only on certain aspects of laser research.

The DFVLR-Stuttgart laser program is subdivided into the following areas:

1. High-energy gas and vapor lasers
2. Novel laser systems
3. Radio-frequency-excited compact gas lasers
4. Beam quality and optical resonators
5. Laser-beam/material interactions
6. Laser applications and laser optics.

Below, I will describe some projects in the areas 1, 2, and 6, and will indicate some future plans of the Institute.

High-Energy Flow Lasers

The particular goal of this research is the study and improvement of electrically excited gas flow lasers with specific energies over 100 J/g and efficiencies higher than 15 percent. Special attention is paid to the full understanding of the laser-kinetic pumping mechanisms and to the achieving of unusually high gas pressures. Scaling studies play a central role since the ultimate goal is the construction of giant laser systems. For industrial purposes, CW-operation with CO₂ lasers over 10-kW power have been successfully developed. For military (tactical) purposes pulsed CO₂ systems have been developed, using the electrical excitation mechanism (rather than the gas-dynamic laser approach of Messerschmidt-Bölkow-Blohm in Munich).

However, the emphasis in the area of high-power gas flow lasers is on the somewhat neglected field of CO lasers. High hopes are placed in the electrically excited, gas-dynamic CO laser, as opposed to the thermally excited gas-dynamic CO₂ laser. Calculations indicate a theoretical quantum efficiency of 90 percent. (Of course, part of the military importance of possible high-power CO lasers is--apart from this high efficiency--that they operate in the atmospheric window of 5.1 μm .) The researchers experimented with a variety of excitation modes, from DC glow discharge and microwave discharge to pulsed, electron beam sustained discharge. (I have a rather detailed technical description of these studies, which I would be glad to share with interested colleagues.) Here I make only three remarks. First, the scientists say that they had particularly good results (output power over 250 W and internal efficiency of 16 percent) with a closed gas circuit CO laser that was operated stably in the CW mode for hours, using a 100-kHz

frequency discharge system. Second, equally good results were found with a pulsed, electron-beam-sustained CO laser, where a gas mixture of CO and Ar was accelerated to Mach 3 at a pressure of 100 mbar. A 150-kV e-beam was passed through a foil into the gas duct in order to create the required secondary electron density. The pulse-forming network supplied flat current pulses of 8- μ s duration. The laser was successfully operated with a 2.5-kHz repetition rate. Finally, RF excitation at 1 MHz was also successfully tried, when the electrical energy was coupled in perpendicularly to the flow direction via segmented metallic electrode plates at the top and bottom sides of the flow conduct. However, the laser output was lower than expected; therefore, current experiments employ dielectric electrodes.

Another line of research led to the development of a chemically excited, continuous oxygen-iodine transfer laser (1.3- μ m wavelength). Encouraged by the results on the CO laser, new work started in 1986 to study the possibility of exciting this iodine laser electrically. Related (in its principle) to this work is the study of a pulsed chemical DF laser with electrical ignition. An RF generator has been developed which works as a self-oscillatory system, the discharge tube acting as one of the capacitors in the feedback oscillating system. Preliminary experiments led to a 10-W peak output, a pulse energy of 0.25 mJ, a mean output power 40 mW, and a pulse repetition rate of up to 1 kHz. About more recent developments (leading to much higher power), and about a CW-operated chemical DF laser at the Hardthausen-site, no data were made available.

New Laser Systems

DFVLR has a long-range, basic science program to search for new, short-wavelength lasers based on electronic transitions. Particular effort is put into the study and development of recombination lasers, which offer the possibility of covering the entire spectrum from near IR to extremely short UV and, hopefully, x-ray wavelengths.

As is well known, the principle of recombination lasers is based on the very rapid cooling of a plasma. One of the methods to achieve this is the segmented plasma excitation recombination (SPER). This approach uses a linear row of small, pulsed arcs created by the arcing across 1- to 2-mm-wide gaps between pieces of metal wire which, in turn, are longitudinally aligned. DFVLR scientists built such a system (see Figure 1), consisting of 12 cadmium wire segments of 10-mm length placed at 1-mm intervals. These

segments were bonded to an insulating substrate. In initial experiments, 2- μ s-long current pulses produced laser activity in the atomic cadmium at a wavelength of 1.4 μ m. The maximum pulse energy was 5 μ J, corresponding to 100-mW peak pulse power. Currently, the power is about 3 times higher. Further experimental studies concern the ignition process and plasma production mechanism, and aim at finding an optimal electrode arrangement. More recently, quasi-continuous operation for periods of over 100-ms duration was achieved. Theoretical calculations were performed to study scaling properties of different recombination lasers, and they showed that the most significant plasma parameter is the maximum achievable electron density. This, in turn, was found to be a simple function of the wavelength range of operation (Figure 2). The DFVLR researchers are confident that eventually, if not an x-ray laser, a practical VUV laser will surely be built with this technology.

Other work in the area of novel laser systems at DFVLR concentrates on CO waveguide lasers, since these promise to be very compact low-energy devices, opening up the 5- μ m band for optical communications and numerous electro-optical applications. One success in this area was the development of a pulsed quartz-walled CO waveguide laser, operating at room temperature, with an output power of 10 W, a pulse energy of 40 μ J, and a pulse length of 50 μ s. Excitation was achieved with a series of anodes and a single copper plate common anode (the bottom side of the waveguide). Ten- to 20-A rectangular pulses of 2- to 6-kV voltage and pulse durations of 0.5 to 1.5 μ s were used.

The development of a tunable CO₂ diagnostic laser (operating on 32 lines) and of a 1-kW TEM₀₀-mode materials-processing CO₂ laser (with longitudinal flow) were the first practical results of a third new-type-laser development program. This program (to be continued and extended to other gas lasers, including excimer lasers) is concerned with the most efficient use of RF excitation. The original experiments were done with a small CO₂ tube laser using dielectric electrodes (employed on the outside of the quartz discharge tube). In this arrangement, the scientists also investigated the possibility of modulating the laser output signal via the gas discharge by modulating the RF input signal.

Laser Applications Laboratory

This research line has two major trends:

- Information and laboratory demonstration of the latest international

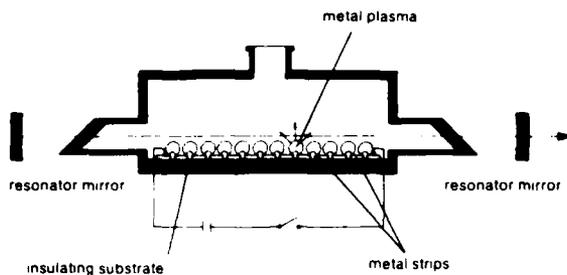


Figure 1: Recombination laser scheme.

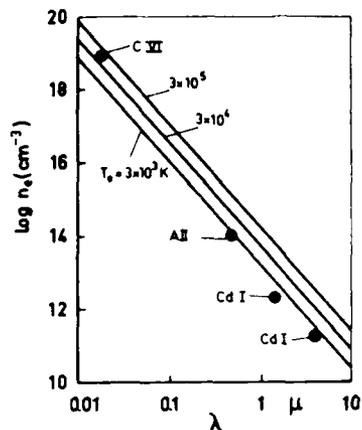


Figure 2: Maximum achievable electron density (n_e) as a function of wavelength (λ). [T_e is the final plasma temperature. The Roman numerals next to the chemical symbols describe the ionization level.]

results of laser applications for the benefit of medium-sized companies in the State

- Experimental assistance in clarifying process-related technical problems.

Affiliated to the applications laboratory is an optical test laboratory where components such as metal mirrors, transmissive mirrors and windows, lenses, etc. can be studied. There is also a developmental materials laboratory.

The equipment in the applications laboratory contains both commercial and custom-made, home-built lasers, including a variety of CO_2 , CO, Nd:YAG (also with frequency doubling), argon ion, and UV excimer lasers. An interesting "extra" is a variety of interferometric devices suitable for studying specimens up to 120-mm diameter and allowing for quality tests with an accuracy of less than 30 nm.

Conclusion and the Center's Future Plans

The area of developing and optimizing excimer lasers was, so far, ne-

glected by the Center. However, experiments are about to start for the study of KrF and XeF lasers; the goal is the construction of UV tools for industrial and military applications in the visible (after the UV emission has been shifted either by stimulated Raman emission or other means).

Furthermore, probably in cooperation with universities (such as Hamburg), an entirely new line of work is planned: the development of tunable solid-state lasers based not on garnets but rather on variously doped sapphire. Opower elaborated enthusiastically on the advantages of sapphire: the foremost being its excellent thermal conductivity, especially if cooled down (modestly, to about 100 K only).

While some of the laser research at Stuttgart's DFVLR is run-of-the-mill, I believe that much new initiative is being used and their courage in exploring risky fields bodes future successes, well worth monitoring.

6/24/87

News and Notes

NATO ADVANCED RESEARCH WORKSHOP ON SOCIAL AND ENVIRONMENTAL PSYCHOLOGY

A NATO advanced research workshop on European social and environmental psychology was held in Lisbon, 22 through 26 September, 1986. A brief description of this workshop is available in ONRL Report 7-018-C. In addition to a brief substantive summary, the report presents an evaluation of the contributions and shortcomings of the NATO meeting. The major focus of the report is an assessment of the talent pool of young southern European social researchers (Portugal, Spain, and Italy) who presented their work there.

A relatively complete picture of the substantive contributions to the conference will be available in a book of the proceedings, which is now being edited by G.M. Stephenson (University of Canterbury, Kent, UK), G. Jesuino (Instituto Superior de Ciencias do Trabalho e da Empresa, Lisbon), D. Canter (University of Surrey, Guilford, UK), and L. Soczka

(Laboratorio Nacional de Engenharia Civil, Lisbon), and is titled *Environmental Social Psychology*. The book will be published by the firm of Martinus Nijhoff of the Netherlands, and will be available by the end of 1987.

William D. Crano
6/24/87

APPLIED ARTIFICIAL INTELLIGENCE: AN INTERNATIONAL JOURNAL

A new serial publication, *Applied Artificial Intelligence: An International Journal*, has recently become available. As its name promises, the journal describes research on applications of artificial intelligence in real-world settings, including education, training, administration, and management. Its editor is Dr. Robert Trappl, Austrian Research Institute for Artificial Intelligence, Schottengasse 3, A-1010 Vienna, Austria. Publisher is Hemisphere Publishing, Journals Department, 79 Madison Avenue, New York, New York 10016. Cost is \$55 per year for individuals. The journal is published quarterly, and its first issue was put out in February 1987.

William D. Crano
6/23/87

NEW SPANISH JOURNAL OF SOCIAL PSYCHOLOGY

A new Spanish Journal, the *Revista de Psicología Social*, is now available. Articles are published in English or Spanish, with abstracts in both languages. In addition to original research, each issue will reprint a classic contribution in social psychology, to be followed by commentary. This feature is an intriguing addition to the typical American journal in social psychology, as it brings to bear contemporary commentary on some of the works that are responsible for the way that we view the field today. Relearning our history can help us to avoid the mistakes of our forebears. Information and orders may be addressed to the following: Secretaria de la Revista de Psicología Social, Facultad de Psicología, Universidad Autónoma de Madrid, 28049 Madrid, Spain. One year's subscription is \$10. The journal is published twice yearly.

William D. Crano
6/23/87

BASIC RESEARCH IN ARTIFICIAL INTELLIGENCE AT BERLIN'S TECHNICAL UNIVERSITY

The Computer Assisted Information Systems group (CIS), a strong component of the Institute (Department) for Applied Informatics of the Technical University, West-Berlin, is headed by Professor Dr. H.-J. Schneider. CIS looks back to a fine 13-year history at the forefront of both fundamental laboratory-level research, and of extensive educational activity in the area of artificial intelligence. By integrating activities in the fields of distributed data bases, information representation systems, information retrieval systems, decision support systems, and knowledge engineering, an artificial intelligence research center with a rather unique character has emerged. While having provisions for technology transfer to industrial development, the basic philosophy of the institute is to further the very foundations of information science, clarifying first-principles rather than specific techniques, and rarely going to the production of a prototype system. Thus, the scientists feel that they can permanently stay at the frontlines of their field and avoid being bogged down in specific tasks. (But of course, this makes it more difficult to secure external fiscal support!)

Apart from a large software environment, several operational systems, compilers and interpreters, and an internal framework with which these systems communicate, the institute has priority use of large IBM, Nixdorf, Vax, and Symbolics computer facilities.

Following are descriptions of the institute's major current research areas. Advanced Data and Knowledge Management System. This research is one "layer" of a large ESPRIT project (see Figure 1). Its overall long-term aim is to develop and implement prototypes of a complex system for managing large resources of data and knowledge with a limited-capability natural language system. Particular emphasis is put on representing incomplete and uncertain knowledge. The project also involves the development of an elaborate knowledge-editing environment which facilitates the use of the knowledge base management system and of the inference engine.

Application of Knowledge-Based Procedures in Machine Translation. This project is supported in full by the West German Federal Ministry of Research and Technology. It is based on a three-fold model of translation (analysis, transfer, synthesis), with distinct levels of representation (generalized phrase structure grammar [GPSG], intentional logic [IL], semantic representation language [SRL]),

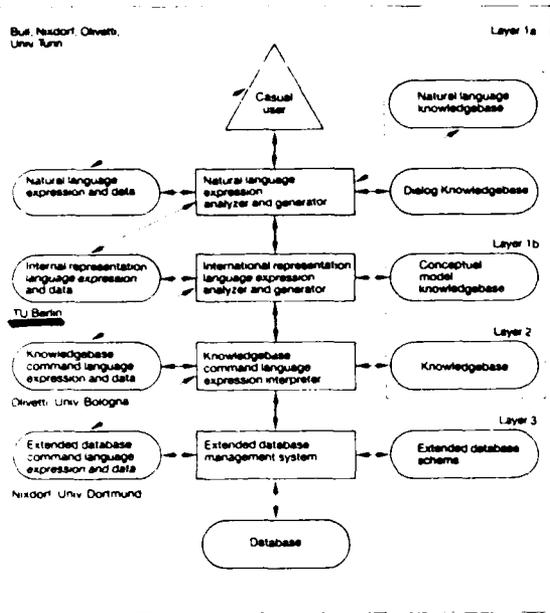


Figure 1. Layer-structure of the ESPRIT project of an advanced data- and knowledge-management system.

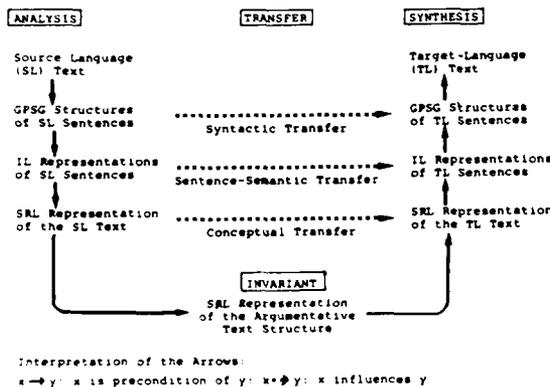


Figure 2. The NASEV project's conceptual scheme.

and with a corresponding multilevel-transfer. The scheme of the model, nicknamed NASEV, is represented in Figure 2. The concept aims at dividing up the enormous complexity of transfer, a point on which early-generation translation machines failed.

Artificial Intelligence and Data Bases. Data base systems so sophisticated that the knowledge to be represented can no longer be described purely in terms of facts, and where rules of inference and deduction are important, occupy the general attention of a strong unit at CIS. A special, very impressive project in this area that I found interesting is called KANON (Greek for meas-

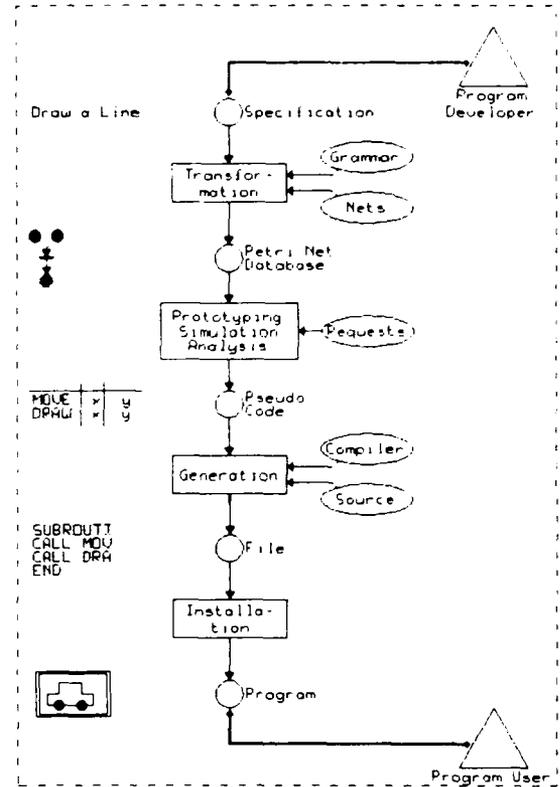


Figure 3. System architecture of the intelligent CAD software development system FUN, based on a Petri network.

uring standard, prescription). The KANON system contains the following basic components: (1) knowledge representation language, (2) knowledge transformation processors, (3) inferential processing facilities, (4) theorem provers, and (5) external data bank. One interesting aspect is that KANON may be used in conjunction with any given data base, of whatever kind or structure; and that the knowledge representation structures it uses are frames, semantic networks, and production rules. (In fact, meta-systems of these can be arranged for if needed.) KANON uses the Prolog programming language.

CAD-Software Production and Sanitation. This next-generation CAD development project is supported by the German Research Society (the equivalent of the American NSF). The system (called FUN) is based on the use of Petri nets (consisting of passive and active elements). The general idea is illustrated in Figure 3, where circles stand for passive elements and rectangles for active procedures. In the course of finding the best procedure, the network's behavior is repeatedly

simulated, and then any selected element of it is appropriately enlarged into a finer subnetwork.

Other Projects. CIS also has projects that involve machine learning, natural language query interfaces for data base systems, and speech command systems with integrated noise reduction. Conspicuously absent from the institute's activity are expert system projects.

Paul Roman
4/1/87

THE LAUNCHING OF BRAIN IN EUROPE

The European Economic Community (EEC) approved, in principle, coordinated support for an ambitious interdisciplinary computing project, Basic Research in Adaptive Intelligence and Neurocomputing (BRAIN). Physicists, psychologists, computer scientists, and neurobiologists from the UK, France, Italy, and West Germany are now working out details.

The project will have two major thrusts: (1) Development of parallel-computing hardware that could simulate the functioning of the brain; and (2) Development of new forms of parallel computing, based on current knowledge of brain functions.

Emphasis will be, naturally, on neuronlike computing elements, as opposed to parallel processing which is centered on the needs of logic programming. (The latter is covered by the British Alvey Project FLAGSHIP.) Special attention will have to be paid to questions such as: what structures should one impose in the "neural network" models in order to do useful (as opposed to model) computations; or how can one train the connection strength between "neurons" to obtain values appropriate for the computations aimed at?

Since the scope of BRAIN involves studies in neurobiology and neuroscience, in the cognitive sciences, in models and simulations, in parallel computing architectures, and also in implementation by Si or other devices, the first task of the working party is to focus the initiative by well-drawn boundary lines. Only then can specific proposals be meaningfully evaluated.

It is rumored that BRAIN is to some extent a reaction to Japan's Human Frontier Program, announced a year ago.

Paul Roman
4/22/87

FLUID MECHANICS--AN EVOLUTIONARY APPROACH

On a recent visit to the Technical University of Berlin, I met with Professor Ingo Rechenberg, who is the head of the Institute for Bionics and Evolution Studies. For more than 20 years he has been involved in the application of the rules of natural selection (Darwinian evolution) as a tool to guide the optimization of the various types of engineering and biological systems. Such selection processes (Darwinian or otherwise) are at the heart of all sorts of expert systems and artificial intelligence schemes. It is not surprising, therefore, that many of his visitors these days are members of these communities. A specific example here might help to clarify the process involved.

Consider the process of designing a surface composed of, say, six interconnected hinged slats (see Figure 1) with the objective of producing the shape which has minimum drag. The shape is changed by altering the hinge settings, corresponding to a "mutation" in a biological sense. Using his evolution-based optimization process, a trial shape is first selected and the corresponding drag measured. If the drag of this shape is less than that of the original shape, the modification is retained; if not, the plate is returned to its original position and a different hinge setting tried. It is to be expected that eventually a hinge setting would be produced which would result in a flat plate. This experimental process was exactly the one which was carried out by Rechenberg for his dissertation research at the Technical University of Berlin more than 20 years ago. Of far greater significance in this particular application than the final shape was the fact that it required only 300 iterations to obtain. An appreciation for the magnitude of this

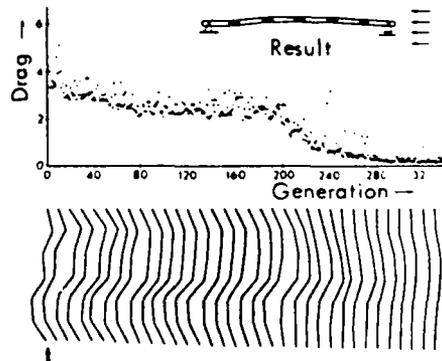


Figure 1. Evolution of a minimum drag profile.

accomplishment can be obtained by realizing that the manner in which the hinge positions was indexed allowed for more than 345 million different combinations. In order to make the scheme work with this level of efficiency, careful attention must be given to the manner in which new generations are produced and to the magnitude of the mutations which they are forced to exhibit. This is what Rechenberg calls his "evolution strategy."

The first step is to decide on how the next generation will be produced. Is there to be only one parent, two, or even four? Do the parents survive their offspring? That is, are they present when the selection process is conducted to choose the parents of the next generation? Regardless of what decision is made for this process, there appear to be a few general rules to observe. The first is that the more parents, the better. Second, the characteristics of the parents should be shared by the offspring in such a way that the norm of the mutation step size (the change in hinge position in the case of the previous example) is passed along. Third, the mutation step size must be chosen in accordance with a rigorous mathematical model of the evolution process. It is this latter characteristic which is at the heart of Rechenberg's evolution strategy. Rechenberg showed that the optimal mutation step size, δ_{opt} , is given by the equation:

$$\delta_{opt} = \frac{C_{\mu, \lambda} r}{\sqrt{n}}$$

Where $C_{\mu, \lambda}$ is the progress coefficient (a description of the "family" structure), r is the radius of curvature of the contours of the optimizing function, and n is the number of variables in the problem.

In addition to his work with the flat plate, Rechenberg has applied his evolution strategy to (1) the design of a 90-degree bend in a circular pipe with the objective of minimizing the pressure loss, and (2) to the design of a flash evaporator nozzle for an MHD application to optimize the thrust performance. In the first case, he found that the 90-degree bend which gave the minimum pressure loss was not a quadrant of a circle but an Euler spiral (the radius of curvature inversely proportional to the arc length) terminated by a short section of reverse curvature. This is a very unusual shape. What naturally comes to mind is that if the experiment were repeated a second time, perhaps a different shape would result. This was not the case. The

experiment was performed repeatedly with identical results. Another possibility which comes to mind is that there was some peculiarity in the inlet flow which produced this rather unusual configuration. That also appears not to be the case since in another bend experiment (supported by Volkswagen) currently underway in which a completely different method of supplying air to the pipe is used the same configuration seems to be evolving. The detailed specification of the bend geometry appears in Rechenberg's book (Rechenberg, 1973) should any enterprising CFD expert want to try his hand at verifying this configuration by computational means.

The new bend experiment is interesting from another point of view and that is that it is completely automated. The shape of the tube is adjusted by a robotic arm and the entire experiment is controlled by a small microcomputer. The microcomputer not only produces the mutations by means of a data acquisition system--it measures the pressure drop for each of the trials, and on his basis selects the offspring for subsequent mutations.

In the design of the flash evaporator nozzle, the evolution strategy produced another surprising result. The optimum thrust configuration consisted of two ringlike expansion chambers ahead of the throat and one following it. See Figure 2. These chambers serve the function of heating the wall ahead of the throat (to enhance the evaporation process) and of mixing the liquid and vapor following the throat once the evaporation has taken place.

Another of Rechenberg's interests is fluid mechanics problems which are biologically inspired but do not involve biological evolution strategies. An example is the investigation of the drag reduction properties of fish mucous. In experiments which he has completed to date, he has simulated fish mucous by adding small amounts of Polyox to a 2-m-high, 40-cm-diameter tank through which a 30-cm-long, 2-cm-diameter finned tube was dropped, accelerated by the force of gravity and guided by a thin nylon thread. Drag measurements were inferred by measuring the projectile's speed. Similar to experiments conducted by many other investigators, he obtained significant drag reductions for minute amounts (1 part in a million) of Polyox. Rechenberg plans to take up this work again once his new 9-m-high tank is completed. A new facility is needed since experiments completed in the old facility revealed that only barely turbulent conditions were present and that the testing times were insufficient to permit the

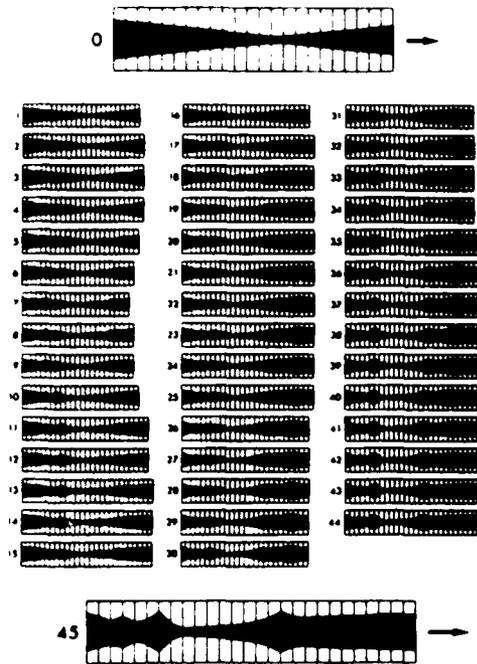
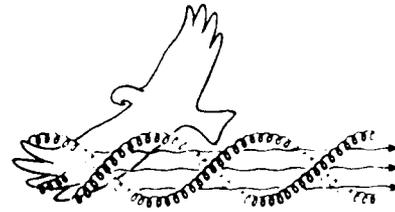


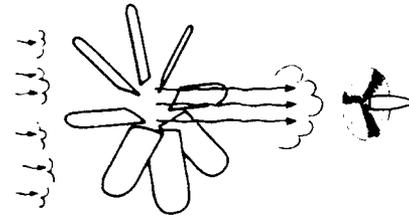
Figure 2. Optimization of a flash evaporator nozzle.

projectile to attain a constant drop speed. His new experiment will also feature an investigation of various means of attaching mucous to the surface of the cylinder to avoid having to add it to the water.

Another example of Rechenberg's biologically inspired activities is the design of a wind-turbine concentrator. This work was stimulated by some experiments which he had done on the aerodynamic qualities of the fingerlike tips of bird's wings. What he found was that the feathers acted like miniature staggered winglets and produced a thrust-augmenting effect by accelerating the free stream flow through the center of a spiral pattern of vortex elements which arises from the tips of each feather. See Figure 3. Rechenberg reasoned that this same effect could be used to produce a local increase in air velocity upstream of a wind turbine, thus allowing the use of a smaller (and therefore less expensive) turbine for a given amount of output power. A further benefit is that the higher rotational speed of the smaller turbine allows the turbine to be directly connected to the generator without the need for a speed-increasing gear box. The high rotational speed also means that the aerodynamic noise produced by the rotating blades is of a higher frequency and thus the smaller turbine's acoustic "foot print" is much smaller than that of a conventional wind turbine.



(a) A biological observation.



(b) A technological application.

Figure 3. Spiral vortex elements.

Wind tunnel and atmospheric tests have verified Rechenberg's concept, and wind concentration factors of as high as eight have been realized. Rechenberg believes that the maximum concentration factor of his design may be as high as 25 if the problem of vortex bursting could be solved. Designing blades to produce vigorous wing tip vorticities under a variety of wind conditions while avoiding vortex bursting is a difficult problem. Reichenberg is conducting his work with a substantial support (approximately \$250,000 per year) from the Bundesministerium fuer Forschung and Technologie (BMFT).

Conclusion

Rechenberg's work on polymeric drag reduction has obvious Naval applications. Furthermore, his evolution strategy (and particularly his more recent computer-controlled optimization experiments) should be of interest to the Navy's systems analysis and artificial intelligence communities.

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Eugene F. Brown
6/18/87

COMPUTATIONAL FLUID DYNAMICS AT THE POLI-
TECHNIC INSTITUTE OF MILAN

During my recent visit to the Politechnic Institute of Milan (Italy) my host was Professor L. Quartapelle of the Department of Physics. There is no strong tradition of computational fluid dynamics (CFD) in Milan and small centers of CFD activity like Quartapelle's are to be found in a number of departments such as the Department of Chemical Engineering, where finite-element solutions of the compressible Navier-Stokes equations are being used to investigate isotropies in silicon crystal growth patterns.

Although in the Department since 1974, Quartapelle spent the first part of his professional career in the field of solid-state physics and only fairly recently began to devote his considerable talents in the field of engineering physics to fluid mechanics problems. In this short period of time however, in collaboration with Professor M. Napolitano at the University of Bari (Italy) and Professor S.C.R. Dennis of the Department of Applied Mathematics, University of Western Ontario (Canada), Quartapelle has made fundamental contributions to the solution of the incompressible Navier-Stokes equations and more recently to the solution of wave propagation (hyperbolic) problems by means of the finite element method.

It is well known that computation of viscous incompressible flows in two dimensions by means of the vorticity and stream function equations meets with difficulties when one attempts to specify boundary conditions for the vorticity transport equation. In fact, two boundary conditions naturally arise for the stream function equation and none for the vorticity transport equation. To overcome this apparent deficiency it is common practice to estimate, in the context of an iteration process, the vorticity values from the curl of the stream function on the boundaries. Unfortunately, results for the various computational schemes based on this approach exhibit great discrepancies in both local and global quantities when they are computed by apparently completely comparable methods. This anomaly can be understood by realizing that the rate at which the local vorticity changes depends strongly on the values of the gradient of the vorticity on the boundary, and this quantity is uncontrolled in the calculations. By means of careful argument and convincing numerical examples, Quartapelle was able to show that the natural condition of the vorticity equation is, in fact, not a boundary condition at all, but an inte-

gral condition which involves all of the points in the computational domain and not just the points on the boundary. Quartapelle subsequently showed the existence of similar integral conditions for the pressure when velocity/pressure splitting is used, and he is currently working on the proper conditions for velocity/vorticity splitting.

One of the most sophisticated applications of this technique is his calculation of the Taylor-Görtler vortices in a spherical gap. The three-dimensional Navier-Stokes equations were solved in vector potential/vorticity form by means of a spectral algorithm (Dennis and Quartapelle, 1985).

Quartapelle's most recent work has demonstrated in a thorough and comprehensive fashion the usefulness of the finite element method for the solution of wave propagation (hyperbolic) problems. One of the advantages of the conventional Galerkin finite element approach in the solution of, for example, the linear, one-dimensional, wave propagation problem is that the discretization based on a uniform mesh of piecewise linear elements yields a four-order spatially accurate transient solution while the familiar central difference method is only second-order accurate. However, in practice, a superior spatial accuracy of linear finite elements only manifests itself for small values of the time increment and practical computations, where time steps as large as possible are used, fail to provide a convincing argument for using the finite element method. Quartapelle discovered, however, that the attainment of high accuracy and large time steps are not incompatible if the order of accuracy of the time discretization is increased. This is accomplished by retaining terms up to third order in time. On this basis, Quartapelle derived higher-order-accurate versions of the Euler, leap-frog, and Crank-Nicolson time stepping algorithms. In calculations which included the advection of a cosine wave in both two and three dimensions he showed how the so-called Taylor-Galerkin method succeeded in overcoming the phase error of the standard Galerkin method and how, in all cases, it outperformed (by as much as two orders of magnitude) finite difference calculations of the same problem (Donea, et al., 1987).

Quartapelle seems justifiably proud of his Navier-Stokes and wave propagation contributions. It appears that they have given him the motivation to seek out other groups at the institute engaged in fluid mechanics studies and to make plans (in evidence during the course of my visit) for sharing information on topics of common interest.

I anticipate that the wider exposure of Quartapelle's exceptional talents for scholarly research--which, surely, collaboration will broaden--will enhance the level of CFD activities in the entire institute.

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Eugene F. Brown
6/11/87

WORKSHOP TO RECONCILE RESEARCH DIFFERENCES ON RADAR IMAGERY OF OCEAN SURFACE FEATURES

Background

G.P. de Loor and H.W. Brunsveld van Hulten (1978) were the first to report features/patterns in real aperture radar (RAR) imagery of shallow water relating to bottom topography. At that time this fact was a real puzzle since the water depth was in the order of meters while the skin depth of microwaves for seawater is only in the order of centimeters. So it is not possible for electromagnetic (EM) radiation to probe the bottom directly. Subsequently, similar manifestations were evident in radar imagery from SEASAT synthetic aperture radar (SAR) of Nantucket Shoals, Massachusetts, the English Channel, and other coastal areas (Beal et al., 1981) and from airborne SAR's and RAR's (Alpers et al., 1981).

Since then our understanding of the physical processes involved has increased rapidly, in particular after the NRL Phelps Bank experiment of July 1982 (Valenzuela et al., 1985) where extensive and coordinated remote sensing and *in situ* measurements were performed and it became clear that current-wave interaction is one of the main processes responsible for the formation of ocean surface features/patterns related to bottom topography present in radar imagery. In coastal areas where these features have been observed with radar imagery, tidal currents of 1 m/s or so are modified spatially by the bottom topography (Zimmerman, 1978). Hence, the resulting non-uniform tidal flow, which is related to

the bottom slopes and depth, refracts the propagation and modulates the energy of the surface wave field--in particular, the short gravity waves of length proportional to the EM wavelength according to the Bragg resonance condition which are responsible for the radar backscatter (Valenzuela, 1978). Of course, other scattering mechanisms, such as specular and wave breaking, should also contribute to a degree to the radar backscatter, and, as usual, wave motion in the ocean should aid image formation or distortion in SAR intensity.

In any case, in the NRL Phelps Bank experiment it was found that other environmental parameters such as wind vector and atmospheric stability (air-sea temperature difference) are also important, affecting the strength of ocean surface features (Valenzuela et al., 1985; Valenzuela and Chen, 1985). Consequently, as one would suspect, the detailed energy balance of the short gravity wave spectrum in the presence of nonuniform currents, wind input, energy transfer by nonlinear interactions and dissipation is pertinent. In this regard, Alpers and Hennings (1984) using Bragg scattering and simple boundary conditions for the tidal flow over a bottom ridge developed a first-order relaxation theory for this problem which explains a number of properties of SAR imagery. This first-order theory was also applied with success to internal waves (Alpers, 1985). However, this approximate theory could not explain the unusually large variations in backscatter power measured at Phelps Bank (over 20 dB at L and X band) for light and moderate winds (less than 7 m/s). One mechanism which has been shown to enhance the modulations of backscatter power for light winds by more than an order of magnitude is atmospheric stability for stable conditions (warm air over cold water) (Valenzuela and Chen, 1985).

Related Research at KNMI

One institute which has contributed to a number of areas related to radar imaging of ocean surface features (e.g., modeling of deep and shallow waves, tides, meteorology, etc.) and has kept close touch with this problem is the Royal Netherlands Meteorological Institute (KNMI) at de Bilt. For example, the Institute's Dr. Gerbrand Komen has contributed extensively to ocean wave modeling and to the understanding of tides (Komen and Riepma, 1981) and the energy balance of ocean waves (Komen et al., 1984).

In the last few years Komen's interests have broadened to include the dynamics of the shorter gravity-capillary waves (van Gastel et al., 1985); he is

presently concerned with the energy balance of gravity-capillary waves in the presence of nonuniform currents which, as stated earlier, impacts directly on the hydrodynamic contributions to radar imaging of ocean surface features relating to bottom topography in shallow water and internal waves. Actually, ocean surface features relating to sea-mounts have been evident in SEASAT SAR images to depths up to 200 m. However, this later manifestation might be due to a different mechanism. In recent numerical calculations by van Gastel (1986) on the energy balance of gravity-capillary waves in the presence of nonuniform currents for internal waves (one-dimensional case) and light winds, modulations of spectral wave energy density as large as 30 dB were obtained when the energy transfer by second-order nonlinear resonant interactions (Valenzuela and Laing, 1972) was included in the forcing. Previously Valenzuela and Wright (1979) had shown that resonant nonlinear interactions reduced the relaxation constant of short gravity-capillary ocean waves. Hughes (1978) obtained a formal solution for these modulations for one-dimensional nonuniform currents that included the input from the wind and quadratic spectral dissipation, but in the absence of nonlinear interactions. Phillips (1984) generalized the spectral power law of the dissipation, and Bagg et al. (1986) has shown that for light winds the modulations of energy spectral density of gravity-capillary waves in the presence of nonuniform currents are enhanced if the transient (passage-related) contribution omitted by Phillips (1984) is included in the result.

Planned Workshop

To reconcile some of the differences and issues discussed above, a workshop is being organized for 24 through 26 May 1988 in the Netherlands (G.J. Komen and G.R. Valenzuela, cochairmen). The attendance to this workshop will be limited to 20 to 30 scientists and will be by invitation only. The workshop will be sponsored by the Office of Naval Research. The organizing committee is composed of the cochairmen, Werner Alpers (University Bremen), Klaartje van Gastel, and Wiebe Oost (KNMI). The objective of the workshop will be to review and discuss recent research (theoretical and experimental) on the modulation of short waves in the gravity-capillary range by nonuniform currents to establish our present knowledge and deficiencies on the processes responsible for ocean surface features/patterns (relating to complex bottom topography in shallow water, internal waves and mesoscale eddies) clearly visible in

radar imagery (SAR/RAR). Recommendations on future work in this area will be given.

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Gaspar R. Valenzuela
Space Sensing Branch
Naval Research Laboratory
6/29/87

NEW JOURNAL ON ELECTROMAGNETIC WAVES AND APPLICATIONS

A new journal, the *Journal of Electromagnetic Waves and Applications*, has been launched in 1987 by the VNU Science Press, the Netherlands. The stated aim of the journal is to report advancement and progress in the modern development of electromagnetic wave theory and its new and exciting applications. The journal will publish original papers on new theories, methodology, and computational techniques, and interpretations of both theoretical and experimental results.

The journal's scope is very broad; it will include the following topics: wave propagation theory, remote sensing, inverse scattering, geophysical subsurface probing, propagation in random media, oceanography, hydrology, meteorology, atmospheric effects, ionospheric effects on wave propagation, ionospheric modifications and heating, antenna theory and applications, radar measurements and applications, extraterrestrial remote sensing, electromagnetic interferometry, ground-based remote sensing, agricultural remote sensing, microelectronic integrated circuits, transients, EM wave transmission in VLSI, electromagnetic compatibility, optical and millimeter wave techniques, integrated optics, fiber optics, communication systems, medical applications, biological effects, ferrite devices, field and network theory, high-power devices and systems, submicron structure, waves in composite and amorphous materials, expert systems in remote sensing, numerical methods, and electromagnetic pulse transmission and coupling.

The Editor-in-Chief is Professor J.A. Kong of Massachusetts Institute of Technology (MIT). There is also an international Editorial Board consisting of 26 well-known people. The journal is to be a quarterly publication with occasional special issues. The first issue (93 pages) contains four interesting and substantive papers. Indications are that the journal will achieve considerable international stature. Prospective authors should contact Professor Kong at Room 36-393, MIT, Cambridge, Massachusetts 02139. There are no page charges. Information on subscriptions and may be obtained from VNU Science Press BV, P.O. Box 2093, 3500 GB Utrecht, the Netherlands.

David P. Cheng
Professor Emeritus, Syracuse University
NFI Liaison Scientist, 1978-79
2/18/87

SIEMENS READY TO SUPPLY HIGH-POWER SEMI-CONDUCTOR LASER ARRAYS

In a recent survey of advanced optoelectronics research at the Siemens Central Research Laboratories, Neuperlach (near Munich) (ESN 41-2:99-103 [1987]) I reported on significant research progress in the area of phase-coupled diode laser arrays. This month I learned of further results in development and I also understand that sample chips are now available from Siemens, even though, in general, only in limited supplies.

The best progress was achieved in both conventional double-hetero and multiple quantum well (MQW) monolithic chips (based on GaAs/GaAlAs and operating around an 880-nm wavelength). Arrays up to 40 stripes are now available with a combined CW-output of near 1.65 W per mirror, and with adaptable beam characteristics. A low threshold current (22 mA), a high differential efficiency (0.55 WA^{-1} per mirror surface), and an overall efficiency exceeding 33 percent characterizes the MQW devices.

The chips are produced by metal organic vapor phase epitaxy. The active zone is about 75 nm thick. The resonator length is arranged to be around 400 μm .

The researchers also demonstrated that, with these laser arrays, very efficient frequency doubling can be achieved in nonlinear crystals, leading to simple and reliable coherent blue light sources.

Paul Roman
3/23/87

A NEW CENTER FOR ELECTRONICS MATERIALS RESEARCH IN ENGLAND

The Science and Engineering Research Council of the UK (SERC), the Department of Trade and Industry of the UK, and several private firms initiated a new, multidisciplinary Center for Electronics Materials at Manchester, UK. The Center is based at the University of Manchester Institute of Science and Technology (UMIST). Collaborative research is envisaged between five departments of UMIST and of the University of Manchester, involving chemists, physicists, electronics engineers, materials scientists, corrosion specialists, and even geologists. The purpose of the Center is to conduct research to study materials suitable for the next generation of electronic and optoelectronic devices. New alloys as well as complex molecules and structures at the atomic level are all under

investigation. Beginning October 1987, the Center will also run an M.Sc. curriculum in electronic materials and offer short courses for industry.

The Center already runs nearly 70 projects, ranging from epitaxial growth to investigations of VLSI circuits. Most of these projects enjoy some support from private industry. However, the bulk of basic equipment (worth more than \$14 million) has been provided by SERC, although local industry helped there, too. This equipment includes the UK's first computer-controlled high-resolution electron microscope from Phillips. SERC also announced a \$1.3 million research grant to support research personnel (mainly on the postgraduate and doctoral level) in molecular beam epitaxy.

Paul Roman
3/4/87

EUROPEAN GEOPHYSICAL SOCIETY--XII GENERAL ASSEMBLY

The XII General Assembly of the European Geophysical Society (EGS) was held at the Université Louis Pasteur in Strasbourg, France, from 9 through 14 April 1987. The meetings were open to presentations from all nations, and over 500 representatives from 26 countries were present. The EGS is a relatively new organization, founded in 1971, established for the promotion of interdisciplinary cooperation among European scientists concerned with the full range of geophysical studies. The society is structured in three main sections according to the broad divisions of geophysics:

- Solid earth and planets
- Hydrospheres and atmospheres
- Upper atmospheres, ionospheres, magnetospheres, and the interplanetary medium.

The sessions and workshops of the general assembly were arranged along precisely these lines.

It is interesting to note that this year, for the first time, the EGS met in a joint conference with the European Union of Geosciences (EUG), a somewhat larger organization devoted primarily to the earth sciences (The EUG is actually a study group of the parliamentary assembly of the council of Europe). This arrangement appears likely to continue in the future at least on an occasional basis, and there are presently discussions underway which could lead to the merging of the two societies. Abstracts of both

the EGS and EUG meetings are to be found in the EUG publication *TERRA Cognita*, Vol 7, No. 2-3, pages 81-595. The volume may be obtained from: EUG, Secretary (E.S.F), Mme G. Schauinger, 1 quai Lezay-Marnesia, 67000 Strasbourg, France.

A number of the open sessions had themes of particular interest. An especially "hot" topic concerned the causes of atmospheric internal gravity waves, how to parameterize them for modeling, and the influence of these waves on the lower atmosphere and on atmospheric prediction schemes. Gravity waves in the atmosphere have been studied for some time, but it was not until increased computer resources became available that it became economically possible to attempt to include frictional energy losses associated with gravity waves into operational and research models. Initial efforts have dealt primarily with orographically induced gravity waves (though thermal/convective excitation was also discussed) and significant improvement in the predictive models appears possible by directly parameterizing the drag effect associated with appropriate-scale orography. Further refinement and understanding of these processes may ultimately lead to modification of operational models and significantly improved short- and long-term forecasting.

Although there was some encouragement on the part of the organizers of the assembly for display of current geophysical instrumentation, very little was in evidence. Several of the papers presented, however, dealt with instrumentation of Navy interest. The first paper, describing an underwater pulse generator, was presented by A.W. Laake of the Max Planck Institute. The generator, for marine seismic profiling, was developed using the principle of the waterhammer, transforming the kinetic energy of an accelerated heavy piston into acoustic energy in the water. Cavitation is used for damping of successive internal waves inside the generator. The pressure pulses radiated into the water are characterized by a pulse length of 0.3 ms and a frequency bandwidth of about 6 kHz. The pressure pulses have a strong forward directivity which may be determined by the shape of a radiating horn.

A new device to determine the seismic velocity of deep-sea sediment cores was described by J. Philipp et al. of the Institute for Geophysics at the University of Kiel, West Germany. A seismic pulse is generated by a powerful ultrasonic transducer at one end of the sample. The wave is propagated through the whole length of the sample and is received by ultrasonic receivers, step-by-step, along the surface. The received

signals are digitally recorded with a transient recorder and stored for later analysis. This device has already been deployed at sea on R/V *Meteor II*.

The oceanographic session, "Oceanic studies of the Mediterranean," was fairly equally divided between work in the western and eastern Mediterranean Sea. The observational programs and modeling efforts in the Mediterranean are providing a new understanding of the dynamics of the area. The major quasi-synoptic field programs, such as the Western Mediterranean Circulation Experiment (WMCE) and Physical Oceanography of the Eastern Mediterranean (POEM) (see ESN 41-3:139-143 [1987]) are demonstrating that the Mediterranean Sea is very dynamic and variable with a highly complex mesoscale structure. The simplistic view of the circulation from 20 years ago is undergoing rapid revision based on satellite and quasi-synoptic *in situ* observations and numerical model studies.

The data from the first two POEM observational periods show that the eastern Mediterranean circulation is much more complex than originally thought. Similarly, the data from the WMCE field program show complex circulations in the western Mediterranean.

One major new revelation at this symposium was the increasing number of numerical models being developed for the Mediterranean. While most of these models have coarse, horizontal resolution and thus can not give reasonable representations of the mesoscale features, they are a start and can be used to examine large-scale, wind-forced circulations. Results from mesoscale eddy-resolving models which examined the efforts of density

forcing (deep water formation) on the circulation in the western Mediterranean and the formation of eddies in the Levantine basin were also presented.

Conclusion

The European Geophysical Society serves, for the European scientist, much the same purpose as the American Geophysical Union serves for Americans. It appears to be a healthy, growing organization which is fulfilling its objective of promoting interdisciplinary cooperation among European scientists. The society meets annually 1 to 2 weeks before Easter. In 1988 the University of Bologna will host the EGS General Assembly.

CDR J. Simpson, US Navy, and
Dr. George W. Heburn
Oceanographer
Naval Ocean R&D Activity
6/25/87

ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two DOD employees for free registration in the conferences ONRL supports. Readers who are DOD employees and are interested in a free registration to one of these conferences should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

STC Knowledge Based Information Systems Symposium, the Hague, Netherlands, 20-22 October 1987.

* * *

ONRL REPORTS

To request reports, indicate the report number (in parentheses after the title and author's name) on the self-addressed mailer and return it to ONR, London.

Behavioral Sciences

A Free-Response Method of Computer Assisted Personality Assessment: A Research Update, by William D. Crano. (7-016-R) The free-response methodology, first reported by ESN in early 1984, has been tested and extended, and the results appear to support the high initial expectations. Recent developments in the techniques are reported, and the author discusses means that could be employed to further develop this important measurement method.

An Assessment of the NATO Advanced Research Workshop on Environmental Psychology and Its Participants, by William D. Crano. (7-018-C) This report on the workshop on European social and environmental psychology, held in Lisbon in September 1986, provides a brief summary of the author's reactions to the meeting, along with some observations on the young Portuguese, Spanish, and Italian social researchers represented there.

Biological Sciences

Biotechnology Conference: Protein Engineering '87, University of Oxford, UK, by Claire E. Zomzeley-Neurath. (7-019-C) Presentations at this major international conference held at the University of Oxford, UK, in April 1987 are reviewed. The topics include theoretical aspects of protein structure, protein structure and dynamics, protein engineering methods, protein engineering stability, protein engineering binding and catalysis, and protein engineering medical and industrial applications.

Computer Sciences

Research and Development at Centre Suisse d'Electronique et de Microélectronique (CSEM), by J.F. Blackburn. (7-015-R) The principal current scientific and technical activities at this laboratory in Neuchatel, Switzerland. Those activities are: design of integrated circuits and systems, microelectronics technology, development of custom integrated circuits, optoelectronics and peripheral components, and materials and microelectronics. Having extraordinary versatility, it is one of Europe's important laboratories.

The British Technology Group, by J.F. Blackburn. (7-022-R) The British Technology Group, when it was established in 1981, incorporated the National Research Development Corporation and the National Enterprise Board. Its primary purpose is to encourage and facilitate transfer of new ideas and technology from university and government laboratories to industry. This report reviews the Group's current activities.

Material Sciences

Applied Material Science in Turkey, by Louis Cartz. (7-013-R) This report covers visits to several of Turkey's leading technical institutions and provides a survey of some of their facilities and ongoing research in applied material science, primarily with minerals, ceramics, polymers, and elastic constants. The institutes visited included: Middle East Technical University (METU), Ankara; Turkish Scientific and Technical Development Agency (Tübitak), Ankara; Mining Research Institute Ankara (MTA); Tübitak Electronics and Electrical Research Institute, Ankara; Marmara Research Institute, Gebse; and Ankara Nuclear Research and Training Center (ANAEM).

Metal Physics, Université de Poitiers, France, by Louis Cartz. (7-014-R) The microstructure of metals is studied by a range of electron optical methods, grazing incidence x-ray diffraction, and conversion electron Mössbauer spectroscopy. The microstructure is related to mechanisms of plastic deformation, defect formation by ion implantation. Dynamic ion beam mixing reactions are being undertaken and studies of surface treatments and modification of surface properties. Superalloys, and various alloys involving Cu, Al, Fe, Cr, Ni, Ti are being investigated as well as various precipitates in metals.

Ceramic-Ceramic Composites Meeting in Belgium, by Louis Cartz. (7-020-R) The problems of obtaining homogeneous dispersions of multicomponent systems were frequently discussed at this conference. The use of acoustic emission was shown to be a useful NDT analytical tool to detect the presence of microcracks in different places. The composite systems considered at the meeting included: zirconia-toughened aluminum (ZTA), SiC fiber-reinforced pyrex, SiC fiber-reinforced SiO₂ glass matrix, mullite-zirconia-Al₂O₃-SiC, C-fiber-reinforced reaction-bonded SiC, ionic conducting NASICON-glass insulator composites, and γ AlON-Al₂O₃ composites. The zirconium oxycarbide system, ZrO₂-ZrC_xO_y and ZrC-ZrC_xO_y composites are interesting, novel systems.

Mechanics

Fluid Mechanics at the Middle East Technical University and the Istanbul Technical University, by Eugene F. Brown. (7-012-R) In surveying the fluid mechanics activity and facilities at two Turkish universities, the author documents the status of the research at these institutions and also reveals the apparent difficulties inherent in the effort to establish satisfactory research activity in a developing country such as Turkey.

Facilities and Research at the French-German Institute of Research at Saint-Louis, by Daniel J. Collins. (7-017-R) The Institute of Research at Saint-Louis, France, is involved in research in ballistics, chemistry of explosives, and detonation aerodynamics of wings and slender bodies, acoustics, lasers, and measurements techniques. This report is a review of some of the research and facilities.

Multidiscipline

Italy's Institute of Research on Electromagnetic Waves--Istituto Di Fiera Sulle Onde Elettromagnet, by Daniel J. Collins. (7-021-R) The activities of this laboratory are reviewed. Of particular interest is the work in micro-optics and optical sensors, integrated optics, remote sensing, and signal processing.

OVERSEAS TRAVELERS

Notes on trip reports to locations in Europe and the Middle East which have been received by ONRL are reported below. For details, contact the traveler directly.

Chemistry

Traveler: Dr. R.N. Hazlett, Chemistry Division, Naval Research Laboratory, Washington, DC 20375-5000.

Dr. Hazlett attended the biennial meeting of the Information Exchange Program on Fuels, Lubricants, and Allied Products held at Bath, UK, in April 1987. The delegates included representatives from the Navies/Defence Forces and from petroleum and chemical companies from Australia, Canada, the UK, and the US. The technical agenda addressed fluids which are vital to ship operations, practices, and safety--shipboard fuels, lubricating oils, hydraulic fluids, and greases.

Topics with a common thread to all fluids included Navy policies, specification changes, operational experience, and R&D results and programs. In addition, topics appropriate to a particular fluid were also considered. For instance, with fuels, items dealt with important properties such as cetane number (relevant to diesel engine operation), fuel instability (relevant to gas turbine and diesel engine powerplants), microbiological growth and control, safety, and low temperature operating conditions.

After the meeting Dr. Hazlett visited Shell's Thornton Research Centre at Chester and Esso's Research Centre at Abington. Hazlett states that Thornton's research efforts in jet fuel are more fundamental and extensive than those of any other petroleum company laboratory in the world. His visit to Esso Research Centre concentrated on the thermal oxidation stability of aviation turbine fuel.

Electronic Engineering

Travelers: Lyle Burnett, Computers, Electronics and Software Division, Naval Coastal Systems Center, Panama City, Florida 32407-5000.

In May 1987, Burnett visited Plessey Naval Systems, Alderstone, UK, which is providing two Nautis-M display consoles for the Naval Coastal Systems Center's evaluation in a NATO Comparative Test. Plessey's technical presentations were focused on the software design, the software methodology being used, the software engineering environment, and the documentation.

Burnett also visited CAP Scientific, London, which is also developing software for the Nautis-M displays. Both Plessey and CAP are using VAX machines for their software development, but Plessey is using Intel PL/M and ASM86 to code their software, and CAP is using CORAL 66. Burnett concluded that the product being developed by these two companies is well designed and of good quality.

Oceanography

Traveler: Paul E. LaViollette, Remote Sensing Branch, Naval Ocean Research and Development Activity, NSTL, Mississippi 39529-5004.

Mr. LaViollette attended the Royal Society Discussion meeting, "Toward Improved Methods of Exploiting Remotely Sensed Imagery," held in March 1987, and gave a paper entitled "Satellite Image Analysis Techniques Applied to Oceanography." Attendees of the meeting consisted of about 150 scientists, including investigators from the UK's Institute of Oceanographic Sciences, the Admiralty Research Establishment, the Royal Aircraft Establishment, and Meteorological Office.

Physics

Traveler: Dr. J.F. Zeidler, Space Systems and Technology Division, Naval Ocean Systems Center, San Diego, California 92168-5000.

Dr. Zeidler visited Dr. Alan Collins and Professor Ed Lighthowers at Kings College, London, in May 1987 concerning diamond technology for semiconductor application. Dr. Collins loaned a synthetic semiconducting diamond sample for NOSC experiments. Dr. Collins, who had recently returned from a visit to Sumitomo Electric Industries in Hyogo, Japan, reported that Sumitomo has developed new techniques for growing single crystal diamonds at high temperature and pressure.

Dr. Collins had also visited Japan's National Institute for Research in Inorganic Materials (NARIM), and had been given a sample of polycrystalline diamond films grown at NARIM. This specimen was grown on a silicon substrate which was subsequently etched away to leave only a thin diamond film. One surprising feature of the film is its high electrical conductivity.

Dr. Collins is on the advisory committee for the First International Conference on New Diamond Science and Technology, to be held in Tokyo in October 1988.

Traveler: Dr. A. Christou, Electronics Technology Division, Naval Research Laboratory, Washington, DC 20375-5000.

Dr. A. Christou met in late March with Professors J. Morgan and H. Thomas at the University of Wales, Institute of Technology, Cardiff, concerning a joint NATO program on refractory GaAs metallization. He also conducted a meeting at Centre National de la Recherche Scientifique (CNET) at Lannion, France, of the paper selection and organizing committee of the 1987 International GaAs and Related Compounds Symposium.

Dr. Christou had the opportunity for an exchange of technical information while in Cardiff. He also reports that the various sessions of the 14th International Symposium on GaAs and Related Compounds have been finalized along with the list of invited speakers.

Space Science

Traveler: Dr. Phillip Mange, Associate Superintendent, Space Science Division, Naval Research Laboratory, Washington, DC 20375-5000.

Dr. Mange attended the Symposium on the Diversity and Similarity of Comets held in Brussels, Belgium, in April 1987. He was an invited speaker, along with others, including Sir David Bates of Queen's University, Belfast, to deliver remarks in honor of Professor Baron Marcel Nicolet, whose first graduate student Dr. Mange was.

Since he did not have the opportunity to systematically follow the cometary sessions, Dr. Mange summarized the points of the scientific program with these brief comments: (1) there is not so far observational evidence to require belief that cometary atomic abundances are significantly different from those of the solar system; (2) the bow shock that shields Comet Halley from the solar wind is so effective that only evaporative heating, not impingement of the solar wind, is responsible for production of material flowing away from the comet nucleus; (3) the plasma flow about the comet (Halley) is not fully understood (modeled), and (4) Comet Halley consists largely (about 80 percent) of (dirty) water ice, being dark (except for heated regions where most of the outflow occurs), with a spongy density perhaps half that of water.

REPORTS ON EUROPEAN SCIENCE AND TECHNOLOGY FROM OTHER COMMANDS

Information on each of the reports listed below was furnished by the activity identified by the abbreviations for that office. Requests for copies of or information about the document should be addressed to the appropriate office:

USARDSG--US Army Research Development and Standardization
Group, Box 15/65, FPO New York, 09510-1500

EOARD--European Office of Aerospace Research and Development,
Box 14, FPO, New York 09510

Aeronautics

Report on Future Spaceplanes Symposium, by LTC Bob Winn, European Office of Aerospace Research and Development. (13 pp) [EOARD-LR-87-47.]

On 29 April 1987 the British Interplanetary Society hosted the Symposium on Future Spaceplanes. It featured briefings by distinguished representatives from several European aerospace firms. In this report, highlights of the briefings on Britain's HOTOL, France's Hermes, Germany's Sanger, Japan's HOPE, and Russia's Space Shuttle are presented.

Applied Electronics

Laser Warning Receiver Development in Scotland, by MAJ Mel Townsend, European Office of Aerospace Research and Development. (5 pp) [Report No. EOARD-LR-87-49.]

The Electro-optic Department of Ferranti Defence Systems, UK, is developing a laser warning receiver for installation on a variety of ground and airborne systems. The system uses a series of passive sensor heads placed around the vehicle and coupled to an IR receiver via optical fibers. The sensors are divided into 45-degree segments and provide the vehicle operator with warning of the direction and eye danger level (intensity) of incoming laser radiation. Current optical band is 0.3 to 1.1 microns. The report provides more detail of the Ferranti development and includes company literature and a previous Office of Naval Research report on the same subject.

Chemistry

Dedicated Microwave Spectroscopy Research Laboratory, by MAJ Scott Shackelford, European Office of Aerospace Research and Development. (3 pp) [EOARD-LR-87-54.]

Professor Alfred Bauder, Eidgenoessische Technische Hochschule (ETH), Zurich, Switzerland, heads a research group whose laboratory facilities are totally dedicated to microwave spectroscopy research. This spectroscopy region measures only the rotational energy of a molecule to determine a specific compound's characteristic moment of inertia. The moment of inertia can then be used to infer the structural features in the molecule. In cases where a symmetrical molecule has no inherent moment of inertia, Bauder's group employs isotopic substitution of a heavier analogous atom in a specific site of the molecule to achieve a measurable movement of inertia. This group has successfully used this method to study larger molecules than is possible by laser-excited Raman spectroscopy techniques.

Novel Organic Non-Acidic Nitration and Biotechnological Synthesis Activities, by MAJ Scott Shackelford, European Office of Aerospace Research and Development. (6 pp) [EOARD-LR-87-33.]

Professor Dieter Seebach and his 40-man research group, Eidgenoessische Technische Hochschule (ETH), Zurich, Switzerland, have demonstrated a novel chemical transformation for nonacidic alkane nitration. When reacted with a lithium enolate salt in THF solvent (78°C to RT), isoamyl nitrate produces an α -nitrocarboxylate in high yield. Additionally, this group is investigating the use of biological systems for selective organic synthesis; this has a direct application to large-scale biotechnology-produced industrial materials. Seebach is in active contact with ICI, Runcorn, England, where biotechnology was first applied to the industrial production of polyphenylene using a benzene-cis-glycol intermediate that is obtained from enzyme-treated benzene.

Life and Behavioral Sciences

Visual Evoked Potentials, by MAJ Jim McDougal, European Office of Aerospace Research and Development. (3 pp) [EOARD-LR-87-46.]

Professor Zeki from University College London has been studying the monkey visual cortex using electrophysiological, anatomical, and perceptual techniques. He records the extracellular electrical activity of single cells in the anesthetized macaque in response to visual stimuli. Anatomical studies showing connections between various areas of the cortex are carried out using injections of horseradish peroxidase. The visualization of these connections within brain sulci is facilitated with a three-dimensional (using red and green glasses) computer program. Zeki expects to receive a "designometer" invented by Edwin Land which he plans to use to uniquely quantate colors used as stimuli with a three-dimensional matrix containing reflectance of long-, medium-, and short-wave light. Zeki plans to extend his electrophysiological work on color perception from anesthetized macaques to awaken rhesus monkeys and to look at motion perception in the cortex.

EEG and MEG Activity, by MAJ Jim McDougal, European Office of Aerospace Research and Development. (9 pp) [EOARD-LR-87-51.]

During the week of 25 May 1987 the AFARD Aerospace Medical Panel held a symposium on "Electric and Magnetic Activity of the Central Nervous System: Research and Clinical Applications in Aerospace Medicine" in Trondheim, Norway. This symposium was attended by a total of 94 panel members, presenters, and observers from various NATO countries and an observer from one non-NATO country (Israel). Thirty-seven papers were presented.

Material Sciences

Buckling of Composite Shells of Revolution, by LTC Jim Hansen, European Office of Aerospace Research and Development. (3 pp) [EOARD-87-25.]

Professor Stavsky from the Technion, Israel, has developed an analytical technique to accurately predict buckling in composite shells of revolution. He is able to solve this highly nonlinear, coupled buckling problem by transformation of differential equations, followed by computer numerical solution. He has shown that for certain situations, his "exact" solutions are four times more accurate than results from analysis using standard finite element packages.

Fragmentation and Cracking of Solids, by LTC Jim Hansen, European Office of Aerospace Research and Development.

Theoretical methods from statistical physics have been applied to cracking and fragmentation of solids. Personnel at SOREQ Nuclear Research Center, Israel, use

percolation theory, transport theory, and maximum entropy to model damage in ceramics, metals, and rock.

Study of New Fluoride Glasses for the Preparation of Infrared Optical Fibers, an interim report under contract DAJA 45-86-C-0050 by Professor Jacques Lucas, University of Rennes, France. (4 pp) [Sponsored by USARDSG. Request information from USARDSG by report title, author, and contract number.]

New indium-based fluoride glasses, called BIZYT, resistant to devitrification, have been investigated in order to measure their chemical durability versus humidity. The corrosion mechanism has been studied and the molar absorption coefficient of the OH parasitic peak has been evaluated. Also the evolution of the refractive index and the material dispersion versus λ have been investigated. In order to design a core-clad structure, the variation of refractive index with chemical composition has been measured for LiF - and PbF_2 -containing glasses.

Shearographic Imaging Systems, a report under contract number DAJA 45-84-C-0042, by Dr. D.K. Das-Guptis, University College of North Wales, UK. (31 pp) [Sponsored by USARDSG. Request information from USARDSG by report title, author, and contract number.]

An optical shearing technique has been used to produce high-quality strain contours of centrally loaded, or thermally stressed and clamped plates. An analysis of strain from these fringes provides good agreement between experimental and theoretical values. It has also been shown that this technique is compatible with infrared thermographs in the detection of delamination in a composite laminated plate. This work was followed by developing an "on-line" electronic speckle shearing technique in which the optical camera was replaced with an electronic camera and its associated data storage and analysis and display system. This latter method shows good promise. However, it requires further work and equipments for better image process facilities to improve the fringe resolutions.

Physics

Center for Electronic Materials, UMIST, by Dr. Einig Davies, European Office of Aerospace Research and Development. (3 pp) [EOARD-LR-87-27.]

Prominent activities at this center in Manchester, UK, include compound epitaxial growth and an exacting materials characterization program which includes silicon. ZnSe growth on GaAs and Ge is at the forefront of II-VI compound work worldwide. In III-V compounds, material limitations have been identified with trace contamination in the metallo-organic gases used for the growth. The difficulty of atmospheric pressure growth on InP is attributed to such contamination and this is now readily circumvented. The Center has also contributed to the evolution of the deep-level transient spectroscopy technique which is used extensively in silicon for evaluation.

Research on Lasers at the Forschungs Institut Für Optik (FFO) at Scholars Kressbach, Near Tübingen, by Dr. Stacey Lajdinis, European Office of Aerospace Research and Development. (5 pp) [EOARD-LR-87-22.]

This institute is performing militarily related research to determine laser atmospheric transmission characteristics. The numerous studies have resulted in a number of data banks applicable to the European theatre.

Fast Acting Beam Detection and Deflection System, a periodic report under contract DAJA 45-83-C-0016 by Dr. D.K. Das-Guptis, University College of North Wales, UK. (17 pp) [Sponsored by USARDSG. Request information by report title, author, and contract number.]

A TeO_2 acousto-optic cell can deflect the He-Ne laser beam wavelength (633 nm) efficiently by an angle of 4° . It has been estimated such a deflection can be maintained in the laser wavelength range of 448 nm to 694 nm by sweeping the TeO_2 cell with ultrasonic frequency in the range of 55-105 MHz.

An alternative approach of deflecting incoming energy of laser beam efficiently from the zeroth order is to use blazed transmission diffraction gratings. It is estimated that 99.8 percent of the incident energy may be stripped off the zeroth order by using four such gratings of appropriate blaze angle in series.

TECHNOLOGY ROUNDUP--ITALY

The items below were received from the American Embassy in Rome. For further information, contact Dr. Gerald Whitman, Office of the Science Counselor, American Embassy, Rome, APO New York 09794-0007.

A New "Expanding" Material. The Italian Company Vela, in cooperation with Northern Italian Universities, has patented a new material capable of expanding greatly at temperatures varying from minus 30° to 100°C. Called "Composito X," one cubic meter heated a few degrees may vary in volume several times, exerting great pressure. With moderate heating the compound can lift several tons of weight. Alternatively, exerting strong pressure on the material liberates great amounts of heat as the volume decreases. The new material is expected to have many applications in the aerospace and automobile industries, energy storing devices, etc.

ENEA's 5-year Program for Robotics Research. ENEA, the Italian agency for nuclear and renewable energies, has developed a 5-year program (1986-90) for robotics research. The program will concentrate on remote control systems, general purpose autonomous systems, special dedicated systems, and advanced mobile robots. One ENEA-developed system, called Mascot, was selected for use in the Joint European Torus (JET) Project. ENEA is also developing an autonomous versatile expandable robot equipped with sensor, intelligence and control, deambulation, manipulation, and energy supply modules. Moreover, ENEA is participating in the EUREKA AMB/Advance Mobile Robot Project aimed at the creation of a robot for the protection of man and environment in cases of natural and industrial disasters.

Discussions Held on Development of Superconducting Materials. The Technical Scientific Committee of Ansaldo's Scientific Center for the Development of Superconductivity met recently with CISE, ENEA, INFN, CNR, and university and private industry representatives to discuss strategies for the development of superconducting materials in Italy. Among the topics discussed were possible applications in the production, transmission, distribution, storage and utilization of energy. Italy recently established a finalized project for developing superconductivity and other cryogenic technologies.

Superconducting Cable for the HERA Accelerator. Metalli Industriali (LMI) has obtained a contract to supply 500 kilometers of high-power (8 ampere) superconducting cable for the "HERA" Accelerator being built in Hamburg. The contract, obtained through the Italian Institute of Nuclear Physics, is worth about \$11.5 million.

Investing in US Biotechnology. A new financial holding society, called Finbiotec, was recently established in Milan to operate in the biotechnology field. The society will invest venture capital in highly innovative biotechnology firms in the US. Members of the society include pharmaceutical and food industries, university representatives and a Milan financial group.

New Research Center for Antibiotic and Chemotherapy Products. Glaxo Italia is building a research center in Verona for the development of new antibiotic and chemotherapy products, similar to the ones operated by Glaxo in England, the US, and Japan. The Italian research center will employ 500 to 850 researchers and occupy an area of 34,000 square meters. The center will cost about \$80 million and will be ready in 1990.

Three Companies in Joint Study for Magnetohydrodynamics Electric Plants. Ansaldo, Snamprogetti, and Franco Tosi have joined in a feasibility study of magnetohydrodynamics (MHD) electric plants, an advanced process for producing electricity from gas, oil, or coal by applying magnetic fields to burned gases at high temperatures. The 5-year joint project is budgeted at about \$154 million and will employ new high-temperature-resistant materials, superconductors, and advanced technologies for gas ionization.

EMBASSY NOTES FROM WEST GERMANY

The items below were received from the American Embassy in Bonn. For further information, contact Dr. Edward M. Malloy, Office of the Science Counselor, American Embassy, APO New York 09080.

Superconductivity Research in West Germany. According to Dr. von Stackelberg of West Germany's Ministry of Research and Technology, the Ministry provided about DM4 million (\$2.3 million) per year during the late 1960's and early 1970's in support of research programs in superconductivity. The main purpose was to support the development of CERN, the European high-energy research center in Geneva. Subsequent federal support for superconductivity declined to less than DM1 million (about \$570,000) a year. However, in the last 3 years support has again risen steeply, to 4 million marks in 1986 and 6 million in 1987. Nevertheless, von Stackelberg was not optimistic that support for superconductivity research would escape the budgetary ax. Essentially, he said, "We have come too late with too few resources to keep up in the race to find technological breakthroughs."

Von Stackelberg said that in the early years, superconductivity research concentrated on applications using liquid helium (4 K). Several interesting applications were found, including a 1.6-kilometer superconducting cable produced by Siemens in 1969 for use in CERN. Nowadays, the Ministry supports 11 programs: five in new superconductors at high temperatures, using liquid nitrogen (45 K); three in applications; two in cryogenic techniques; and one in development of new magnets.

As principal centers of excellence, von Stackelberg selected the Nuclear Research Laboratories at Juelich, which works in cooperation with the University of Karlsruhe, followed by the Max Planck Institute in Stuttgart, and the Hans Meitner Institute in Berlin. He said that about 12 German firms are also deeply involved in superconductivity research, including Siemens, AEG, and Leybold-Heraeus.

According to the press, superconductivity research in West Germany recently achieved significant successes. Most recently, *Wirtschaftswoche*, a German weekly economics magazine, published an article about new promising results of Professor Constantin Politis of the Nuclear Research Center Karlsruhe (KFK) in the development of a ceramic material with superconductivity characteristics at a temperature of 105 K. In the same article, it was also reported that Professor Politis and his team during one test even achieved superconductivity at 240 K, a result, however, that has not yet been confirmed.

On May 15, the *VDI Nachrichten*, a German weekly technical newspaper, reported about Dr. Yunas Khan of the University of Bochum, who has developed a variant of the well-known barium-lanthanum-cooper oxide composite that is capable of superconductivity at 135 K. At the present time, this result is said to be the absolute top value in transition temperature. Other advantages of the new superconductive ceramic composite are a narrow, defined transition temperature and maximum currents of up to 300 mA/mm².

As one of the first European commercial superconductivity enterprises, the Dutch firm Philips has built up a research group which is focusing on superconductive ceramics suitable for commercial applications. The research group is comprised of scientists from the Philips Research Laboratories at Eindhoven, the Netherlands, Aachen, West Germany, and Briarcliff Manor, US. The ultimate main objective of the Philips researchers is to develop superconductive materials with transition temperatures at normal room temperature.

SCIENCE NEWSBRIEFS FOR SEPTEMBER

The following *Science Newsbriefs* were published by the ONR, London, Scientific Liaison Division during September. *Science Newsbriefs* provide concise accounts of scientific research developments, meeting announcements, and science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

Number

- 5-5 Holographic Memories Using the Dielectric-Induced Photorefractive Effect, by Robert W. Vest.
- 5-6 Levitation of Ceramics Spheres by Acoustic Waves for Studies at 6000 K by Laser Beam Heating, by Louis Cartz.
- 5-7 ONPL Workshop on Engineering Materials for Very High Temperatures, by Louis Cartz.

JUNE AND JULY MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during June and July. The *MAS Bulletin* is an account of accomplishments in European naval research, development, test, and evaluation. Request copies of the *Bulletins*, by number, from ONR, London.

Number

- 22-87 Unique Monitoring and Control of Remote Data Broadcasting Stations
- 23-87 Two European Doppler Weather Radars
- 24-87 Missile Aerodynamics Calculations and Testing at Matra
- 25-87 Anti-Ship Missile Towed Decoy
- 26-87 Second Quarterly Index 1987
- 27-87 Siren Offboard Countermeasures System
- 28-87 French Spaceplane--HERMES Update
- 29-87 Rina Warship '87
- 30-87 Hydrographic Survey Training Simulator

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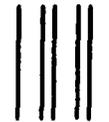
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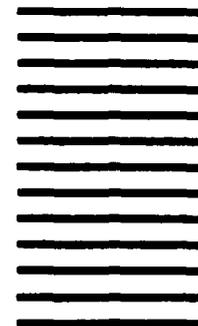


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