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Reports on Current  
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|                        |    |
|------------------------|----|
| Behavioral Sciences    | 1  |
| Biological Sciences    | 5  |
| Chemistry              | 28 |
| Computer Sciences      | 30 |
| Environmental Sciences | 33 |
| Material Sciences      | 38 |
| Mechanics              | 47 |
| Ocean Sciences         | 51 |
| Physics                | 53 |

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SECURITY CLASSIFICATION OF THIS PAGE

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## REPORT DOCUMENTATION PAGE

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| 16. SUPPLEMENTARY NOTATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |       |                                                                  |                                                                                                    |                                                               |                                  |
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## Behavioral Sciences

- Factors Associated with the Decision to  
Emigrate: Research from the University  
of Oporto ..... William D. Crano 1

This report focuses on the research carried out by Professor Felix Monteiro Neto, director of the Portugal's University of Oporto Center of Social Psychology. Neto's work is concerned with the massive migrations of people in contemporary Western Europe.

## Biological Sciences

- Fourth European Congress on Biotechnology ..... Claire E. Zomzely-Neurath 5

Selected presentations in the areas of downstream processing and biocatalysis are reviewed in this report on the congress which was held in June 1987 in Amsterdam, the Netherlands. The author states that it is evident from the reviews she provides that European scientists are doing first-class research in biotechnology.

- Third International Congress and  
Exhibition for Biotechnology ..... Claire E. Zomzely-Neurath 11

This conference, also called BIOTECHNICA '87, was held in Hannover, West Germany, in September 1987. Summaries of some of the presentations are given. The topics are: polypeptides in therapy, enzymatic and microbial transformation, and fundamentals of bioprocess engineering.

- International Conference on  
Separations for Biotechnology ..... Claire E. Zomzely-Neurath 16

The Conference on Separations for Biotechnology was held in September 1987 at Reading, UK. Selected presentations are summarized under the topics of cell harvesting and disruption, analytical techniques and process control, adsorption and chromatography, and liquid/liquid extraction.

- Groningen Biotechnology Center,  
The Netherlands ..... Claire E. Zomzely-Neurath 22

The Groningen Biotechnology Center--formed originally from 10 major activities of biotechnologically oriented research groups of the Departments of Biology, Chemistry, and Pharmaceutical Sciences at Groningen University--are reviewed. The Center develop and carries out multidisciplinary research programs and coordinates the support to biotechnology-oriented teaching. This report focuses on the research.



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## Chemistry

- Chemical Engineering Research at the  
University of Patras in Greece ..... Daniel J. Collins 28

A brief overview and a summary of the research at the Institute of Chemical Engineering and High Temperature Chemical Processes, located at the University of Patras, is given. Topics include high temperature and new materials, petroleum and petrochemical industry, industry and environment, and catalysis.

## Computer Sciences

- The Computing Surface of the Company Meiko ..... J.F. Blackburn 30

The Meiko company developed and is producing a line of supercomputers, called "Computer Surfaces," which is based on the use of transputers. This report gives the background for the development and discusses the characteristics of the machines.

## Environmental Sciences

- Meeting on Atmospheric Studies by  
Optical Methods ..... Jerome Williams 33

This 15th annual meeting was held in September 1987 in Granada, Spain. Topics of the meeting were: aeronomy, radiative processes in the middle atmosphere, instrumentation and airglow, and aurora and airglow. The author summarizes the presentations; he concludes that the field of aeronomy appears to be on the brink of major advances.

- Atmospheric and Oceanic Remote Sensing  
Sessions at the 38th International  
Astronautical Congress ..... Jerome Williams 36

The sessions on oceanic and atmospheric remote sensing at this congress, held in October 1987 in Brighton, UK, are reported. The author states that the speakers, both European and American, were optimistic about the international space program in general, and the future of remote sensing in particular.

## Material Sciences

- Stainless Steels/87 Highlights  
Welding of New Duplex Steels ..... A. John Sedriks 38

This report gives a brief overview of the papers presented at the Stainless Steels '87 Conference, which was held in September 1987 at York University, UK. The author states that the most striking aspect was the evidence of the large European R&D effort that has gone into the provision of welding technology for the new duplex stainless steels.

|                                                             |             |    |
|-------------------------------------------------------------|-------------|----|
| NATO Meeting on Ion Beam Modification<br>of Materials ..... | Louis Cartz | 40 |
|-------------------------------------------------------------|-------------|----|

Selected papers given at this NATO-ASI meeting, held in August 1987 in Viano do Castelo, Portugal, are reviewed. The stated objective of this meeting--materials modification at high fluence--was well covered, and it is on that subject that this report focuses.

|                                                   |             |    |
|---------------------------------------------------|-------------|----|
| Powder Metallurgy Meeting in<br>Switzerland ..... | Louis Cartz | 44 |
|---------------------------------------------------|-------------|----|

This meeting, "PM Aerospace Materials 87," was held in November 1987 in Lucerne, Switzerland. The meeting was concerned with the powder metallurgy of the tough, lightweight metal alloys--Ti, Al, Mg, and Li alloys--required by the aerospace industry. Selected presentations under the various relevant topics are summarized.

## Mechanics

|                                                                                              |                   |    |
|----------------------------------------------------------------------------------------------|-------------------|----|
| XIX International Symposium "Heat and Mass<br>Transfer in Gasoline and Diesel Engines" ..... | Daniel J. Collins | 47 |
|----------------------------------------------------------------------------------------------|-------------------|----|

Selected presentations from this meeting, which took place in August 1987 at Dubrovnik, Yugoslavia, are reviewed. Topics include engine heat transfer, vaporization and spray, external heat transfer, numerical flow simulation, and engine heat transfer.

## Ocean Sciences

|                                                                          |                 |    |
|--------------------------------------------------------------------------|-----------------|----|
| Meeting of the Estuarine and Brackish<br>Water Science Association ..... | Jerome Williams | 51 |
|--------------------------------------------------------------------------|-----------------|----|

This meeting attracted about 100 investigators, primarily from the UK, but also from West Germany and France. It was held in September 1987 in Dundee, Scotland. Proceedings in the sessions on remote sensing, biological sampling, sediments, and physical processes are summarized.

## Physics

|                                                                                   |            |    |
|-----------------------------------------------------------------------------------|------------|----|
| Far Ultraviolet Coherent Lightsources<br>and Laser Spectroscopy at Garching ..... | Paul Roman | 53 |
|-----------------------------------------------------------------------------------|------------|----|

Using four-wave mixing in metal vapors (buffered by noble gases), the research group of Professor C.R. Vidal at the Max Planck Institute for Extraterrestrial Physics found a methodology to produce efficiently extremely narrow wave-band coherent VUV and XUV radiation. The vapor is produced in specially designed heat-pipe ovens. Primary applications focus on sophisticated VUV spectroscopy of astrophysically important molecules.

## News and Notes

|                                                                                               |                           |    |
|-----------------------------------------------------------------------------------------------|---------------------------|----|
| Conference on Stress and Adjustment .....                                                     | W.D. Crano                | 56 |
| Two Scientific Meetings in Budapest .....                                                     | W.D. Crano                | 56 |
| New Journals in Biological Sciences .....                                                     | Claire E. Zomzely-Neurath | 56 |
| New Journals Concerning the Human<br>Neural System .....                                      | Claire E. Zomzely-Neurath | 57 |
| Fishing in the Desert .....                                                                   | C.J. Fox                  | 60 |
| European Heat-Pipe Technology<br>Development and Application .....                            | Frederick R. Best         | 60 |
| Major Materials Meeting in Europe 1988 .....                                                  | Louis Cartz               | 61 |
| Control Research at the Technical<br>University of Munich .....                               | Daniel J. Collins         | 62 |
| Applied Research at West Germany's<br>Motoren und Turbinen-Union .....                        | Daniel J. Collins         | 63 |
| Second International Conference on<br>Tethers in Space .....                                  | Jerome Williams           | 64 |
| The Remote Sensing Group at the<br>University of Naples .....                                 | Jerome Williams           | 66 |
| The Scottish Marine Biological Association<br>at Oban .....                                   | Jerome Williams           | 67 |
| Remote Sensing at the University of Dundee .....                                              | Jerome Williams           | 69 |
| Thick-Film Hybrid Microelectronic<br>Packages used in Magnetometer Project .....              | Paul Roman                | 70 |
| Transverse Effects in Optical Bistability--A<br>Special Session Sponsored by ONR-London ..... | Paul Roman                | 70 |
| Significant Progress in Organic Nonlinear<br>Optical Materials .....                          | Paul Roman                | 72 |
| Some Spanish Programs in Optics and<br>Electronics .....                                      | Paul Roman                | 73 |
| ONRL Cosponsored Conferences .....                                                            |                           | 73 |
| ONRL Reports .....                                                                            |                           | 74 |
| Biological Sciences                                                                           |                           |    |
| Material Sciences                                                                             |                           |    |
| Overseas Travelers .....                                                                      |                           | 74 |
| Chemistry                                                                                     |                           |    |
| Computer Manufacturing Technology                                                             |                           |    |
| Oceanography                                                                                  |                           |    |
| Reports on European Science and Technology<br>from Other Commands .....                       |                           | 75 |
| Aeronautics                                                                                   |                           |    |
| Chemistry                                                                                     |                           |    |
| Energetic Materials                                                                           |                           |    |
| Material Sciences--Surface Structure                                                          |                           |    |
| Semiconductors                                                                                |                           |    |
| Structural Materials                                                                          |                           |    |
| Physics                                                                                       |                           |    |
| Science Newsbrief .....                                                                       |                           | 77 |
| Military Applications Summary Bulletins .....                                                 |                           | 77 |

## Behavioral Sciences

### FACTORS ASSOCIATED WITH THE DECISION TO EMIGRATE: RESEARCH FROM THE UNIVERSITY OF OPORTO

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.

#### Introduction

Considerable contemporary European social research is concerned with the problem of unemployment (e.g., see ESN 41-6:287-296 [1987]). At the most obvious level, this research interest reflects the severity, or potential severity, of the problem. But it is also the case that unemployment is studied because of its dislocating effect on the fundamental culture of the afflicted country. In America during the great dustbowl era, thousands of Midwesterners whose farms had literally blown away for lack of rain packed up and moved westward. This sad pilgrimage had one common feature--the migration was carried out within the boundaries of the mother country. In the European context, the opposite is most often the case. When people pack up to find new work, they must usually search in lands other than their own.

It is commonly assumed that the search for jobs is the central reason for most massive (nonwar-related) migrations in contemporary Western Europe--but is this common assumption correct? Research carried out by Professor Felix Monteiro Neto, director of the University of Oporto's Center of Social Psychology, is concerned implicitly with this issue, and consideration of some of his interesting results is the focus of this report.

#### The Scope of the Problem in Portugal

Is emigration worth studying? Is the issue of sufficient proportion to justify research attention? To decide this issue, let us consider two factors: contemporary attitudes of young Portuguese, and the relative magnitude of emigration from the mother country (which, in this instance, is Portugal).

Contemporary attitudes. As Neto (1987) has observed, if we were to ask the typical French or American high school student what he or she intends to do in the future, there is a 50-50 chance

that the answer would be, "I want to become a doctor (or a priest, or a lawyer, or a sailor, etc.)." If the same question were posed to a young adolescent in the north of Portugal, however, more than 50 percent would answer, "I will become a migrant worker." This astounding statistic is drawn from Neto's carefully controlled stratified sample of Portuguese adolescents. If intentions mean anything, the problem of migration is important.

Magnitude. The meaningfulness of intentions to emigrate, and the resulting effects on the society, can be inferred from data on contemporary Portuguese migration patterns. The Portuguese have always been a wandering people, at least since the discovery of Madeira in 1414. This is in part a consequence of the seafaring tradition of this beautiful country. In many ways, such wanderings have resulted in some very positive outcomes for the society. They created new avenues for trade, helped enrich the cultural heritage of the host and the mother country, etc. This is not to say that such interactions have always been carried out without exploitation of the host society--far from it--but rather that on balance, much good can come of such interactions, especially for the visiting (or colonizing) society.

Recent social statistics, however, provide a stark picture of the other side of the coin (cf., Godinho, 1978). In some ways, emigration can create severe dislocations in the society that is the source of the emigrants. Consider the case of Portugal as an example. An official government bureau in Lisbon estimated that in 1970, 180,000 Portuguese had emigrated. In a country whose population numbered approximately 8.7 million at the time, this figure represents a remarkable rate of loss. Consider another statistic: The total number of Portuguese today who are living outside of the territorial boundaries of their mother country is estimated at 3.5 million. If we assume a population of roughly 10 million, it is easy to calculate that somewhere between 30-40 percent of all Portuguese citizens are living outside Portugal. This figure is "neutral," in that it does not necessarily lead to a positive or a negative value judgment. Depending upon one's values, vested interests, theories of society, etc., migration of this magnitude may be good or it may be bad. It is beyond argument, however, that in the case of Portugal, it is massive.

To provide some feel for the magnitude of this wave of emigration in terms that are closer to home, imagine the consequences to American society if in one year, 2-3 percent of the US population packed their bags and left the country,

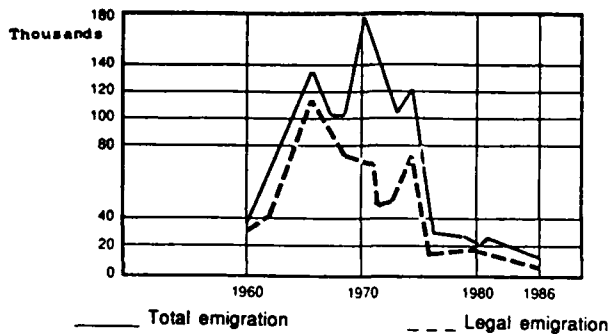


Figure 1. Clandestine and legal Portuguese emigration (1960-1986). (Source: "Secretaria de Estado das Comunidades Portugueses," 1987.)

with the intention to stay away more or less permanently. And assume further that these migrants were, in the main, the principal bread winners for their families, who stayed behind. The effects on the society of a population movement of this scope are difficult to envision.

Recent legal and clandestine Portuguese emigration figures are presented in Figure 1. As shown, migration rates are far from steady. This illustration suggests yet another disruptive aspect of massive migration: population movements of this size exert an influence on the society not only in terms of relative numbers, but also as a consequence of variations in rates of removal. In some years, the population base is relatively constant--few people leave (as in very recent years in Portugal [Figure 1]). In other years (e.g., the early 1970's), however, massive emigration is commonplace. The see-saw nature of such emigration waves must inevitably cause problems for the society.

In light of all of these data, it seems fairly obvious that the general question, "Does it matter?" must be answered in the affirmative. Emigration is worth studying. It is of sufficient proportion to demand close scrutiny.

#### Emigration: Who and Why?

**Research Questions.** Having concluded that emigration is worth studying, we are now in a position to appreciate more fully Neto's work on Portuguese migration. Before considering the mechanics of his design, let us focus on Neto's central research preoccupations. The design of this research is such that it allows for the investigation of the following interesting questions:

- What is the proportion of respondents who find emigration a likely possibility?

- Are there differences between those who intend to emigrate and those who do not?
- What are the most appealing countries of destination?
- Are there differences in the desirability of emigration among various strata of the youth population (discussed below) that were sampled?
- Why do people plan to emigrate? What are the determinants of the process?

**Sample.** The plan of the research is relatively straightforward. Neto constituted a sample that was stratified on three factors:

- Community type: urban/rural
- Sex: male/female
- Socioeconomic status (SES): moderate/low.

Equal numbers of respondents were included in the eight conditions formed by the factorial combination of these three strata. In total, 480 young adolescent Portuguese from the northern provinces of Portugal were sampled. The common feature of all of the respondents was that they were in their eighth and final year of mandatory education. The respondents ranged in age from 13 to 17 years.

**Measures.** Three distinct sets of measures were administered to the respondents in two separate data gathering sessions. The first of these was a free association test, in which respondents were asked to reflect upon the emigration experience, and to write anything that came to mind. Following this measure was a 132-item structured scale, containing 121 close-ended, and 11 open-ended questions, concerned with attitudes toward, and knowledge of, various aspects of emigration, previous (familial) experience with emigration, motivations for emigration, etc. Cattell and Beloff's (1966) High School Personality Questionnaire (HSPQ) was administered at the second data gathering session. This questionnaire, which is used to measure a host of persistent personality characteristics, is composed of items drawn from the California Personality Inventory and Cattell's (1970) 16 PF. Its central focus is on the dimensions of anxiety, and introversion/extroversion.

#### The Results

**How Many, and Who?** Fully 47 percent of the sample expressed the intention to migrate. Of this group, nearly 44 percent mentioned that they had formed this intention before reaching the age of 13. The HSPQ was relatively unhelpful in differentiating those with the intention to emigrate from those who did not foresee

this as a possibility. There was a marginally significant difference between these groups on anxiety--higher anxiety scores were associated with the intention to migrate--but this statistically significant difference is so small that it is not useful in predicting who would and who would not find emigration a likely life option. There were no differences in introversion/extroversion scores between the two groups.

Sociodemographic data were somewhat more informative with respect to the decision to emigrate. The variables that appear to predict a positive emigration decision are:

- Age: older respondents were more likely to report positive emigration preferences
- Religion: more active religious practice was associated with positive preferences
- Low SES
- Rural (vs. town or city) residence (probably associated with lower SES)
- Middle or later birth order, coupled with a large nuclear family
- Previous internal (within Portugal) migration, or close association with family or friends who had returned from an earlier (external) migration experience.

**Why?** Respondents were asked to note the reasons why they were considering emigration. Those who were not contemplating such a course were asked to guess why people did so. Neto then counted the number of times that a specific reason or motive was given by respondents as their first, second, or third choice. A summary of these choice frequencies for respondents with negative and with positive intentions to emigrate are presented in Figures 2 and 3. Figure 2 summarizes the hypothetical reasons for emigration of the group who did *not* intend to emigrate. In other words, this group was asked to *guess* why people emigrated. As shown in Figure 2, economic reasons predominate in the estimates of such respondents. This group assumes that the major reasons for leaving Portugal are employment, wages, housing, and success, in that order. The reason receiving the most number of first place votes is employment, with wages running a close second. Wages received the greatest number of second place votes.

A similar pattern is produced by those who *do* intend to emigrate, as shown in Figure 3. However, the implications that may be drawn from this figure are quite different from those of Figure 2. As shown, among those who intend to emigrate, the motive mentioned first by most

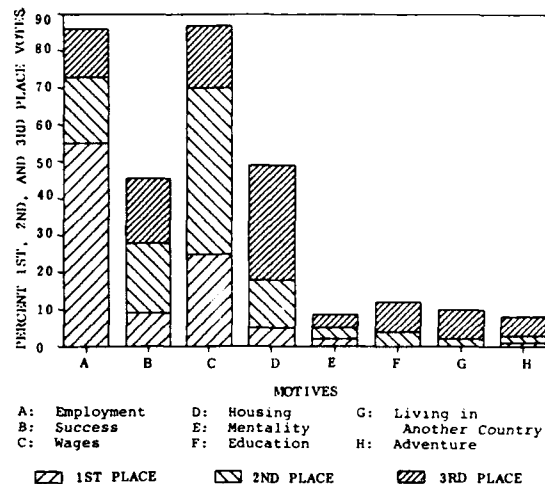


Figure 2. Assumed motivations for migration of those who do not intend to emigrate.

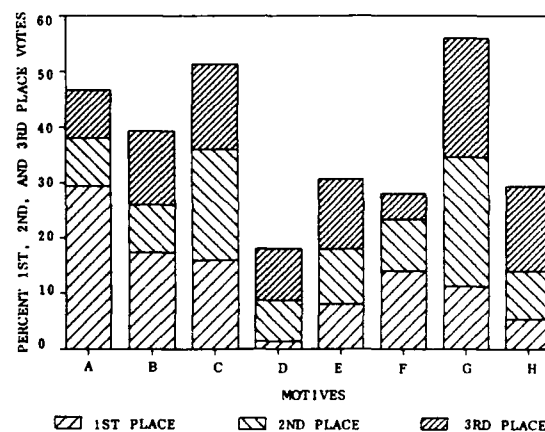


Figure 3. Motivations for migration of those who intend to emigrate.

respondents was employment, then wages, then education. These results seem to confirm the "common knowledge" about emigration--people leave their homes to find work, preferably high-paying work. But there is more to it than this. As Figure 3 demonstrates, a high number of choices were given to "Living in another country," "Adventure," "Education," and "Mentality" (i.e., learning about the ways that other people think). Certainly those planning to emigrate were doing so for economic reasons; but to ascribe the decision totally to economics would be to disregard the data. There is a sense of adventure in the choices of those who plan to emigrate. They are concerned not only with economic necessities, but also

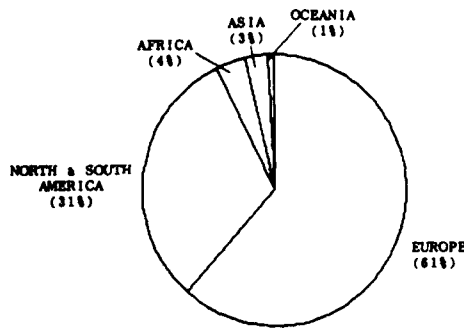


Figure 4. Preferred destinations.

with experiencing life in another country, with learning about how people of very different regions view the world, and with education.

As subsequent data indicate, education in the "emigré" group is not seen as confined within the walls of the classroom. Those planning to leave are no more likely than the nonleavers to profess a desire for higher (university-level or professional) education. Over all respondents, 29 percent expressed an ambition to attend college, and 56 percent to complete high school; the remaining 15 percent had made no clear decision. Variations from these percentages as a consequence of emigration choice were minimal.

**Where?** The preferred countries of destination among those expressing a desire to emigrate, and the reasons for the preferences, are revealing and interesting. Over the entire sample, 21 different countries were mentioned, spread over the five continents. First choice of nearly two-thirds of the respondents was Europe, followed by North America, South America, Africa, Asia, and Oceania (see Figure 4).

By far the most frequently mentioned country was France, followed closely by the United States. France was chosen because of the established network of Portuguese contacts (there are now more than 1 million Portuguese citizens residing in France), and the positive response to the Portuguese by French authorities. Those choosing the US did so for other reasons: "because it is a country with greater development, greater culture, and more opportunities;" "because it is a country with great universities and schools;" "because I would like to become a scientist;" were common responses.

#### The Dream and the Reality

As noted, the sample on which Neto's research was based was relatively young (13-17 years of age) and not capable at

the time of the survey to emigrate independently. What is the value, therefore, of his data. Is there any evidence to suggest that the dreams of his young respondents will become reality? There is circumstantial evidence that bolsters the ecological validity of his findings. This evidence is as follows:

- First, in a comparable survey completed shortly before the present work, Neto (1986) found almost identical proportions of young Portuguese expressing a preference for (or against) emigration. The results of the current investigation, that is, do not appear to be a fluke.
- Second, the various motivations for emigration are comparable to those mentioned by Portuguese migrant workers living abroad, as found by Neto and Mullet (1987).
- Third, attitudes toward, and knowledge about, emigration were consistent with preference differences. Those who wished to emigrate were more informed about the process, and had more positive attitudes toward it. Their answers to the emigration question were not whimsical.
- Fourth, nearly 90 percent of those expressing the intention to emigrate believe that they have (or will have) the wherewithal to fulfill this desire.
- Finally, further supporting the supposition that those who prefer to emigrate have given some thought to the decision is the finding that 88 percent of this group plan to return to Portugal after living abroad, while 12 percent plan to stay away permanently. The desire to return is perfectly consistent with the preferences of those who actually have left the country, as revealed in surveys of first generation Portuguese migrants conducted in 1977 and 1983.

While far from completely airtight, these data suggest considerable consistency between preferences for, and eventual, emigration.

Earlier work presented in *European Science Notes* reviewed European research on the causes and consequences of unemployment, in Italy and Belgium (see ESN 41-6:287-296 [(1987)]). The work of Monteiro Neto is not directed specifically toward the effects of unemployment, per se, but it shares a common heritage, since the decision to migrate is motivated at least in part by considerations of future employment. Neto's research is somewhat more basic than that surveyed earlier, in that it is focused on the motivations underlying the choice to leave one's home

and country. It cannot be said with certainty that the data presented by Neto represent the true underlying thoughts and feelings of those who actually do emigrate. It could be that none of the respondents who professed the intent to emigrate will do so--but this appears extremely unlikely. The circumstantial evidence supporting the ecological validity of Neto's data seems to me to be reasonable. His work, in conjunction with the findings reviewed earlier, can be used to form a more complete picture of the wide panoply of values, needs, goals, and desires that underlie what is, perhaps, one of the most important and, at times, wrenching, decisions a person can make.

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- 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

The Fourth European Congress on Biotechnology took place in Amsterdam, the Netherlands, from 14 through 19 June 1987. The congress attracted more than 2000 participants and offered a very wide spectrum of activities. The meetings and extensive exhibitions were held in the RIA Congress Center, which provided excellent facilities for the many varied activities in close proximity to each other. Fifty nations were represented at the congress. The nations with the largest group of participants were: the Netherlands, West Germany, UK, France, Italy, Sweden, and Switzerland. However, the US and Japan were also well represented. In addition, Hungary, Yugoslavia, and Czechoslovakia had strong contingents.

The more than 50 minisymposia and workshops were the main attractions. They were favored by the participants because they provided recent results in the context of developments in specific scientific fields. Nearly 800 posters were presented and constituted as usual, an important exchange of information. Here, fresh data and new ideas were presented.

All the general lectures served as valuable introductions to scientific fields in which one was not a specialist. The best of the lectures also yielded high benefits for the specialists of the particular field. They presented new results or personal visions, or they placed the developments of a specialty in perspective to other current developments.

The topics covered at this extensive conference in the general lectures, minisymposia and workshops were:

- Biocatalysis
- Animal cell cultures
- Molecular genetics
- Downstream processing
- Measurement and control
- Microbial physiology
- Fine chemicals
- Pharmaceuticals
- Protein engineering
- Bioreactors
- Environmental biotechnology

Due to the enormous amount of material that was presented at this biotechnology congress, it is only possible to present selected brief summaries of some of the topics in this relatively short

12/2/87

## Biological Sciences

#### FOURTH EUROPEAN CONGRESS ON BIOTECHNOLOGY

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

report. However, a much more extensive and detailed review is available in ONRL Report 8-001-C.

### Downstream Processing

Animal and Plant Cell Products. Two minisymposia and one workshop dealt with various aspects of downstream processing. The first minisymposium addressed the downstream processing of animal and plant cell products. In the development of downstream processes the specification of the end product that has to be achieved influences greatly the choice and optimization of the method used. The aim of this minisymposium was to focus on some methods and processes suitable for downstream processing of products mainly from animal cells but also from plant cells as well as on some quality criteria of the end product.

The quality control of highly purified bioproducts from transformed animal cells was discussed by A. Jungbauer (Institute of Applied Microbiology, University of Agriculture, Vienna, Austria). He emphasized that bioproducts from transformed cells require a high level in quality control if the products are used as therapeutics. Absence of DNA and foreign proteins have to be proved. The purity of proteins was checked by sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE), isoelectric focusing by the immobiline system (IEF), and reversed phase chromatography (RPC). A product is considered to be highly purified if it displays one band in SDS-PAGE and in IEF and also one peak in RPC. This set of quality controls can also be used for checking the identity of proteins in the crude culture supernatant and their changes during the different purification steps up to 99.9-percent purity. After IEF in the immobiline system the separated proteins are transferred to nitrocellulose paper. With specific antisera an immunological assay is done similar to a conventional western blot. Jungbauer presented some examples for different monoclonal antibodies. Jungbauer and his group also used an in-line steam-sterilizable process line for the purification of animal cell products since biologicals produced by transformed animal cells should be recovered in a closed sterilizable process line. The closed in-line sterilizable process unit consists of microfiltration, mass ion exchange chromatography with Zeta-Prep, ultrafiltration, and steam-sterilizable high-performance liquid chromatography (HPLC). This unit operation was fitted together to one process line and enabled these investigators to work in closed line.

Large-scale affinity partition of enzymes by using polymer-bound triazine dyes in aqueous two-phase systems was addressed by G. Johansson (Department of Biochemistry, Chemical Center, University of Lund, Sweden). Johansson and his group have been working for some time with aqueous two-phase systems. Aqueous two-phase systems composed of Aquaphase PPT (a hydroxypropyl starch) and polyethylene glycol (PEG) have been used by Johansson for the extraction of a number of enzymes (for example, phosphofructokinase, glucose-6-phosphate dehydrogenase, lactic dehydrogenase) from crude cell extracts or homogenates from both animal and plant sources. The selectivity of the extraction was achieved by binding a dye ligand (for example, Procion yellow HE-3G) to one of the phase-forming polymers. The extraction was also dependent on a number of other parameters including temperature, polymer concentration, ligand concentration, kind of added salts and their concentrations, pH, and presence of natural ligands. The heterogeneity as well the influence of ligands on enzymes present as crude extracts were analyzed by use of a counter-current distribution machine with centrifugal-enhanced separations. Extractions in large scale (10 to 200 liters) were carried out with the aid of a small centrifugal separator (Alfa-Laval LAPX) which could process a 30- to 60-liter system per hour.

According to Johansson, the advantage of the system Aquaphase PPI and PEG is the low cost, the biocompatibility, and the rapid separations that can be achieved. The scale-up problems that affect other separation techniques are to a high degree avoided. The partition of membranes, cell particles, and cells by the two-phase system can easily be steered by the concentration of salt and the salt composition. DNA and nucleic acids can be separated using a stepwise extraction. Proteins can be purified using affinity partitioning. Johansson said that the possibility of using affinity partition in large scale exists since the loss of PEG-ligand is low. Enzymes from *E. coli* cultures have been partitioned by Johansson and his group with the use of affinity ligands.

Recombinant DNA Products. Another session on downstream processing dealt with the production and downstream processing of recombinant DNA (rDNA) products in *E. coli* and yeast systems.

The subject of process design for recombinant protein recovery from inclusion bodies was discussed by M. Hoare (Department of Chemical and Biochemical Engineering, University College London, UK). A major feature of many processes to produce heterologous or recombinant

mammalian proteins in bacteria is the formation of insoluble inclusion bodies (refractile bodies) that contain the protein product. According to Hoare, while the solubilization of protein from the inclusion bodies followed by refolding of the product to the correct conformation are critical to the recovery and purification of these proteins, the release of the inclusion bodies by disruption and their separation from the soluble protein and cell debris material are essential steps. The initial steps in the processing of inclusion bodies by Hoare and coworkers involved: (1) the concentration of microbial cells by centrifugation, (2) cell disruption by high-pressure homogenization, and (3) the differential separation of inclusion bodies from soluble cell protein and the particulate cell debris by centrifugation. The complete separation of inclusion bodies from soluble cell protein and cell debris may involve several cycles of resuspension of the sediment followed by recentrifugation. According to Hoare, each cycle may additionally contain an homogenization step. In some instances more than 90 percent of the inclusion body may be the desired product. It is advantageous, if possible, to obtain a pure inclusion body from these initial steps as this would aid greatly in the subsequent protein purification. Hoare and his group examined the engineering principles underlying the recovery of inclusion bodies; they used an electrical sensing zone analyzer and an analytical disk centrifuge for prochymosin- and  $\gamma$ -interferon-based inclusion bodies produced in *E. coli*. Hoare concluded that while it appears that cell debris settles at a slower rate than the inclusion bodies, the degree of overlap and the relative closeness of the settling rates indicates the difficulties which may be encountered when effecting this recovery on an industrial scale.

A process development study on the purification of recombinant human superoxide dismutase produced in yeast was presented by A.I. Daniels (Pharmacia AB, Process Separation Division, Uppsala, Sweden). Human superoxide dismutase (hSOD) is a cytoplasmic enzyme which is thought to provide a defense against post-ischemic damage in blood vessels caused by the production of oxygen radicals. hSOD can now be produced in large quantities by fermentation of recombinant yeast. The aim of this study was to develop a fast and economical purification method compatible with high purity requirements on the final product. The starting material was obtained from a clarified yeast lysate in which the hSOD constituted 50 percent of the total pro-

tein. The purification of hSOD by Hoare and his group included: (1) an initial conditioning step using Sephadex R G-25 M; (2) an initial purification step (to separate the proteins according to the difference in charge at a given pH, strong anion exchanger Q Sepharose R Fast Flow was used); (3) the final purification step--a gel filtration step, the purpose of which was to obtain a single peak on an analytical gel filtration column after the purification. The gel of choice was Sephacryl R S-200 HR. The desired single peak purity of hSOD was achieved by Daniels and his group using the above procedures.

Membrane Technology. A workshop session on downstream processing dealt with the topic of membrane technology. This included the performance of microporous membranes in separation processes. It appears that certain limitations for the application of microporous membranes on a large scale for the separation of soluble biopolymers are related to the unexpected retention in the presence or absence of solids, to the hydrodynamics of different modules, and to the viscosity of solutions. Integration of fermentation and recovery via membranes and improvements in production as well as recovery of different classes of fermentation products are expected by the use of membranes which serve as a selective barrier in the process.

Concentration, polarization, and retention properties of microporous membranes was studied by C. Leaver (Biotechnology and Separations Division, Warren Spring Laboratory, Stevenage, UK). Leaver said that the application of microporous membrane materials to biological cell recovery is potentially a useful alternative to centrifugation processes. However, trials with cross-flow microporous systems have proved disappointing with respect to low filtration rates and low product yields. Thus, Leaver decided that a better knowledge of membrane/solute interactions is required to improve this technology. Therefore, he and his group studied the transport of proteins through microporous membranes to help understand the factors preventing efficient use of these filters. They found that proteins interacting with microporous filters form a secondary membrane with filtration properties similar to ultrafiltration membranes. Cross-flow microfiltration has disadvantages compared to stirred cell microfiltration systems with respect to unfavorable product retention.

Studies on filtration resistance during cross-flow filtration of microbial cell suspensions were reported by B. Riesmeier (Institute for Biotechnology Research, Braunschweig, West Germany).

This was a collaborative study with M.R. Kula (Institute for Enzymology, University of Düsseldorf in the KFA Jülich, Jülich, West Germany). At present, cross-flow filtration, according to Riesmeier, is used for different solid-liquid separations--for example, in waste water treatment or in the medical and pharmaceutical industries. The major problem affecting large-scale applications in downstream processing is the fouling of membranes. Particle and/or solute interactions with the membrane cause the formation of dense sublayers on the membrane surface. Riesmeier and coworkers, therefore, investigated cell harvesting of microbial cells with well-defined *E. coli* and baker's yeast fermentation broths. Two self-built lab-scale module types (tubes and a flat channel) were used, and the parameters responsible for the fouling process were studied in detail. Different membrane materials (for example, polypropylene, nylon) as well as different pore sizes (0.1 to 1.2  $\mu\text{m}$ ) were used to investigate the structure of the sublayers formed. Variations of the permeation rates as a function of the pressure drop and the flow velocity were studied with respect to the lengths of the channels. The corresponding layer heights developed were determined indirectly with cell number measurements. The results showed that layer heights decrease with increasing channel length; scanning electron micrographs support these findings. Layer heights between 0.5 and 30  $\mu\text{m}$  were found.

The following parameters were found to be responsible for the fouling process: particle concentration and size, properties of the membrane material (porosity/pore-size), properties of the suspensions (viscosity/antifoam content), wall shear rate, compressibility of the suspended particles, applied transmembrane pressure, and the geometry of the module system.

Membrane affinity purification was discussed by B. Mattiasson (Department of Biotechnology, Chemical Center, University of Lund, Sweden). This method is based on the binding of a macromolecular soluble ligand to the target molecule, which causes the latter to be retained on an ultrafiltration membrane, while the impurities are washed away. In a subsequent step, dissociation of the affinity complex is performed and the molecule in the purified form is recovered in the ultrafiltrate. An alternative is to use small particles carrying the ligands, together with a microfiltration membrane. Table 1 lists some of the compounds purified by Mattiasson and his group using this technology. The group has also carried out affinity purification using

Table 1  
Proteins purified by membrane  
affinity technique

| Target                     | Ligand                                  | Membrane         |
|----------------------------|-----------------------------------------|------------------|
| Protein A                  | IgG or IgG-dextran                      | UF-filter        |
| Concanavalin A             | Starch particles or<br>dead yeast cells | UF- or MF-filter |
| Alcohol dehydro-<br>genase | Cibacron blue-starch<br>(silica)        | UF- or MF-filter |

heterofunctional ligands as well as affinity precipitation. Mattiasson stated that in an aqueous two-phase system of, for example, polyethylene glycol (PEG) and dextran, most proteins are recovered from the dextran-rich bottom phase. Introducing an affinity ligand modified with PEG leads to affinity partition of the protein to the PEG phase. Although it may be difficult to remove phase polymers from a preparation of affinity-purified protein when exploiting conventional procedures, Mattiasson and his group found that when particles carrying the ligands were introduced and were modified to go to the top phase, removal of the phase polymers was no longer a problem. He said that this opens the possibility of combining the best of affinity partitioning with the elution procedures in conventional chromatographic procedures. Mattiasson also presented data based on the use of Reppal PES that he and his group developed. Potato starch was modified with propylene oxide and hydrolyzed to give high solubility, low viscosity, and a low degree of retrogradation. The Reppal PES is much cheaper than dextran which is generally used in aqueous two-phase systems and proved to be very effective in achieving purification of proteins.

#### Biocatalysis

A review of the subject of biocatalysis was presented by M.D. Lilly (Department of Chemical and Biochemical Engineering, University College, London). He said that biocatalysis, by definition, encompasses all reactions catalyzed by enzymes whether in free or immobilized form. The enzymes may be associated with cells or in solution. Traditionally fermentation processes have been considered separately from biotransformations using enzymes or cells, but recent developments with immobilized catalysts have led to much greater overlap between these two areas of biocatalysis.

The use of immobilized biocatalysts, whether enzymes or microbial cells, for single-step conversions involving water-soluble reactants and products is now well established, according to Lilly.

Recently, this has included reactions involving oxidation or reduction and co-factor regeneration. There is still much work to be done, according to Lilly, before the usefulness of immobilized cells for biosynthesis can be properly assessed.

Lilly said that the use of biocatalysts for conversions involving reactants or products with low solubilities in water is developing rapidly. Microbial cells and enzymes are being used in reactors where the water content may be low and in some cases the water activity is much less than unity. Lilly thinks, therefore, that we are at a very exciting stage in the development of biocatalytic processes.

**Extraction of Enzymes.** The reversed micellar extraction of enzymes was discussed by C. Laane (Department of Biochemistry, Agricultural University, Wageningen, the Netherlands). He and his group, studying the distribution behavior and extraction efficiency of  $\alpha$ -amylase, found that a liquid-liquid extraction with an apolar solvent containing reversed micelles was very promising. Reversed micelles are aggregates of surfactant molecules in an apolar solvent surrounding an inner core of water. Polar compounds such as enzymes can be solubilized in an apolar solvent by these reversed micelles. To enable the use of a reversed micellar phase for enzyme extraction, the transfer of the enzyme from an aqueous to the reversed micellar phase--and vice versa--must be possible (see Figure 1).

Laane and coworkers investigated the performance of a continuous forward and back extraction with a reversed micellar phase in two mixer/settler units. Using the surfactant trioctylmethylammonium chloride (TOMAC) in isooctane, the enzyme  $\alpha$ -amylase could be concentrated in a continuous process, by performing these two extractions at different pH values in the aqueous phases. In their studies with  $\alpha$ -amylase, Laane and his group found that the distribution of the enzyme between a reversed micellar phase and an aqueous phase was determined by electrostatic in-

teractions. Increase in the ionic strength resulted in an increase in pH value at which maximum solubilization took place. Laane said that the extraction process can be described by a model using the data on the distribution coefficients, the mass transfer rate constants, and the inactivation rate constants. Increase of the distribution coefficient results, as predicted by the model, in an increase in activity recovery and a decrease in surfactant losses.

**Esterification of Alkanols.** The esterification of alkanols in multiphase biocatalytic systems was reported by J.M.S. Cabral (Laboratory of Biochemical Engineering, Institute of Technology, Lisbon, Portugal). Cabral described the extraction with reaction of ethanol from a fermentation broth as a model system of the esterification of an alkanol with water-immiscible organic acids, catalyzed by lipases. Cabral and his group screened lipases from different microbial sources and selected a lipolytic enzyme from a *Mucor miehei* strain because of its high ester synthesis activity in the presence of high water content (50 percent). This enzyme showed a pronounced substrate specificity, the degree of esterification increasing with the chain length of both aliphatic alcohols and water-immiscible fatty acids. The partition coefficients of ethanol and butanol in the presence of the lipase increased 10- and 30-fold, respectively, when oleic acid was used as extractant.

The esterification kinetics and equilibrium studies of ethanol with oleic acid were carried out at the ethanol fermentation conditions, 30°C and pH 4.5, which allowed the integration of the enzymatic catalysis in the extractive fermentation system. The kinetic parameters and the biphasic equilibrium constant were determined. Cabral and coworkers found that the enzymatic reaction was inhibited by ethanol, at relatively high alcohol concentration (150 g/l). The enhancement of the liquid extraction of alkanols by enzymatic esterification led to fermentation processes with improved productivity.

**Enzymatic Hydrolysis.** The stereoselective enzymatic hydrolysis of  $\alpha$ -substituted amino acid amides with an aminopeptidase from *Mycobacterium neoaurum* was reported by E.M. Meijer (DSM Research, Bio-organic Chemistry Section, Geleen, the Netherlands). Meijer said that biologically active systems containing enantiomerically pure  $\alpha$ -disubstituted amino acids have received increasing attention mainly because of their activity as enzyme inhibitors. Some examples are: (1) L- $\alpha$ -methyltyrosine, which is used as

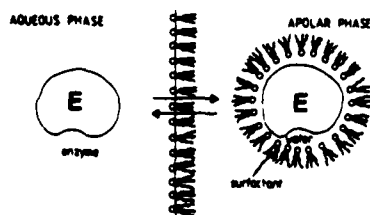


Figure 1. Transfer of an enzyme (E) between an aqueous phase and an apolar phase containing reversed micelles.

a tranquilizer; (2) L- $\alpha$ -methylphenylalanine, utilized in the synthesis of anti-mitotic peptides, which may ultimately be useful as inhibitors of cancer tumor growth; and (3) D-isovaline, which is a constituent of the antibiotic antimycin. A well-known example, demonstrating the industrial importance, is the hypotensive agent L- $\alpha$ -methyl-(3,4-dihydroxyphenyl)-alanine (L- $\alpha$ -Me-DOPA). An increasing demand for novel  $\alpha$ -disubstituted amino acids useful as chiral intermediates in the synthesis of physiologically active compounds is to be expected, according to Meijer.

A process based on the stereoselective hydrolysis of  $\alpha$ -disubstituted amino acid amides with an L-specific aminopeptidase *Mycobacterium neoaurum* is under development at DSM. Starting from a ketone under "Strecker" reaction conditions, the  $\alpha$ -disubstituted aminonitrile is obtained which can be converted to the appropriate D,L- $\alpha$ -disubstituted amino acid amide. Subsequently, the stereoselective enzymatic hydrolysis yields the L- $\alpha$ -disubstituted amino acid and the D- $\alpha$ -disubstituted amino acid amide. The biocatalyst shows a remarkably broad substrate specificity and a very high stereoselectivity. Permeabilized whole cells or crude enzyme preparations of *Mycobacterium neoaurum* can be used.

Meijer and his group are also involved in a collaborative project with the Department of Biochemical Engineering of the Delft University of Technology, the Netherlands. According to Meijer, they are developing a countercurrent fluid bed enzyme reactor, showing several attractive features from an industrial point of view. For proper functioning in this type of reactor, biocatalysts with high mean density and a large particle diameter are needed. Meijer said that this can be achieved by immobilization of the biocatalyst on sand particles as a cheap carrier. As a model, the immobilization of *Bacillus pasteurii* cells with urease activity has been investigated by Meijer and collaborators. The immobilized biocatalyst can be applied for the continuous degradation of urea-containing waste water in a countercurrent fluid bed reactor.

The immobilization procedure involves coating of the sand particles with agar as matrix mixed with compounds such as hexane diamine and epilink (decarboxylated casein) reactive with glutardialdehyde, followed by addition of a cell paste of *B. pasteurii* containing polyethyleneimine (in order to protect the biocatalyst against the inactivating effect of glutardialdehyde), hexanediamine, and epilink. Crosslinking with glutardialdehyde results in a rigid, erosion-

insensitive particle. Meijer thinks that this immobilization method can be successfully extended to other biocatalysts. Stability measurements have been carried out on a laboratory-scale fluid bed reactor. Intrinsic kinetic parameters have been estimated using an empirical model based on Michaelis-Menten kinetics.

#### Isolation of Soil Microorganisms.

The isolation of soil microorganisms by a number of enrichment procedures designed to gain a wide variety of microorganisms and to investigate the conditions which favor the growth of hydantoinase-producers was described by M.R. Kula (Institute for Enzymology of the University of Düsseldorf in the KFA Jülich). Racemic amino acids can be chemically produced by converting aldehydes with hydrogen cyanide and ammonium carbonate to amino acids or nitriles. These are either directly hydrolyzed to amino acids or they are first converted to hydantoins by treatment with carbon dioxide and then saponified to amino acids. However, amino acids can also be produced through biocatalysis by using hydantoinase, which catalyzes the stereoselective opening of the ring of dihydropyrimidine and several 5-monosubstituted hydantoins giving chiral N-carbamyl amino acids. These N-carbamyl amino acids can be chemically converted to amino acids by reaction with nitrous acid.

In their screening of hydantoinase-producing microorganisms, Kula and her group found 15 strains out of 76 isolated strains of microorganisms representative of different groups of microorganisms that were found to possess an hydantoin-hydrolyzing activity. Six unidentified strains (1-2, 1-9, 1-15, 2-2, 2-5, and 10-3) including Gram-positive, Gram-negative, cocci and bacilli were used for further studies. Kula and coworkers found that the highest hydantoin-hydrolyzing activities were obtained when dihydrouracil was used as substrate. The substrate specificity was found to vary among the six strains. Dihydrouracil was by far the preferred substrate for most of the six strains possessing a high activity. Para-hydroxy-benzylhydantoin was poorly hydrolyzed by all strains. It was also found that hydantoin, isopropylhydantoin, dihydrouracil, and uracil were able to induce the enzyme activity of some selected strains.

Reactions catalyzed by hydantoinase have been described in the literature for whole cells and crude tissue extracts. However, as the hydantoinase reaction is a process involving only one enzyme, Kula considered that it would be advantageous to use it in an immobilized state, for instance, in an enzyme membrane reactor. Therefore, Kula and her group used a

laboratory-scale enzyme membrane reactor to evaluate the stereospecificity of the hydantoinase produced by their six strains. Kula and her group found that all six strains produced only N-carbamoyl-D-valine. They used a rapid spot test developed by this group for testing of hydantoinase activity on solid medium. Kula said that the use of enzyme membrane reactors allowing the rapid evaluation of a given hydantoinase with regard to its continuous performance proved to be a useful screening tool. Preliminary characterization of the hydantoinase produced by the most active isolates revealed that they differed in stability and activity upon fast gel filtration and ion-exchange chromatography.

Kula also presented some studies on the isolation of acetamidocinnamate-acylase, an enzyme suitable for L-phenylalanine production. She said that the application of enzymes proved to be an efficient method for the synthesis of chiral amino acids. For production of L-phenylalanine, she described some prochiral precursors that can be converted to (1) t-cinnamic acid by phenylalanine-ammonia-lyase or (2) phenylpyruvate by a transaminase or a NADH-dependent dehydrogenase. Kula said that the dehydrogenase coupled with an effective coenzyme-regenerating step (developed by Kula and her group) offers the advantage of nearly complete conversion.

A new acylase isolated from *Brevibacterium* species was able to liberate phenylpyruvate *in situ* out of acetamidocinnamate (ACA): ACA (imino-derivative) spontaneous hydrolysis acylase phenylpyruvate. Therefore, the three-enzyme-system acylase offers, according to Kula, a promising route for L-phenylalanine production. Kula described the isolation of acylase-containing microorganisms and conditions for induction and production of the enzyme. (It should be noted that Kula is one of the top researchers in Europe in biotechnology research.)

### Conclusion

This report covers only a fraction of the presentations at the Fourth European Congress on Biotechnology. However, it is evident even from this limited selection that European scientists are forging ahead with first-class research in biotechnology. Additional information on topics not included in this report such as: bioreactors, animal cell cultures, molecular genetics, measurement and control, and enzymes in biotechnology are available in ONRL report 8-001-C.

### THIRD INTERNATIONAL CONGRESS AND EXHIBITION FOR BIOTECHNOLOGY

by Claire E. Zomzely-Neurath.

### Introduction

This conference, also termed BIO-TECHNICA '87, was held in Hannover, West Germany, from 22 through 24 September 1987. More than 4000 attendees from a total of 29 countries attended this annual biotechnology congress and exhibition fair. Of these participants, 25 percent came from non-European countries. The industrial sector, universities, and research institutes were represented with the majority of attendees from industrial organizations. The programs of the meeting were focused on scientific and technological innovations in biotechnological products and processes and on laboratory and plant engineering.

There were more than 400 exhibitors at this congress showing their products. Biotechnology research institutes and enterprises seeking cooperation partners for technological developments and services formed a fairly large sector of the exhibition. The largest groups were equipment and process engineering companies, which traditionally are intermediaries in the transfer of research results into application and play a key role in development of industrial know-how for biotechnology.

A large number of seminars also covered the application of biotechnology. East Germany presented a seminar with some 30 scientists reporting about their development work and seeking partnerships for exploitation. As in previous meetings at Hannover, the US had representatives presenting a seminar on US biotechnology. One of the many special-topic seminars dealt with the state of development, prospects and economic viability of biotechnology in agriculture--in particular, in plant production and processing of by-products. This seminar was organized by West Germany's German Agricultural Society.

Commercial aspects of biotechnology were discussed in the Bio-Business program. Three workshops covered problems such as shortage of trained and specialized personnel (Bio Job Workshop), protection of developments and inventions (Bio Patent Workshop), and the financing of biotechnology (Bio Invest Workshop).

In the scientific field, the application-oriented international congress focused on three topics: (1) polypeptides in medical therapy, (2) enzymatic and microbial transformation, and (3) processes involving genetically modified cells.

12/13/87

The opening plenary lecture was presented by E. Katchalski-Katzir (Department of Biotechnology, Tel Aviv University, Tel Aviv, Israel, and the Weizmann Institute of Science, Rehovot, Israel). He is an internationally recognized scientist as well as a former president of Israel. Katchalski-Katzir presented an excellent lecture in which he gave a historical account of the development of biotechnology and discussed the impact of the basic sciences on modern biotechnology.

Summaries of some of the reports at the scientific sessions are presented in this report. A detailed account of the topics covered can be obtained from ONRL Report No. 8-002-C.

### Polypeptides in Therapy

**Production of Peptide Hormones.** New methods for the production of peptide hormones including the genetic engineering of the insulin-like growth factor-I (IGF-I) were discussed by S. Josephson (KabiGen AB, Stockholm, Sweden). Many of the studies he cited were carried out in collaboration with scientists at the Royal Institute of Technology and the Karolinska Institute, Stockholm, Sweden. IGF-I appears to be a major regulating hormone of postnatal growth. Most tissues appear to be targets for IGF-I action, as indicated by receptors on a wide variety of organs and cells. Research on IGF-I and other somatomedians has so far been hampered by shortage of the material since it is present in only minute amounts in human plasma. However, with the use of recombinant DNA (rDNA) technology it is now possible to obtain pure IGF-I in amounts sufficient not only for basic research purposes, but also for studies relating to specific clinical applications such as wound healing and growth of cartilage and bone.

Josephson and his collaborators chemically synthesized the IGF-I gene on a DNA synthesizer developed at KabiGen. The gene was inserted into the production plasmid called pZ2. These investigators developed an rDNA system which resulted in a high production level as well as the secretion of a fusion product into the culture medium in *E. coli*. Obtaining a secreted protein made it much easier to isolate the fusion protein, which was cleaved chemically and the IGF-I purified. Josephson and his group were able to obtain 100 mg of purified IGF-I with their techniques. In collaboration with the Royal Institute of Technology, Alfa Laval, and Pharmacia their production and purification system has been scaled up to 1000 liters. Josephson said that the production system is currently being used

for the production of other peptide hormones--i.e., human secretion, and vasoactive intestinal peptide as well as brain-IGF and IGF-II. Another use for KabiGen's production system has recently been found. According to Josephson, it can be used as a general method to obtain specific antibodies against several peptide hormones as well as against short peptides. Josephson also suggested that the above aspects present an excellent way of preparing new vaccines since the production level of the fusion protein obtained by KabiGen's rDNA method has a high level of production and, in addition, the immune response is very strong. KabiGen has also developed two new peptide-based animal vaccines which are currently being tested. Of course, KabiGen has patent applications on all the methods described above.

**Human Interleukin from Recombinant Mammalian Cell Lines.** Interleukins comprise a class of polypeptides regulating growth and differentiation of lymphocytes and other cells active in immune responses. The synthesis of these substances as well as the exerted biological effects are part of the complex network of differentiation and function of the immune system. Interleukins are secreted by defined classes of producer cells upon intrinsic signals. Their functions on the target cells are mediated by interaction with specific membrane receptors. The most extensively studied interleukin is IL-2, also called T-cell growth factor (TCGF). It is produced by T-lymphocytes upon antigenic or mitogenic stimulation. As in the case of the IGF's the production of large amounts of pure IL-2 is a prerequisite for biochemical and functional studies as well as for clinical trials. Immunodeficiencies, organ transplantation, and cancer therapy are the main areas of clinical interest in the interleukins.

A report on human interleukin from recombinant mammalian cell lines was presented by H. Hauser (Institute for Biotechnology Research, Braunschweig, West Germany). The complementary DNA (cDNA) gene of IL-2 has been cloned, and Hauser and his group have genetically engineered the gene to be expressed efficiently. For this purpose, these investigators constructed vectors with various viral and cellular promoters. In addition, retroviral vectors, based on the murine myeloproliferative sarcoma virus (MPSV), were developed, allowing transfer of foreign genes in a variety of different rodent cell types. To improve expression of these constructs, different parts of the structural IL-2 gene were integrated into these vectors and introduced into different cell types. Selected recombinant

hamster ovary, baby kidney, and mouse-L cells were found to secrete IL-2, which was then purified from serum-free culture supernatants in a two-step procedure. Recombinant cell lines producing IL-2 were grown in fermenters under various conditions, including serum-free media, allowing the purification of IL-2 with low protein contamination. Hauser and his group have also expressed the IL-2 receptor gene (Tac) in mammalian cell lines. They are now studying the interaction of receptor with ligand.

#### Production and Isolation of ANF.

Methods for the production and isolation of atrial natriuretic factors (ANF) and their clinical application were reported by K.D. Dohler (Bissendorf GmbH, Wedemark, West Germany). This was a collaborative study with W.G. Forssmann, (Anatomical Institute, University of Heidelberg, West Germany). ANF's have been shown to reduce blood pressure and to stimulate natriuresis (sodium excretion) and diuresis (water excretion) and therefore are important in the treatment of hypertension (high blood pressure) as well as other conditions in which there is excessive fluid accumulation in the body, as in congestive heart failure. Currently available conventional preparations for the treatment of hypertension, renal failure, and various edematous states have important limitations and undesirable side effects. Therefore, production of ANF for clinical use is very important since ANF is more specific in its biological effects than other preparations.

Forssmann and his group discovered that only a part of the precursor ANF molecule was necessary for biological activity, namely, amino acids 99 to 126 of ANF. Dohler and Forssmann's groups are engaged in collaborative efforts in the search, structure elucidation, and synthesis as well as the pharmaceutical development of ANF's and other new peptides (cardiac hormones). The methods used by Dohler and his group for the preparation of ANF and other peptides includes the extraction of these compounds from human hemofiltrate by treatment with alginic acid followed by purification using various chromatographic procedures. Synthesis of newly elucidated peptide structures with low molecular weight is performed by a solid-phase technique. The principle of this technique is the stepwise attachment of amino acids to an insoluble polymer (benzhydrylamine resin) as an insoluble support for synthesis. Synthesis of peptide structures with high molecular weight is performed by rDNA techniques.

ANF 99-126 has been used in human volunteers as well as patients with

various diseases such as severe heart failure, renal failure, chronic liver disease with ascites, hypertension, heart transplantation, and kidney transplantation. The compound was shown to reduce blood pressure and to stimulate natriuresis and diuresis and to have therapeutic effects on the above-mentioned diseases, according to Dohler.

Production of Proteins. The large-scale production of proteins by mammalian and hybridoma cells in a continuous bioreactor system was discussed by K. Venkat (Verax Corporation, Lebanon, New Hampshire, US). Venkat described a fluidized-bed bioreactor system for continuous culture with particular emphasis on scale-up and long-term aseptic operation. Cells are immobilized inside collagen-sponge beads (microspheres), which are strongly cross-linked to achieve long operational life. Venkat stated that the fluidized-bed system scales up without difficulty at constant depth; increases in reactor volume are obtained through expansion of bioreactor cross-sectional area. According to Venkat, the bioreactor system lends itself well to full automation and computed control without human intervention except for routine maintenance and medium addition.

Venkat also presented performance data for the large-scale production of monoclonal antibodies (Mabs) and mammalian cell-derived proteins for medical use. Mammalian cells immobilized in Venkat's culture system demonstrated higher cell-specific yields and productivity than the same cells in free-cell suspension or microcarrier culture. Venkat emphasized that economic modeling of this immobilized-cell-continuous-culture process compared to batch and fed-batch cultures of hybridomas and attachment-dependent cells demonstrates large potential reductions in the production cost. For proteins for medical use such as Factor VIII, tissue plasminogen activator (tPA), interleukins, and hormones, Venkat predicts culture cost reductions of as much as 70 percent.

#### Enzymatic and Microbial Transformation

Processes for Production of Useful Compounds. The topic of microbial and enzymatic processes for the production of biologically and chemically useful compounds was addressed by H. Yamada (Department of Agricultural Chemistry, Kyoto University, Kyoto, Japan). Yamada and his group have recently been carrying out studies on the synthesis and transformations of various biologically and chemically useful coenzymes, amino acids, and amides using microbial enzymes as catalysts. The basis for their studies is

that reactions catalyzed by enzymes and enzyme systems display far greater specificities than more conventional forms of organic reactions and, of all the reactions available, enzymatic synthesis and transformations have the greatest potential. Yamada presented two examples of the enzymatic processes for the production of D-amino acids and amides. These are (1) synthesis of D-phenylalanine and related D-amino acids and (2) production of acrylamide and some chemically useful amides.

As a result of fundamental studies of the production of D-amino acids, Yamada and coworkers have developed a new process for the production of D-p-hydroxyphenylglycine. This amino acid is an important component of semisynthetic penicillins and cephalosporins. A plant for the large-scale production of several D-amino acids (D-phenylglycine, D-p-hydroxyphenylglycine and D-valine) has been built at the Jurong Industrial Estate of Singapore by Kaneka Singapore Company.

Acrylamide and methylacrylamide are produced industrially as monomers for synthetic fibers, flocculent reagents, etc. Yamada and his group have developed a new process using a microbial enzyme, nitrile hydratase, as a catalyst for the hydration of the nitriles. Screening of microorganisms with high enzymatic activity revealed that *Pseudomonas chlororaphis* B23 showed the highest enzymatic activity when grown with isobutyronitrile as a major nitrogen source. Yamada said that under suitable conditions, more than 400 g/l of acrylamide could be produced in a molar yield of nearly 100 percent. High yields were also obtained for the production of methacrylamide, acetamide, propioamide, n-butyramide, and crotonamide. Yamada stated that the Kaneka Singapore Company would begin the commercial production of acrylamide using the immobilized cells of *Pseudomonas chlororaphis* B23 by the end of 1987.

**Conversion of Insulin.** The enzymatic conversion of porcine insulin and biosynthetic precursors into human insulin was reported by E. Rasmussen (Novo Industri A/S, Bagsvaerd, Denmark). The conversion of porcine insulin to a human insulin ester as used by Novo in the production of human insulin is a transpeptidation reaction in which porcine insulin reacts with trypsin in a predominantly organic medium to produce a human insulin ester in a one-step reaction. After the necessary purification, the ester group of the human insulin ester is then cleaved off and the resulting human insulin is subsequently purified further to meet specifications for human use.

Rasmussen also discussed one of the special problems encountered in the production of insulin by rDNA technology, i.e., how to produce a two-chain molecule containing three disulfide bridges. Rasmussen and his group are also producing insulin by rDNA technology. He stated that at Novo, single chain precursors are used which, during production in the manipulated microorganism (yeast), are folded correctly with simultaneous formation of the correct disulfide bridges, and which can be converted after isolation to human insulin by simple enzymatic reactions. Two types of insulin precursors have been produced at Novo by rDNA technology. One type of precursor can be converted to human insulin ester by the same type of transpeptidation reaction as is used at Novo for the conversion of porcine insulin. The purification and final conversion to human insulin follows a scheme similar to that used for the conversion of porcine insulin. The conversion of the second type of precursor proceeds in two steps. First, the bond between Arg and A(1-21)--i.e., in the A chain of insulin--is cleaved by trypsin, and then the two basic residues, Arg and Lys, are removed by the action of carboxypeptidase B with subsequent purification to yield human insulin. Rasmussen concluded that enzymatic conversion is of great importance today in the production of human insulin, and also in years to come will play a central role in the production of human insulin by rDNA technology. Whether in the future it will be possible to produce insulin directly in microorganisms in sufficient yields remains to be seen.

**Microbial Conversion.** The microbial conversion of alpha keto isocaproic acid to L-leucine was discussed by J. Berke (Degussa AG, Hanau, West Germany). This research was carried out in collaboration with R. Wichman (KFA Jülich GmbH, Jülich, West Germany). L-amino acids can be produced stereospecifically from chemically produced precursors as alpha keto carbonic acids by biocatalysis. According to Berke, the use of whole microorganisms as biocatalysts enables the use of complex multistep reaction pathways towards the product desired. Berke and his group found that by retention of biomass (a fermentation byproduct which is usually discarded) an enhancement of productivity or conversion yield was possible for continuous fermentation. However, the steps in the product-forming reaction should not be linked strongly to cell growth. After preliminary experiments with a fermentation volume of 4 liters, a scale-up was carried out using a fermentation system with 100 liters of fermentation volume. A steam sterilizable centrifugal

separator was used for cell retention. At a concentration of 50 g/l of cell dry weight, a conversion of 98 percent was reached at a space/time yield of 38 g of L-leucine per liter per day.

**Enzymes as Catalysts.** The topic of enzymes as practical catalysts in carbohydrate synthesis was addressed by C.H. Wong (Department of Chemistry, Texas A&M University, College Station). Carbohydrates constitute a class of important molecules which are the current targets for synthetic organic and medicinal chemists, according to Wong. Increasing evidence shows that this class of compounds plays a central role in immunology and other biochemical recognitions. Wong and his group have recently developed several enzymatic approaches to carbohydrates and their derivatives. The enzymes, aldolases, are used in asymmetric C-C formation for the synthesis of usual as well as unusual monosaccharides and for the preparation of isotopically labeled sugars. Lipases are used as catalysts to selectively deprotect acylated sugars and to acylate free sugars. Hexokinases coupled with an ATP regeneration are used for selective phosphorylation of fluorinated sugars. Alcohol dehydrogenases coupled with an NAD(P)H regeneration are used for selective reduction of acyl furan derivatives and of keto aldehyde acetals to alcohol derivatives which are precursors to L-sugars. Glycosyl transferases coupled with the regeneration of UDP-sugar and UTP are used for the synthesis of oligosaccharides. According to Wong, these enzyme products can be further converted to different sugar derivatives of potential interest as pharmaceuticals.

#### Fundamentals of Bioprocess Engineering

**Bioreactors for Animal Cell Cultures.** This topic was discussed by A.J. Sinskey (Department of Applied Biological Sciences, Massachusetts Institute of Technology, Cambridge). He indicated that the need for mammalian cell culture bioreactors is expanding. The primary reason is the need for production of therapeutic proteins, including monoclonal antibodies (Mabs). *In vitro* cultivation of mammalian cells allows for standard production processes of such proteins and in many cases is the only acceptable technology, according to Sinskey. He said that currently, the lack of mathematical cell culture kinetics limits the ability to optimally design and control animal cell bioreactors. As a model for overcoming such limitations, Sinskey discussed a strategy for developing mathematical equations relating both the growth rate and the specific antibody productivity of

the CR-1606 hybridoma cell line to its environmental state. An equation was developed relating the initial growth rate to serum, ammonium, lactate, glutamine, and cell concentrations, with serum and ammonium exerting the greatest influence. Sinskey and his group also found that the addition of thiols, or the elimination from the media of cystine, a disulfide, stabilized the growth-promoting activity of serum. Experimental implementation of an optimal control policy based on the equations resulted in cell and antibody levels which were twice those which are typically obtained in batch cultures.

**Evaluation of Processes.** The evaluation of gene expression efficiency and performance of recombinant fermentation processes was discussed by D.D.Y. Ryu (Department of Chemical Engineering, University of California at Davis). Ryu stated that genetic stability of certain recombinant microorganisms is one of the most important problems in scaling up and commercialization of the recombinant fermentation processes. One strategy, according to Ryu, in dealing with the recombinant cells which are unstable due to an increased productivity of cloned gene is to separate the growth stage from the production stage by controlling the levels of cloned gene expression by using a genetic switch. He said that a two-stage fermentation system in combination with a temperature-sensitive gene switching system offers the possibility of minimizing the instability problem of high expression recombinants in continuous production of cloned gene product. The use of a thermoinducible promoter-operator enabled Ryu and his group to separate the growth and production stages by simply adjusting the culture temperature. They were then able to grow the cells under the repressed state with little or no expression of the cloned gene product in the first stage, thereby minimizing the expression-related instability problem. When expression is desired, it can easily be turned on by a temperature shift in the second production stage.

In order to develop a general methodology for evaluation of the gene expression efficiency for gene product, theoretical and experimental studies were undertaken by Ryu and coworkers using recombinant *E. coli* K12 H1 trp/pPLc23 trpA1 as a "gene-host cell" model system in a two-stage continuous culture system. Based on their experimental results, the gene expression efficiency of the model system was found to be about two-fold more efficient than the average rate of protein biosynthesis by *E. coli* cells.

**Scale-up and Manufacture.** The scale-up and manufacture of drugs produced by recombinant organisms was discussed by D.M. Fenton (AmGen Company, Oak Terrace Lane, California). Fenton focused on important parameters which should be considered during research and development of new proteinaceous drug substances produced when using recombinant DNA (rDNA) technology. He stated that it is imperative that in the early stages of molecular biology research the ultimate scale of product manufacture be considered. He thinks that given the state of the art, a prototrophic *E. coli* strain possessing extensive phage resistance and a stable inducible vector system should be used whenever possible. Following research maximizing expression levels in a molecular biology group, a project devoted to the production of a new drug substance usually moves into fermentation research. The goal of fermentation research, according to Fenton, is to increase the scale of fermentation from flask to small fermentor and to increase fermentation productivity. Protein expression is often increased 2- to 10-fold by manipulation of fermentation conditions. For example, work at AmGen has shown that by increasing the concentration of available amino acids and glucose during product synthesis in *E. coli* fermentation, the intracellular concentration of insulin-like growth factor was increased 10-fold.

Fenton said that if a product is pursued into human clinical trials, fermentation and purification process development is usually initiated. The goal of process development is to ensure that one is capable of producing projected market requirements in an existing or planned manufacturing facility. In addition, manufacturing cost considerations become critical items. The final task of the process development group, according to Fenton, is to work with the manufacturing group to ensure that sufficient quantities of product are available for clinical trials and market entry. The manufacturing group must successfully implement the protocols developed by research and process development--but with the added constraints of operating under government regulations.

#### Conclusion

BIOTECHNICA '87, the third international conference on biotechnology held in Hannover, West Germany, was geared towards fostering contacts between academia and industry--as exemplified by the variety of programs and extensive exhibitions. It is evident from the scientific presentations summarized in this report that much progress is being made not only in basic research in biotechnology but

also in the application of the research findings to products for the market. Recombinant DNA technology has played a major role in the impetus given to biotechnology. However, the use of microbial enzymes and continuous tissue culture methodology also has played an important role. It is also evident that production poses many problems that must be resolved by the manufacturing companies and that progress has also been made in this area.

12/10/87

#### INTERNATIONAL CONFERENCE ON SEPARATIONS FOR BIOTECHNOLOGY

by Claire E. Zomzely-Neurath.

#### Introduction

This conference, sponsored by the Solvent Extraction and Ion Exchange Group and the Biotechnology Group of the Society of Chemical Industry, was held at the University of Reading, UK, from 15 through 18 September 1987. Of the total of 181 participants, 68 percent represented industrial organizations with the balance from academic institutions. Although the majority of attendees were from the UK, an appreciable number also came from 10 West European countries as well as the US. The program format of this focused and informative conference included plenary lectures, oral presentations and poster sessions on the following topics:

- Cell harvesting and disruption
- Analytical techniques and process control
- Adsorption and chromatography
- Liquid/liquid extraction
- Product containment and safety
- Membrane processes.

There is increasing commercial and industrial potential for the growing range of products from the "new biotechnology," and much emphasis has been placed on the production processes for substances with biological activity. However, very little has hitherto been available on the important topic of downstream processing, covering the principles involved in recovering a product in a usable form. Several speakers presented recent developments in this important area. Some of the presentations described many of the developing techniques for both new and established products such as enzymes, antimicrobial

agents and hormones. Thus, the principal aim of this conference was to discuss the influence of new materials and techniques on the isolation of new and established microbial products. Some papers gave a state-of-the-art review while others were concerned with specific techniques, some of which are at an early stage of development.

Since there was a great deal of material presented at this conference, only selected topics are summarized in this relatively short report. However, a detailed review of several of the areas covered at this conference is available in ONRL Report No. 8-003-C. In addition, all the papers and selected posters presented at this conference will be published in a volume entitled *Separations for Biotechnology*, to be published by Ellis Horwood, Ltd., Chichester, UK.

#### Cell Harvesting and Disruption

Studies designed to evaluate six novel separation processes were presented by P.N. Whittington (Biotechnology and Separations Division, Warren Spring Laboratory, Stevenage, UK). This was a collaborative project by Whittington and his group on downstream processing and was funded by industry and the UK Department of Trade and Industry. The six novel separation technologies studied were:

- Dielectrophoresis
- Electrophoresis
- Ultrasonics
- Liquid-liquid partitioning
- High gradient magnetic separation processes
- Foam separation.

Whittington and coworkers considered dielectrophoresis to be a particularly novel technology and are currently evaluating its application to bioprocessing. Ultrasonics also rates highly, and some potential was demonstrated for liquid-liquid (two-phase aqueous separations) and magnetic separations.

The subject of biochemical engineering aspects of cell disruption was discussed by E. Keshavarz (Department of Chemical and Biochemical Engineering, University College, London, UK). While there are many specific examples of chemical or lytic-based disruption for the release of intracellular proteins, it is the mechanical disruption methods which have found general application on the pilot and industrial scales. When processing heat-labile materials which are also prone to microbial and proteolytic degradation, it is necessary, according to Keshavarz, to use low residence time and continuous operations. Furthermore--especially with the advent of modern re-

combinant DNA (rDNA) techniques for the manufacture of mammalian proteins in microorganisms--it is necessary to operate cell disruption equipment in a contained fashion with the possibility of in-place cleaning and sterilization. Two disruption techniques available to meet the above requirements, according to Keshavarz, are: (1) high-speed bead mills and (2) high-pressure homogenizers. She discussed the operating characteristics of these techniques with respect to the overall efficiency of protein and enzyme release as well as the effect of cell choice and growth on the success of the disruption process. Keshavarz thinks that there is now a reasonably good description of the factors influencing the performance of bead mills and high-pressure homogenizers. Thus, she suggested that scale-up can be predicted and that the release of water-soluble proteins and enzymes can be achieved without significant damage using either of these two methods of cell disruption.

Biosurface properties and their significance for primary separation was the subject of the next paper. S.R. Warne (Biotechnology and Separations Division, Warren Spring Laboratory, Stevenage, UK) spoke about the forces which maintain bacterial walls in a dispersed state, and described the mechanisms by which they are overcome during the formation of cell aggregates. Such mechanisms involve a number of physico-chemical properties of the cell surface. Warne indicated that insofar as these properties are attributable to specific molecules at the cell surface they may be subject to genetic control. He described one example of a bacterial strain being studied in his laboratory which exhibits autoaggregation (i.e., natural aggregation). One advantage of natural aggregation, according to Warne, is the avoidance of contamination by flocculants in subsequent downstream processing following the primary separation stage. There is relatively little known about the molecular basis of natural aggregation. Therefore, in order to obtain a more complete understanding of the mechanisms involved, a particular example of natural clump formation is being studied by Warne and his group. The aggregation phenomenon being investigated is known as fluffing and is exhibited by some strains of *E. coli* K12. This fluffing phenomenon involves the formation of cell aggregates, known as fluffs, which precipitate from unshaken cultures. The control of this ability to fluff has been ascribed to a gene designated *flu*. The location of the *flu* gene on the *E. coli* chromosome has been determined. The aim of the research of Warne and his group is to demonstrate the way

in which changes at the genetic level affect the composition of the cell surface and how this in turn affects the physico-chemical properties of the cell. Warne presented extensive studies that have already been carried out in his laboratory on the fluffing phenomenon. He also outlined a series of continuing experiments in this area.

The topic of flocculation of bacterial cell debris as an aid to solid/liquid extraction was discussed by E. Gellan (North East Biotechnology Center, Department of Chemical Engineering, Teeside Polytechnic, Middlesbrough, Cleveland, UK). Gellan described the results of a series of experiments investigating flocculation of whole bacterial cells and cell fragments by pH change. It was found that flocculation of both cells and cell debris appears to be strongly dependent on the presence of absorbed material. The sonication process used by Gellan and coworkers yields an extremely complex mixture of cell fragments, protein, and DNA. Washed cells can be flocculated over a wide pH range up to pH 5, while unwashed cells show flocculation in the pH range 2-4. Cells are known to absorb media components onto their surface. Gellan and coworkers showed that washing removes protein from the surface (and probably ions). Washing the cells and cell fragments could remove components which act along with hydrogen ions to bring about flocculation and settling. Repeated washing of the cells caused an increase in initial absorbance from 0.2 to 0.3 after six washes with saline. This increase had been observed in other studies and appears to be an osmotic phenomenon, according to Gellan.

Initial results of a study of thermolysis in microorganisms was presented by J.R. Watson (North East Biotechnology Center, Department of Chemical Engineering, Teeside Polytechnic, Middlesbrough). He and his coworkers found that heat treatment of bacteria results in the release of intracellular protein. The incubation temperature, cell type, and growth phase all influence protein release at high temperatures. This release of protein is due to rupture of the cell wall in *E. coli*, but *B. megaterium* having a different cell wall structure appears to remain intact.

#### Adsorption and Chromatography

The production of dextran and fructose in a chromatographic reactor separator was reported by P.E. Barker (Chemical Engineering Department, University of Aston, Birmingham, UK). He and his group purified the enzyme, dextransucrase from fermentation broth containing dextransucrase which was produced by the micro-

organism *Leuconostoc mesenteroides*. Barker presented the methods used for the purification of dextransucrase with yields of up to 60 percent of the enzyme. The purified enzyme was used to synthesize dextran and fructose in a chromatographic reactor-separator. In this reactor, simultaneous reaction and separation resulted in not only pure high-molecular-weight dextran but also the recovery of high-purity sucrose. Barker found that the molecular weight distribution of dextran produced from the chromatographic reactor was higher at the sucrose concentrations used as compared to a conventional batch reactor. The parameters affecting reactor behavior were investigated by Barker and his group, who found that the chromatographic reactor required more enzyme than a conventional batch reactor for a given conversion of sucrose. Although there are alternative methods of manufacturing dextran, which has many industrial applications, Barker thinks that many of the problems associated with other production methods are lessened if a chromatographic reactor-separator is used to manufacture dextran and fructose. (There are British and US patent applications for the methods developed by Barker and his group.)

The use of cycling zone adsorption in continuous protein purification was reported by N.N. Beaumont (Department of Chemical Engineering, University of Cambridge, UK). Beaumont described cycling zone adsorption in detail as a possible process for purifying proteins. He presented experimental results for the concentration of a single-component protein feed, using bovine serum albumin (BSA) and lysozyme as two model proteins and Cibacron Blue-Sepharose CL-6B as adsorbent. Cycling zone adsorption uses a packed bed of conventional liquid chromatography adsorbent and a continuous feed of product. Concentration of the product into periodic peaks in the exit stream is caused by forcing the partition coefficient between adsorbent and solution to cycle between two levels. Peaks can be diverted into a product stream by a valve on the column outlet. Thus, the system is only semicontinuous in operation. With nonadsorbed contaminants, purification is by concentrating the product relative to the level of impurities. This is the single component form of cycling zone adsorption which Beaumont described in the studies he presented.

Beaumont said that he and his group found that cycling zone adsorption can be successfully used to concentrate a continuous feed of a single protein in solution into a series of peaks of higher mean concentration than the feed. According to him, it replaces, a complicated

set of pipework, valving, and packed beds by a single bed (with two feeds) of product and salt and a separating valve on the outlet. This will lead to a reduction in capital costs, amount of adsorbent used, complexity in use and construction, size, and running costs. Beaumont stated that although an affinity adsorbent had been used in his experiments there is no reason why ion-exchange and reverse-phase media could not be used. However, gel filtration cannot be used since no adsorption occurs. All that is required for cycling zone adsorption to be applicable is an adsorbent/protein system in which the isotherm is strongly influenced by a parameter readily controlled by the operator such as ionic strength, temperature, or pH. Unlike the fluidized bed techniques, much of the preparative equipment currently available can be used, along with the existing knowledge of packed bed operations, according to Beaumont. However, although the feed of protein is continuous, the product stream is only intermittent, which suggests that the method is only usable for the final stages of a purification scheme, and since the product is contaminated with eluent, it will have to be removed by a final gel filtration step. Beaumont indicated that the experimental data suggests further work to be done. He and his group are now carrying out a quantitative study of the effect of flow rate, protein feed concentration, salt levels, and lengths of addition as well as particle size and distribution. A series of theoretical models are also being developed in which dispersion and finite mass-transfer and kinetic rates are introduced as performance-limiting steps, beginning with the the assumption of instantaneous local equilibrium between adsorbate and adsorbent, but with dispersion of the salt. Beaumont said that preliminary results show that cycling zone adsorption can also be used to fractionate a feed containing several adsorbing proteins.

The subject of Macrosorb kieselguhr-agarose composite adsorbents as new tools for downstream process design and scale-up was discussed by M.G. Bite (Sterling Organics Research and Development, Newcastle upon Tyne, UK). Macrosorb composite adsorbents which are suitable for large-scale protein extraction are manufactured using a three-stage process. In the first stage, purified kieselguhr (diatomaceous earth) is fabricated into Macrosorb-K. In the second stage, a hydrogel is introduced into the interconnected internal pore volume of the granule. The third stage, involves the chemical derivitization of the agarose content to provide the desired adsorbent. Bite and coworkers found that Macrosorb

composite adsorbents extend the applications range of classical agarose-based adsorbents not only by speeding up process flow-rates in column equipment, but also by making available the use of these hydrophilic hydrogels in fluidized beds. Bite said that composite adsorbents enable the downstream process designer to scale up from laboratory equipment to large-volume processing by eliminating the compressibility problem, but without losing the highly desirable characteristics of agarose-based adsorbents.

#### Liquid/Membrane Extraction

The topic of liquid membrane extraction was addressed by D.L. Pyle (Department of Food Science and Technology, University of Reading, UK). In his report, Pyle considered the potential of liquid membrane technology as a means of separating biotechnological products. He reviewed some of the work in this field as well as presenting his own and his group's work on the separation of carboxylic acids from real and simulated broths. By virtue of its immiscibility the so-called "membrane" phase separates two other liquid phases. In most applications, the membrane phase is an organic solvent, separating two aqueous phases. Solute is transferred from phase 1 into the membrane (phase 2) and then into phase 3, where conditions prevent back-extraction of the solute; for example, the solute may contain a reagent which is insoluble in the membrane. There are two methods of achieving the membrane system. In the liquid membrane emulsion (LME) the internal phase (phase 3) is emulsified at high shear in the membrane phase to form a dispersion of droplets. A surfactant is normally required to stabilize the emulsion. The emulsion is then itself dispersed as globules 2 to 5 mm in diameter in the continuous external phase in a mixing vessel (with slow stirring) or in a column reactor. The "membrane" is thus the continuous phase within the droplets. A supported liquid membrane (SLM) can be achieved by impregnating a porous solid film with the membrane phase and using this device to separate phases 1 and 3. Pyle suggested that liquid membrane processes offer significant and unexplored potential for application to biotechnological systems. However, there are many experimental and theoretical problems still to be resolved before fully developed processes are likely to be available and before a definitive critical assessment of the technology's true potential can be made.

The use of reactive extraction in biotechnology was discussed by K. Schügerl (Institute for Technical Chemistry, University of Hannover, West

Germany). He and his group have been using this method extensively in their research. According to him, the solvent extraction of primary metabolites is hampered by their low partition or distribution coefficients and high solubility of the organic solvents (hydrocarbons and hydrocarbon derivatives) in the aqueous phase. The solvent extraction of secondary metabolites at the optimal pH value frequently becomes problematic because of their pH instability. Sometimes the metabolites are insoluble in apolar organic solvents which have low solubility in the aqueous phase. This problem can often be solved, according to Schügerl, by the use of solvents which have stronger and more specific solvation bonds than the carbon-bonded oxygen-bearing extractants or those which form ionic bonds. Such extractants are: (1) organophosphorous extractants and (2) high-molecular-weight aliphatic amines, which form ion pair complexes with the solute. Since either strong and specific solvation bonds with definite stoichiometry or ionic interaction exists between solvent and solute, these extraction processes have been termed "reactive extraction."

Schügerl presented some of the work that he and his group have done on the reactive extraction of primary metabolites focusing on acetic and citric acids. He also spoke about the reactive extraction of secondary metabolites such as antibiotics and vitamins. In particular, Schügerl presented the research in his group on the successful extraction of Penicillin G from the fermentation broth using the reactive extraction method. He said that the scale-up of the process was easy to perform and that the recovery losses of Penicillin G were less than 1 percent. Schügerl stated that by means of reactive extraction, especially by means of ion pair extraction, the performance of several extraction recovery processes in biotechnology can be improved considerably. The advantages of reactive extraction are: (1) the loading capacity of the solvent can be increased considerably, (2) the selectivity of the recovery can be improved, and (3) the recovery can be performed under conditions at which the recovery losses due to the decomposition of the product are low.

The subject of extraction in aqueous two-phase systems for biotechnology was discussed by B. Mattiasson (Department of Biotechnology, Chemical Center, University of Lund, Sweden). Mattiasson and coworkers have contributed a great deal to the development of the aqueous two-phase system and have been using this method in much of their research. Aqueous two-phase systems have a high water content and a low interfacial tension and

are regarded as being biocompatible. Both phases consist of water to a large extent (85 to 95 percent), yet they are immiscible and form phases within a few minutes after mixing. Frequently used compositions of such phase systems are polyethylene glycol (PEG)/polysaccharide and PEG/salt. The polysaccharide may be dextran or hydrolyzed starch. Examples of salts include sodium phosphate and other salts having a multivalent anion. Mattiasson and his group have recently developed a starch-based polymer which is inexpensive as compared with dextran and in most cases behaves like the dextrans. This polymer, called Reppal PES, is modified with hydroxypropyl groups to an extent that it retains the property of biodegradation.

Affinity-mediated partitioning is used for the preparative purification of proteins. Affinity partitioning involves the need of modifying each individual inhibitor or ligand to go to the top phase. According to Mattiasson, this may be unpractical and in some cases even unsuitable. Therefore, he and his group developed the strategy of applying second separator molecules having an affinity for the ligand-target protein complex and a partition behavior strongly favoring the top phase. An example of this is the protein avidin that was PEG-modified, and the ligand was modified with biotin residues in a mild and gentle modification reaction. Mattiasson said that aqueous two-phase systems have proven to be extremely useful reactants with, in many cases, unique properties that meet the needs of biotechnology. In his presentation Mattiasson gave several examples of the use of this method in his own group as well as reviewing work done by other investigators. At the present time, there is still limited use of these methods for interesting large-scale applications, but Mattiasson thinks that much more use will be made of the aqueous two-phase system in the future.

#### Analytical Techniques and Process Control

The on-line monitoring of flux and rejection during microfiltration of protein solution was discussed by P. Heinemann (School of Chemical Engineering, University of Bath, UK). Heinemann and her group have developed a microprocessor-coupled system which allows the monitoring of transmembrane flowrate and protein rejection at the same time. This new technical approach offers the possibility of detecting changes in flux and rejection almost instantaneously. These researchers have used the device to investigate the effect of pH and ionic strength on fouling of membranes in both the long and the short term. Figure 1

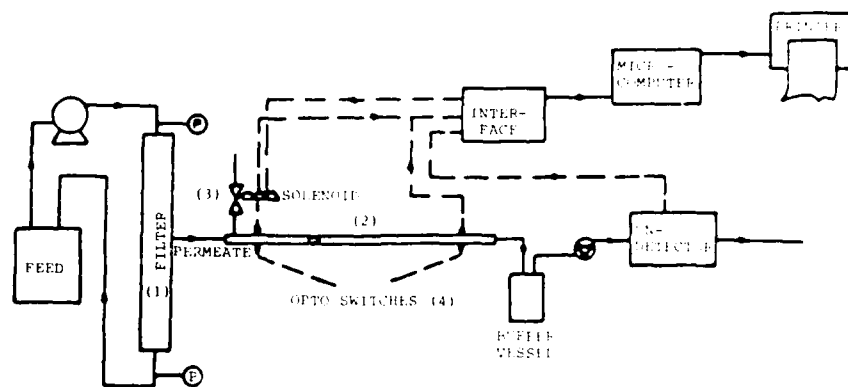


Figure 1. Experimental setup with flowmeter and UV-detector inserted to allow continuous monitoring of flux and permeate protein concentration.

shows a flow sheet of the apparatus developed by Heinemann and coworkers. The results obtained by Heinemann and coworkers showed that the computer-coupled flowmeter responded almost instantaneously to changes in flux. Furthermore, flux and rejection data could be simultaneously obtained at very short time intervals which was particularly desired during the initial dynamic phase. Also, the system was appropriate for monitoring long-term runs.

Biosensors for use in downstream processing were discussed by C.F. Mandenius (Department of Pure and Applied Biochemistry, University of Lund, Sweden), who presented a review of research carried out by several laboratories in addition to work done by himself and his group. These investigators have been working intensively on research in this area and have developed several types of biosensors.

Mandenius pointed out that a variety of biosensors have been described so far. To classify them into categories of electrochemical, optical, and thermal biosensors is only one of several possible classifications. Depending on the definition of the concept that is chosen, other categories could be included--for example, sensors for measurement in biological fluids such as mass spectrometers, electrodes, semiconductors, etc. However, biosensors have, with very few exceptions, not yet been employed in downstream processing. Mandenius thinks that the already elaborated methods and principles of many biosensors could, to a relatively large extent, be adapted to downstream process monitoring. The on-line concept, according to Mandenius is of particular value. Biosensors based on an immobilized enzyme reactor followed by a detection device--for example, an electrode cell or a spectrophotometer flow

cuvette--constitute versatile examples of such applications. As a specific example, an enzyme thermistor with glucose oxidase has been used by Mosbach and Danielsson (coworkers) to monitor the outlet glucose concentration of a lactase column for the conversion of whey and also used to control the addition of whey to the column reactor in order to optimize its yield. Mandenius and his group have also used a twin enzyme thermistor for simultaneous monitoring of glucose and sucrose to control the outlet of an immobilized invertase column for sucrose inversion. Enzyme thermistors have even been used to monitor chromatographic separation procedures. By mixing an enzyme with its substrate in the thermistor the relative activity, and thereby the protein concentration, can be determined. By connecting the enzyme thermistor to the outlets of columns for gel filtration, ion-exchange chromatography, and affinity chromatography, Mandenius and his group have detected the enzymes hexokinase, lactate dehydrogenase, and glucose 6-phosphate dehydrogenase after separation. On-line monitoring of blood and plasma serum has also been successfully performed by a glucose monitor with the dialyzer incorporated in the apparatus. This group has also used a membrane gas sensor which utilizes a gas-permeable membrane for the transfer and purification of, for example, ethanol and butanol.

Although the number of applications of biosensors to downstream processing is still limited, the use of biosensors in this field seems promising with respect to the amount of experience in closely related fields, according to Mandenius.

#### Conclusion

The above summaries of reports presented at this conference on separation methods in biotechnology represent only a

fraction of the extensive material that was presented. The summaries emphasize the research carried out by European scientists, and it is evident that they have made significant progress in this area. Two excellent presentations by US scientists on the use of high-performance liquid chromatography and displacement chromatography have not been covered but are available in ONRL Report 8-003-C.

12/19/87

# GRONINGEN BIOTECHNOLOGY CENTER, THE NETHERLANDS

by Claire E. Zomzely-Neurath.

Biotechnology is becoming increasingly important to society. This is due to important developments in cell biology and in recombinant DNA technologies as well as improvements in bioreactor technology, analytical and preparative equipment, and computer sciences during the past decade. The effects of the rapid growth of biotechnology are such that the emergence of a biosociety is predicted to occur early next century. It is expected that in this biosociety applications of biotechnological research and development will increasingly determine developments in public and environmental health and in the pharmaceutical and chemical industries.

All this led to the foundation in 1981 of the Groningen Biotechnology Center (GBC), which combined 10 biotechnologically oriented research groups of the Departments of Biology, Chemistry, and Pharmaceutical Sciences at Groningen University. The aim of the GBC is twofold: first, to develop and carry out multidisciplinary research programs and second, to coordinate and support biotechnology-oriented teaching.

The GBC has grown rapidly since 1981 because biotechnologically oriented basic research was and is well established in the participating departments, and because there has been increasing interest in biotechnological studies in related disciplines. Based on strong university support, the GBC has been able to respond rapidly and effectively to national and international developments, which in turn, led to considerable growth of the participating GBC research groups. This has resulted in:

- Increased research and teaching potential

- Increased employment of graduate students, technical personnel, and post-docs by GBC groups, as well as the development of several new research groups
- Increased contacts and contracts with national and international industries, due to the fact that the GBC has an increasingly wide range of interacting research activities.

GBC research is at present supported by the University of Groningen, various industries, the Dutch Program Committee on Biotechnology, the Netherlands Organization for Applied Scientific Research (TNO), and several government departments (Economic Affairs; Agriculture and Fisheries; Education and Sciences; Public Health and Environment). ZWO, the Dutch Organization for Basic Research, supports biotechnological research projects via its foundations--SON, BION, and STW--and the EEC supports GBC research via its Biotechnology Action Program.

The research of the GBC focuses on the following areas:

- Biosynthesis of fine chemicals (biochemistry, pharmaceutical sciences, organic chemistry)
- Application of molecular genetics to plant improvement (biochemistry, molecular genetics, plant physiology)
- Development of host-vector systems for industrial applications (biochemistry, molecular genetics)
- Applications of microbial exo-enzymes in industrial processes (molecular genetics, microbial physiology)
- Biological oxidations (biochemistry, microbiology, organic chemistry, chemical engineering)
- Biodegradation (biochemistry, microbiology)
- Chemistry and biotechnology of carbohydrates (biochemistry, genetics, organic chemistry, polymer chemistry, chemical engineering).

In addition to the above topics, GBC has invested heavily in two major programs: the Protein Engineering Program and Extremophilic Industrial Microorganisms. These two programs, established in 1986, will be expanded further in the coming years.

The following sections deal with information about specific projects which are emphasized at GBC.

## Industrial Microorganisms

For centuries mankind has exploited bacteria, yeast, and fungi for all kinds of purposes. Well-known examples are the use of yeast for bread baking, fermentation of beer and wine, and the production

of penicillin. In the course of this century many of the metabolic routes of these microorganisms have been elucidated. It has become clear that the properties of microorganisms are determined to a great extent by enzymes, of which the synthesis and operation is influenced by environmental circumstances.

For several years now, GBC has performed biochemical, genetic physiological, and technological research on industrial microorganisms. In addition, as mentioned above, a new research program on extremophilic microorganisms has recently started. The microorganisms of choice are thermophiles which can grow at temperatures up to 100°C and alkalophiles which can grow at high pH (9-10). In general, the research focuses on the following microbiological processes and techniques:

- Production of fine chemicals, such as alkanols, epoxides, carboxylic acids, amino acids, vitamins, and new biopolymers
- Production of industrial enzymes
- Improvement of cheese preparation
- Development of host-vector systems for industrial microorganisms.

**Fine Chemicals.** Within GBC, research is carried out with a variety of microorganisms equipped with unique metabolic routes. Methylotrophic bacteria and yeasts are the subjects of research in the Microbiology Department. These organisms are able to assemble all complex cell components from methanol, the relatively cheap fermentation substrate.

In the Biochemistry and Chemical Engineering Departments, pseudomonads are the subject of research. These bacteria are known for their broad substrate range; for example, alkanes, toluene, or naphthalene can be used as the sole source of carbon and energy. Furthermore, these bacteria were found to produce interesting new biopolymers. The research in these groups is focused on manipulating metabolic routes by genetic modifications and by optimization of fermentation conditions. In this way it will be possible to use these microorganisms for overproduction of specific metabolic products. Furthermore, bioreactors suitable for specific microbial transformations have been developed. A few examples of commercially interesting fine chemicals and their producers are shown in Table 1. Figure 1 shows an electron micrograph of biopolymers isolated from a pseudomonas strain.

**Industrial Enzymes.** *Bacilli* are producers of economically important proteins, such as starch-cleaving amylases and protein-cleaving proteases. The in-

Table 1  
Microbial production of fine chemicals

| Microorganism                 | Products                                                   |
|-------------------------------|------------------------------------------------------------|
| <i>Pseudomonas oleovorans</i> | epoxides, carboxylic acids, alcohols and polyesters        |
| <i>Hansenula polymorpha</i>   | riboflavine and dihydroxy-acetone                          |
| <i>Nocardia</i> sp. 209       | aromatic amino acids                                       |
| <i>Butyribacterium</i>        | acetic acid, butyric acid                                  |
| <i>Bacilli</i>                | butylene glycol, amino acids, enzymes                      |
| <i>Mycobacterium</i>          | androst-4-ene-3,17-dione and androsta-1,4-diene-3,17-dione |



Figure 1. Electron micrograph of biopolymers isolated from octane-grown *Pseudomonas oleovorans*. The freeze-fracture technique used results in stretched structures.

dustrial interest in these microorganisms is great, especially because they are equipped with systems for protein excretion. Such proteins are easy to isolate and purify. Furthermore, a well-developed fermentation technology is available in the Netherlands for large-scale production of *Bacilli*. In the Department of Molecular Genetics, research is being carried out with *Bacillus subtilis*, a physiologically well-characterized organism for which recombinant DNA technology has already been developed. The aim of the research is to analyze and modify functions involved in protein excretion which should eventually lead to a higher production of extracellular proteins.

**Improvement of Cheese Preparation.** The Netherlands is the world's largest cheese producer, having a production of 400 million kilograms of cheese per year. Lactic acid *streptococci* play an essential role in the cheese preparation process. Mixtures of these bacteria, so-called starter cultures, are added to the milk together with chymosin, an enzyme

from the stomach of young calves. The *streptococci* grow quickly in milk, converting lactose into lactic acid. Together with the action of chymosin this acidification leads to the precipitation of milk protein. The precipitate (curd) is separated from the fluid (whey) and finally pressed and salted.

The resulting young cheese containing many lactic acid bacteria, is stored in cooled warehouses for ripening. Lactic acid *streptococci* produce protein-cleaving enzymes, responsible for the degradation of milk protein to peptides and amino acids. These proteases are important for good growth and efficient acidification during the cheese manufacturing process. Furthermore, they determine the taste of the cheese. It has been shown that during ripening, the protein cleaving ability is spontaneously lost by some *streptococci*. In cooperation with the Dutch dairy industry, research is in progress aimed at gaining insight into the mechanism of protein cleavage and the cause of the loss of this ability of *streptococci*.

Development of Host-Vector Systems for Industrial Microorganisms. An essential part of the applied research of industrial microorganisms is the development of suitable host-vector systems. This implies the development of gene cloning systems and methods of introducing manipulated DNA into the organism. For the well-known bacterium, *E. coli*, an extensive set of good cloning systems has been developed, though they are not directly applicable to industrial microorganisms. Within GBC, host-vector systems are being developed in cooperation with industry and other institutes for *Pseudomonas*, *Bacilli*, methylotrophs, *Clostridia* and lactic acid bacteria. Considerable progress has been made, especially for *Bacilli* and lactic acid bacteria, resulting in several patents.

#### Plant Biotechnology

This area is going through rapid development. Modern techniques in biology are being used in plant improvement and in research directed at industrial applications of plant tissues. Basic and strategic research in this area is being carried out at GBC by research groups of the departments of Pharmaceutical Sciences, Plant Physiology, and Genetics, often in collaboration with industries and other research institutes. Several important research areas are described below.

Research Directed at Mushroom Cultivation. The Netherlands produce about 100,000 tons of mushrooms yearly, most of which are exported. A major problem in cultivating mushrooms is that they are

subject to a viral infection which causes early death. The Department of Plant Physiology is developing sensitive detection methods to allow early diagnosis of this infection. In addition, protoplast fusion is being used to introduce resistance genes from other fungi into commercial mushroom strains.

Biosynthesis, Biotransformation, and Accumulation of Interesting Pharmaceuticals by Plant Tissue Culture. The Department of Pharmaceutical Sciences uses cell cultures of *Symphytum* species for the production of pyrrolizidine alkaloids, which show antitumor activity. The department is also engaged in the development of biotechnological processes for the production of L-DOPA (used for treatment of Parkinson's disease) and other catechols by *Mucuna pruriens* and scopolamine by *Datura* and *Duboisia* species. This research is aimed at both biotransformations of precursors supplied in the medium, and at endogenous production by plant tissues. The department is also involved in the development of plant bioreactors for these production processes.

Genetics of Plant Host Functions. The Department of Genetics is investigating symbiotic nitrogen fixation in the pea by isolating and characterizing pea mutants which show altered interactions with *Rhizobia*, and testing such pea mutants in field trials. The same group is also examining potato blight, which is caused by interaction of the cyst nematode with the root hairs of the potato plant. The potato genes responsible for the production of cyst nematode attractants, which activate the cyst nematodes and induce them to interact with the root hairs, are being sought and characterized. The aim of such studies is to develop improved plant strains, resistant to agricultural pests or strains with improved growth and production characteristics.

Molecular and Cell Genetics of the Potato. The Department of Genetics is also engaged in the localization of specific genes on potato chromosomes and the introduction of genes in the potato via somatic cell hybridization. This research is directed at improvement of frost resistance and changes in potato starch composition. In addition, genes encoding some of the major enzymes which affect starch composition, are being cloned and biotechnological research on starch is being carried out at GBC.

#### Carbohydrate Research

Qualitatively, carbohydrates constitute the largest group of biological agromolecules because of the enormous amounts of starch and cellulose present in nature. Both of these carbohydrates

Table 2  
Biotechnological Research on Starch

| Modification                                                                                  | Purpose/Application                                                       | Departments                                                               |
|-----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Changing starch/composition via manipulation at plant-level                                   | New potato producing pure amylopectin/amylose                             | Cell and Plant Genetics, Biochemistry, in cooperation with NIKO and Avebe |
| Changing starch structure, e.g., via manipulation at plant-level                              | Improvement of derivatizing processes                                     | Biochemistry, Electron Microscopy, Structural Chemistry                   |
| Increasing branching degree "in vitro" via branching enzymes                                  | Improvement of the conversion of products such as custard and tinned soup | Molecular Genetics, in cooperation with NIKO and Avebe                    |
| Esterification, etherification of starch slurries (or suspensions) in multiple phase reactors | Creating optimal conditions for commercial applications                   | Technical Chemistry in cooperation with Avebe                             |
| Decreasing molecular weight in combination with esterification and etherification             | Component of UV-hardening lac (coating industry)                          | Polymer Chemistry in cooperation with AKZO AND Avebe                      |
| Conversion to various optically active polymers such as epoxides                              | Coating industry, fibre industry                                          | Organic Chemistry in cooperation with NIKO                                |

have high molecular weights and are built from D-glucose subunits. They differ only in the way the glucose molecules are coupled in chains of thousands of units in length. Carbohydrates are used for nutrition, but at an industrial level, they are also transformed to a range of different products, such as sweeteners, glueing agents, paper, textile, and a variety of pharmaceutical and cosmetic products. In addition to these purposes, carbohydrates are also used in the oil and gas industry (to raise the viscosity of fluids) and for the production of compounds such as polyurethane foam.

The Netherlands produces more carbohydrate than it consumes. Therefore, it is of interest to modify a large portion of the carbohydrates to valuable derivatives (modified starch and chemicals). GBC participates extensively in starch research. A number of differently oriented groups perform research aimed at the development of new products and improvements of production processes already in use (see Table 2).

Starch modification is carried out at two different levels: (1) at the molecular biology level, for example, by manipulation of the potato such that starch is synthesized, either with an altered structure or composition and (2) at the molecular chemical level, aimed at (bio)-chemical modification of harvested starch to commercially interesting derivatives. The combination of different biotechnological disciplines in this field together with closely related activities of Avebe (a large Dutch potato starch producing company) and the Dutch Institute for Carbohydrate Research (NIKO-TNO) make the GBC a fruitful place for carbohydrate research.

#### Biotechnology and the Environment

Biotechnology can contribute to environmental protection since it provides techniques for the treatment of wastes and for the removal of degradation of specific compounds. Bacteria, yeast and fungi can degrade numerous natural and synthetic organic compounds. A more detailed understanding of the ecology, physiology and biochemistry of the underlying processes should enlarge the application potential of biological waste water treatment.

Waste Water Treatment. The application of microorganisms for the treatment of waste water and solid wastes is well established and biological treatment techniques have been used successfully in the Netherlands for decades. Recent improvements in this area are the use of anaerobic processes and of reactors containing immobilized microorganisms. The Department of Chemical Engineering is working on the development of a process for the thermophilic digestion of pig waste. The reactor system used contains microorganisms immobilized on a solid support of synthetic material, and allows efficient degradation of organic material at short residence times.

Xenobiotic Compounds. Although microorganisms have the capability to mineralize many different organic compounds, there are limitations which must be considered. The so-called xenobiotics, or synthetic chemicals, have often been found to be refractile to biodegradation, which causes such compounds to pass through the biological treatment system and persist in the environment. Since, in recent years, more efficient selection techniques could be developed based on a detailed understanding of the

physiological cause of this recalcitrance, it has now become possible to isolate microorganisms that can degrade compounds that previously were found to be resistant to biodegradation. Furthermore, genetic engineering allows the construction of new degradative routes or of organisms that are better suited for a certain treatment system. In the Department of Biochemistry, several microorganisms for the degradation of aromatic solvents, chlorinated hydrocarbons, pesticides, and polymer building blocks have been obtained in pure culture. Addition of such cultures to biological filters for waste gas purification increases the degradation rates of specific problem compounds. The degradation of organic chemicals in polluted soil may also be stimulated by the addition of specific microbial isolates.

**Biodegradation at Low-Oxygen Tension.** Apart from compound-related factors, poor degradation can also be caused by unsuitable environmental conditions such as an excess or a lack of oxygen. The Department of Microbiology is studying the effect of limiting concentrations of oxygen which may be found in groundwaters or sediments on the conversion of compounds that require both aerobic and anaerobic steps for the degradation. It is anticipated that a more detailed understanding of processes that proceed at low-oxygen tension will uncover novel degradative potentials.

### Protein Engineering

Every living organism is composed of an enormous variety of proteins which carry out a wide range of functions, such as: highly specific biocatalysts of chemical reactions (enzymes); carriers of small molecules (for example, hemoglobin); messengers (hormones); regulators of complex processes (such as the coagulation of blood); signal sensors and structure recognition devices (receptor proteins, antibodies), or ion-gates and transporters in membrane transport systems.

Every protein has a specific three-dimensional structure which is determined by its amino acid sequence and which dictates its function. Based on present-day DNA technology, it is possible to introduce specific changes in an amino acid sequence, which makes it possible to study the role of a given amino acid in determining the three-dimensional structure and function of a given protein. Such directed modifications by protein engineering should allow the design and development of improved proteins for applications in the industrial, medical, and agricultural sectors. Improved proteins might show altered substrate speci-

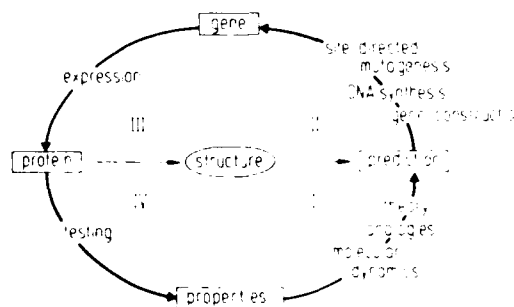


Figure 2. Protein engineering cycle.

ficity, a higher turnover number, increased stability, improved binding to an insert support, etc.

Protein engineering requires a multidisciplinary approach. A first requirement is an accurate three-dimensional model of the protein in question, which can be depicted via computer graphics, after which the effects of local amino acid modifications on the overall structure and stability can be predicted with molecular dynamics calculations. The most successful predictions can be tested experimentally by altering the corresponding gene and tested by the enzymologist. It will probably be necessary to go through the protein engineering cycle several times before a protein with desired characteristics is obtained (Figure 2).

An ambitious Protein Engineering Program was launched in the summer of 1985 by the GBC in collaboration with the Biomolecular Study Center and with considerable support from the Dutch Program Committee on Biotechnology. A large number of research groups, which together have considerable expertise in protein crystallography and structure determination, protein chemistry, molecular dynamics, enzymology, membrane transport, microbial physiology, and molecular genetics participate in this program. The proteins being studied, and the aims of the studies are:

- Alpha amylase and beta glucosidase of *Bacillus subtilis*--to raise the stability of these industrially interesting proteins
- Yeast alcohol-oxidase--to determine which signal sequences direct the protein to specific cell organelles
- Alkaline-hydroxylase of *Pseudomonas oleovorans*--enzyme variants with altered substrate specificity, directed at the synthesis of fine chemicals
- Calcium transport of *P. subtilis*--to develop understanding of hydrolytic dehalogenation of chlorinated aliphatics and to develop variants with altered substrate specificity.

### Biomolecular Information Sciences

This area deals with data bases and data handling related to biological systems at the atomic or molecular level. As computer speed and data handling capacity increase, the role of the biomolecular information sciences in biotechnology will also increase. The activities of the GBC and related groups in Groningen already cover a considerable spectrum of activities: from the development and construction of hardware, via software and algorithms to a variety of applications as indicated:

1. Experimental data obtained for proteins by x-ray crystallography, two-dimensional nuclear magnetic resonance, and digitized electron microscopy data can be converted to three-dimensional models using powerful computers and the associated software and algorithms.

2. Computer simulation methods have been developed in the past decade with which it is possible to mimic and predict the behavior of proteins, hormones, and DNA segments based on three-dimensional structural information and postulated interactions between atoms.

3. The rapid accumulation of experimental data has led to the formation of sizeable data banks for nucleotide sequences (DNA, RNA), amino acid sequences (protein, hormones), and three-dimensional structural information (proteins, RNA). At the same time, software has been developed which allows searches and comparisons between sequences and thereby aids in the interpretation of such information.

4. Modeling of complex biological structures requires very high computer speeds, coupled with a relatively simple algorithm. These requirements can be met by constructing specific hardware which sacrifices flexibility to speed. Such special-purpose computers are now being developed for biomolecular applications at GBC.

### Vaccines

One of the most important discoveries of mankind was the possibility of fighting viral and bacterial diseases by vaccination. As a result, some infectious diseases, such as smallpox, have been eliminated completely. Classical vaccines consist of inactivated (dead) or attenuated (weakened) bacteria or viruses. However, both vaccine types may show undesirable side effects such as the possibility of reversion of attenuated forms. Research directed at the development of synthetic vaccines which show no side effects is therefore being carried out at GBC. In this approach, immunity is achieved by vaccination with subunit vaccines. This might be a protein constit-

uent of a viral envelope, or a specific portion of such a protein. Such proteins or large peptides are produced by recombinant DNA technology, while smaller fragments (10 to 20 amino acids) are synthesized with automated solid-phase peptide synthesizers. Using this approach, synthetic vaccines are being prepared against herpes simplex virus type 1 and 2 (HSV-1 and HSV-2). Oral and genital infections caused by these viruses appear to be increasing, as a result of which they are now considered to be public health problems.

To develop an efficient subunit vaccine, it is important to understand the structural basis of the immunity. To this end, interactions between viral proteins (the antigens) and the binding domains of monoclonal antibodies must be studied. This requires detailed knowledge of the three-dimensional structure of the interacting regions of both antigen and antibody, a knowledge which can be obtained with the protein engineering approach. Such studies are being carried out at GBC, as well as many laboratories worldwide. It can be anticipated, therefore, that increasingly more specific and effective subunit vaccines will become available in the next decade.

### Monoclonal Antibodies

Monoclonal antibodies (Mabs) are glycoproteins which recognize highly specific structures in other molecules. They originally derive from the animal immunological defense system against foreign compounds or structures (so-called antigens). In this system, each specific antigen elicits the production of specific antibodies by specific plasma cells. As is well known, Millstein and Köhler discovered in 1975 that such short-lived antibody-producing plasma cells can be hybridized with long-lived myeloma cells, resulting in so-called hybridomas. Each hybridoma produces a single antibody, as did the original plasma cell. By allowing the hybridoma to divide, a clone of identical cells, all of which produce the same "monoclonal" antibody, is obtained. By using selection techniques, it is possible to identify and isolate clones which produce specific monoclonal antibodies. By growing the hybridomas in one of several bioreactor systems or in laboratory animals, it is possible to prepare large amounts of specific Mabs. Such Mabs are useful because they can be used for the recognition of highly specific molecular structures (antigens) in very low concentrations, such as specific parts of eukaryotic cells, bacteria, viruses, proteins, carbohydrates, etc. They are typically used for research purposes, routine analyses,

clinical tests, vaccine development and, in some case, processing of expensive biotechnological products.

A few examples of Mabs produced at GBC are antibodies directed against tumor cells (lung cancer, lymphomas), viruses (cytomegalovirus, herpes simplex virus), and normal red blood cells (human, rat). Mabs are developed and produced at the GBC for both research and commercial purposes. The commercial production of Mabs is carried out by MCA Developments B.V. (a company recently established by several laboratories) and the Groningen Science Park Foundation.

12/20/87

## Chemistry

### CHEMICAL ENGINEERING RESEARCH AT THE UNIVERSITY OF PATRAS IN GREECE

*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 Institute of Chemical Engineering and High Temperature Chemical Processes (ICE/HT) is located at the University of Patras and staffed by professors of the university's Chemical Engineering Department (CED). ICE/HT was founded in January of 1984 as a legal entity in the private sector, funded and overseen by the General Secretariat of Research and Technology (GSRT). Professor G.N. Papatheodorou, the director of the institute, told me that the institute was founded on the initiative of a group of professors from the CED in order to foster research at the university. There has not been a strong tradition of research at the Greek universities, and ICE/HT and six similar research institutes in different disciplines in Greece have recently been established through government and private action to improve research.

ICE/HT's organizational arrangement is very similar to the CNR laboratories of Italy and the CNRS laboratories of France. Funding for the institute is about 50 percent from the government, 40 percent from the EEC, and 10 percent from private industry. A professor is considered a member of ICE/HT when he has a contract through the institute.

At present, there are six research scientists, three associate research scientists, and two research associates with the institute. The professional staff is assisted by about 20 graduate students, all of whom are working for their doctorates. Five of the research scientists obtained their doctorates in the US and spent a good deal of time doing research there. Papatheodorou, for example, has spent over 20 years working in the US.

Perhaps as a result of the establishment of ICE/HT the CED has well-equipped laboratories, which I will list after reviewing the scientific activities of each of the research scientists. Their activities can be grouped in four main areas:

- High temperatures and new materials
- Petroleum and petrochemical industry
- Industry and environment
- Catalysis.

There is some overlap between the different categories and several of the research investigators have projects in more than one area.

#### High Temperatures and New Materials

In addition to his ongoing collaboration with the Argonne National Laboratory in the US, Papatheodorou is engaged in collaborative efforts with the Technical University of Denmark, where he was a visiting professor in 1984, and with the Norwegian National Institute of Technology. His research interests are directed at the application of Raman spectroscopy to molten salt catalysts and to the characterization of materials and vapors at high temperatures. Molten salt catalysts are used in industrial processes, such as the production of sulphuric acid. In a recent EEC-sponsored project (R. Fehrmann et al., 1986), Papatheodorou investigated the crystal structure and infrared and Raman spectra of  $KV(SO_4)_2$ . The chemistry of vanadium oxide dissolved in molten  $KHSO_4$ - $K_2S_2O_7$  is quite important due to the catalytic importance of these salts in the oxidation of  $SO_2$  to  $SO_3$  in the production of sulphuric acid.  $KV(SO_4)_2$  has been found in the course of work to precipitate out of the molten salts. Papatheodorou believes that new solid compounds such as this contribute to the undesired poisoning of the catalyst. The results of the studies should be of use in improving the effectiveness of known catalysts and in the development of new ones.

Papatheodorou's other area of investigation is concerned with Raman spectroscopic studies of vapor complexation of metal halides (Boghosian et al., 1986). The apparent enhancement of the volatility of solids in the temperature range

of 300-1000 K can be of the order of  $10^8$ - $10^{12}$ . The experimental results and calculations can be important in the separation of inorganic solids and liquids in industrial processes, such as new methods of aluminum production. The results could also be useful in the development of highly efficient halide discharge lamps, in the design of new lasers, and in the making of new material through vapor deposition.

Professor D.E. Rapakoulis is investigating the preparation of hydrogenated amorphous silicon for photovoltaic applications (Rapakoulis et al., 1987). Production of solar cells in glow discharge reactors is beginning to be operational on an industrial scale. The research effort is directed to two problems. The first effort is to increase the deposition rate in the glow discharge by using different feed gases ( $\text{SiH}_4$  and  $\text{Si}_2\text{H}_6$ ). The second, more fundamental study, concerns the analysis of the plasma kinetics close to the gas/solid interface and at the association of the film properties with the preparation conditions. The basic tool in the plasma studies is laser-induced fluorescence; the films are evaluated by means of optical and electrical measurements.

#### Petroleum and Petrochemical Industry

Professor A.C. Payatakes does research in two-phase flow in porous media. The basic objective is to achieve enhanced oil recovery (Hinkley et al., 1987). Primary and secondary oil recovery produces on the average only 33 percent of the available oil in a reservoir. Water flooding is also inefficient in that it only achieves about 16-percent recovery. In his research Payatakes has tried to better characterize the porosity of rock and to model the porous flow in two-dimensional models (sandpacks) which permit visual studies of breakup of ganglia and their accumulation. The visual data aids in the modeling of this complex process of water displacement of oil in porous rock. Payatakes' extensive publications in the area of the experimental and theoretical investigation of the motion of oil ganglia have included review articles in the annual review of *Fluid Mechanics* and in reviews in *Chemical Engineering*. His present work is supported by Greece's Public Petroleum Corporation and the EEC.

#### Industry and Environment

The research projects listed in this area are closely related to industrial application in Greek industry. Current programs include the design and optimization of filtration systems for industrial waste, the utilization of fly ash,  $\text{SO}_2$

removal from stack gases, and the study of the dynamic behavior of mixed cultures of microorganisms.

Payatakes has a project in this area which is concerned with the design and optimization of filtration systems for industrial wastes. He is particularly concerned with deep bed filtration systems, which are the most efficient means for the elimination of fine, suspended particles (1 micron) in liquids. This work complements his oil recovery investigations.

Professor C.G. Vayennas is investigating the cogeneration of electrical energy and chemicals in which the aim is to investigate on the laboratory scale novel electrocatalytic processes for simultaneous generation of electrical power and useful chemicals. One aspect of this program is the experimental optimization of the high-temperature  $\text{NH}_3$  fuel cell for the the cogeneration of NO and power. Another project involves the removal of  $\text{SO}_2$  from thermal powerplant stack gases. Because of limitation in the Greek environment emphasis is being placed on the development of an inexpensive dry method of removal of the gas.

Lecturer S. Pavlou is conducting theoretical investigations of microorganisms inhabiting the same environment--such as in a biological reactor (chemostat). The interactions investigated through mathematical modeling include competition of two microbial populations for one or more nutrients, and predation of one population on another. Environmental effects include temporal and space inhomogeneities in the chemostat, attachment to and competition for wall space, and time delays in population dynamics. Pavlou has papers in most of these areas. I have always had a personnel interest in population dynamic modeling and it is interesting to see the comparisons between models and controlled experiments that can be made with microorganism in chemostats that cannot be made in, for example, the classical Lynx and Hare population fluctuations in Canada. Pavlou indicated that he intends to spend his sabbatical next year at the University of Minnesota, where he earned his Ph.D.

#### Catalysis

In the catalytic area the research is directed at developing fundamental knowledge of catalytic phenomena as well the solution of practical problems related to the preparation and optimal design of industrial catalysts. There is strong participation in this area by several of the professors; thus, Papatheodorou has a project on molten salt catalysts and Rapakoulis another project on catalytic effects in plasma solid

interaction. Professor Vayennas, has a project on the modeling of the hydrodesulfurization (HDS) process. He has developed a mathematical model to describe the steady-state behavior of partially wetted catalyst particles which catalyze reactions between volatile and nonvolatile components. A second part of the program is directed at the optimal distribution of catalytic pellets (C.G. Vayennas and S. Pavlou, submitted for publication).

Professor X.E. Verykios, is another active investigator in the area of catalysts. His project involves the study of strong metal/support interactions (SMSI) in promoted catalysts (Akubuiro and Verykios, 1987). The study involves the examination of the existence as well as the mechanisms of induction of SMSI. The objective is to develop a more active, selective, and poison-resistant CO hydrogenation catalysis.

#### Laboratory and Computer Equipment

The Institute has a Vax 11-750 and several PC's and minicomputers, which are adequate for the Institute's computational needs. The laboratories are equipped with vacuum systems and furnaces as well as a versatile Raman spectroscopy system, a laser-induced fluorescence system, an optical multichannel analyzer, a spectrophotometer, and a full complement of other modern chemical equipment.

#### Concluding Remarks

There are three other researches at ICE/HT whom I was not able to meet, but their activities are described in a booklet on ICE/HT which is obtainable from Professor Papatheodorou, University of Patras, Patras, Greece.

In conclusion, I should say that ICE/HT is a highly successful venture, its energy and intelligence demonstrated, among other evidence, by an output from its small staff of over 50 publications in the past 2 years alone. Since five of its six research scientists took their Ph.D.'s in the US and spent an additional combined total of well over 40 years in teaching and research there, it is not surprising that I originally titled this report as "American Style Research at the University of Patras."

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10/9/87

## Computer Sciences

### THE COMPUTING SURFACE OF THE COMPANY MEIKO

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

#### The Meiko Company

Meiko of Bristol, UK, is a computer manufacturing company founded a few years ago by seven employees of INMOS Company. These employees had been participants in the development of the INMOS transputer, which has proven to be a very successful product (ECR 40-9:306-308 [1986]; ECR 40-4:142 [1986] and ECR 39-9:443 [1985]). As of September 1987 there were 37 announced hardware products based on the transputer in the UK, US, Japan, and West Germany. Also there were 38 products and projects under development in the UK, US, France, and the EEC based on the transputer.

Because of the importance of the transputer to Meiko I will give a brief description of the most recent version of the transputer (the T800) before discussing Meiko's computer surface products.

#### T800 Transputer

The T800 is a 32-bit CMOS microcomputer with a 64-bit floating point unit and graphics support. It has 4 kbytes of chip random access memory (RAM) for high-speed processing, a configurable memory interface, and four standard INMOS communication links. The instruction set achieves efficient implementation of high-level languages and provides direct support for the OCCAM language model of concurrency when using either a single transputer or a network of transputers. Procedure calls, process switching, and typical interrupt latency are submicrosecond. The processor speed can be pin selected in stages from 17.5 MHz up to the maximum allowed for the part. A device running at 30 MHz achieves an instruction throughput of 15 million instructions per second.

The T800 provides high-performance arithmetic and floating point operations. The 64-bit floating point unit provides single and double precision. It is able to perform floating point operations concurrently with the processor at a rate of 1.5 megaflops at a processor speed of 20 MHz and 2.25 megaflops at 30 MHz.

Graphics support is provided by microcoded block move instructions which operate at memory speed. The two-dimensional block move instruction provides for contiguous block moves as well as block copying of either nonzero bytes of data only or zero bytes only. Block move instructions can be used to provide graphics operation such as text manipulation, windowing, panning, scrolling, and screen updating.

Cycle redundancy checking instructions are available for use on arbitrary length serial data streams, to provide error detection where data integrity is critical. Another feature of the T800 useful for pattern recognition, is the facility to count bits set in a word.

The T800 can directly access a linear access space of 4 gigabytes. The 32-bit-wide memory interface uses multiplexed data and address lines and provides a data rate of up to 4 bytes every 100 nanoseconds (40 million bytes/sec) for a 30-MHz device. A configurable memory controller provides all timing, control, and memory refresh signals for a wide variety of mixed memory systems.

#### Meiko's Computing Surfaces

Meiko has based its product line of what they have termed "Computing Surfaces"--which are supercomputers--on the transputer. The company began sales in 1986 and had sold 130 systems by September 1987 and expected to have had a turnover of £12 million (\$21 million) in 1987. Most of the 130 systems were sold in the UK but there were sales in the US, Japan, and Western Europe.

The Computing Surface is a highly parallel, flexible, extensible concurrent supercomputer. Beginning in 1979 the co-founders participated in a team of developers at INMOS which concluded that the communication of sequential processes, as suggested by Professor Hoare at Oxford University, offered the best model for matching computation and communication with integrity. This work led to the T800 transputer and the OCCAM programming language. The Meiko founders were managers in the design group responsible for the transputer and its peripherals. In developing the transputer, a CAD system with over 200,000 lines of code and customized work stations was created and supported by the team. This knowledge provided a basis for developing the Computing Surface at Meiko.

Meiko did, indeed, develop a very fast supercomputer with flexible user-determined topology. It is composed of modular subsystems that permit optimization of "compute," "store," and "input/output" to particular classes of application, together with straightforward software and tools essential for programming this class of machine.

The Computing Surface was first shown in July 1985 at SIGGRAPH in San Francisco, and it was ready for general release in the summer of 1986.

Various approaches to the use of the Computing Surface are possible. Since every standard transputer is a significant computer by itself the Computing Surface can be treated as a multitask environment with a separate, independent task per computing element. An example is a numerically intensive simulation. Often, many simulations have to be performed on the same data set, but with different starting or operating conditions. The set of simulations is the overall task, but conventionally the performance of an individual simulation is measured and optimized. Performing each one of the set of simulations simultaneously with the others, with no interaction between them, leads to a linear decrease in elapsed time.

The other extreme is the truly distributed implementation, involving a fresh look at the problem, or tackling a problem which was previously looked upon

as infeasible with conventional computers.

A Computing Surface is formed by networking many computing elements in an applications-specific topology. Each computing element is a self-sufficient, independent hardware process, with processor, memory, and high-speed point-to-point communications channels.

In the Computing Surface users impart their own concepts to the machine, without the constraint of arbitrary choices by the developer. Thus, configurations can be optimized for the applications.

The support infrastructure can detect hardware or run-time errors in any individual computing element, and perform an immediate analysis. A problem is pinpointed by positioning the program source editor at the offending line of code and naming the process instance in which it has occurred. Application diagnostic messages are assured of a guaranteed route to the console or host computer using a communications structure which is independent of, and orthogonal to, the configurable network.

Software is used to specify the machine as well as the application program. OCCAM specifies connections, communications, and computations in one consistent formally based notation. The transputer was designed to implement the OCCAM model and execute OCCAM code. The Computing Surface was designed to deliver transputers and to support application development.

The Computing Surface can also be programed in Fortran, C, Pascal, and other languages. Often, existing programs can be run on the Computing Surface without alterations. Executing such programs requires an OCCAM harness to handle communication with other processors, which may be executing copies of the same program.

Physically, a Computing Surface is contained in one or more modules. Connectivity allows the same level of interconnection between computing elements in separate modules as within the same module. The modules come in two sizes:

1. The M40 Computing Surface Module yields 1.1 billion instructions per second with 42 megabytes of concurrently accessed dynamic RAM. The effective bandwidth of the store is 24 gigabytes per second, with a peak bandwidth of 9 gigabytes per second to 300 kilobytes of closely coupled static RAM. An arbitrary number of modules can be used together.

2. A smaller desktop module, the M10, can deliver 250 million instructions per second and provides a compatible personal

supercomputer for workstation or development use.

#### Data Concurrency and the Computing Surface

The comments of Eric Barton, a co-founder of Meiko, are summarized herein.

In a single pipeline of processors when the time to perform the computation on a subproblem is less than the time taken to receive the operands or transmit the results, the performance-limiting factor becomes the communications bandwidth. Adding extra processors to the pipeline will not increase throughput. The solution is to construct several pipelines in parallel, each dealing with independent segments of the problem.

The throughput of a pipeline is limited by the throughput of the slowest element, therefore full use of all the processors can only be achieved when all are performing tasks of the same duration. Computing must be allowed to proceed at all times in order to use fully all processors in a system. In the Computing Surface, once an external communication has been initiated by the processor, it is free to continue execution of another process while the link controls carry out the message passing, only stealing single memory cycles from the processor when a complete word of the message is passed between link and store. This requires stealing one memory cycle in 160 in the Computing Surface in steady-state operation. However, startup costs and variable message size must be considered. For small message size the fixed cost of startup becomes dominant. If the message size is increased to amortize the startup costs, the time to flow a message through a processor is correspondingly increased. This requires that the processor be given a more lengthy and difficult task to ensure it is kept busy.

In the extreme it appears that one makes best use of a Computing Surface when its processors engage in no communication at all, thus allowing full use. This results in a style of use called "the processor farm." The idea is to engage each processor in an independently computed part of the entire process.

In ray tracing, each pixel in a scene is rendered by tracing rays from a point on the emulsion of a film in an imaginary camera through the lens and out into the world. More rays are traced to determine the appearance of any surfaces that the original ray may have hit. Sequential ray-tracing algorithms do not usually care about the order in which pixels are calculated, as all ray scene intersections have to be recomputed pixel by pixel. The natural implementation on

a Computing Surface is to replicate both a standard sequential ray-tracing algorithm and the world model it will be tracing over all the processors of the system. Each processor can then be assigned a subset of pixels which make up a frame and can proceed with rendering them independently.

To balance the load the user should divide the scene into many more portions than there are processors and should use a load-balancing task server to distribute tasks to processors which have finished a previous task. Such a scheme has been implemented on a system with over 300 processors, and performance remained linear with the number of processors.

A Computing Surface can provide a system throughput proportional to the number of processors from which it is composed. The simplest method both of programing and of guaranteeing full use is to replicate sequential programs over all the processors, thus increasing throughput but keeping single task latency constant. However, with suitable attention to the ratio of computing to communications and the sizes of messages, and by programing with the intention of minimizing the extent to which algorithms are divided between processors, single task latency can also be reduced while still providing full use of all processors.

12/14/87

## Environmental Sciences

### MEETING ON ATMOSPHERIC STUDIES BY OPTICAL METHODS

*by Jerome Williams. Professor Williams was the Liaison Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He completed his tour at ONRL and has returned to the US Naval Academy, where he is Professor of Oceanography.*

The fifteenth annual meeting on atmospheric studies by optical methods was held in Granada, Spain, from 6 through 11 September 1987. Hosted by the Instituto de Astrofísica de Andalucía in Granada, the conference was attended by about 70 scientists from Italy, Finland, US, UK,

France, Spain, Brazil, Denmark, Mexico, Sweden, Norway, Canada, Japan, and South Africa. As in previous years, conference proceedings will probably be published, but final plans for publication have not been made at this time. However, abstracts should be available from the Instituto de Astrofísica de Andalucía, PO Box 2144, 18080 Granada, Spain.

The keynote address was delivered by D.R. Bates (Queens University, Belfast, UK), who reviewed the various theoretical approaches that have been attempted by investigators to explain the oxygen nightglow from the early days up to the present time. The demonstration by Bates that there is no single theory that is completely satisfactory was picked up by a number of the participants throughout the meeting, as they either attempted to show agreement of data with existing theories or put forth new ideas to explain conflicting data. Generally speaking, each session followed the same pattern--an invited tutorial paper, followed by contributed papers on more or less the same theme.

### Aeronomy

The nightglow medium (the lower thermosphere) was discussed by R.G.H. Greer, Queen's University, Belfast, in terms of the nightglow measurements that have been made since 1895. This phenomenon usually cannot be seen by the naked eye, making measurement difficult, but in recent years advanced techniques such as spectral analysis have been applied. Until 1955, all measurements were ground-based, but since then rocket-based soundings have become commonplace. The ground-based techniques have also become more sophisticated with the introduction of light detection and ranging (LIDAR) systems. Such a system for the determination of stratospheric and mesospheric density was described by A. Andriani, representing a group from Istituto Fisica dell'Atmosfera, Frascati, Italy. This group, operating in Frascati since early 1982, made observations of the lower stratosphere during the period immediately following the eruption of the El Chichon volcano, and they monitored the evolution of the resulting aerosol cloud. Since then the 532-nm laser system has been upgraded to obtain molecular density profiles using Rayleigh scattering, and new instrumentation for photon counting is now in place. Preliminary sensitivity tests indicate an accuracy of 3 percent for measurements made at an altitude of 65 km with a resolution of 1.5 km, when an integration time of 30 minutes is used.

In a somewhat different vein, G. Witt, University of Stockholm, Sweden,

reviewed some of the more modern theories of lightning, and the resulting EM radiation. He indicated that the earth's atmosphere is an electrically active environment with the fair weather atmospheric current density usually around  $2 \text{ pA/m}^2$  and the EMF between outer space (infinity) and the earth's surface varying between 290-300 kV. Since the conductivity of the atmosphere increases exponentially with altitude in the charged layers, most of the electrical current generated by storms goes out into space and returns. This earth electrical network is probably modulated by solar activity (sunspots). A lightning flash has a total energy of about  $4 \times 10^8$  joules and emits energy over a broad spectrum, but most of the energy is in the low-frequency region. The channel resulting from a flash is heated to a temperature of 10,000-35,000 K, producing relatively large amounts of  $\text{NO}_x$ . Nevertheless, this is estimated to be only about 4.3 percent of the anthropogenic production and 1.3 percent of the production from biological sources per year. Whether  $\text{NO}_x$  production by lightning is important in the ozone cycle is not clear at this point.

The theoretical background behind the development of a new algorithm for the calculation of Mie scattering was described by V.E. Cachorro, University of Valladolid, Spain. This algorithm is unique in that it is not dependent on particle size or refractive index. A mechanism to explain the precipitation of ions in the atmosphere related to the existence of ion cyclotron harmonic waves was suggested by G. Gustafsson, Uppsala Ionospheric Observatory, Sweden. These waves have been observed from the Viking satellite, and they seem to be generated by the loss cone of the ion population. Even though the wave amplitudes are small (on the order of  $1 \text{ mV/m}$ ), they may occur within large volumes, thus significantly altering the loss cone and contributing to the precipitation of ions in the atmosphere.

Total atmospheric ozone measurements taken in the spring over a 20-year period at Tromsø, Norway ( $70^\circ\text{N}$ ) and Syowa, Antarctica ( $69^\circ\text{S}$ ) were compared by S.H. Larsen, University of Oslo. He found that although Southern Hemisphere ozone appeared to decrease markedly, especially over the past 10 years, values in the Northern Hemisphere over this period show no significant change. To explain the depletion of ozone over the Antarctic, J.M. Cisneros, Instituto Nacional de Meteorología, Madrid, Spain, considered some of the possible sources and sinks of ozone. He suggested that the ozone hole might be related to an increase in  $\text{NO}_x$  and may be caused by volcanic eruption,

solar proton events, solar variability, and human activities. Although he was unable to offer any supportive evidence, he believes commercial stratospheric flight contributes heavily to the ozone hole.

#### Radiative Processes in the Middle Atmosphere

Using the radiative properties of a middle-atmosphere-type environment, F.W. Taylor, Oxford University, UK, described some future experiments designed to study the atmospheres of Mars, Jupiter, and Venus. Some of the questions to be addressed are:

- Where does the atmosphere of Venus get angular momentum high enough to support wind speeds up to  $100 \text{ m/s}$ ?
- Where did the surface water of Mars go? Is it under the planet surface as ice?
- The red spot of Jupiter delineates a very stable region of Jupiter's atmosphere. Contiguous to this area is a region of high turbulence. How can these two regions exist side by side?
- Also to be answered is the general question of the quality of the measurements that have been made, along with those that will be taken from future spacecraft.

Using data from the Spectral Infrared Rocket Experiment (SPIRE), R.D. Sharma, Air Force Geophysics Laboratory (AFGL), Massachusetts, modeled the emission around 6 micrometers observed from tangent heights between 40 and 70 km in day and night atmospheres. Emission bands of water and  $\text{HNO}_3$  during the day, and  $\text{NO}_2$  at night were identified; using their model, Sharma's group estimated the temperature and mixing ratio of these species as a function of altitude. Evidence of departure from local thermodynamic equilibrium (LTE) by mesospheric  $\text{CO}_2$  was presented by M. Lopez-Puertas, representing a group from Instituto de Astrofísica de Andalucía, Granada, Spain, and University of Oxford, UK. A non-LTE radiative transfer model using absorption at 2.7 and 4.3 micrometers as the principal mechanism was employed with some success, but unexplained anomalies at certain latitudes still exist. J.R. Winick, AFGL, Massachusetts, described his group's attempts at analysis of radiance data at 4.3 micrometers from the aurorally dosed lower thermosphere. Their model seems to agree reasonably well, considering uncertainties in dosing history and hardness, but better background data would certainly help. Their future plans call for the inclusion of a full radiative transfer treatment in an attempt at improving the model.

The large amount of new spectroscopic information that has recently become available, combined with the downward revision of the absorption cross sections in the Herzberg continuum region, make recalculation of atomic oxygen production rates by photodissociation in the Schumann-Rung bands necessary. The use of line-by-line calculations for this purpose was discussed by D.P. Murtagh, University of Stockholm, Sweden. This type calculation is also applicable to other aeronomy problems, and absorption of the  $O_2$  A-band dayglow, as observed from the limb, was described in some detail as an example. The importance of the vertical structure of various dynamic parameters, including temperature, was investigated by C. Gay, Centro de Ciencias de la Atmosfera, as a coupled problem of radiation and dynamics; using radiative eigenfunctions, he considered energy coupling between radiation transported by the 15-micrometer band of  $CO_2$  and isolated two-dimensional gravity waves, including the effects of photochemistry. The results indicate that while below an altitude of 30 km vertical propagation of gravity waves is affected by radiation, photochemistry is not important above 30 km.

#### Instrumentation and Airglow

This session was begun with an invited tutorial paper by T.G. Slinger, SRI International, California, describing current airglow-related laboratory measurements. In many cases natural phenomena can be duplicated in the laboratory, but in many more they cannot. He demonstrated that energy is being reshuffled between various airglow processes in a manner that is not too well understood at present. Before nightglow is understood to the extent that oxygen atom densities can be extracted from emission intensities of a particular feature, the details of these processes will have to be elucidated.

Field measurements of a specific type were addressed by O. Wedell, Swedish Space Corporation, Kiruna, Sweden, who described the rocket range complex at Esrange, located at a latitude of almost  $68^\circ N$ . Available are ground-based instrumentation and satellite telemetry gear, along with facilities for launching sounding rockets and balloons. A unique feature of this range is the capability to recover rocket- and balloon-launched instrument packages by the use of helicopters to pick up the parachuted gear. This makes the use of very expensive airborne instrumentation such as high-sensitivity television cameras or microgravity sensors quite feasible.

A new suite of UV and visible spectrometers using photodiode array detectors has been developed for atmospheric trace species measurements by J.P. Pommereau and F. Goutail, Service d'Aeronomie, Verrieres le Buisson (SAVB), France. Designed at first for monitoring stratospheric  $NO_2$  and  $O_3$  the technique can be applied to other trace species like  $SO_2$ , sulfur,  $ClO$ ,  $OCIO$ , etc. The ozone measurements compare within 3 percent of the best known data, so that a zenith sky device for use in Antarctica is being developed. A study attempting to relate noctilucent clouds (NLC) with the OH nightglow emission was conducted by an international team consisting of M.J. Taylor, Southampton University, UK, R.P. Lowe, University of Western Ontario, Canada, and D. Baker, Utah State University, US. The OH nightglow was measured at 85 km, while the NCL were measured at 82 km. Results indicate that the OH emission intensity variations are not related to NLC, but are related to the passage of gravity waves.

#### Aurora and Airglow

Since the excitation processes responsible for many of the atomic and molecular oxygen emissions in the aurora (originating above 100 km) and airglow (originating in the layer between 80 km and 100 km) are still uncertain, it was of great value for E.J. Llewellyn and I.C. McDade to review the different excitation processes that have been proposed. It turns out that the choice of which scheme to use depends heavily on how much atomic oxygen is assumed to be present. What makes it even worse is that the amount of atomic oxygen is probably in a state of continual change. In addition, it was suggested that structure within the aurora may make the identification of the auroral excitation mechanisms much more difficult than is generally recognized.

An effort to find a mechanism for the 3-Hz component in pulsating aurora was described by M.W.J. Scourfield and his associates at the University of Natal, Durban, South Africa. Examinations of simultaneous recordings of auroral and VLF (3-5 kHz) emission intensities have shown that common periodicities of  $1.5 \pm 0.3$  Hz and  $3.0 \pm 0.4$  Hz occur in the power spectra of both the VLF and optical signals. They suggest that one possible mechanism might be an external oscillator which induces wave growth and strong pitch-angle scattering via the cyclotron resonance interaction. This occurs when the electron pitch-angle distribution function is such that the flux levels exceed the flux trapping limit.

The last scheduled presentation, by G. Thuillier, SAVB, France, was a description of the use of a ground-based Michelson interferometer to make high-altitude wind measurements. By the use of a Cassegrainian telescope it is possible to focus the interferometer on auroral and airglow emissions at altitudes between 85 and 250 km. Since line width is related to temperature, and velocity may be determined from emission line Doppler shift, interferometer data may be used to determine winds at known altitudes. Data collected so far show good agreement with zonal wind values.

#### Summary

As more and more high-quality field data become available to the aeronomy community, it is becoming more and more obvious that the relatively simple emission models that have been suggested in the past are inadequate. Judging by the papers presented at this meeting, a large portion of the aeronomy community has come to this conclusion at the same time. In addition to the implicit cry for theorists to stand and be counted, there was also a strong belief among the attendees that the amount of laboratory work being done was insufficient, and, in some cases, irrelevant. It was apparent to me that there is a severe lack of understanding of atmospheric chemistry, and knowledge of its relation to the observed phenomena of aurora and airglow leaves a lot to be desired. One of the possible solutions to this predicament is to get quantum chemists involved in atmospheric problems, but just how this can be accomplished was not discussed.

In summary, workers in the field of aeronomy appear to be on the brink of making some major advances. It will be interesting to see if any progress has been made along these lines when this group meets again. The sixteenth annual meeting on atmospheric studies by optical methods will be held at the University of Oulu, Oulu, Finland, 28 August through 2 September 1988.

12/2/87

#### ATMOSPHERIC AND OCEANIC REMOTE SENSING SESSIONS AT THE 38TH INTERNATIONAL ASTRONAUTICAL CONGRESS

by Jerome Williams.

The International Astronautical Federation held its 38th Congress in Brighton, UK, from 10 through 17 October 1987.

Although it turned out to be a massive potpourri of presentations by anyone and everyone interested in any aspect of space activity, there were excellent sessions devoted to oceanic and atmospheric remote sensing upon which I shall report. A selection of survey and state-of-the-art papers will be published by the International Academy of Astronautics in special issues of its journal, *Acta Astronautica*; abstracts and preprints are now available from The Executive Secretary, The British Interplanetary Society, 27 South Lambeth Road, London SW8 1SZ, UK.

#### Atmospheric Remote Sensing Systems

Still in the development stage, a novel high-resolution spectrometer for atmospheric research, called SAFIRE, was described by J.E. Harries, Rutherford Appleton Laboratory (RAL), UK. He represented a large group of investigators from RAL, NASA, Duke University, Cambridge University, Oxford University, and Italy's Istituto di Ricerca-Sulle onde Elettromagnetiche. The SAFIRE project is an attempt to satisfy future stratospheric sounder requirements of high sensitivity, broad spectral coverage, and high spectral resolution to give measurements of as many chemical species as possible. The present design uses a cooled very-high-resolution Michelson interferometer/grating spectrometer which is planned to be deployed on the polar orbiting component of the Space Station.

One of the universally recognized inherent errors in radar altimeters has to do with the effect of atmospheric constituents on the speed of transmission of radar energy through the atmosphere. The strategies being considered for correcting this type of error within the TOPEX-POSEIDON project were discussed by H. Cerbelaud, Centre National d'Etudes Spatiales, France. The model being used corrects for the effects of free electrons in the ionosphere and both water vapor and the pressure profile in the troposphere. It is estimated that the use of this model results in decreasing the mean residual altitude error to around 4-5 cm.

The use of microwave radiometry for atmospheric measurements was examined in some detail by A.R.L. Tatnall, British Aerospace, Bristol. These sensors can be used for the measurement of total air column water content, temperature and humidity sounding (by using the water absorption lines), and limb sounding to determine atmospheric constituents such as ozone and chlorine. Tatnall indicated that radiometers will fly on the next series of NOAA satellites (TIROS replacements), ERS-1, and the next generation of

METEOSAT. Further, a microwave limb sounder (MLS), to measure the minor upper atmospheric constituents, is scheduled to be launched in 1990. A large number of other satellite microwave radiometers, both operational and experimental, are planned for the next 10 years, some of which will boast multifrequency capability, while others may have antennae up to 30 meters long.

#### Oceanic Remote Sensing Systems

The side looking radar (SLR) carried aboard all recent Cosmos satellites was briefly described by V.I. Dranovsky, Intercosmos Council, USSR Academy of Sciences (ICUSSRAS), Moscow. Most data processing is done on board this 3.15-cm radar which has been used over both land and water regions. Dranovsky reports penetrations into ice of 50 m and into sand between 10 and 20 m. The USSR also had a rather elaborate and elegant display in the exhibition portion of the meeting, which included models and some technical specifications of various spacecraft now in orbit or soon to be launched.

A system concept for a new oceanic sensor was announced by A.M. Mika, Hughes Santa Barbara Research Center, California, in conjunction with M.R. Willard, Earth Observation Satellite Company (EOSAT), Lanham, Maryland. The Sea Viewing Wide Field Sensor (SeaWiFS) is designed to be included with LANDSAT 6, scheduled for launch about 1990. Eight bands: 443, 500, 565, 665, 765, 865, 1100, and 1200 nm were chosen for inclusion after consultation with the oceanic user community, so it is hoped that maximum use will be made of the images when they become available. The two IR bands will have band widths of 1000 nm, but the visible bands between 443 and 665 will have widths of 20 nm with the two near-IR bands somewhat wider at 40 nm. Resolution will be selectable between 1 and 4 km, and daily coverage of a specific area will be possible by using data obtained at broad scanning angles. At present, it appears the package will weigh only 70 kg and require 85 watts of electrical power.

As the Americans have done off the coast of California, the Russians are using visible satellite images as a tool in managing their fishing fleets. Yu.V. Zonov (ICUSSRAS) described efforts along this line for the region of the North Atlantic where the Gulf Stream splits into the Irminger Current and the North Atlantic Drift. By relating remote sensing data with sea truth, he was able to show that the best predictor of increased catches (actually greater catch per unit effort) was atmospheric pressure. In contrast to the American scheme,

which used high chlorophyll concentrations as indicators of high- and low-pressure systems, which could be tagged by high fish populations, the Russians found that good catch areas could be delineated by forecasting the passage of both characteristic cloud patterns, presumably.

#### Future Missions

A number of future missions were outlined by various investigators, but those with any direct atmospheric or oceanic application were few in number. The Shuttle Imaging Radar-C (SIR-C) experiment was described by D. Evans, Jet Propulsion Laboratory, Pasadena, as the next evolutionary step in JPL's continuing program in spaceborne imaging radar, which started with SEASAT in 1978 and continued with SIR-A in 1981, and SIR-B in 1984. In addition to allowing experiments that require multitemporal coverage, SIR-C, when it flies in 1991-2, will allow the acquisition of digital images simultaneously at two microwave frequencies (L and C band) with multiple signal polarizations (HH, VV, HV, and VH). It will also be possible to electronically steer the antenna beam so that the radar look angle can be varied, and to excite different parts of the antenna to maximize swath width. SIR-C will be a dual bandwidth system, so that both high (20 MHz) and low (10 MHz) resolution modes will be available. In addition, a German/Italian X-band SAR with VV polarization will be aboard, resulting in a three-frequency capability. Multifrequency images will allow better determination of wave spectra on the ocean surface because of the inherent sensitivity of such a system to a wider range of roughness scales.

The concept of placing a SAR in a geosynchronous orbit to provide images from greater altitude was suggested by L.M. Murphy, British National Space Center, Farnborough. It is possible to use a geosynchronous orbit in which the required relative motion for SAR operation is generated by the satellite's inclination. One possible use for which such a scheme is particularly well suited is the monitoring of sea and polar ice in remote Arctic regions. Murphy outlined a system optimized for this use, listing characteristics such as 50-m spatial resolution, but he also indicated there were disadvantages with presently available hardware. The major drawback seemed to be an average power requirement of about 3.5 kw, which is very high by present standards.

The last pertinent presentation on future missions was by R.J. Arnold, NASA, who described some of the instrument

systems planned for the Upper Atmosphere Research Satellite (UARS). Instruments will remotely measure concentrations of ozone, methane, water vapor, carbon monoxide, carbon dioxide, hydrogen fluoride, and a broad range of species in the nitrogen and chlorine families, including fluorocarbons 11 and 12. In addition, measurements of wind velocity, atmospheric temperature and pressure, local and global charged particle energy inputs to the earth's atmosphere, and ultraviolet solar spectral irradiance (wavelengths between 115 and 430 nm) are planned. UARS is scheduled to be launched from a shuttle sometime in 1991.

### Conclusion

This was a very large conference with over 2000 attendees. There were a total of 69 concurrent sessions (not including four general interest meetings) that varied in context from extraterrestrial intelligence to space propulsion. With a program having a scope this broad, one would not expect too many technical papers dealing with specific details, and indeed, most of the presentations were either tutorial or comprehensive in nature. Nevertheless, the speakers, both European and American, were optimistic about the international space program in general, and the future of remote sensing in particular. A lot of old programs, such as ERS-1, were reviewed (indicating they were still in good health), while one or two new ones, such as SeaWiFS, were introduced, indicating a continuing strong European interest in remote sensing.

My impression is that the will (and apparently the means) to support a growing oceanic and atmospheric remote sensing effort exists in Europe, so that the input of remote sensing data to many different types of numerical models should continue well into the foreseeable future. This is true even though the UK has decided not to go along with a request from the European Space Agency for an increase in participation next year. It appears to me that the UK is willing to support an increased remote sensing effort, but not an increase in space exploration activity.

## Material Sciences

### STAINLESS STEELS/87 HIGHLIGHTS WELDING OF NEW DUPLEX STEELS

by A. John Sedriks. Dr. Sedriks is a Scientific Officer in the Materials Division of the Office of Naval Research, Arlington, Virginia.

The triennial conference, Stainless Steels/87, dealt with the scientific and technical advances in stainless steel research and development via technical sessions on processing, welding, corrosion, mechanical properties, and elevated temperature effects.

The conference was held from 14 through 16 September 1987 at York University, England. The sponsor and organizer was the UK's Institute of Metals. Over 170 delegates attended from 21 countries.

This article provides a very brief overview of the 49 papers presented in the five technical sessions. For more detailed information the reader should consult the conference proceedings, which will be published soon by The Institute of Metals, 1 Carlton House terrace, London SW1Y 5DB, UK.

### Processing

Of the five papers presented, two in particular dealt with novel aspects of processing. These were horizontal continuous casting (HCC) and the production of duplex stainless steels by a gas-atomizing/hot-isostatic pressing technique. The paper on the HCC technique by E.C. Hewitt (Davy McKee Ltd., Sheffield, UK) described its development and subsequent modifications, leading to the manufacture and sale of the three HCC "Horicast" twin-strand machines to European specialty steel producers. The three main features which characterize Horicast and differentiate between HCC and vertical continuous casting (VCC) are:

- The tundish and mold are joined together in a configuration which does not allow molten metal penetration.
- The mold is fixed and does not oscillate as on VCC machines.
- The solidifying strand is withdrawn in a cyclic manner comprising a pull-pause-push combination.

Among the advantages claimed for the HCC process, using type 304 stainless steel, were smaller secondary dendrite arm spacings, greater suppression of

12/3/87

delta ferrite formation, and improved surface finish in final rolled bar and rod.

The paper on gas-atomizing/hot-isostatic pressing was presented by M. Lindenmo (ASEA Powdermet AB, Surahammar, Sweden), who described the manufacture of near-net-shape components from a duplex stainless steel containing 26 percent Cr, 4.5 percent Ni, 2.5 percent Mo, and 0.3 percent N. The melt is cast through nozzles in the bottom of the ladle into a gas atomization unit where the molten steel is broken up by horizontal gas (nitrogen or argon) jets. The atomized melt rapidly solidifies into small spherical particles (at cooling rates of 1000°C/second) which are then collected, sieved to <500 µm, and placed into sealed capsules. The capsules can be of very complex forms approximating the required near-net-shape. The powder in the capsules is compacted by hot isostatic pressing using argon as the pressure medium at pressures in the range 100-150 MPa and temperatures in the range 1100-1200°C. The compaction results in a fully dense material with prior particle boundaries of the same strength as the rest of the material. Final steps comprise heat treatment and finish machining.

#### Welding

In the session on welding the keynote speaker, T. Gooch (The Welding Institute, Cambridge, UK), reviewed stainless steel welding research and development from the viewpoint of material behavior, welding procedure, and service performance of welds. Particular emphasis was placed on the welding of duplex stainless steels in terms of controlling the ferrite-austenite transformation and the precipitation of second-phase particles.

This emphasis on the welding of the duplex grades was continued by presentations from organizations involved in the developing and selling of welding consumables. In this regard presentations were given by J.L.P. Hilkes (Smitweld v.v., Nijmegen, the Netherlands), M. Niset (Soudometal sa, Brussels, Belgium), and L-E. Svensson (ESAB AB, Göteborg, Sweden) on welding consumable chemistry for piping to be used in the as-welded condition (i.e., without postweld heat treatment), the effects of heat input on submerged arc welds, and the influence of welding processes on mechanical properties, respectively.

Other presentations relating the welding of duplex stainless steels were given by T.A. Towers (Teesside Polytechnic, Middlesbrough, UK) and K-J.V. Blom (AST AB, Fagersta, Sweden). Towers de-

scribed phase transformations during aging at 1050°C, and Blom described the utilization of a shielding gas containing nitrogen. The latter procedure results in improved localized corrosion resistance in the weld region.

#### Corrosion

In the session on corrosion 1, the keynote speaker, reviewed the effects on localized corrosion of microstructure and alloy composition for the new superferritic, duplex, and superaustenitic stainless steels. I also noted recent exploratory approaches to providing new materials involving laser surface alloying, amorphous alloys, microcrystalline alloys, and special alloys for which attempts have been made to replace chromium.

Subsequent corrosion presentations were grouped under the ferritic/superferritic, superaustenitic, and duplex categories. Papers on superferritics were presented by J.C. Bavay (Usinor Chatillon Research Center, Isbergues, France) and F. Mancina (CSM SpA, Rome, Italy). Bavay described the microstructural stability and corrosion resistance of a titanium-stabilized superferritic, while Mancina identified processing procedures designed to eliminate localized corrosion problems associated with the precipitation of sigma, chi, and carbides during processing. A major drawback to greater utilization of the superferritics remains their low ductile-to-brittle transition temperatures in thicker sections. B. Baroux (Ugine SA Research Center, Ugine, France) presented a paper describing a new ferritic grade developed for automobile exhaust systems. A typical composition of Fe, 17 percent Cr, 0.4 percent Nb, 0.25 percent Zr, 0.02 percent C, 0.03 percent Al reportedly provides good resistance to creep, high-temperature oxidation, and chloride-induced aqueous corrosion.

Regarding the superaustenitics, three papers dealt with their proposed use to contain and transport chlorinated seawater. R. Francis (BNF Metals Technology Center, Wantage, UK) described chlorinated seawater laboratory tests in which the superaustenitics were found to be superior to the duplexes. R.E. Malpas (Shell Research Ltd., Chester, UK) described electrochemical studies with chlorinated and unchlorinated seawater and related observed potential changes to formation of biofilms in the latter. J. Charles (Creusot-Loire Industrie, Le Creusot, France) described a new superaustenitic with lower molybdenum and higher chromium (i.e., Fe, 25 percent Ni, 25 percent Cr, 5 percent Mo, 0.2 percent N, 1.6 percent Cu) being considered for

marine applications. Usually super-austenitics contain 20 percent Cr and 6 percent Mo.

Regarding other new austenitic alloys M.O. Speidel (Swiss Federal Institute of Technology, Zurich, Switzerland) presented a paper describing an exceptionally high-nitrogen, high-strength steel with a yield strength in the range 1400-1500 MPa (Fe, 18 percent Cr, 18 percent Mn, 0.6 percent N, 0.05 percent C). In a subsequent discussion I suggested that it would be particularly useful to evaluate its hydrogen embrittlement resistance since there are very few high-strength alloys with such resistance. J.E. Truman (Forgemasters Engineering Ltd., Sheffield, UK) described the development of another high-nitrogen austenitic stainless steel for nonmagnetic drill collars used in the drilling of oil and gas wells (Fe, 16 percent Cr, 7 percent Ni, 11 percent Mn, 0.4 percent N, 0.05 percent C) which is reportedly more resistant to stress-corrosion cracking than the traditionally used grades.

The corrosion behavior of the duplex grades was discussed in papers dealing with chlorinated seawater, stress corrosion, and hydrogen embrittlement in sulfide-containing environments, and selective attack in sulfuric and hydrochloric acid solutions.

#### Mechanical Properties and Elevated Temperature Effects

Some 15 papers were presented covering these two topics. Nitrogen-induced strengthening was discussed for both austenitic (P. Gumpel, Thyssen Edelstahlwerke AG, Krefeld, West Germany) and duplex (G. Wahlberg, Chalmers University, Goteborg, Sweden) stainless steels. It was noted that the effect of nitrogen is to introduce a planar mode of slip in the austenite, this being the strengthening mechanism.

Three papers were presented on the development of new martensitic grades for applications requiring wear resistance.

Papers dealing with elevated temperature behavior covered phenomena encountered both in processing and in service. Two papers dealt with type 316 austenitic stainless steel covering the topics of strain aging and behavior of weldments.

#### Conclusion

My general impression was that this triennial conference continues to succeed in blending basic research with applications technology. The most striking single aspect was the large European research and development effort that has gone into the provision of welding technology for the new duplex stainless steels. They are now being identified as

the preferred materials for pipelines in marine and oil field technologies because of attractive combinations of corrosion resistance and mechanical strength. Presently, submerged arc welding is used for longitudinal seam welding of pipes, while circumferential welding of pipes is mainly done using manual (shielded) metal arc, tungsten-inert-gas, or metal-inert-gas techniques.

12/1/87

#### NATO MEETING ON ION BEAM MODIFICATION OF MATERIALS

*by Louis Cartz. Dr. Cartz is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from Marquette University, College of Engineering, Milwaukee, Wisconsin.*

#### Introduction

A NATO-ASI (Advanced Study Institute) meeting was held in Viano do Castelo, Portugal, in August 1987 on "Materials Modification by High-Fluence ion beams." There were about 125 participants, of whom about 20 percent were from the Americas, 20 percent from Germany and Austria, 20 percent from the Mediterranean countries, 20 percent from Scandinavia (particularly Denmark), and the remainder from the UK, the Low Countries, and France. The proceedings were well organized. There was plenty of time for discussion and ample opportunity for the younger scientists (more than 75 percent appeared to be under 35) to consult with their more senior colleagues.

As is usual at the NATO-ASI meetings, a series of review papers were presented by invited speakers well-known in their field. These reviews covered the topics of: stopping and sputtering theory, defects in solids, compositional changes, topographical changes, and electronic changes in metals. Other review papers were concerned with mechanical behavior and tribology of ion-implanted ceramics and glasses, ion-induced chemical changes in inorganic insulators, and laser/surface interactions. Lectures were held from early morning until midday, then were continued in the early evening, with discussion periods after dinner. About 30 short communications were presented, as well as 50 posters. The full proceedings are to be published by Martinus-Nijhof, Dordrecht, Holland.

The stated objective of this meeting on Materials Modification at High Fluence, was well covered in the short talks and posters, and it is mainly these communications that I will review in this report.

#### High-fluence Ion Irradiation

The review paper by G. Carter (University of Salford, UK) discussed the effects of high-fluence ion bombardment on materials. It is this talk where Carter defined high-fluence effects as the case when individual damage regions begin to overlap, which went directly to the stated objective of the meeting. He pointed out that irradiation can be by ions, photon beam lasers, or electron beams, modifying properties by implantation or by ion beam mixing of the atomic constituents of the solid. The surface boundary of the solid during the high-fluence irradiation can be static, receding by etching, or growing by deposition of metal.

#### Depth Location of Sputtered Atoms

Experiments to determine the original location below the surface of sputtered atoms were described by B. Jørgensen (Odense University, Denmark). The depth of the origin of sputtered atoms is an important quantity for experimental and theoretical surface physics. The sputtering was carried out in an apparatus for surface analysis by resonance ionization of sputtered atoms (SARISA). Studies were carried out of copper monolayers on ruthenium single crystals of orientation (001) using argon ions of energy 4 keV. Specimens of copper on ruthenium were used since it is known that the copper deposits one monolayer at a time and so can provide a calibrated copper-coated layer. The ratio of copper to ruthenium atoms sputtered from a single monolayer of copper on the ruthenium single crystal is about 3 to 1, which indicates, after allowing for the different dissociation energies of copper and the ruthenium, a sputtering depth of approximately 2Å. Since the SARISA analyzer has a 60° angle of acceptance, questions were raised whether this affects the detected copper/ruthenium ratio. Similar experiments are possible in the case of copper on tungsten, since it is known, once again, that the copper deposits as monolayers.

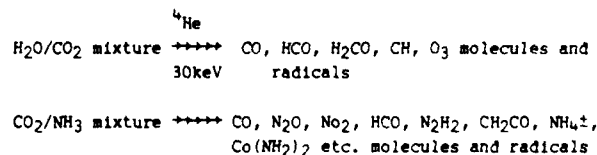
#### Stopping Power

K. Freitag (University of Bonn, West Germany) described the measurements of stopping power for low-energy ions in gases (Freitag et al., 1987). An electromagnetic separator is used to detect singly charged ions at energies of 10 to

90 keV. Hydrogen is used as the stopper gas at pressures up to 0.2 mbar and a pulsed time-of-flight spectrometer to detect the reduced energies. Freitag discussed the advantages of using a gaseous target compared to that of extremely thin metal foils. The thickness measurement becomes a gas pressure measurement. The stopping powers of a wide range of 5p, 6s and 4f elements have been measured. There is considerable experimental advantage in bombarding a gas target with a low-energy metal ion as against bombarding a metal foil with a low-energy gaseous ion.

#### Synthesis of Complex Molecules in Space

J. Bénit (Orsay, France) described irradiation studies of icy films of H<sub>2</sub>O, CO<sub>2</sub>, NH<sub>3</sub> by H<sub>2</sub> to Kr ions of energies from 1 keV to 100 MeV (Bénit, 1987). The purpose of these ongoing studies has been to provide evidence to explain the presence of organic matter in space as due to cosmic interactions of energetic ions and crystal grains under stellar environments. Bénit said that thin films of condensed vapors of H<sub>2</sub>O, CO<sub>2</sub>, and NH<sub>3</sub> are prepared on a potassium bromide substrate at liquid nitrogen temperatures. The thin films, 200 to 2000 nm thick, are bombarded at an angle of 45° by ions from an ion separator. Infrared IR analysis is carried out during the irradiation using a Fourier transform infrared spectrometer of spectral band 4300 to 400 cm<sup>-1</sup>. The intensity of the bands in the infrared can be used to calculate the thickness of the icy films and also to identify the products. The erosion yield of H<sub>2</sub>O molecules per incident MeV ion is enormous--for example, 10<sup>5</sup> molecules of H<sub>2</sub>O per krypton ion of energy 1.16 MeV. The H<sub>2</sub>O decomposes into H<sub>2</sub> and O, which diffuse out. When irradiating mixtures by <sup>20</sup>Ne<sup>+</sup>, <sup>1</sup>H<sub>2</sub><sup>+</sup>, <sup>1</sup>H<sub>1</sub><sup>+</sup>, <sup>4</sup>He ions, the products observed are, for example:



Bénit pointed out that the IR peaks observed correspond to astrophysical signals as, for example, from the Albedo of Halley's Comet nucleus, and also from icy satellites of giant planets.

In his review paper, "Modification by Bombardment of Inorganic Insulators," J.C. Dran included a discussion of solar wind implantations in lunar dust. He examined the effects of carbon implanted into SiO<sub>2</sub>, using the same experimental methods as Bénit. Some 60 molecular types in space can be accounted for in this

way. Dran discussed the irradiation of ice by carbon at high fluence when  $\text{CH}_3\text{OH}$  is formed. He reviewed irradiation effects in silicate glasses, halides, oxides, garnet, silicate glasses, frozen gases, inorganic salts, organometallics, and polymers. These experiments are of interest for considerations of (1) first wall of fusion reactors, (2) synthesis of small molecules in space, (3) radioactive waste encapsulation, and (4) ion beam lithography.

#### Irradiation Effects in Silicon

Several papers were presented on irradiation effects in silicon, particularly concerning the formation of amorphous and microcrystalline surface and subsurface layers in silicon, and annealing by laser or by general heating.

Silicon on Insulator Microstructures. C. Griffith (Imperial College, London, UK) described secondary ion mass spectrometry (SIMS) and cross-sectional transmission electron microscopy of subsurface layers of  $\text{SiO}_2$  in Si single crystals formed by oxygen ion bombardment. His study concerns the formation of silicon-on-insulator SOI structures suitable for very large scale integrated circuitry (VLSI). Oxygen ions at 150 keV were implanted into (100) silicon wafers at  $74 \mu\text{Acm}^{-2}$  at a fluence of  $1.6 \times 10^{18}$  ions per  $\text{cm}^2$  and then covered by a layer of  $\text{SiO}_2$  of thickness 0.6  $\mu\text{m}$ . After annealing at 1300°C in dry nitrogen, very sharp boundaries are formed on the silicon wafer between the surface layers of 0.6- $\mu\text{m}$   $\text{SiO}_2$  on 0.2  $\mu\text{m}$  of silicon and on the buried layer of 0.3  $\mu\text{m}$  of  $\text{SiO}_2$ .

Microcrystalline Silicon. Microcrystalline silicon containing hydrogen impurity ( $\mu\text{c-Si:H}$ ) was described by G. Kiriakidis, (University of Crete, Greece). This material is of interest for use in thin-film devices such as contact interlayers in solar cells. The microcrystalline silicon is formed by reactive sputtering in an atmosphere containing both hydrogen and argon of total pressure kept to 20 mtorr, substrate temperatures between 150 and 250°C, and deposition rates up to 3.3 Å per second. Kiriakidis has characterized the microcrystalline structural properties using a rotating analyzing ellipsometer in the energy range 1.66 to 5.6 eV, by conductivity measurements as a function of temperature, and by cross-sectional transmission electron microscopy and electron diffraction. He has been able to show that  $\mu\text{c-Si:H}$  can be produced using a RF magnetron system with substrate temperatures between 200 and 250°C and ratio of pressure of hydrogen compared to the total pressure of hydrogen plus argon  $>0.4$  in the plasma. The microcrystalline

silicon exhibits an increase in electrical conductivity of more than 4 orders of magnitude.

Profile Analysis of Amorphous Silicon at Boundaries. The problems associated with this subject were discussed by H.J. Van Daal (Eindhoven University of Technology, the Netherlands). In particular, he was concerned with the boundaries on crystalline silicon, magnesium, or  $\text{SnO}_2$ . The interfaces at such boundaries occur in several applications: bipolar transistors, metal contacts, and solar cells, for instance. The profile analysis is carried out by Auger electron spectroscopy (AES) and SIMS combined with argon ion sputtering. The amorphous silicon containing hydrogen is deposited on substrates at 200 to 250°C by a RF glow discharge from  $\text{SiH}_4$ . The profiling is carried out using argon ions at 3 keV, with a current of 150 nA, of beam diameter 0.2 mm incident at 30°, and scanned over 4  $\text{mm}^2$ . Typical thicknesses of the amorphous silicon layer are 40 to 50 nm. Oxygen is frequently found as a contaminant at the surface and also at the crystalline interface. Van Daal concluded that interface profile analysis is subject to systematic errors due to preferential sputtering and also to surface segregation effects, and that recourse should be made to additional methods of analysis such as x-ray photoelectron spectroscopy.

Laser Annealing of Germanium Implanted Into Silicon. Using pulsed laser irradiation, Aydınlik (Middle East Technical University, Turkey) annealed, silicon implanted with heavy doses of germanium. His objective has been to examine the differential annealing characteristics of the silicon-germanium surface layer due to the alloying with germanium. He used Rutherford backscattering (RBS), transmission electron microscopy (TEM), and optical reflectivities by UV-IR-visible wavelength spectrometer. The annealing was carried out using a Q-switched ruby laser of wavelength 694 nm and pulse length 20 ns with laser energy densities varying from 0.5 to 2.0  $\text{J cm}^{-2}$ . The depth of the amorphous crystalline interface could be inferred from the RBS and TEM observations. The Si (100) wafer was implanted at room temperature to a fluence of  $2.3 \times 10^{16}$  ions per  $\text{cm}^2$  and also to  $5.5 \times 10^{16}$   $\text{Ge}^+$  ions per  $\text{cm}^2$  at 150 keV. The thicknesses of the amorphous layers were found to be 250 nm and 280 nm respectively. It is known that the thermal parameters, melting point, thermal conductivity, and latent heats of the amorphous layer are lower than those of crystalline silicon. The pulsed annealing is believed to give rise to an explosive recrystallization based on the latent heat

release from the very thin amorphous layers. Aydinlik described the changes in the RBS, deducing the depth of the melting zone and relating the energy densities required to anneal partially or completely the amorphous regions. Aydinlik concluded that the thermal parameters of the SiGe alloy are significantly different from those of pure silicon.

#### Gases In Metals

Several studies were concerned with the effects arising from the irradiation of metals by gases such as xenon, argon and nitrogen.

Xenon Bubbles In Metals. C. Templier, (University of Poitiers, France) described observations of solid xenon bubble precipitates (ppt) in nickel-aluminum alloys, aluminum alloys, and several fcc, hcp, and bcc metals. Irradiation of nickel-aluminum 50-atomic-percent alloy by  $1.15 \times 10^{16}$  Xe<sup>2+</sup> ions per cm<sup>2</sup> at 77 K gave rise to an extra diffraction ring in the x-ray diffraction pattern. The irradiation of aluminum by  $10^{16}$  xenon ions per cm<sup>2</sup> leads to a concentration of xenon of 3 to 4 atomic percent. Diffraction rings of the (111) and (200) of solid xenon can be observed at 293 K. Solid xenon is f.c.c., and has a lattice parameter of 0.620 nm. One can deduce that the internal pressure on the solid xenon precipitate is greater than 0.4 GPa.

In the fcc matrices of aluminum, silver, gold, copper, nickel, the xenon is fcc. In hcp metals--zinc, zirconium, titanium--the xenon is hcp, while in bcc Fe, the xenon is probably fcc. The xenon solid precipitate is epitaxial in hcp zinc, zirconium, and titanium. In bcc Fe, the close-packed xenon planes are parallel to the close-packed metal planes.

The xenon bubble pressures can be obtained from the x-ray-measured lattice parameters using an experimental equation of state. These pressures are estimated to be of the order of 4 GPa in zinc and zirconium, of the order to 0.8 GPa in gold, of the order of 1.2 GPa in aluminum and silver, of the order of 1.6 GPa in copper, and of the order of 2.9 GPa in nickel and iron. With increasing fluence the xenon solid precipitate grows in size, and the xenon lattice parameter is observed to increase so that the internal pressure decreases with increasing fluence. Thermal treatments enable the xenon solid-liquid transition to be observed and these occur at about the same pressures as for bulk solid xenon. In copper, the xenon solid precipitate exhibits facets. The (111) of xenon is parallel to the (110) of copper, and the (110)

direction of xenon is parallel to the (110) direction of copper.

Templier concluded that studies of the simplest solids--that is, of the rare-gases--can be undertaken in this way inside a metal matrix. He said that studies are also possible of precipitates of insoluble species within a metal matrix, and, in addition, melting and interface effects can be investigated.

#### Argon in Molybdenum and Silicon.

Studies of the retention of argon in molybdenum and in silicon have been reported by H.A. Filius, (Inter-University Rector Institute, Delft, the Netherlands). He used thermal desorption spectrometry and TEM. The results of his study are important for reasons of gas incorporation during surface cleaning by ion bombardment, and also for gas-treated surfaces. In thermal desorption spectrometry, a crystal is mounted in an ultra-high-vacuum chamber and irradiated with low-energy ions such as argon. The crystal is now heated by electron bombardment, and the desorbed gas is analyzed with a quadrupole mass spectrometer. When irradiating molybdenum with argon, there is an increase of argon content with fluence, followed by a quasi-saturation due to gas sputtering effects. There is then a further increase in argon content due to changes in the microstructure of the metal. Approximately one part in 1000 of argon, 100 keV or 150 keV ions, remains in molybdenum, and the quasi-saturation occurs at about  $2 \times 10^{15}$  ions per cm<sup>2</sup>; the argon content increases again after  $10^{17}$  ions per cm<sup>2</sup>. This occurs when interstitial loops can be observed in the TEM. In silicon the increase in argon content is considered to be due to the formation of bubbles.

#### Adhesion of Molybdenum Sulfide to

Steels. K. Kobbs, (Philips GmbH, Forschungslaboratorium, Hamburg, West Germany) has carried out studies of the adhesion of molybdenum sulfide films to steels. The coefficient of friction of steel on molybdenum sulfide is of the order of 0.02 in vacuum, while that of steel on steel is greater than 0.5. The interface between the molybdenum sulfide layer and the steel substrate is the problem. Ion beam mixing can improve the adhesion. Optimization of the sulfide films shows that molybdenum sulfide, MoS<sub>x</sub>, with  $x \approx 1.8$  the most useful case. Crystalline MoS<sub>x</sub> is required because amorphous molybdenum sulfide gives rise to a high coefficient of friction. Irradiations are carried out of 0.43-μm thickness of MoS<sub>x</sub> using a fluence of  $1 \times 10^{16}$  ions per cm<sup>2</sup>. If argon ions are used, 400 keV is required; for the same penetration of nitrogen ions, 200 keV is required. To optimize the adhesion effects,

the parameters to be varied are ion fluence, ion energy, film thickness, number of cycles, and load on the friction surfaces (plus considering the case of rolling friction). Sputtered molybdenum sulfide films are porous with 40-percent density and with a columnar structure.

### Discussion

Many of the review papers were concerned with calculations of the penetration of energetic ions into solids, generally considered to be averaged amorphous structures. This subject was somewhat out of proportion to the intent of the meeting. There were also extensive reviews and discussions concerning the phenomena of sputtering.

The papers that did discuss materials modification at high fluence covered a very wide range of topics: synthesis of complex molecules in space; irradiation effects in semiconductors, gas bubbles, and solid precipitates in metals; adhesion of surface films to metals; and the original location of sputtered atoms. Carter, in particular, defined very carefully the term "high fluence" to be the case when individual damage regions overlapped, and he gave many examples of high fluence phenomena: major surface phase changes, ion pumping, high-rate sputtering sources for film growth, impurity depth profiling of semiconductors and other materials, lithographic patterning or etching of semiconductors and other devices, first-wall fusion reactor technology, simulation of radiation fission reactor materials, and solar wind and extraterrestrial phenomena, and also in the analysis of inorganic and biomolecular materials.

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12/26/87

### POWDER METALLURGY MEETING IN SWITZERLAND

by Louis Cartz.

### Introduction

"PM Aerospace Materials 87," held in Lucerne, Switzerland, from 1 through 4

November 1987, was organized and sponsored by the periodical, *Metal Powder Report* (MPR). The more than 200 participants at this meeting consisted of a very representative international gathering from over 20 countries--approximately 25 percent from Germany, 20 percent from the US, 20 percent from the UK, 10 percent from France, 10 percent from Switzerland, and the remaining 15 percent from Japan, Sweden, Belgium, Austria and Israel. A very healthy sign for the technology was that about 50 percent of those present were younger than 40 years of age.

The meeting was held in the splendid surroundings of a hotel alongside the lake at Lucerne. All the lectures and posters were in English. The proceedings of the meetings will be published in early 1988 (probably February) by MPR Publishing Services, Shrewsbury, UK.

The meeting was concerned with the powder metallurgy (PM) of the tough lightweight metal alloys--Ti, Al, Mg and Li alloys--required by the aerospace industry. Since the conference followed on from an earlier 2-day meeting on rapid solidification (RS [defined as more rapid than  $10^{-2}\text{Ks}^{-1}$ ]), there was much discussion of it. Several sessions were concerned with the PM of superalloys. There was also a special session titled "Ceramics, Coatings, and Composites."

This report reviews some aspects of the light metal and superalloy sessions, and the ceramics coating session.

### Preparation of Metal Powders

There were many papers on the preparation of powders by: RS (or RSP), rotating electrode process (REP), plasma rotating electrode process (PREP), and inert gas atomization.

R. Ruthhardt (W.C. Heraeus GmbH, Hanau, West Germany) described "jetomization," that is, the use of RS together with gas atomization. The rapid cooling of microdroplets is achieved by an overpressure melt-injection in combination with supersonic gas jets. This method has not yet been applied to superalloy materials.

W.G. Hopkins (PSI Atomisers Ltd., Crowhurst, UK) discussed high-performance gas atomization equipment, and the benefits of RS with cooling rates of  $10^5\text{Ks}^{-1}$ . This enables the production of fine powders below 20- $\mu\text{m}$  diameters, minimization of segregation effects, and the production of new metastable and microcrystalline structures under conditions of extreme cleanliness. Hopkins discussed the design of the atomization die, and of a cyclone die to separate metal powder from the carrier gas.

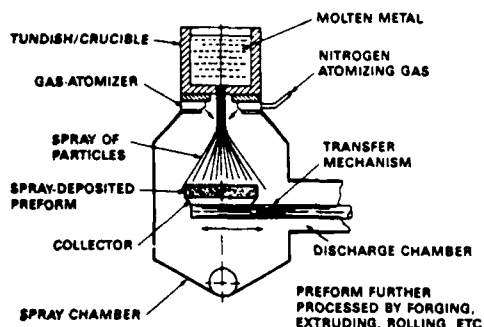


Figure 1. Spray deposition process for the production of preforms, using the Osprey process.

### Processing of Metal Powders

The presentations covered a wide range of methods for processing powders; these included: reactive sintering, HIP, WIP, CIP, forging, and using blended elemental powders (BE) as well as powders of the desired composition. At all times, the speakers bore in mind the costs involved with the technical developments.

Spray Deposition Technology. There were several papers on spray deposition technology. In particular, the use of the Osprey process for Al alloy was described by AJW Ogilvy (Osprey Metals Ltd., Neath, UK). The advantages of this technique, where the temperature at the growth surface remains the same, are that one can form a more homogeneous uniform microstructure, at a lower cost. There is an absence of oxidation films and there is the possibility of forming metal-matrix composites (see Williams, 1987). In the Osprey spray-deposition system, gas-atomized hot metal droplets are deposited onto a collector, forming highly dense preforms of an extremely uniform character (see Figure 1). The atomizing gas, argon or nitrogen, is directed at pressures up to 15 bar to break up and shape the stream of molten metal. The gas aids in the rapid cooling as the fine metal droplets solidify and prevents oxygen pick-up during their flight, and the deposition of the droplets occurs with sufficient kinetic energy to produce dense preforms.

Several Osprey processes are used under license by a wide range of industrial companies (e.g., Sandvik, Sweden; Cabot Corp., US; Glacier Metals, UK). Osprey Metals acts as a research and development company for spray deposition methods, licensing out their advanced process systems.

N.S. Stoloff (Rensselaer Polytechnic Institute, Troy, New York) reported on the preparation of high-temperature intermetallics by powder processing. He

has carried out reactive sintering on Ni and Al powders in which there is an exothermic reaction to form high-density NiAl and  $\text{Ni}_3\text{Al}$ . Additives of B,  $\text{Y}_2\text{O}_3$ , and  $\text{Al}_2\text{O}_3$  fibers, have been included. The sintering of these materials depends critically on the particle sizes of the metal powders and of the additives and their mixing.

### Clean-Room Work

Considerable emphasis was given at the meeting to the necessity of working under extremely clean conditions both in powder preparation and in powder processing. G. Wirth (Deutsche Forschung und Versuchsanstalt für Luft und Raumfahrt [DFVLR], Cologne, West Germany) studied the effects on the metal powder properties of contaminants deliberately added in controlled quantities. A prealloyed Ti-6Al-4V powder, obtained by PREP was HIP-processed with added contaminants of  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ , and stainless steel of particle sizes  $\sim 150 \mu\text{m}$ . The detrimental effects due to the presence of such impurities could be only partially overcome by thermal treatments.

Particularly relevant was one of the posters from Imphy S.A., France; it described the level of cleanliness required in the PM of superalloy components (see Dowson, 1987).

### Methods of Examination

Scanning electron microscopy, ultrasonics, and x-radiography methods were discussed in the examination of microstructure and fractography and for non-destructive testing. The high costs of ultrasonic testing of components were reviewed by W. Betz (Motoren und Turbinen-Union, Munich, West Germany).

The retention of argon after HIP processing was discussed by W. Diehl (Thyssen Guss A.G., Bochum, Germany) for superalloy parts. Diehl related the retained Ar to the microstructure, particularly to the closed porosity, showed the Ar content to depend on the porosity, and estimated a saturation value of 40 ppm Ar in the case of porosities greater than 4 percent.

An elegant method of examining atomization systems was described by S.D. Ridder (National Bureau of Standards, Washington, DC) using Schlieren optics to examine the details of turbulence, of shock wave structures, and of the flow from the jets. A very clear visualization can be achieved and can be used in the development of nozzle designs.

M. Jeandin (Ecole des Mines de Paris, Evry, France) has undertaken microstructural studies of gas turbine PM materials using a high-resolution scanning electron microscope equipped

with a hot stage to 1500°C, capable of operating for periods of several hours at high temperatures. Provisions have been made to restrict the thermally emitted electrons from the microscope image. Jeandin reported on microstructural studies of superalloys and ceramics, observing the kinetics of sintering and the microstructural changes. He also reported on microstructural studies of thermal barrier coatings (TBC), and the effects of laser-glazing.

#### Amorphous Metals

The formation of amorphous metal alloys of Ti-Pd-Cu and of Hf-Ni and Hf-Cu alloys by mechanical grinding of powders of the elements involved was described by W. Krauss (Kernforschungszentrum, Karlsruhe, West Germany). The milling was carried out using hardened steel or WC balls in commercially available mills. The milling process was continued until no further changes were observed in the x-ray diffraction patterns. Differential thermal analysis (DTA) measurements were made. For comparison purposes, splat quenching was carried out on the same compositions. Krauss and coworkers examined Ti-Pd-Cu alloys when single-phase amorphous  $Ti_{1-x}Pd_x$  alloys are obtained for Ti between 45 and 85 atomic percent. Amorphous alloys of  $Ti_{1-x}Cu_x$  are obtained for 10- to 90-atomic-percent Ti. By rapid quenching, amorphous alloys were obtained for Ti compositions only between 30 and 70 atomic percent. Amorphous phases have also been obtained for Hf-Ni and Hf-Cu alloys, and Krauss reports the amorphous range to occur from 25- to 85-atomic-percent Cu and from 15- to 85-atomic-percent Ni. DTA measurements on amorphous Hf-Ni alloys give good agreement between the mechanically ground and rapid-quenched alloys. X-ray diffraction patterns were carried out with temperature, which showed the annealing of amorphous Hf-Ni alloys to a crystalline condition by about 1000 K. Krauss reports also the formation of amorphous alloys in the Fe-Zr-B, Fe-Ni-B, and Fe-Si-B systems. Krauss described the compaction of the amorphous powders by cold pressing, hot pressing, and HIP.

#### Growth of Short Fatigue Cracks

J.E. King (University of Cambridge, UK) reported on the growth characteristics of short fatigue cracks of size comparable to the powder particle size in a powder-based Ni superalloy (Nimonic API, Astroloy) developed for turbine-disc applications. This work has been sponsored by Rolls-Royce, UK (see King, 1987). The behavior of the short fatigue cracks is different from that observed in standard fatigue crack propagation tests. The

Cambridge group conducted cyclic bending tests on small test bars, replicating the surface for electron microscope studies. The initiation and growth rates were measured in this way. [During the discussions, the problem was reviewed concerning the effect of oxides present at the surfaces, which might retard cracks and so give rise to differences between the behavior of the surface and the bulk material.] King concluded that short cracks, of the dimension of the microstructure, grow at stress levels lower than longer cracks, so that the fatigue life is overestimated from longer crack data. The growth rates of shorter cracks are less dependent on microstructure, though fine-grained material gives better control. King added that at room temperature the site for crack initiation is important for growth rates and that slip-band-initiated cracks have higher growth rates than cracks from inclusions.

#### Ceramic Thermal Barrier Coatings

G.W. Meetham (Rolls-Royce) gave an extensive review of high-temperature materials required for aircraft engines (the degradation conditions of a gas turbine engine are summarized in Figure 2). Meetham discussed the use of thermal barrier coatings consisting of an outer layer of  $ZrO_2$  bond-coated to MCrAlY alloys, where M is an alloy of Ni and Co.

An account of argon-shrouded plasma coatings for gas turbines was given by B.J. Gill (Union Carbide Coatings UK Ltd., Swindon, UK). These coatings have been used successfully for about the past 10 years for gas turbine components. The processing tool is either a plasma torch or a detonator gun, where controlled

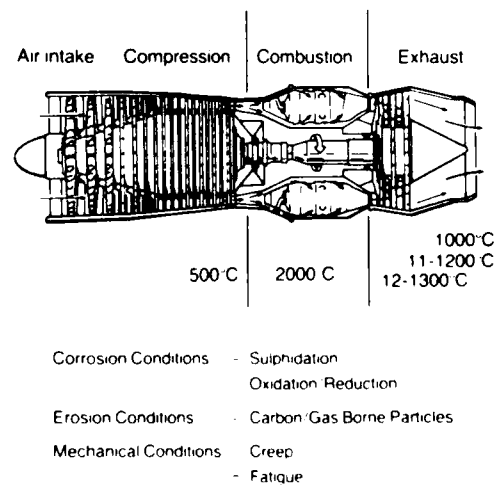


Figure 2. Degradation conditions of a gas turbine engine.

detonation of oxygen in acetylene gas mixtures heat and accelerate powder particle to high velocities and project them onto the prepared substrate. The purpose of the argon shroud, an essential part of the system, is to prevent oxidation of the hot particles. Materials used for the coatings are  $ZrO_2$ ,  $Al_2O_3$ ,  $MgO$ , and  $Y_2O_3$ . The bond coating is MCrAlY. Plasma spraying in an argon shroud can give rise to high-density uniform coatings. These are usually about 25  $\mu m$  thick, with a good interface, and with a porosity which effectively decreases the thermal conductivity of the surface coating, thereby improving its thermal barrier performance. However, the coatings do not necessarily prevent oxidation of the substrate, since oxygen can diffuse freely through the ceramic. Coatings applied for improved wear resistance at high temperatures--approximately 1030°C--can consist of WC-Co coatings on, for example, bearings used in compressors. Gill described other coatings developed to provide improved oxidation and wear resistance at temperatures up to 1100°C for turbine applications, and these are based on oxidation-resistant metallic materials strengthened with dispersions of  $Cr_2O_3$  or  $Al_2O_3$ . Gill showed examples of very uniform thermal barrier coatings on MCrAlY-bonded magnesia and yttria-stabilized zirconia. The bondcoats are typically 250  $\mu m$  and the overlayers 500  $\mu m$  and even up to 2 mm thick.

### Conclusion

The PM Aerospace Materials 87 meeting was well attended and well organized, though the session on ceramic materials did have fewer participants than the other sessions. Much prominence was given to the need of clean-room working because the properties of PM superalloys, for example, are very sensitive to the presence of inclusions. There is a trend towards ceramic materials because of the requirement to use materials at temperatures well above the 1300°C limit of the superalloys. Defect tolerance both in the PM and in the new nonmetallic materials is essential for reliable engineering materials.

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1/3/88

## Mechanics

### XIX INTERNATIONAL SYMPOSIUM "HEAT AND MASS TRANSFER IN GASOLINE AND DIESEL ENGINES"

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 XIX International Symposium, "Heat and Mass Transfer in Gasoline and Diesel Engines," was held in Dubrovnik 24 through 28 August 1987. Over 120 participants from 19 countries attended; about 50 papers, including 6 survey papers, were given. The symposium was held under the auspices of the International Center for Heat and Mass Transfer, which is located in Belgrade, Yugoslavia. One of the objectives of this organization is to promote international cooperative research in heat and mass transfer through sponsorship of international symposia and advanced courses and through technical information exchange.

The conference was certainly international, including even a relatively large number of papers from communist countries. There were a surprising 11 papers from China, and since this is the first time that China has participated in the conference, it appears at least from this evidence, that China is making a concerted effort to participate in international symposia. Since there were also five papers from the USSR the conference presented an excellent opportunity to review the research effort of the two largest communist countries in the field of gasoline and diesel engines. The US led the Western Block contributions with eight papers, followed closely by the UK with seven; Japan had six papers. The

preprint volume was somewhat challenging in that there was no pagination and the papers were printed in random order. A final volume of selected papers will be available from the chairman of the conference, Dr. B. Spalding (an international expert in heat and mass transfer), at Imperial College, London, UK.

Since there were no simultaneous sessions it was possible to listen to every paper. My review, which is highly selective among the papers, will follow the topics given in each session:

- Engine heat transfer
- Vaporization and spray
- External heat transfer
- Numerical flow simulation.

#### Engine Heat Transfer

Perhaps the most interesting paper in this session was that of G. Woschni (Technical University of Munich, West Germany) on an experimental investigation of the heat transfer in internal combustion engines (ICE) with insulated walls. There has been some speculation that as an engine approached adiabatic conditions with insulation or by use of ceramic parts that fuel efficiency could be increased by as much as 30 percent. This speculation is somewhat controversial and Woschni conducted the present experiment to determine the fuel efficiency of an engine with an Al-alloy piston and with an insulating piston made from Nimonic. A well-conceived experiment showed that contrary to predictions the insulated piston was less fuel efficient. The increase in fuel consumption was attributed to increased heat transfer to the wall of the higher temperature ceramic--an effect called "convection vive." I believe that this was the most significant practical result of the conference. Most of the other papers in engine heat transfer were from Russia and China.

The Russian Papers. Of the four scheduled Russian papers on heat transfer one was not presented and there was no copy of it in the proceedings. Another paper was withdrawn but a substitute presentation made. I am not certain who made this presentation, and indeed it was difficult for me to understand--the speaker's poor knowledge of English coupled with his handwritten viewgraphs left me in the dark. Evidently modern computer graphics, which has considerably improved slides and presentations in the Western nations, has not arrived as yet in Russia. The other two papers were reasonable presentations. M.K. Ovsjanikov (Leningrad Marine Engineering College) talked about the measurement of convective and radiant heat flow to the walls of a diesel engine compression

chamber. The paper consisted essentially of several sketches of oscillograph traces obtained from a surface thermocouple for a number of low- and medium-speed two- and four-stroke diesel engines. A sapphire window in front of the thermocouple was used to separate the radiant heat component from the convective component. The radiant component was appreciable only at the beginning of visible combustion. No references or conclusions were given. A. Kostin (Leningrad Politechnical Institute) talked about an experiment in radiative heat transfer in a diesel engine. The co-authored paper is difficult to read because of the authors' language problem but does contain references. A reasonably systematic investigation was made of radiation effects in different regions of a diesel cylinder using thin-film gauges.

Even though it was an invited lecture given in the session on measurement techniques it makes sense at this point to discuss the final paper from Russia because it dealt also with the measurement of heat fluxes in reciprocating engines. A.F. Shekhovtsov (Kharkov Polytechnic Institute) analysed in detail a thin-film gauge (surface thermocouples) used in the determination of instantaneous heat transfer and temperatures in reciprocating engines. He gave the complete design of the sensor as well as a detailed analysis of the data reduction and computer interface of the sensor. A finite difference numerical model of the temperature field in the cylinder was obtained, but there were no experimental measurements given in the paper using the sensor. Such measurements would have permitted comparisons of experimentally measured heat transfer rates and the mathematical model. The finite difference calculations were, however, used in studying the effectiveness of an adiabatic engine.

The Russian papers were all concerned with instantaneous measurements of convective or radiant heat transfer. The similarity of approach and the sensors used in their studies leads me to believe that there is a national project in this area in Russia. This assumption is further strengthened by the fact that many of the Russian participants are also members of a National Committee for Heat and Mass Transfer. The technology illustrated in the presentations was rather straightforward application of known techniques.

The Chinese Papers. The Chinese contributions to this session were a mixed bag. S. Shen et al. (Dalian Institute of Technology) reported on measurements of heat transfer to a ceramic wall in a combustion chamber of a diesel engine. The

authors compared their locally measured heat transfer rates with an empirical correlation for the mean or global heat rate in a cylinder. This prompted a short lecture on the difference between local and mean rates from the audience. L. Reisong et al. (Wuhan University) reported on an experimental and theoretical evaluation of thermal loads in the cylinder head of a diesel engine under transient and steady-state loading. A finite element program was used to predict the temperature field, and experimental measurements were compared with the predictions with supposedly excellent results. The wall thermal boundary conditions were, however, synthesized from the experimental measurements, so the agreement appears to be forced. A general conclusion that I would make is that many of the Chinese presentations at the conference were curiously naive. Perhaps there is a learning curve involved.

#### Vaporization and Spray

In contrast to the rather unexciting technology of the heat transfer session the vaporization and spray session concerned applications of advanced laser and holographic methods used to characterize diesel sprays. The invited lecture by H. Hiroyasu (Hiroshima University, Japan), with heavy emphasis on experimental methods, was excellent. Hiroyasu described the application of pulsed-laser holography to diesel sprays in high temperature and pressure atmospheres. From the reconstructed hologram identical schlieren and shadowgraph images of the same spray pattern were obtained. The concentrations of fuel vapor and the drops in the spray were obtained from these images. He further described the determination of the drop size by means of an optical experiment based on Fraunhofer diffraction using a program developed by Malvern Instrument Ltd. of the UK.

Among a series of further excellent papers I would like to highlight that of A. Cavaliere et al. (Istituto di Ricerche Sulla Combustione, Naples, Italy) on the analysis of diesel spray characteristics through a two-dimensional laser light scattering technique. By use of a high-power pulsed laser and a sensitive image intensifier Cavaliere has been able to obtain information on the initial breakup of the fuel jet close to the injection nozzle. Essentially, a laser sheet is used to illuminate the cross section of the jet. By means of a series of exposures at different distances from the nozzle one can fairly well characterize the entry jet. Although it needs further development the experimental method appears to yield a good diagnosis

of the fragmentation and atomization of the jet immediately after injection.

The paper on spray penetration, vaporization, and mixing in diesel engines given by J.I. Ramos et al. (Carnegie-Mellon University, Pittsburgh, Pennsylvania) was a numerical analysis of the flow field and fuel-air mixing in a direct-injection stratified-charge (DISC) diesel engine. A two-equation model of turbulence and a stochastic discrete droplet model was used in the analysis of a flat piston-cylinder configuration. A grid consisting of 7000 points with a computational time of 2 hours on a Cray XMB was used in the determination of the velocity field in the cylinder. The result of the calculations showed that an eddy was formed beneath the annular intake valve in the intake stroke with the size of the eddy decreasing on the compression stroke. Turbulence was generated in the shear layers of the indrawn annular air flow. Fuel/air mixing was not satisfactory and modification of the cylinder to include a bowl-piston and swirl was suggested by the authors. Fundamental advances in the understanding of IC engines will come from the type of calculation done by Ramos and his coworkers.

In one of the more ambitious Chinese papers X. Maozhao (Dalian Institute of Technology) discussed numerical studies based on multidimensional combustion modeling (MDM) of a hollow-cone-spray combustion system. The computations (CONCHAS, a code developed at Los Alamos National Laboratory) were based on the arbitrary Lagrangian-Euler method developed by Hirt in the US. The paper showed a clear knowledge of previous work by A.D. Gosman (Imperial College, London) and F.V. Bracco (Princeton University, New Jersey). Velocity fields and fuel mass fractions were shown for a variety of cylinder conditions. Swirl was found to be detrimental to fuel-air mixing. Two criticisms were raised on the calculations; one concerned the correct sign of a term in an equation by Bracco and the other concerned the small number of grid points in the cylinder, which limited the accuracy of the calculations.

Two further papers from the Dalian Institute of Technology involved applications of computer modeling of combustion processes. One of these papers, by B. Chen et al., was an analysis of three types of diesel combustion systems using a quasi-dimensional model. The three systems studied included traditional multi-hole injection, conic spray with large top angle, and film impingement. The papers, with perhaps some anomalies, showed sophisticated application of western-developed computer codes. This was the strictest area in which the Chinese

contributed, and one might expect that with more experience and perhaps development of their own codes they could become competitive in numerical simulation.

The last paper that I will discuss in this area is the one of J.B. Moss et al. (Cranfield Institute of Technology, Cranfield, UK) on the computer simulation of induction flows in spark engines. The stationary turbulence flow field through a butterfly valve and a variable geometry ramp restriction were modeled computationally and compared with water analogy flow visualization of a transparent model. Further limited hot-wire measurements lent support to the more detailed aspects of the computational predictions. The PHOENICS code, developed by Spalding, was used in the analysis. (In fact, there were several papers that used the PHOENICS code in the analysis of ICE at the conference.) The essential flow field characteristics were satisfactorily reproduced and the comparison was particularly good with respect to the extent of the recirculation region in the lee of the throttle and the in the relative persistence of the turbulence generated downstream for varying throat apertures. The diagnostic potential of such modeling was clearly demonstrated.

#### External Heat Transfer

The papers in this area were basically technology oriented rather than fundamental investigations. Typical of the papers was that by I.C. Finlay et al. (National Engineering Laboratory, Glasgow, UK) on the results of an investigation on the effect of a more sophisticated cooling system on the fuel economy of an ICE. The essential idea is that there are two cooling systems which keep the cylinder head cool and the block hot. If the temperature of cylinder walls was raised by 100°F fuel consumption was improved by 4 to 6 percent and HC emissions declined by 20 to 35 percent, but NOX emission increased by a similar amount. At full throttle conditions, however, the detonation borderline ignition setting was severely retarded.

#### Numerical Flow Simulation

What I considered the strongest area of the conference was introduced by an excellent invited lecture by G. Blair (The Queen's University, Belfast, Northern Ireland). Blair has been investigating the design and operation of the two-stroke engines since the late 1950's. His paper gave a historical development of this type of engine, which is used in motorcycles and outboard engines. In particular, he analyzed the scavenging of such engines and reported on the effectiveness of the PHOENICS code in the pre-

diction of experimental results obtained in his laboratory.

There were two excellent papers from the Institut de Français de Pétrole, France, on the prediction and comparison with experiment of spark ignition engines. In the first paper Ph. Pinchon et al. reported on a combined experimental and computational investigation of flame flow interaction in an engine with a shrouded valve at the intake port. Since the combustion model was not predictive it was fitted in order to provide a computed global burning rate close to the experimental one. Computed flame fronts were then found to agree relatively well with the experimental ones obtained from schlieren visualization. A multidimensional method (MDM) was used in the numerical calculations with three-dimensional modeling of intake process, compression, and burning. Good space and time descriptions were obtained of the velocities and concentrations.

The second paper, from the Institut de Français de Pétrole, by P. Gilaber, concerned the validation of a multidimensional heat transfer model for spark ignition engines. The computational fluid dynamic codes used in the prediction of ICE performance need to approximate wall frictions and heat transfer between gas and wall as boundary conditions for the momentum and energy equations. The research consisted of two phases, the first of which involved experimental fast response surface heat flux gauges and a laser Doppler velocimeter (LDA) to determine the effect of the fluid mechanics near the wall on the heat transfer. It was found that the global heat transfer rate for a thermodynamic cycle of the engine decreased as the speed of the engine increased but the peak value of the wall heat-flux increased because of the increase in the turbulence level. Volumetric efficiency had little effect on turbulence levels; its influence on the heat transfer appeared mainly in the increase in density. In the computational phase the boundary layer was not meshed and the heat transfer was approximated by a wall function which was a strong function of local density, velocity, and turbulence. A  $k-\epsilon$  model was used in the KIVA code for turbulence, and combustion was modeled with an eddy break-up formulation. A comparison between measurements and computational prediction showed good agreement in terms of instantaneous and local heat-flux and in terms of global heat balance.

Using a transparent engine and LDA measurements, T. Kamimoto et al. (Tokyo Institute of Technology, Tokyo, Japan) made further comparisons of computed velocities and experimentally measured

velocities with good agreement except in the case of high swirl ratios (3.6). Further LDA measurements and comparisons with PHOENICS-generated numerical solutions were done by J.J. Seppan et al. (TNO research Institute for Road Vehicles, Delft, the Netherlands) for inlet manifolds.

This series of papers was very interesting in that sophisticated experimental measurements (LDA) were used in code verification. Such investigations will permit better modeling and thus better understanding of internal combustion engines.

#### Conclusion

The strength of the conference was in numerical simulation and, in particular, the code verification papers. The conference gives a clear indication of the state of the art of ICE and the participants in Europe and in the orient in this field. Although the Chinese papers were somewhat naive, my impression was that the authors were competent, but somewhat inexperienced. The Russian authors, at least those I could understand, appeared to be experienced experimentalists, but somewhat old-fashioned in their approach.

10/26/87

## **Ocean Sciences**

#### MEETING OF THE ESTUARINE AND BRACKISH WATER SCIENCE ASSOCIATION

by Jerome Williams. Professor Williams was the Liaison Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He completed his tour at ONRL and has returned to the US Naval Academy, where he is Professor of Oceanography.

The Estuarine and Brackish Water Sciences Association (EBSA) held their seventeenth symposium at the University of Dundee, Dundee, Scotland, from 15 through 18 September 1987. Entitled "Recent Development in Marine and Estuarine Methodologies," the meeting attracted about 100 investigators, primarily from the UK, but West Germany and France were also represented. Abstracts are not

available at this time but they may be published in an issue of the EBSA *Bulletin* in the near future. Following are summaries of the presentations under four of the topics.

#### Remote Sensing

This session attracted only two papers that addressed the title topic, and they were both given by people from the University of Dundee. One was an overview paper by A.P. Cracknell, and the other, describing some IR techniques that have been used in estuarine waters, was by J.M. Anderson. Cracknell gave a tutorial lecture on the characteristics, limitations, and possible applications (actually, previously successful uses) of visible and IR remote sensing, both from aircraft and satellites. He discussed swath coverage and resolution in terms of altitude and wavelength used, boundary problems, effects of aerosols and suspended sediments, and interpretation of the electromagnetic signal in terms of the hydrospheric parameters. Anderson described some IR data taken in the Tay Estuary and his partially successful attempts to utilize these data in a productive manner.

Although presented in another session, a paper describing the use of radar for wave refraction studies could certainly be classified as dealing with remote sensing. C.R. Boalch and J. McManus from the University of Dundee removed the clutter filter from an X-band radar and, by assuming Bragg scattering from capillary waves along the swell crest lines, were able to image wave refraction patterns off the Tay Estuary. The system they are using employs a scanner 9 feet in diameter, which is probably not a limiting factor since the setup is mounted on the shore and does not go to sea.

#### Biological Sampling

There were a large number of papers in the general category of biological sampling, many of which described older methodologies, some of which have been around for a long time. For example, P. Tett, University College, Bangor, UK, discussed chlorophyll-salinity diagrams as a tool for investigating plankton dynamics, while I.C. Telfer attempted to relate various environmental factors to specific organisms. J.M. Baker, Field Studies Council, Shrewsbury, showed that qualitative data taken by different investigators can be dissimilar when interpreted quantitatively, and P.F. Kingston, Heriot Watt University, described his efforts in using a benthic indicator organism in pollution monitoring. A relation between turbidity and algal depth distribution was reported by C.M. Lumb of

the Nature Conservancy Council, while J. Pomfret, Northumbrian Water Authority, Newcastle upon Tyne, showed that benthic organisms may not be the best indicators of the quality of a sludge disposal area. The use of the lowly cockle as an indicator mechanism was discussed by A.M. Jones of Dundee University. He used shell size measurements in conjunction with yearly growth rings to relate specific year classes to environmental events and to determine mortality rates for particular year classes. Jones also demonstrated how microcomputer spread sheets can be used in studies of this type.

### Sediments

Measurements and data analysis techniques for both suspended and bottom-deposited sediments were addressed in this session. A new *in situ* method of observing an undisturbed bottom section using the Rhoads-Cande profile camera was described by T.H. Pearson, Scottish Marine Biological Association. Pictures are taken through a transparent plastic chamber filled with distilled water that is inserted into the bottom. The more conventional methods of analyzing bottom sediments were discussed by G.R. Rideal, Christison Scientific Equipment, Ltd., Gateshead, who presented a rather complete summary of sieve methods used for particle size analyses.

In contrast to the methods used for sizing these larger particles, laser diffraction devices for the *in situ* measurement of very small diameter suspensoids were described by A.J. Bale, Institute for Marine Environmental Research (IMER), Plymouth. This device was used in the Taymar Estuary to look at the relationships between suspended particles and turbulence. One of the results of this study was to show that suspended particle median diameter decreases dramatically with an increase in total load, as a great many fine particles are apparently resuspended during maximum current periods. Extremely small size (less than 1 micrometer in diameter) hydrosols can be addressed by other techniques. One of these, described by R. Bryant of University College, Swansea, involves electrokinetic measurements. This is a very touchy methodology that considers particle mobility (diffusion) under very controlled conditions and the mobility using various theoretical considerations, relates to particle size. With multi-sized distributions, such as naturally occurring clays and silts, the relational theory becomes very complex, and in addition, there is a very high sensitivity to changes in pH, making this methodology difficult to use in an estuarine environment.

Aside from the size spectrum of particulates, there is also some interest in the body properties of cohesive sediments both in estuarine bed and high-density suspensoid environments. The determination of such properties as yield stress, shear stress, and flow rate was discussed by D.J.A. Williams as he reported the work of his group at University College, Swansea. One method used with some success with suspensoids is to propagate a 300-Hz shear wave through the sample, while with a sediment bed it is common to apply a stress and measure the strain recovery. Results indicate that the sediment sample for each test should be undisturbed, as previously disturbed material reacts in a different manner. New techniques have also been developed that allow measurements to be obtained of the parameters important for very short-time phenomena.

### Physical Processes

Although numerical models for estuarine systems are becoming more and more commonplace (and complex, it seems) with each passing day, it was interesting to hear a relatively simple model of the Taymar Estuary described by R. Uncles, IMER. He uses a one-dimensional model with 36 constant-volume moving elements with the most seaward element, at 5 km from the mouth, having a constant salinity of 35. The model is calibrated at two deep-channel stations during spring and neap tides with velocity and salinity measurements. Calculated tidal elevations, currents, and salinities all agree reasonably well with measurements. The model predicts large variations of axial dispersion coefficients with changes in runoff, tidal range, and location.

Based on a local concern about concentrations of metals in Liverpool Bay, a program to monitor fluxes through the Mersey Narrows was explained by P.D. Jones, North West Water Authority, Warrington. A moored buoy with current, turbidity, salinity, oxygen, atmospheric pressure, and wind sensors has been deployed for this purpose. Surface sensors are restandardized every 14 days, along with salinity, temperature, and current sensors mounted on the bottom at the same location as the buoy. J. Jarvis, St. Andrews University, also described a flux study program, this one concerned with water and sediment transport in St. Andrews Bay. A relation between bed load transport and current speed was developed.

An entirely different topic area was that of D.A. Pilgrim of Plymouth Polytechnic, Plymouth. He suggested a new dimensionless parameter that should aid

in the description of benthic light penetration for benthic productivity studies.

### Summary

Although billed as an opportunity to share information concerning the most recent methodologies being used in estuarine and marine science, the meeting, with some notable exceptions, turned out to be a discussion of techniques familiar to most, if not all, the attendees. Certainly, at a meeting of the Estuarine and Brackish Water Sciences Association, one would not expect much attention to be given to blue water oceanography. On the other hand, I did expect many presentations describing new concepts, or at the very least, new devices for use in data gathering or data interpretation in the coastal environment. The fact that I was disappointed raises interesting questions as to the causes of this disappointment. It would seem the lack of recent developments being reported at this meeting could be the result of two factors: there are few recent developments to report, or many of the people with new ideas just did not come to the symposium. Based on my impressions gained from the EBSA meeting last year (see ESN 41-3:166 [1987]) and from my numerous visits with UK scientists, I strongly believe there is no lack of new or innovative ideas in Britain. It appears that for various reasons, all of which are unknown to me, this meeting did not attract very many people who were willing to depart from the commonplace in their discussions. Perhaps this is the result of too many meetings over too short a time span.

10/30/87

## Physics

### FAR ULTRAVIOLET COHERENT LIGHTSOURCES AND VUV LASER SPECTROSCOPY AT GARCHING

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.

While most West German academic research on laser development and advanced laser spectroscopy in the Munich area is done at the Max Planck Institute for

Quantum Optics at Garching (often in conjunction with researchers from the two Munich universities), there is one special field which has its home in another research center at the Garching complex: the Max Planck Institute for Extraterrestrial Physics. The topic I am talking about is the efficient generation of far ultraviolet coherent radiation, below 200-nm wavelength (VUV domain), and now even below 100 nm (XUV region). The principal investigator is Professor C.R. Vidal. The work under his direction is primarily aimed for doing advanced high-resolution VUV spectroscopy, but this obviously necessitates the in-house development of often unusual, relatively high-power, narrow linewidth, tunable VUV sources. This work is the major topic of this article, and it should be clear that efficient VUV and XUV laser radiation is also important for many other scientific research projects, as well as for industrial materials processing, or perhaps even defense applications.

### Background

While some electronically excited gas lasers (such as  $H_2$ ,  $CO$ ,  $F_2$ ) can produce VUV radiation (up to a few GW's), they have a low efficiency, very little tunability, and worst of all, a rather large linewidth of typically  $10\text{ cm}^{-1}$ . Since these aspects make them unsuitable for high-resolution spectroscopy, resonant and nonresonant harmonic generation or frequency mixing is customarily the methodology used for analyzing high lying states of atoms and molecules. In this case, the excitation is detected by the resulting sum- or difference-frequency signal. But the Stark effect induces serious distortions of the spectrum, and therefore--Vidal told me--it is advisable to separate the nonlinear processes from the atomic (or molecular) system under investigation. Moreover, it is best to expose the sample only to moderate VUV intensities. These goals can be well achieved by generating the VUV radiation before entering the sample--four-wave sum-frequency mixing in atomic systems is the methodology preferred by Vidal. Actually, while in the past mostly nonlinear crystals were used, Vidal pays special attention to gaseous nonlinear media: one reason is that such media are not destroyed or damaged by laser-induced electric breakdown.

A simple analysis shows that for the efficient generation of coherent VUV radiation by means of four-wave mixing, the nonlinear medium must meet three major requirements:

1. The third-order nonlinear susceptibility,  $\chi^{(3)}$ , must be large.

2. Proper phase matching is crucial for exploiting large column densities and to achieve large conversion efficiency.

3. The optical depths for the incident waves and for the sum-frequency wave must be small enough so as to ensure that the sum of these optical depths be still less than 1. (The optical depth is defined as the product of the absorption coefficient and the length of the nonlinear medium.)

Vidal explained to me that the third requirement also speaks strongly for using gaseous media. In addition, the first two requirements are generally met if one uses (as he does) a two-component gaseous system where one component has a large nonlinear susceptibility, and the second component is appropriately chosen to achieve the phase matching condition. (This led him, and other researchers, to use a metal-vapor plus noble-gas mixture for VUV, and a mixture of two noble gases for the XUV.)

It is rather difficult to meet the very stringent homogeneity requirements imposed by the phase-matching condition. It was this special point to which Vidal dedicated for a long time his pioneering efforts (and he is still thinking of improvements). He invented a method whereby the metal-vapor/inert-gas mixtures are realized in devices based on the heat-pipe oven.

#### The Heat-Pipe Oven

A heat-pipe oven consists of a tube and a mesh structure covering the tube's inner surface which acts as a "wick." It also has a heating element and a heat sink. It contains a working material whose vapor is confined by a noble gas. The heater evaporates the working material inside the central portion of the tube. From here, the vapor flows out toward the ends of the tube and condenses in the outer, slightly colder parts of the oven. The condensed liquid then returns through the mesh (as in the wick of a candle). The extension of the vapor zone over a length of the pipe is determined by the balance between the power supplied by the heater and the losses due to radiation and to heat conduction through the walls. Because of the continuous evaporation and condensation of the working material, a large fraction of the heat is transferred through the heat pipe oven. This causes a large heat conductivity which exceeds that of any solid by several orders of magnitude. Hence, it causes an extremely homogeneous temperature and density distribution over the entire length of the vapor column--which was the primary purpose of the exercise. Finally, a stable equilibrium is reached

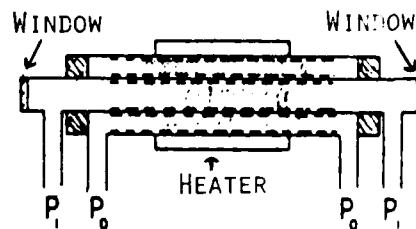


Figure 1. Arrangement of a concentric heat-pipe oven. Dotted areas=metal vapor; shaded areas=water cooling chamber; dash lines [---]=wick.

in which the central vapor column is confined by the noble gas whose pressure determines the vapor pressure inside the heat-pipe oven. Of course, the noble gas has the additional virtue of protecting the windows at the tube-ends from vapor deposition and corrosion.

The simplest actual device of the Vidal laboratory which operates on the basis of the above described principles is shown schematically in Figure 1. This is a concentric arrangement of, actually, two heat-pipe ovens, where the inner oven, containing the metal-vapor/noble-gas mixture is surrounded by an outer oven. The latter acts as an isothermal heater, and imposes an extremely homogeneous temperature distribution on the inner oven. The temperature is determined by the confining noble-gas pressure of the outer oven, which, of course, depends on the vapor pressure curve of the working material. Often the inner and outer ovens are operated with the same working material. Then, if the noble-gas pressure of the inner pipe is larger than that of the outer pipe, the *total* pressure of the outer heat-pipe oven will be equal to the *partial* pressure of the working material in the inner heat-pipe oven. Consequently, the latter is filled with a metal-vapor/noble-gas mixture such that the partial pressure of the metal vapor is that of the outer pipe's noble-gas pressure,  $p_0$ , and the partial pressure of the inert gas is  $(p_1 - p_0)$ , where  $p_1$  denotes the noble-gas pressure of the inner pipe. In view of these considerations, the partial gas pressures can be easily and independently adjusted. Apart from the basic merit of extreme homogeneity, this is yet again a conspicuous advantage of Vidal's heat-pipe oven arrangement over the traditional cells containing noble-gas mixtures, and it contributes much to the meeting of the phase-matching condition.

In cases when the metal vapor acting as the nonlinear medium must be operated at rather low pressures (so as to maintain a small optical depth), it may be

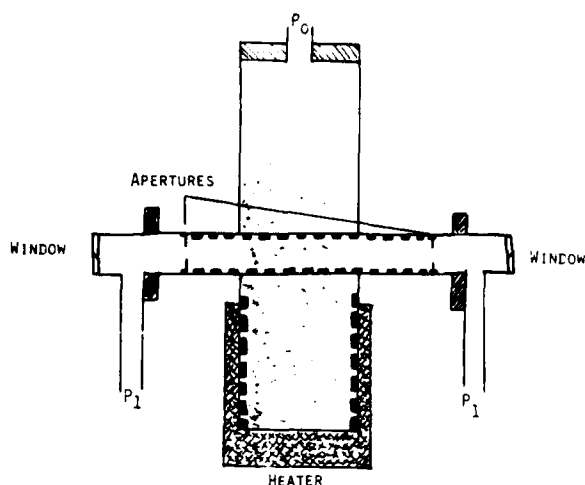


Figure 2. Arrangement of modified heat-pipe oven. Dotted areas=metal vapor; shaded areas=water cooling chamber; dash lines [----]=wick.

necessary to operate the outer heat-pipe oven with a working material which has a higher vapor pressure for the desired temperature than has the working material of the inner heat-pipe oven. Greater stability and homogeneity will then result. Of course, the analysis of the preceding paragraph is then not applicable, but the partial pressure of the metal-vapor inside the inner heat-pipe oven can be now easily calibrated as a function of  $p_0$ . In a typical example studied in Vidal's laboratory, the inner oven had a Sr-Xe mixture and the outer oven was operated with Na.

The concentric heat-pipe oven illustrated above is only the simplest device in this category. In some cases it is necessary to regulate the heater power, and for obtaining a stable equilibrium, a long warm-up time is needed. To circumvent such problems, Vidal and co-workers developed a modified oven which combines the virtue of the accurately defined partial pressures with a well-defined column-density. Here, a horizontal single-heat-pipe oven is combined with a vertical one. (See Figure 2.) Here the vapor zone is shorter; but this is actually an advantage, since it allows for a better fitting of the beam profile to the vapor zone. In most current applications for his spectroscopy work, Vidal uses this modified oven.

Finally, a third variant has been also developed which is for use in instances when mixtures of metal vapors (such as Na and K or Mg) are used. The variant of the heat-pipe oven used for such situations generates mixtures of

saturated and unsaturated metal vapors, where, again, the pressure ratio can be adjusted.

Some of the systems developed by the Vidal group have truly remarkable capabilities. When pumped with visible light lasers of various kinds, the outgoing coherent radiation in the 100- to 200-nm range has a pulse length of a few nanoseconds and can provide  $10^{11}$  to  $10^{13}$  photons per shot, at a repetition rate of a few Hz, and with a spectral linewidth less than  $0.1 \text{ cm}^{-1}$ . In this manner, Doppler-limited spectra can be obtained. Moreover, the spectral brightness of the nonlinear sources (number of photons per time interval and per unit solid angle) exceeds the spectral brightness of the (noncoherent) synchrotron radiation or laboratory plasma discharges by several orders of magnitudes. The beam profile is diffraction limited, much better than what could be achieved with excimer lasers. On the other hand, at wavelengths shorter than, say, the Lyman  $\alpha$ -line, the spectral brightness of the VUV source decreases to something like  $10^6$  photons per shot. The reason for this is that a number of different nonlinear processes start competing with the four-wave mixing. It also remains to be seen if the Vidal device could be adapted for producing picosecond pulses (quasi-CW-operation.)

#### Some Applications

As I noted in the introduction, Vidal is primarily a molecular spectroscopist, using forefront technologies. While, personally, my interest was in the nonlinear four-wave mixing device that he developed for coherent VUV radiation source, I wish also to at least list the areas of high-resolution molecular spectroscopy research that are currently pursued in the institute. They are:

- Absorption and excitation spectroscopy
- Fluorescence spectroscopy
- Photodissociation spectroscopy
- Ionization spectroscopy
- Two-step excitation spectroscopy
- Multiphoton spectroscopy.

A detailed review of these items, with an extensive bibliography, may be found in the 1987-1988 volume of *Advances in Atomic and Molecular Physics*. The purpose of these spectroscopic studies is, in Vidal's words, "to study the interstellar medium in a nutshell."

In this line also fall Vidal's new experiments, currently in the advanced planning stage. These will study ion-molecule reactions, both in hot and cold systems. (Comparison of "hot" and "cold" data will, hopefully, reveal if van der

Waals forces or very large direct excitations are the mechanism behind the observed interstellar medium ion-molecule reactions.) The methodology for these experiments center on the production of molecule beams at very low temperatures and at very low concentrations: special jet-valve techniques do the trick.

12/17/87

## News and Notes

### CONFERENCE ON STRESS AND ADJUSTMENT

The Fourth International Conference on Psychological Stress and Adjustment in Time of War and Peace will be held in Tel-Aviv, Israel, from 8 through 12 January 1989. Previous conferences in this series have been extremely successful; the most recent symposium was attended by more than 2000 participants. The conference theme at the forthcoming meeting will be "post-traumatic stress reactions and disorders: prevention, diagnosis, and treatment." Conference chairman is Noach Milgram of Tel-Aviv University. Information and registration materials can be obtained from the Conference Secretariat, Fourth International Conference on Psychological Stress and Adjustment in Time of War and Peace, P.O.B. 50006, Tel-Aviv 61500, Israel.

W.D. Crano  
1/12/88

### TWO SCIENTIFIC MEETINGS IN BUDAPEST

The Third European Conference on Developmental Psychology will take place in Budapest, Hungary, from 15 through 19 June 1988, under the chairmanship of Dr. Magda Kalmar. The conference will consist of invited addresses, symposia, poster workshops (see ONRL Report 7-006-C), and poster displays, based on empirical, methodological, and theoretical contributions which are relevant to the study of human development at any stage in the life cycle. The language of the conference is English. Registration information may be obtained from the Organizing Committee, Third European Conference on De-

velopmental Psychology, Institute of Psychology, Eotvos University of Budapest, Izabella u. 46, H-1378 Budapest, Hungary.

In addition, an international symposium on "Work Values and Achievement Motive" will be held from 23 through 27 June in Budapest, Hungary. Registration details and other information may be obtained from the organizer, Professor Dov Elizur, Bar-Ilan University, 52100 Ramat Gan, Israel.

W.D. Crano  
1/12/88

### NEW JOURNALS IN BIOLOGICAL SCIENCES

Several new journals in the biological sciences have recently been announced. Following are details on three that should be brought to your attention.

#### Neuroscience Research Communications

The purpose of this new journal is the rapid publication of important, original contributions to the neurosciences. The journal is both international and multidisciplinary and welcomes papers in all areas of the neurosciences. It comprises short papers, selected minireviews, and timely comments by leading authorities on current topics. According to the publishers, papers are quickly and fully reviewed by independent leading experts in the various disciplines and only high-quality papers are accepted. Interval between acceptance of papers and publication is no longer than 2 months.

The editor of the journal is W.H. Gispen, Institute of Molecular Biology, State University of Utrecht, the Netherlands. The advisory and editorial boards are international in scope. The journal is published as a volume with three issues per volume. The price per volume is \$140. It is published by John Wiley and Sons Inc., 605 Third Avenue, New York, 10158. UK address is John Wiley and Sons Ltd., Baffins Lane, Chichester, Sussex, PO 19 1UD, UK.

#### Electron Microscopy Reviews: Subcellular and Biomolecular Structure

The first issue of this new journal will be published in 1988. It will provide critical, up-to-date reviews of new developments in the field of transmission and scanning transmission electron microscopy of subcellular organelles, membrane fractions, macromolecules, and macromolecular assemblies from animal, plant, fungal, and bacterial cells. Also

included will be extracellular proteins and supportive structures, together with viral particles and their components. Emphasis will be placed upon results and applications together with methodology. Reviews which include high-resolution studies leading to two- and three-dimensional image analysis and reconstruction are particularly welcomed. The correlation of biophysical, biochemical, immunological, and other data of a structural and functional nature with that derived from electron microscopy is encouraged. The publishers state that the journal will publish material of the highest quality which has undergone strict editorial control. The production of all electron micrographs will be of consistent high standard.

The publisher of this new journal is Pergamon Journals; the US address is Fairview Park, Elmsford, New York 10523, US. For the UK and all other countries, the address is Headington Hill Hall, Oxford OX3 0BW, UK. The editor-in-chief is J.R. Harris, North East Thames Regional Transfusion Center, Brentwood, Essex, UK. The associate editor is R.W. Thorne, School of Biological Sciences, University of East Anglia, Norwich, UK. The editorial board is comprised of an international roster of scientists. The annual subscription (1988) per volume of two issues is DM240.00 or approximately \$158.

### Aphasiology

This is a new international and interdisciplinary journal published bi-monthly. According to the publishers, the enormous growth of interest shown in the effects of brain damage on language ability and related functions has generated a pressing demand for this new journal. *Aphasiology* is the only international, interdisciplinary journal in the field which provides a forum for the exchange of knowledge and the dissemination of current research and expertise from a wide range of disciplines and professional groups. *Aphasiology* includes:

- Papers on clinical, psychological, linguistic, and neurological perspectives of aphasia
- Studies using a wide range of empirical methods, including experimental, clinical, and single-case studies, surveys, and physical investigations
- A review article to appear in each issue dealing with a major topic area in aphasiology
- A clinical forum in which clinical/therapeutic issues will be addressed through the presentation of studies, reviews, and notes with interdisciplinary comment and critique

- Aphasiology-in-print, a comprehensive list of new literature on aphasia and related areas including titles, authors' names and addresses.

The editors are Chris Code, School of Speech Pathology, Leicester Polytechnic, Scraptoft Campus, Leicester, UK, and Dave J. Miller, Dean of Science, Lancashire Polytechnic, Preston, UK. The North American editor is Robert C. Marshall, Veterans Administration Medical Center, Speech-Language Pathology, Portland, Oregon. The associate editors are Jason W. Brown, Clinical Neurology, New York University Medical Center, New York, and Yvan Lebrun, Head of Department, Neuro-linguistek, Vrije University, Brussels, Belgium. The editorial board is comprised of an international roster of scientists.

This new journal is published by Taylor and Francis Inc., 242 Cherry Street, Philadelphia, PA, 19106-1906. The address for the UK and Europe is Rankine Road, Basingstoke, Hants, UK. The price of each volume is \$110 and the personal subscription price is \$55 per volume.

*Claire E. Zomzely-Neurath*  
12/8/87

### NEW JOURNALS CONCERNING THE HUMAN NEURAL SYSTEM

Several new journals concerned with research on or related to the human neural system have been announced. Following are the details on five of them, some of which could be of particular interest to scientists in other fields.

#### Neural Networks

Now a major focus of study by university, industry and government investigators, neural network research concerns the modeling of brain and behavioral processes and the application of these models to computer and related technologies. This research, now understood as an important aspect of the cognitive and neurosciences, is also precipitating a fundamental shift in computer science and artificial intelligence. Scientists and engineers are now using neural network models to help solve key technological problems. Interest in implementing these models in real-time hardware is, therefore, very high.

Appearing in early 1988, *Neural Networks* will be a quarterly international journal which will publish original contributions on brain behavior and modeling

and their application to computer technology. The journal is expected to create a scientific and educational forum for students, scientists, engineers, and others to learn about and advance the state of knowledge in this new field of inquiry. *Neural Networks* will therefore serve as a single, interdisciplinary publication of interest to neurobiologists, psychologists, computer scientists, mathematicians, engineers, and physicists.

Topics will include:

- Vision and image processing
- Speech and language understanding
- Pattern recognition
- Associative learning and long-term memory
- Self-organization
- Cognitive information processing
- Cooperative and competitive network dynamics and short-term memory
- Sensory-motor control and robotics
- Parallel distributed processing
- Local circuit and systems analyses of brain-behavior relationships
- Combinatorial optimization
- Electronic, optical, hybrid, and virtual devices and neurocomputers.

Special issues and review articles on topics of current interest will also be published. *Neural Networks*, the official journal of the International Neural Network Society (INNS), will be edited by a board of leading experts representing neuroscience, psychology, computer science, engineering, mathematics, and physics approaches to neural network research and application. A subscription to *Neural Networks* is included with a membership to INNS.

The co-Editors-in-Chief of this new journal are: for Australasia: Professor Shun-ichi Amari, University of Tokyo, Faculty of Engineering and Instrumentation Physics, Bunkyo-ku, Tokyo 113, Japan; North and South America: Professor Stephen Grossberg, Boston University, Center for Adaptive Systems, Mathematics Department, 111 Cummington Street, Boston, Massachusetts 02115; Europe and Africa: Professor Teuvo Kohonen, Helsinki University of Technology, Technical Physics Department, Rakentajanaukio 2C, SF-02150, Espoo 15, Finland.

*Neural Networks* is being published by Pergamon Journals, Inc., Maxwell House, Fairview Park, Elmsford, New York 10523. The institutional subscription rate for 1988 in the US is \$95; individual US rate is \$49 but available only to those whose library subscribes. The membership fee in the US for the INNS is \$45 and includes a subscription to *Neural Networks*.

### Journal of Psychophysiology

This is an international journal designed to provide an outlet for original research in all areas employing psychophysiological techniques, or research of relevance to their interpretation. Contributions are welcomed from psychology, physiology, clinical psychology, psychiatry, neurosciences, pharmacology, and genetics. The journal also acknowledges the important contribution that animal research makes to these areas. In addition, communications on new methodology, such as recording technology, data reduction, statistical methods, and computer hardware and software are also encouraged. In addition to reports of original research, consideration will also be given to reviews and theoretical papers including open peer commentary, when appropriate.

Psychophysiology has gone through an era of standardization and consolidation of methods and theoretical stances. Therefore, according to the editors, the time seems to be ripe to go beyond and explore new paradigms and applications. The journal will provide a forum for discussion of such ventures, supplying space for replies to contributions on which no consensus can be obtained. Space will also be allocated for letters to the editor, book reviews, announcements of meetings, and proceedings of society meetings.

The editors of this journal are: Gudrun Sartory, Fachbereich 3 Psychologie, Gesamthochschule Wuppertal, Max-Horkheimer-Strasse 20, D-5600 Wuppertal, West Germany, and Irene Martin, Department of Psychology, Institute of Psychiatry, De Crespigny Park, London SE5 8AF, UK. The editorial board is international in scope. The journal is being published by Oxford University Press, Walton Street, Oxford OX2 6DP UK. Subscription rate is \$90.

### Journal of Psychopharmacology

This journal is essentially the official journal for the British Association of Pharmacology (BAP), founded in 1974 as a scientific association to promote knowledge of and research into the entire field of psychopharmacology. Its membership has increased several-fold over the past year, reflecting the upsurge in interest and activity in this area of pharmacology and therapeutics. Present membership covers a wide range of individuals, such as biochemists, pharmacologists, psychiatrists, and many others from academic institutions, the pharmaceutical industry, and medical practice. The BAP holds several scientific meetings each year to provide

opportunities to disseminate the latest research and practice.

The *Journal of Psychopharmacology* seeks to continue this tradition of representing a wide range of backgrounds and interests. It will provide a more formal forum in which research and review papers will be published. The entire range of psychopharmacology will be covered, from drug effects on molecular systems to epidemiological studies. Research papers will form the bulk of each issue but critical review papers will be welcomed. Papers describing clinical trials will be accepted on their merits and papers from all over the world will be encouraged.

This journal will appear quarterly. Each issue will contain six to nine research papers, one or two reviews (solicited and unsolicited), and some brief communications. Editorials will be invited on topical and controversial matters. Book reviews and news of interest to psychopharmacologists will also be published. Occasional supplements dealing with major symposia and special issues are also intended.

This journal is being published by Oxford University Press, UK. The managing editor is Dr. R. Maggs, Pendower House, Hillcommon, Taunton, Somerset, UK. The editorial board consists of eminent UK scientists with expertise in the areas covered by the journal. The subscription rate for US subscribers is \$90.

#### Brain Dysfunction

This interdisciplinary journal was founded to advance the understanding of brain dysfunction caused by mental retardation, malnutrition, and aging. Experimental, clinical, and technical papers will report investigations on chromosomal abnormalities, genetically determined errors of metabolism, developmental anomalies, learning disabilities, and endocrine disorders. The journal will also provide readers with recent data on the correlation between nutrition and brain function and on early detection and treatment of aging-related disorders. The aim of this journal is to provide a prime source of up-to-date information concerning the etiopathogenesis and treatment of brain dysfunction.

The editors invite researchers and clinicians to submit original papers in English concerning the following areas: genetics, biochemistry, neurology, neuro- and psychophysiology, neuro- and psychopharmacology, neuro- and psychoendocrinology, pediatrics, and auxoendocrinology.

The managing editor is E. Segal, Rome, Italy and the editorial board is international in composition.

This journal is being published by S. Karger AG, P.O. Box CH-4009, Basel, Switzerland. The address in the US is: S. Karger Publishers Inc., 79 Fifth Avenue, New York, New York 10003. The Subscription price per volume with six issues is \$170 for institutional subscription and \$119 for personal subscription.

#### Journal of Chemical Neuroanatomy

During the past decade the field of chemical neuroanatomy has reached maturity, according to the editors of this new journal. Chemical neuroanatomy relates functional and biochemical aspects of the nervous system with its microscopic organization. This has been made possible by the proliferation of new and powerful methodologies in recent years. Among these are sensitive microassays, receptor autoradiography, hybridoma technology, improved immunocytochemistry, microdissection techniques, and *in situ* hybridization, to list just a few. The *Journal of Chemical Neuroanatomy* will be the natural vehicle for these integrated studies. The aim of the journal is to provide the means of publishing integrated studies of excellence in this emerging field of the neurosciences.

The journal will consider papers dealing with any aspect of the nervous system, including development, evolution, aging, behavioral aspects related to one or more neural systems--characterized on the basis of chemical neuroanatomy--and with methods used in studies such as those in immunohistochemistry, hybridocytochemistry, transplantation studies, receptor autoradiography, tissue culture experiments, etc. The journal will consider for publication manuscripts of an interdisciplinary nature, rather than those dealing solely with one discipline (for example, classical morphology).

The European Editor of this journal is: H.W.M. Steinbusch, Department of Pharmacology, Free University, van der Boechorstraat 7, 1081 BT Amsterdam, The Netherlands. The North American Editor is A.C. Cuellar, Department of Pharmacology and Therapeutics, McGill University, McIntyre Medical Sciences Building, 3655 Drummond Street, Montreal, Quebec H3G 1Y6, Canada. The editorial board is composed of an international group of scientists with expertise in the areas covered by the journal.

The subscription rate for Volume 1, 1988 (6 issues) is \$255. This new journal is being published by John Wiley and Sons Ltd, Baffins Lane, Chichester, Sussex PO19 1UD, UK. The US address is: John

Wiley and Sons Inc., 605 Fifth Avenue,  
New York, New York 10168.

Claire E. Zomzely-Neurath  
1/4/88

duck farms, which can achieve the very high yields at a fraction of current commercial costs, holds out hope for such protein-scarce countries."

C.J. Fox  
1/19/88

### FISHING IN THE DESERT

Amid the sand and gravel flats of Israel's Arava Valley, farmers participating in a unique experiment are literally pulling fish out of the desert--a record-setting 12 tons of fish annually per 1000 m<sup>2</sup> of pond area, according to a Tel Aviv University press release. Using a method devised by Tel Aviv University scientists, these farmers are breeding a specially developed hybrid *tilapia*--Israel's popular St. Peter's Fish--in high-salinity ponds fed by underground water sources.

Previously unexploited, such water sources proliferate throughout arid regions all over the world. They are high in mineral content and therefore rich in production of algae, which serve as a plentiful food source for certain eurythermic fish.

This new method of desert pisciculture was created by Professor Lev Fishelson of Tel Aviv University's Department of Zoology, and his students. Employing a new method for keeping the brackish waters clean, they found that fish density per square meter could be increased dramatically: in normal commercial ponds two or three *tilapia* can be raised per square meter, while the desert ponds yielded up to 30 fish per square meter without detriment to growth.

It was found that 80 percent of the *tilapia*'s metabolic demand could be met through the natural production of algae alone, which meant appreciable savings on feed. By efficiently utilizing the annual 360 days of sunshine, production was maintained all year round. Annual yields averaged over 40,000 kg per acre, 15 times higher than in normal commercial fish ponds.

In a related experiment, scientists bred ducks simultaneously in the fish ponds, feeding them mainly on grains and algae. The ducks, besides providing the farming community with an additional food source, produced waste which served as a natural means of fertilizing the ponds, thereby sustaining the food cycle.

Speaking of his development, Fishelson said, "The need for cheaper sources of animal protein for human consumption is assuming great importance worldwide. The development of integrated fish and

### EUROPEAN HEAT-PIPE TECHNOLOGY DEVELOPMENT AND APPLICATION

During a short tour of duty in the summer of 1987 at the Commissariat A L'Energie Atomique, Grenoble, France, and the Joint European Research Center, Ispra, Italy, I was able to observe the current state of European heat-pipe technology. This note reflects what I observed. [See page 54 for a discussion of a special-purpose heat-pipe oven.]

Heat pipes are passive, multiphase devices having apparent thermal conductivities hundreds of times greater than that of copper and able to transport large amounts of thermal energy with little temperature drop. A heat pipe consists of a closed volume containing the vapor and liquid phases of a working fluid circulating under the influence of some passive force. Figure 1 shows a simple heat pipe composed of a closed copper pipe internally lined with a water-saturated copper screen (wick). The screen mesh is filled with liquid water and the remainder of the internal volume is filled with water vapor. During operation, thermal energy is conducted through the pipe wall-liquid-wick causing evaporation of the working fluid at the vapor-liquid interface in the "evaporator" region. The vapor travels under the influence of a pressure gradient into the "condenser" region where it returns to the liquid phase, surrendering the latent heat of evaporation. This energy is conducted away through the wick-liquid-wall. The condensed liquid returns to the evaporator due to wick capillary forces which produce the pressure gradient driving the flow around the cycle.

The major thermal energy transport mechanism in a heat pipe is gross physical transport by moving vapor. The isothermal nature of a heat pipe is due to

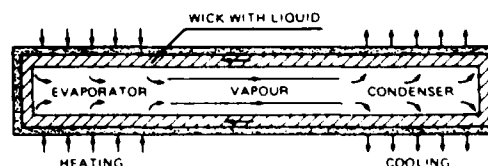


Figure 1. A heat-pipe schematic.

the thermodynamic principle that the liquid and vapor phases of a given working fluid coexist at the same temperature. Therefore, the vapor-liquid-wick region of a heat pipe is essentially isothermal. The temperature drop across a heat pipe from the evaporator outer wall to the condenser outer wall is due almost entirely to the conduction temperature drop through the walls and may be made as small as desired, consistent with pipe structural integrity.

Heat pipes have been built and operated with a wide range of structural materials and working fluids. Heat pipe fluid recirculation may be driven by capillary (surface tension) forces, by gravity (thermosyphon operating mode), by concentration gradients, or by any force which acts differentially on the vapor/liquid phases. Working fluids have included cryogenic hydrogen and nitrogen, ammonia, freons, water, mercury, sodium, potassium, lithium, and silver. Structural materials have included aluminum, copper, stainless steel, glass, graphite, tungsten, and molybdenum-rhenium alloys.

#### Applications

Heat pipes can be made to operate over a wide range of temperatures, transporting a wide range of heat fluxes, and producing isothermal (constant temperature) conditions over large areas. Heat pipes have been made as long as 16 m and as short as 5 mm. They have cooled infrared detectors, integrated circuits, travelling wave tubes, and other electronic components.

Virtually all spacecraft utilize heat pipes as thermal energy management devices and they are included in proposed space station systems. Heat pipes are being designed to cool the leading edges of supersonic aircraft, as well as cool the blades of high-performance jet engines. The isothermal aspect of heat pipes has found application in furnace temperature control for which temperature stabilities of  $\pm 10^{-6}$  (DT/T) have been demonstrated. These furnaces are very important wherever temperature control is crucial--e.g., in the diffusion dopant treating of semiconductor materials, allowing unprecedented uniformity and reduced wastage.

#### Research Needs

Existing heat-pipe theory is based almost entirely on steady-state analysis. Nevertheless, advanced applications require performance calculations for: high-speed transient conditions such as the rapid or uneven application of external energy; start-up/shutdown with frozen working fluid and noncontinuum vapor flow; advanced capillary structures for

increased energy throughput; priming/recovery of heat-pipe operation following adverse conditions. Materials and compatibility questions must also be answered for pipe performance at 1000 K (and above) and for unattended lifetimes of 10 years (and greater).

Frederick R. Pest  
3/27/87

#### MAJOR MATERIALS MEETING IN EUROPE 1988

Many meetings on materials are to be held in Europe during 1988. A selection of those that appear to me to be most promising are provided.

- *Fatigue Crack Growth*: 15-17 June; Paris, France. Contact: La Société Française de Métallurgie, 1-5 rue Paul-Cézanne, 75008 Paris, France; Tel: 1-45-63-17-10; Telex: Frasia 280172.
- *Ion-Beam Surface Modified Ceramic (NATO-ASI)*: 28 August to 9 September; Castelrecchio Pascal, Italy. Contact: Dr. Carl McHargue, Oak Ridge National Laboratory, Building 4500 S, P.O. Box X, Oak Ridge, Tennessee 37831.
- *11th European Crystallographical Meeting*: 28 August to 2 September; Vienna, Austria. Contact: Institut für Mineralogie Kristallographie und Strukturchemie, TU-Wien, Gestreidemarkt 9, A-1060 Wien, Austria; Tel: 0222-58-801; Telex: 131000 tvfaw a.
- *AntiWear '88*: 20-22 September; London, UK. Contact: Ms. J. Upton, Institute of Metals, 1 Carlton House Terrace, London SW1Y 5D8 UK; Tel: 01-839-4071; Telex: 8814813.
- *Carbon '88*: 18-23 September; Newcastle-upon-Tyne, UK. Contact: Conference Secretary, Carbon '88, Society of Chemical Industry, 14/15 Belgrave Square, London SW1X 8PS UK; Tel: 01-2553681; Telefax: 01-259-6286.
- *Residual Stresses*: 23-25 November; Nancy, France. Contact: ICRS 2, Société Française de Métallurgie, 1-5 rue Paul-Cézanne, 75008 Paris, France; Tel: 1-45-63-17-10; Telex: Frasia 280172.

Further information about these meetings can be obtained from me at the Office of Naval Research Branch Office, London. General enquiries about other meetings on Materials not listed here should also be addressed to me.

Louis Cartz  
1/5/88

# CONTROL RESEARCH AT THE TECHNICAL UNIVERSITY OF MUNICH

The Technical University of Munich (TUM), which is organized in the typical German pattern, has 268 institutes. I visited one of these institutes, the Institut und Lehrstuhl B für Mechanik, headed by Professor F. Pfeiffer. About 850 students are in the institute's vordiplom (beginning) courses but since the attrition rate is at the level of over 50 percent there are only 400 students in the hauptdiplom (last 2 years) part of the curriculum. The curriculum emphasizes robotics and the mechanics of robots. This emphasis carries over into the institute's research interests.

Twenty professional people work in the institute, nine of these supported by TUM and the other 11 by outside support (DFG, Volkswagen, AIF, etc.). The research can be divided into three areas--multibody dynamics, nonlinear vibrations, and rotor or gyroscopic dynamics--with some overlap between areas. Although emphasis would appear to be on the dynamics of motion there is also a large effort devoted to the control of the dynamics.

## Multibody Dynamics

Consideration is given to modeling concepts and to control concepts of multibody systems with applications to fast elastic robots, elastic gears, and elastic rotors. A multistage-approach to the dynamics and control of elastic robots was developed in a recent publication (Pfeiffer and Gilber, 1988). The control of an elastic robot along a reference trajectory which may border restricted area is performed in several stages. An optimal rigid robot trajectory is first calculated, with subsequent modification of the path by the inclusion of the elastic influence of the links and joints. This second step requires that the robot be modeled as an elastic multibody system. Control which dampens the oscillation of the elastic robot is obtained by feedback of strain gauge measurements of the elastic displacements. The modeling is demonstrated on a three-degree-of-freedom, elastic laboratory robot; the results for the tangential path deviations are shown in Figure 1, taken from the reference. Some of this work has been funded by Messerschmitt Bölkow-Blohm (MBB). Other recent work with respect to robots is the design of an optimal velocity profile for a prescribed path of the end effector (Johannni and Pfeiffer, 1987). Constraints of the joint velocities and the velocity of the end effector are taken into consideration. Other work, more in the area of dynamics, is a mathematical description of the transient

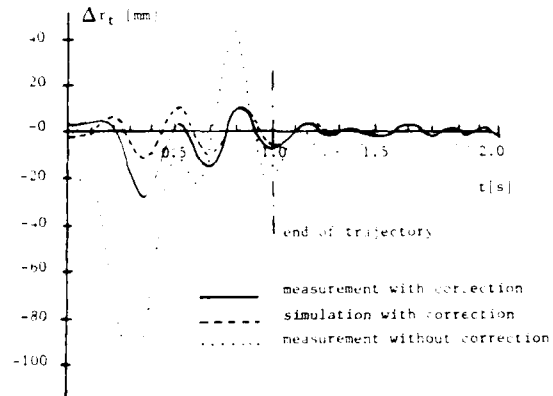


Figure 1. Deviation of robot endpoint with and without elastic correction;  $\Delta r_t$  = deviations in tangential path direction.

behavior of flexible rotors (Bremer, 1987). Using the Euler-Bernoulli hypothesis Bremer has shown that the governing equations have a very simple structure if the eigenstructure of the nonrotating state is inserted.

## Nonlinear Vibrations

In the nonlinear vibration area investigations are in progress on parametric-excited vibrations, self-excited vibrations, unsteady vibrational processes, and the active control of vibrations. Applications involve asymmetric rotors, gear boxes, and geared rotors.

An interesting current program is that connected with the characterization of a complex gear system of a motor by measurement of the complete sound field outside the housing (F. Kückay et al., 1986). It is thought that the measured sound field can be used as a diagnostic in maintenance and quality control. Based on an impulsive theory for multibody systems a method was presented for analysis of the vibration with a view to optimizing the essential parameters of the system--i.e., excitation form, tolerances, damping, and friction. The clattering noise is assumed to be proportional to energy losses due to impacts at the edges of the plays. Results appear to compare well with practical experience, particularly for diesel engines.

A experimental and theoretical program that is just beginning for the Motoren und Turbine Union (MTU) (see the following note) is an investigation of a frictional damper to alleviate flutter conditions of blades or aerofoils. This is a perennial problem of long standing in turbomachinery. Pfeiffer indicated that his group has a new theory connected

with friction damper and that results would be available on completion of a doctoral thesis.

#### Rotor Dynamics

The primary effort in rotor dynamics is directed at the study of elastic rotors and the active control of the vibrations of elastic rotors. In a series of papers, R. Ulbrich (1986) has developed a system for active control of the vibration of a flexible rotor. One of the key elements in the system is a rather elegant bearing-sensor unit. Incorporated into the magnetic bearing are noncontacting magnetic displacement and velocity sensors which permit active feedback control of the vibrations of the rotor. Another magnetic bearing is used as an actuator to apply forces to the rotor as a function of the feedback signal from the sensors and the chosen control law. Displacements and velocities may be measured from more than one bearing, and one can also have multiple actuators. A quite effective laboratory system, which was recently demonstrated at the Hannover Technical Fair, consisting of an unbalanced rotor and two actuators was shown to me. By means of feedback of displacements and velocities of the rotor to the two actuators the vibrations of the unbalanced rotor were easily eliminated.

#### Conclusion

The Institut und Lehrstuhl B für Mechanik approaches control problems from a dynamics or mechanics viewpoint with emphasis on the dynamics of multibody systems, nonlinear vibrations, and rotor dynamics. Because of this there is more unity in the type of control problems that the institute investigates than in a typical electrical engineering department. The institute has a nice balance between experiment and theory in that each of its areas of investigation is solidly based on experiments in the laboratory. Although many of the publications are listed in German there are also many publications in English. Very recent work appears to be published first in German, then extension to the work reported in English.

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Daniel J. Collins  
 12/30/87

#### APPLIED RESEARCH AT WEST GERMANY'S MOTOREN UND TURBINEN-UNION

The research environment of a country depends not only on its university and research institute activities but also on the support given by commercial companies in the applied research area. It is for this reason that I visited the Motoren- und Turbinen-Union (MTU) company in Munich, West Germany. MTU is active in the design, development, and testing of motors and turbomachinery. The company is not normally a prime contractor but is often a subcontractor on many engines and a large part of its effort is devoted to the design and manufacture of low-pressure turbines (LPT). MTU's activities may be divided into research, manufacturing, and testing.

#### Research

MTU's applied research is excellent, and they appear to have close connections with the Turbomachinery Institute of Aachen, run by H.E. Gallus, which is one of the best academic laboratories in West Germany. MTU's current research in turbomachinery is well represented by two recent AGARD papers given by MTU employees (Broichhausen and Gallus, 1987; Happel et al., 1987). Broichhausen along with Gallus investigated the performance and losses of transonic and supersonic axial compressors influenced by shock structure, shock/boundary-layer interactions, and boundary separation. Theoretical approaches based on semiempirical correlations for shock and boundary losses were compared with experimental measurements. Appropriate combinations of these models led to successful predictions of performance of the compressors over a wide range of performance. The method leads to a better understanding of the design of highly loaded supersonic compressors.

Happel described a time-marching finite area method to obtain along an axisymmetric stream surface the steady two-dimensional (2-D) blade-to-blade cascade solution with changing radius and stream

tube thickness. Using an explicit numerical scheme with first-order accuracy in space and time, numerical viscosity is added to achieve stability. Different methods of ensuring a zero normal velocity to the wall were investigated. Comparisons between schlieren photographs and computed isodensity lines for turbine blades show excellent agreement. Further comparisons of predicted isentropic Mach number with measured isentropic Mach number on the pressure and suction surface of a turbine rotor blade also showed excellent agreement. Comparisons for compressor blading where one has stronger shocks showed what could be called good agreement. The 2-D time-marching code has been integrated into a quasi-3-D code which has been effective in the 3-D design and analysis of turbomachinery.

Complementing the theoretical applied research is an extensive compressor-testing laboratory which will shortly have the capability of testing to a power level of 16,000 kW. The laboratory, as shown to me by H. Jackwerth, is well equipped with a Tektronics graphical display station, microprocessors for data reduction, scanivalves, 600 pressure taps, and 300 temperature taps. A large number of experimental measurements of velocity fields have been made with variable stators using laser anemometry based on the two-focus method. There is also an extensive effort based on the water analogy using transparent models. Cooling flows in rotor blades and combustion chambers have been investigated since 1984 in a fairly intensive manner in this laboratory.

Computing facilities include many Siemens 7891 PC's, which are IBM-compatible, and a Vax 8700 for more complicated calculations. For the 3-D Euler code calculations there will shortly be a direct hookup to a Cray XMP. MTU is starting to use computer aided design (CAD) in the analysis of complex systems. This latter work is facilitated by the existence of a subsidiary company engaged in the development of computer software and hardware.

#### Manufacturing

A large part of the effort of the company is directed at the development and manufacturing of turbomachinery parts and stages for both civilian and military engines. About 30 percent of the company's work is for the civilian sector with the remaining 70 percent for the military. MTU has cooperative work with almost all major engine manufacturers. Work is currently in progress on either the development or manufacture of spare parts for, among others, the following engines: RB 199 (Tornado), Larzac 04

(Alpha Jet), MTM 385 (helicopters), JT 8 D-200 (MD-80), CF 6-50/-80, and PW 2037/2040, PW 300. For Pratt and Whitney's PW 300, MTU is responsible for about 25 percent of the engine in the form of the low-pressure turbine (LPT) and its exhaust casing. The design and development of the LPT appears to be an area of strength for the company since on several of the other engine development projects MTU's effort is in this area.

The manufacturing plant is quite impressive in its display of advanced technologies; these include electric discharge machining, electrostream drilling, plasma spray coating, electron beam welding, laser beam machining, and friction or inertia welding. Powder-metalurgy is used in the manufacture of highly-stressed turbine components, and there is an active program directed at the use of composite materials in gas turbines.

#### Testing

In addition to its compressor testing laboratory MTU has just finished construction of the largest engine proof-testing facility in West Germany--the size of the building was determined by the needs of fan jet engine testing. A Hitachi NAS XL80 computer is used to collect, analyze, and present the data. Again, 600 pressure taps and 300 temperature taps are available, and unsteady measurements can be made at the rate of 1 per millisecond. The facility is intended for 200- and 600-hour engine proof-testing.

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Daniel J. Collins  
11/6/87

#### SECOND INTERNATIONAL CONFERENCE ON TETHERS IN SPACE

The second international conference on space tethers was held in Venice, Italy,

from 4 through 8 October, 1987. Preceding this meeting were the first international conference held in Arlington, Virginia in 1986, and two binational workshops, one in Williamsburg, Virginia, and the other in Venice, Italy. The primary driving mechanism for these sessions has been the bilateral agreement on space tethers between Italy's National Space Plan and the US's NASA. The major result of this agreement has been an Italian/US program to develop the Tethered Satellite System (TSS), so that a large portion of the meeting was taken over with discussion of TSS progress, although other applications of the tether concept were also considered.

#### The Tethered Satellite System

Space shuttle engineering tests of the space tether concept are planned for the early 1990's with the goal being to test the feasibility of deploying, controlling, and retrieving a tethered satellite from the Space Shuttle, as well as to demonstrate the system's usefulness for scientific research. As presently conceived, the system consists of an instrumented satellite to be deployed at the end of a thin, flexible tether (about 2 mm in diameter and up to 100 km in length) attached to an enhanced Spacelab pallet mounted in the shuttle cargo bay. Aeritalia Space Systems Group is the Italian prime contractor responsible for the satellite, while Martin-Marietta Aerospace (Denver) is the American prime contractor responsible for the deployment mechanism and tether.

Two TSS missions are currently planned:

- An electrodynamic mission to study the earth's ionosphere and magnetic field using an electrically conducting tether with satellite deployed spaceward
- An atmospheric mission devoted to studies of the earth's upper atmosphere in which the tether and satellite are deployed earthward.

Both of these projects were discussed in the technical sessions, and both the prime contractors had displays illustrating current progress in hardware development. It appears that TSS is on track and will be ready to fly when shuttle space becomes available in the early 1990's.

#### Other Tether Concepts

Many ideas for the application of the tether concept were presented at this meeting. At times it was difficult for me to separate the science from the science fiction, but a list of the more reasonable suggestions appears below.

1. A module, or space elevator, capable of crawling in a controlled manner along a deployed tether could be used for variable microgravity studies, transport between two tethered bodies, system center of gravity management, tether inspection and repair, sounding sensors, and as a carrier for reentry probes.

2. A conducting tether could be used to generate DC electrical power as it moves through the earth's magnetic field.

3. By lowering an instrumented, aerodynamic model into the upper reaches of the atmosphere, a tethered open, continuous wind tunnel could be produced.

4. A tethered system combined with an elevator carrier could be used to return materials to earth (or dispose of them through atmospheric burnup) without the use of rockets.

5. Tether dynamics make it possible to deploy a payload (e.g., a satellite) into a higher orbit from a spacecraft (e.g., shuttle) in low-earth orbit using momentum transfer.

6. Active control of a movable attachment point on a tethered body represents a new method of attitude control on orbital platforms such as the shuttle or space station.

7. Because of the gravity gradient that results from tethering, a tethered system is self-orienting along the local vertical. This feature could be used during construction activities in space to maintain correct orientations between components.

8. A conducting tether system could be the basis of an orbiting long antenna suitable for use with ELF, ULF, and VLF communications systems.

9. It may be possible to conduct atmospheric studies at different levels with good time correlation of measurements by stringing several instrumented probes along a tether deployed earthward from a spacecraft.

#### Oceanic and Atmospheric Applications

Aside from the general discussion and listing of possible specific applications, a few of the papers indicated some ongoing work has a marine or atmospheric science flavor. Simulation of a synthetic aperture radar (SAR) interferometric scheme used to produce three-dimensional images was described by A. Moccia and his group at the University of Naples, Italy. They modeled a system with antennae separated by 1 km where constancy of separation, attitude, and relative direction were considered to be important. Their results indicate such a system would work with electronic beam steering of the antennae and the usual SAR data-processing techniques.

The general problem of doing atmospheric research with tethered vehicles was addressed by J.W. Slowey, Smithsonian Astrophysical Laboratory, Massachusetts. He indicated that expected changes in some parameters at altitudes above 100 km would probably be much greater than we have previously experienced. Changes in density at 200 km, for example, may be as much as 100 percent over a time span of just a few hours. Nevertheless, measurements of chemical constituents and UV at these altitudes are badly needed. Since the use of tethers provides a possible mechanism to obtain long-term continuous data, J.D. Anderson indicated that a list of outer atmosphere tether experiments is now being compiled.

#### Summary

As a result of attending this conference, I am now convinced that the concept of tethers in space is completely feasible. It is also apparent to me that this methodology makes it possible to acquire atmospheric and oceanic data heretofore out of reach. If the initial proof of concept experiments such as the TSS work out when performed in the early 1990's, very powerful tools will become available to environmental scientists. The people at this Tethers in Space conference appeared to be unanimous in their belief that the TSS missions would be successful.

*Jerome Williams*  
11/20/87

#### THE REMOTE SENSING GROUP AT THE UNIVERSITY OF NAPLES

Tucked away in the Istituto di Gasdinamica, Facolta di Ingegneria at the Universita Degli Studi di Napoli, is a small remote sensing group headed by Professor Sergio Vetrella. Although numbering only seven professional people, the group has successfully completed many studies and has built an enviable reputation for itself. This is in part due to the decision of Vetrella to limit the group's activities almost exclusively to simulation studies.

#### Tethered Satellite Simulations

Most of the projects undertaken by Vetrella's people originate with parties having a specific mission or task in mind. User requirements, available hardware, and the mission description are combined with ambient environmental data, geometrical and locational effects, and

other pertinent information to produce a suitable computer simulation. A continual feedback process is used to refine the model and redefine the mission as more data become available.

Among those projects having the highest interest level with the University of Naples team are those having to do with tethered satellites. Work is being done on simulation of a number of factors associated with double satellites (two satellites connected by a tether) and with satellites tethered to a space station. Some of this work is being done in conjunction with the Smithsonian Astrophysical Laboratory, which is also developing simulation models independently. The tethered satellite models include both mechanical and sensor simulation scenarios. Mechanical parameters under study include tether properties such as weight, flexibility, length, resonant oscillation frequencies, optimal system rotational rates, and drag effects. Temperature effects are also important since heating from solar radiation may change cable length by as much as 100 meters because of the lack of any heat loss mechanisms except back-radiation.

The group's study of sensor problems deals mainly with the use of a dual sensor system where the two sensors are joined by a flexible coupling. These include both stereoscopic and interferometric systems using optical as well as microwave sensors. Changes in parameters such as altitude, attitude, spacing, sun contamination, relative motion, and sensor aging are being simulated to aid in sensor design and deployment by determining the relative sensitivity of the various factors involved. One such device undergoing simulation modeling is a projected synthetic aperture radar (SAR) interferometer, for possible use aboard the space platform or a space shuttle. It consists of single-source and dual-receiving antennae, with the second antenna mounted on the tethered satellite. The resulting stereo images are expected to markedly improve the effectiveness of the SAR system, especially in the areas of sea-state monitoring and tracking moving objects.

#### Other Simulation Studies

One of the first software projects undertaken by the newly formed group in 1968 was the simulation of the geometric errors common to all satellite images. The resulting program has been highly successful and is used as a package in just about all projects tackled by the group. Other characteristics being simulated include orbit parameters, sensor attitude, precision of location determination, geographic coordinate relations,

and atmospheric refractive effects. This latter parameter is particularly important when dealing with high-resolution sensors, and present models allow the utilization of standard atmospheric profiles, actual data, or any combination of the two. A rather detailed analysis has been accomplished for the high-resolution pushbroom sensor, such as used on SPOT, with particular attention to the degradation of high-frequency data resulting from dynamic morphology. Other special problem areas associated with SPOT, such as the translation of altitude and nadir angle errors to inaccuracies in horizontal location and local elevation, are also being considered.

Active microwave sensors such as SAR are being studied in great detail, reflecting the strong interest of the oceanic remote sensing community. A simulation of the X-band SAR to be used on the next shuttle mission includes data from fixed corner reflectors serving as image intensity standards as well as points of known location. Another SAR project, called Maestro, is being accomplished in conjunction with NASA. Here, C- and L-band radars are being used with the Naples University X-band gear in a program designed to calibrate water surfaces and relate the different radar types by setting corner reflectors on a conveniently located lake.

Another capability of more than passing interest is the group's capacity for simulating various target characteristics. Backscattering properties of any geometric shape (or any linear combination of any two or more shapes) allow the determination of the relationships between SAR signals of any frequency and simple-shape topographic features. A special SAR processor has been developed that digitizes analog data and allows the use of data from aircraft, shuttle, and satellite platforms.

#### Computer Facilities

With the resulting high levels of expertise and specialization, it has apparently been relatively easy to justify the acquisition of very good computer facilities, dedicated to the group. The present system is third generation and has as its core a 32-bit Gould computer, similar to a VAX 750. Peripheral elements allow for data analysis, digitization of images, integration of different types of data and models, and the development and testing of new simulation approaches. As the models developed by the group have become more and more sophisticated, the computer requirements have increased in proportion. It has gotten to the point where some of the programs being run require as much as 5 days of computer time.

As a result, within a short period of time it is expected that an upgrade to the equivalent of a VAX 780 will be completed.

#### Software

The institute has vigorously supported development of its own software. All the software used by the group has been developed in house, so that a single format is common to all projects. In addition, the intimate familiarity with the software resulting from the development process allows them to verify existing programs with relative ease, which is especially important when a number of programs have to be modified at the same time. This entire process is greatly aided by the fact that most of the people in the group have been there since its inception, so that the corporate memory is large. One of the areas where the software development has been particularly impressive is in the conversion of analytical to digital models. The Naples group appears to accomplish this with more ease than most other groups can.

#### Conclusion

The performance of this relatively small collection of scientists, engineers, and technicians at the University of Naples is an excellent demonstration of what can be accomplished with strong, informed, and imaginative leadership coupled with adequate resources and dedicated people. Professor Vetrella, primarily by limiting the scope of his group's efforts, while at the same time providing maximum support, has molded one of the best, if not the very best, remote sensing simulation groups in Europe. The work they produce is not only of high quality, but it is also unique in many areas. I was very favorably impressed with what was going on in Naples, and it would seem desirable for all those with an interest in remote sensing simulation to keep a close watch on the activities and output of these people.

Jerome Williams  
9/15/87

#### THE SCOTTISH MARINE BIOLOGICAL ASSOCIATION AT OBAN

Located on the western coast of Scotland, 3 hours from Glasgow by train, the Scottish Marine Biological Association (SMBA) occupies a relatively new facility in the mist of an environment

rich in lakes, rivers, fiords, estuaries, and embayments of all types. Consequently, there is an almost endless number of different types of natural laboratories available within close proximity of the lab. Judging by the wide variety of active projects in evidence as I toured SMBA, many of these natural environments are being used by the different investigators. Although SMBA was founded in 1905, it has only been in its present quarters for the last 10 years, so the facility is quite modern and well maintained. As might be expected from the institutional name, much of the work done here is biological in nature, with some chemical, physical, and geological support. There is, however, a sizeable amount of physical oceanographic research being done independently at SMBA, as is described below.

#### Physical Oceanography

Out of a total professional staff of about 80 at SMBA, somewhere between 8 and 10 are employed in the physical area. This includes a small, but active, group concerned with instrument design, development, repair, and modification. There are also a couple of support people in the computer area. A great deal of emphasis is placed on acquiring a better knowledge of the surrounding Scottish waters, as may be seen from the nature of typical current projects. One of these is a study of the circulation west of Scotland using radiocesium isotopes whose source is wastewater discharging into the Irish sea from the Windscale nuclear fuel processing plant at Sellafield. Another venture is concerned with currents in the Rockall Channel using data from both drifting buoys and moored current meters. A recent experiment using 12 drifting buoys was able to follow water mass movement of waters coming from the Norwegian Sea. This study has also included salinity and temperature data to help in tracking water mass movements.

Other areas of concern have included the Clyde Sea and the Inner Hebrides, both of which have been the subject of rather extensive hydrographic surveys. Attention has also been given to the Faroe-Shetland Channel and the Faroe Bank, where an anticyclonic circulation has been verified through the use of drifting drogues. In the Channel a salinity-temperature time series dating back to 1902 has allowed the review of variations in these parameters of both seasonal and multiyear periodicity. Examination of a similar long-term time series for northeast Atlantic salinities and temperatures has shown a major salinity anomaly of about 0.1 ppt occurring during the period between 1970 and 1980.

On a completely different note, an attempt is being made to calibrate airborne synthetic aperture radar (SAR) systems with flights over a nearby loch that is almost rectangular in shape with a length of about 10 miles and a width of about 1 mile. Efforts are also under way to calibrate HF Ocean Surface Current Radar (OSCAR) using a commercial rotor-type current meter modified in-house to measure near-surface currents. Plans are being made to use this device, along with conventional current profilers, in the upcoming North Sea Project for both monitoring and research activities. Enough data are to be obtained so that a reasonable estimate of current extreme values, both temporal and spatial, can be made.

A small amount of numerical modeling is done at SMBA, since there is a tie-in to the national computer system, but most of the effort in this area is in the application of existing models (such as Pingree's tidal model) to local areas. In addition to working on its own programs then, the physical group is able to offer support to biological and chemical programs in the areas of modeling, dynamics, and instrumentation.

#### Marine Biology

As might be expected from an old, established laboratory such as this one, there is a large, ongoing effort in what might be considered "classical" marine biology. A rather extensive collection of organisms is supported which is being continually updated and cataloged, and is available for study by outside investigators. Plankton culture is also emphasized, with new methods being continually examined and large stocks of selected phytoplankton types maintained to supply seed stock to other laboratories and material for in-house experiments. Plankton energetics are being considered as industrial pollution problems are being addressed and the effect of frontal systems on plankton populations are being studied.

The marine biologists are participating in a number of interdisciplinary programs that include chemical, geological, and physical inputs. One of these is concerned with the analysis of sediments and benthic organisms in relation to pollution. The laboratory has developed a new coring mechanism that successfully recovers an undisturbed sample of the bottom and the overlying water (about 6 inches of each) to provide samples for these analyses. Other benthic studies include the nature of organic degradation in sediments and the use of mussels as possible pollution indicators.

Other projects include work on the classification of the acoustic reflectance properties of various fishes with swim bladders, and the relation of target strength from these fish to their orientation with respect to irradiating beam direction. Some effort is also being expended in nutrient chemistry in an attempt to determine and quantify the key regulatory elements in productivity by looking at and comparing productivity values in different geographical areas. Of particular value in this study is a data set acquired over a period of 15 years in a thermally enriched area.

#### Summary

The Scottish Marine Biological Association is a modern, well-equipped, and well-situated laboratory engaged in a wide range of studies. Dormitory accommodations, along with laboratory and lecture facilities are available, so the SMBA is used by most Scottish universities for summer marine science courses. In addition, visiting scientists can be supported with laboratory and office space. I was very impressed with both the quantity and quality of the work being done here, some of it quite unique, and all of it interesting and well done.

*Jerome Williams*  
10/28/87

#### REMOTE SENSING AT THE UNIVERSITY OF DUNDEE

The Physics Department at the University of Dundee has been involved in image analysis of oceanic and atmospheric remote sensing data for almost 20 years, and is the acknowledged leader in this field among British universities. Just recently a reorganization has placed physics in a renamed Department of Applied Physics and Electronic and Manufactured Engineering (DAPEME), which may make the remote sensing activity even more efficient. The kingpin of this effort at Dundee is Professor A.P. Cracknell, who described their remote sensing activities to me during my recent visit.

#### Academic Programs

A program leading to a masters degree is offered by the department in the general area of "Remote Sensing, Image Processing, and Applications." It consists of lecture and laboratory courses covering the physical and engineering principles of remote sensing data acquisition and handling; optical and digital image processing and pattern analysis

techniques; and cartographic and environmental scientific and engineering applications of remote sensing data and techniques. All types of applications of remote sensing techniques are covered, but special attention is given to atmospheric and marine applications. With proper preparation, the program is designed to be completed in 12 months, with half being devoted to formal instruction and half to project work at some cooperation remote sensing institution.

#### Research Programs

Although the newly formed department has 32 staff members, only about six of these are directly engaged in remote sensing activities. These activities include image processing software development, atmospheric correction algorithm development, and data processing and interpretation. Data are obtained from multispectral and pushbroom scanners, both from unmanned satellites and manned aircraft, as well as large-format cameras, such as those flown on Shuttle missions. The objectives of this program are first to obtain a greater understanding of the nature of the reflection and emission processes at the surface of the earth and the transmission of electromagnetic radiation through the atmosphere. The second objective is to use this greater understanding in the extraction of geophysical parameters from the data. These data are being utilized in the following applications:

- Description of marine geophysical processes
- Coastal mapping
- Study of coastal erosion
- Bathymetry
- Monitoring pollution
- Monitoring sea-surface temperature
- Study of oceanic fronts and eddies
- Development and use of image processing software.

#### Software Development

Algorithms have been developed and computer programs written for the atmospheric correction of data from the visible channels of various sensors such as the Coastal Zone Color Scanner (CZCS). Using these corrections, further algorithms have been developed for the determination of chlorophyll and suspended sediment in differing water types varying from turbid estuaries to relatively clear open ocean water.

At the present time software development is proceeding so that when the new generation of remote sensing satellites comes on line, the Dundee group will be prepared to handle the data immediately. These include the new LANDSAT and

SPOT series, ERS-1, and perhaps even NROSS.

One of the more interesting projects that DAPEME has pursued quite effectively is the development of image analysis software suitable for use on personal computers. Both the BBC and the IBM microcomputers have been considered and discs are now available for both types of computers. These are reasonably priced (about \$90), and since data discs are also readily available for both computers, just about anyone interested in teaching the fundamentals of image processing can easily provide the necessary support materials. Even basic image processing can be done with this software. Future information may be obtained from Professor A.P. Cracknell, Department of Applied Physics and Electronic and Manufacturing Engineering, University of Dundee, Dundee, DD1 4HN, Scotland, UK.

#### Summary

The remote sensing group at the University of Dundee has followed an independent and innovative research path ever since its formation almost 20 years ago, and continues to do so today. Being acknowledged leaders in the field, the group has attracted graduate students, and at the present time there are about 10 of them pursuing advanced programs in remote sensing. Although the research activities within DAPEME are of high quality by anyone's standards, Dundee's major contribution to British science might very well be the continuing production of a significant number of scientists who are not only aware of the power and limitations of remote sensing techniques, but are also adept at using them to maximum advantage. In addition to the more traditional training of remote sensing specialists, the department is able to offer summer courses of a more general nature to give environmental science workers a broad foundation in those areas of the field in which they have particular interest.

I was impressed with just about everything I saw at Dundee, and I believe that as long as Professor Cracknell stays there he will continue to set the standards by which other institutions are judged.

Jerome Williams  
10/28/87

#### THICK-FILM HYBRID MICROELECTRONIC PACKAGES USED IN MAGNETOMETER PROJECT

The Naval and Electronic Systems Division at British Aerospace (BAe) is currently producing a three-axes magnetometer to be employed as a sensor in the standby heading system for the new SAAB-JAS39-Gripen multirole combat aircraft. The magnetometer is a strapdown device, containing no moving parts. It senses the Earth's magnetic field along three orthogonal axes and thereby provides essential attitude reference data. An important requirement for highly sensitive functioning of the magnetometer device is that it should have a very low magnetic signature. In the BAe project this is achieved by using, in the electronics of the sensor, novel thick-film hybrid microelectronic packages of different designs. These packages, termed "Mynapaks," have been developed (and are now supplied in quantity) by the Microelectronic Technology Center of the Air Weapons Division of BAe.

A Mynapak comprises a ceramic substrate with up to three separate conducting layers. The integrated circuits and other components mounted directly on the substrate are electrically connected by gold wires to the uppermost gold circuit layer. Screen-printed resistors may be included in the circuit patterns. These patterns are laser-trimmed with unusual accuracy. A peripheral ceramic frame fused to the substrate base encloses the components. A kovar or ceramic cover fused to the frame completes a Mynapak package. The package is filled with nitrogen.

Apart from low magnetic signature, a Mynapak has a high component density and excellent heat dissipation characteristics. (Mynapaks can cope with heat dissipation intensities of up to 0.155 W/cm<sup>2</sup>.)

For further information contact directly Mr. S. Raynes, British Aerospace, Manor Road, Hatfield, AL10 9LL, UK. Telephone (011-44) 7072-62300.

Paul Roman  
8/28/87

#### TRANSVERSE EFFECTS IN OPTICAL BISTABILITY--A SPECIAL SESSION SPONSORED BY ONR-LONDON

A NATO-ASI school on "Instabilities and Chaos in Quantum Optics" took place in Lucca, Italy, from June 26 through July 6 1987. This was followed, July 8

through 10, by an International Workshop on Instabilities, Nonlinear Dynamics, and chaos in Quantum Optics. Taking advantage of the assembly for two related meetings of many outstanding experts, the Office of Naval Research Branch Office, London (ONRL) sponsored a freestanding special research seminar session for the day between the two conferences. The session, titled "Transverse effects in optical bistability," held on July 7, consisted of three, hour-long invited talks and much informal discussion. The director of the seminars was Professor M. Inguscio, Naples University, Italy.

The full texts of the three special seminars, together with the lectures of the entire International Workshop, are scheduled to be published in early 1988 by Plenum Press, under the title "Instabilities and Chaos in Quantum Optics," with N.B. Abraham, F.T. Arecchi, and L. Lugiato as editors. Following is a brief review of the three presentations.

#### Spatial Dissipative Structures

L.A. Lugiato (Department of Physics, Polytechnic, Torino, Italy) talked about spatial dissipative structures arising in connection with transverse effects. Lugiato first pointed out that no phenomena in optics have been found so far that would exhibit the spontaneous onset of a *spatial* dissipative structure. While such systems are well known to occur in other areas governed by nonlinear dynamics (such as in nonlinear chemical reactions), all familiar unstable phenomena in optics lead to the spontaneous onset of a *temporal* structure.

Lugiato then presented his recent research (done in collaboration with R. Lefever, University of Bruxelles, Belgium) in which he proposed a theoretical model of an optical system that displays the onset of a spatial stationary, transversal dissipative structure. The model consists of a rectangular cavity filled with a passive medium which has a third-order nonlinear refractive index (leading to self-focusing effects). The endplates in the longitudinal direction have a (small) finite transmissivity, while the side walls are perfectly reflecting. Hence, the cavity supports modes of the form

$$\cos(\pi n_x x/b) \cos(\pi n_y y/b) \cos(\pi n_z z/L),$$

where  $b$  is the X- and Y-direction length,  $L$  the length along the Z direction of the cavity, and  $n_x, n_y, n_z$ , are non-negative integers. The slab is longitudinally injected with a coherent, stationary plane wave field. Lugiato's model then describes the time evolution of the transmitted field, and incorporates diffraction. The model admits a transversally

homogeneous stationary solution and, for a sufficiently large value of the detuning parameter, displays bistability. The linear stability analysis shows that the stationary solution becomes unstable against the growth of the transverse mode (labeled by  $n_x, n_y$ ) when certain inequality conditions on the transmitted intensity and on  $n_x^2 + n_y^2$  are fulfilled. Essentially, the robust instability arises because there can evolve transverse modes whose frequency distance from the homogeneous mode is near to the value of the modal width. Hence, these modes compete, and via the instability give rise to a spatial coexistence, quite different from the temporal coexistence that arises in several oscillatory behaviors. A bifurcation-theoretical analysis was performed, and the major result is the prediction that a plane wave input field can be spontaneously converted into a *stationary* transmitted beam which presents a transverse grating structure (filamentation). Experimental test of this prediction was urged by Lugiato.

#### Nonlinear Optical Waves

Instability and propagation of nonlinear optical waves in layered dielectric structures was the subject of the talk given by J.V. Moloney (Department of Physics, Heriot-Watt University, Riccarton-Edinburgh, UK). He reminded the audience that, in recent years, the existence of exotic nonlinear guided waves (whose shapes are dependent upon the incident flux) has stimulated considerable theoretical interest, partly also because these nonlinear wave solutions suggest a variety of "all-optical" device applications. Moloney then expressed his strong opinion that the traditional approach to the theoretical analysis of nonlinear interfaces and waveguides is much too restrictive, yielding at most equilibrium solutions. Stability properties of these equilibrium solutions cannot be addressed within the framework of equilibrium solutions. Moreover, he noted, experience with numerical simulations established the existence of a much broader class of nonstationary waves which may be approximated in some instances by perturbed spatial solitons. Moloney's and his colleagues' recent work has addressed the more general propagation problem which may be posed as a nonlinear partial differential equation often called "nonlinear Schrödinger equation." The possibility of soliton-like nonlinear waves is immediately evident from the nature of the nonlinear evolution equation. The stability properties of some of the equilibrium waves could be established by direct analysis of the original partial

differential equation, and they have been confirmed by direct numerical simulation.

In the following--and more detailed--part of his presentation, Moloney described what he called "an equivalent particle theory," recently being developed in cooperation with A. Aceves and A.C. Newell. This study attempts to understand the global dynamical features of nonlinear waves at interfaces and in planar waveguides. The theory has proved remarkably successful in (1) establishing the stability properties of surface polariton waves at nonlinear interfaces, (2) predicting the trajectories of optical beams incident at an angle close to that for total internal reflection on a single (and at multiple) nonlinear interfaces, and (3) providing an analytic formula for the nonlinear Goos-Haanchen shift. The equivalent particle theory for interfaces was discussed in Moloney's talk both from an analytic and a numerical point of view. He also presented first results on the full three-dimensional problem, showing a new instability of the modulation type.

#### Spatial Chaos in Bistable Optical Arrays

The third talk in the special seminar session was given by W.J. Firth (Department of Physics, University of Strathclyde, Glasgow, UK). He discussed the topic of spatial chaos in bistable optical arrays, which has future relevance for areas such as optical computing and image processing. Firth pointed out that mutual coupling (cross-talk) between elements of an array of bistable elements can lead to collective states of the system, undermining the independence of each element or "pixel." He developed an analogy between diffusive coupling and nonlinear dynamics and established a correspondence between chaos in the dynamics and pixel independence. In his analysis of cross-talk between elements of arrays of optically bistable elements, Firth assumed that diffraction and other optical couplings can be neglected, so that diffusion is the sole coupling mechanism. By implementing a code that treats both diffraction and diffusion, he and his coworkers confirmed that this is a good approximation for media in which the transverse diffusion length is much larger than the Rayleigh range. Firth emphasized that analysis of the model builds on two dynamical analogies. The stability of pixel patterns (the "on" and "off" states) is governed by a Schrödinger-like equation, while the possible patterns in linear arrays are determined by an equation equivalent to the classical dynamics of a driven hyperbolic oscillator--this dynamics is well known to be generally chaotic. In the concluding remarks Firth

admitted that he could, so far, deal only with the problem for one-dimensional arrays. Moreover, he dealt only with a very specific form of cross-talk, and it would be interesting to see how general the conclusions are, for example, for mixed diffusive-diffractive cross-talk, for thermal coupling, or for systems which are physically pixelized to inhibit diffusion. In each case the question of how closely pixels can be packed will arise, and it is likely that the current considerations will retain some relevance even in more realistic complex systems.

*Paul Foman*  
9/8/87

#### SIGNIFICANT PROGRESS IN ORGANIC NONLINEAR OPTICAL MATERIALS

Under the aegis of the European Joint Opto-Electronic Research Scheme (JOERS) and with the support of UK government grants, collaborative work between Queen Mary College (London) and the GEC Hirst Research Center (Wembley) led to the successful growing and optoelectronic testing of 2-(N,N-dimethylamino)-5-nitroacetanilide single-crystals (for short: DAN). Initial powder experiments showed that DAN, due to its delocalized electronic system characteristic of conjugated organic molecules, may have an unusually high second-order optical nonlinear coefficient. Eventually, single-crystals of sufficient size were grown and tested in second-harmonic-generation experiments. A typical crystal measured 5×3×2 mm. Linearly polarized light for a Q-switched Nd:YAG laser (1.064-μm wavelength) operated in 10-ns pulse-mode was passed through the crystal placed in proper phase-matching position. The laser beam pulse energy varied between 0.5 mJ and 2 mJ. Throughout this range, a second-harmonic conversion efficiency (into 0.532-μm radiation) of 20 percent was observed. (This should be compared to the 2-percent conversion efficiency of a 15-mm-long conventional KD\*P crystal at the same frequency and in the same energy range.) The scientists think that by using optically polished input and output faces, and by optimizing the crystal's orientation, significantly higher efficiencies may be eventually obtained.

More recent experiments with 1.3-μm fundamental beams (pulsed at 7-ns rate and having an energy of 0.5 mJ) showed that the DAN crystals have, under these conditions, an 18-percent second-harmonic conversion rate. Long-term plans aim at

using DAN for optical parametric amplification (leading to tunable sources).

While other optically nonlinear organic materials are now also known, DAN excels not only because of the high conversion rate, but also because it has a relatively high melting point (166.7°C). In addition, it has a very short (picosecond) response time.

Further information may be available from Dr. C. Hilsum, FRS, Director of Research, GEC Hirst Research Centre, East Lane, Wembley, HA9 7PP, UK.

Paul Roman  
12/16/87

#### SOME SPANISH PROGRAMS IN OPTICS AND ELECTRONICS

In a recent contribution (ESNIB 88-01), I gave a general characterization of the role and activities of the Spanish Council for Scientific Research (CSIC). In this brief note, I want to list some of the current CSIC projects that fall in one of my specific fields of interest, and wish to let you know that details of these (and related) Spanish research projects are available on request.

- Surfaces of solids and interfaces (basic physics studies)
- Optical properties of microcrystalline materials in the infrared domain
- Silicon and GaAs materials (especially study of contacts and interconnections)
- Interfaces in microelectronics and optoelectronics
- New optoelectronic materials and their study (as well as production) by laser processing techniques
- High-resolution molecular spectroscopy
- Nonlinear Raman laser spectroscopy
- Infrared laser spectroscopy of free-radical luminescence
- A variety of physico-chemical laser applications
- Quasi-two-dimensional systems and the study of their electronic properties
- Infrared optical properties of microcrystalline oxide systems
- Optical and digital methods for image recognition and analysis
- Fabrication of novel optoelectronic materials.

Please address your requests to me at ONR London, and--most important--be specific about the information you want.

Paul Roman  
4/30/87

#### ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two DOD employees for registration-free participants 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. (Please site reference number.)

Second Conference on Hyperbolic Problems, Aachen, West Germany, March 1988. (81009)

Structure and Function of the Cytoskeleton, Lyon, France, April 1988. (81005)

Modulation of Short Wind Waves in the Gravity-Capillary Range by Nonuniform Currents, Gergenaan-Zee, the Netherlands, 3-5 May 1988. (81006)

A Critical Analysis of Synthetic Aperture Radar, Capri, Italy, 14-16 May 1988. (81014)

Critical Currents in High  $T_c$  Superconductors, Birmingham, UK, 16 May 1988. (81021)

Spring School on Surface and Technology, Ankara, Turkey, May 1988. (81024)

11th European Conference on Thermophysical Properties, Umea, Sweden, 13-16 June 1988. (810017)

Conference on Mathematical Methods in Computer Aided Geometric Design, Oslo, Norway, 16-22 June 1988. (810019)

Symposium on Ontogeny of Neural Peptides, Jerusalem, Israel, 19-24 June 1988. (81007)

Dynamics of Protein Development and Function, Heidelberg, West Germany, 26 June-1 July 1988. (81008)

3rd Annual Conference on Operator Theory and Operator Algebras, Cork, Ireland, 29 June-2 July 1988. (810016)

Symposium on Application of Laser Anemometry to Fluid Mechanics, Lisbon, Portugal, 11-14 July 1988. (81009)

Nonlinear Problems and Symmetries, Schloss Hofen, Austria, 25-29 July 1988. (81010)

Solid Compounds of Transition Materials, Oxford, UK, 4-8 July 1988. (81011)

Thermodynamics Applied to Biological Systems, Sta Margherita, Italy, 11-17 September 1988. (81012)

Physical Mechanisms in Polymer Failure, Lausanne, Switzerland, 16-30 September 1988. (810023)

Technical Development in the Area of Submillimeter and Far Infrared Technology, Zermatt, Switzerland, 22-25 September 1988. (81022)

2nd Workshop on Imagery and Cognition, Padorna, Italy, 21-23 September 1988. (810018)

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.

Biological Sciences

*Fourth European Conference on Biotechnology*, by Claire E. Zomzely-Neurath. (8-001-C) Presentations in selected topics given at this meeting, held in June 1987, are summarized. Based on the variety and depth of the presentations at this conference as compared to those at the conference in previous years, the author states that biotechnology research in Europe has expanded tremendously and that European scientists are in the forefront of research in biotechnology.

*Biotechnology Congress: BIOTECHNICA '87 Hannover*, by Claire E. Zomzely-Neurath. (8-002-C) This is a summary of the third international exhibition and congress for biotechnology, held in September 1987 at Hannover, West Germany. Topics of the presentations reviewed are polypeptides in therapy, enzymatic and microbial transformation, and fundamentals of bioprocess engineering.

*International Conference on Separations for Biotechnology: Reading, UK*, by Claire E. Zomzely-Neurath. (8-003-C) Selected presentations given at this conference, held in September 1987, are reviewed. Topics are: cell harvesting and disruption, adsorption and chromatography, analytic techniques and process control, liquid-liquid extraction, and membrane extraction.

Material Sciences

*Nitrogen Ceramics Meeting in France*, by Louis Cartz. (8-004-C) Presentations given at this meeting--JEN17--held in Rennes, France, in September 1987, are briefly reported. A very wide range of nitrogen ceramics properties was discussed at the meeting, in particular, their chemistry, crystallography, and sintering behavior.

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. Kurt H. Stern, Surface Chemistry Branch, Naval Research Laboratory, Washington, DC 20375-5000.*

Dr. Stern visited Billinten Research--the chief shell laboratory devoted to metallurgy--in Arnhem, the Netherlands, in September 1987. Billinten's 200 or so scientists and engineers study processes (from basic research through pilot plant production) which are likely to make a profit for the company. He says of this well-focused operation that, being all in one location, the scientists and engineers work together to see that the products of research result not just in publications or patents, but in materials for use in industrial production.

Stern spent most of his time with the group concerned with electrowinning of refractory metals from molten salts. One of their processes which is rather far along is the production of pure titanium by the electrolysis of titanium chloride in a molten halide bath. The reduced titanium dissolves in a molten zinc cathode which is periodically drawn off as it becomes enriched in titanium, and the zinc is removed by distillation and recycled. The purity of the titanium is quite high and the process appears to have definite advantages over the standard Kroll process.

Stern says that the staff, numbering 20-30 in electrochemistry, is young and enthusiastic, with considerable research going on in the electrowinning of the refractory metals. One of their problems is to decide what to do with their expertise--i.e., what products are likely to be commercially successful--and they have therefore invited several scientists, such as himself, for informal discussions to help them make these decisions.

Computer Manufacturing Technology

*Traveler:* Dr. J.F. Blackburn, London representative of the US Commerce Department (Dr. Blackburn may be addressed at ONRL).

Dr. Blackburn attended the IEE conference titled "Recent Advances in Manufacturing Technologies," which was held in November 1987 in London, UK. He reviews the seven papers which were presented and concludes with three observations: (1) the main impediment to rapid advances in manufacturing processes is the cost of financing robotics systems and automatically controlled vehicles in small- and medium-sized firms--large firms can justify these expenses; (2) perfecting of vision systems for robots is a technical constraint at present but this constraint will gradually be removed as vision systems are improved; and (3) as the cost of robots and automatically controlled vehicles comes down they will be more widely used, thus leading to further reductions in their costs.

Oceanography

*Traveler:* Mr. Richard J. Hecht, Naval Oceanographic Office, Bay St. Louis, NSTL, Mississippi 39522-5001.

Mr. Hecht visited various individuals in the Norwegian Research Establishment in September 1987 to discuss a survey of Norwegian hybrids and other shallow water areas. Of primary interest were propagation loss measurements with emphasis on bottom interaction. Secondary measurements concerned bottom backscattering and supporting oceanographic information for the acoustic measurements.

*Traveler:* Dr. Alex Warn-Varnas, Head, Ocean Hydrodynamics/Thermodynamics Branch, Naval Ocean Research and Development Activity, NSTL, Mississippi 39529-5004.

Dr. Warn-Varnas visited Bergen, Norway, in June 1987 to participate in the Marginal Ice Zone Workshop (MIZEX). He states that the overall objective of MIZEX is to perform ERS-1 type sensors signature studies of different ice types in order to develop synthetic aperture radar (SAR) algorithms for ice variables such as, for example, ice concentration and ice type discriminations. ERS-1 retrievals in real time of such variables in conjunction with other atmospheric and ocean variables will be used as inputs to a mesoscale coupled ice-ocean forecasting model for the Barents Sea. Furthermore the SAR images will be used for estimation of ice volume flux from the Arctic Ocean to the Greenland and Barents Sea.

The investigations consist of pre- and postlaunch experiments in the Barents Sea, Fram Strait, and Greenland Sea. Two major prelaunch winter experiments, MIZEX 87, done in March/April 1987, primarily in the Fram Strait, and MIZEX 89, to be done in March 1989, primarily in the Barents Sea. During the postlaunch period a large international experiment is planned for the winter of 1991 in the Barents Sea.

The prelaunch MIZEX 87 and 89 experiments will each cover a month period. During this time (March) extreme winter conditions (maximum ice cover, maximum air-ice/ocean interaction, maximum winds, waves, and ocean swells) are likely to occur. Airborne remote sensing with SAR (X-C-L-band) and passive microwave sensors integrated with similar *in situ* remote sensing observations and *in situ* physical measurement of ice and ocean will be done by several aircraft, ships, moored and drifting buoys, etc. (Winter MIZEX 87/89, Science Plan, MIZEX Bulletin number VIII, April 1986.)

The postlaunch 1991 experiment in the Barents Sea will follow MIZEX-type strategy (MIZEX Group 1986), integrating ERS-1 observations with underflying remote sensing aircraft and *in situ* remote sensing and physical observations of ice, atmosphere, and ocean variables. During the ERS-1 period operational ice forecasts will be done for the Barents Sea.

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:

USARSG--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

*Technical Status of the X-31 Program*, by MAJ Tom Speer, EOAKD. (6 pp) [EOARD-LR-87-102.]

The X-31 program is a joint effort between DARPA, Messerschmitt-Bölkow-Blohm (MBB), Rockwell, and the US Navy. The purpose of the program is to build a light

research aircraft which will investigate the technical problems and operational utility of fighter maneuvers at extreme angles of attack. This report gives a technical snapshot of the X-31 Program as of October 1987. It is based on briefings given by MBB, and covers the program objectives, tactical advantages of enhanced maneuverability, and describes the state of the X-31 aerodynamic, structure, flight control system, and propulsion system development.

### Chemistry

*Aminohalide and Substituted Hydrazine Chemistry Research*, by MAJ Scott Shackelford, EOARD. (2 pp) [EOARD-LR-87-74.]

Professor Roger Cohen-adad heads the Laboratory of Physical Chemistry at the Claude Bernard University, Lyon, France. This laboratory discovered and developed the current French industrial unsymmetrical dimethyl hydrazine (UDMH) production process which was developed from a fundamental small-scale bench synthesis to a pilot-plant production process at Professor Cohen-adad's laboratory in the later 1970's. Other aminohalides being studied include  $NH_2X$  and  $NHX_2$ , and  $NX_3$  ( $X=Cl, Br, I$ ); and in the very near future fundamental synthesis and mechanism studies will be conducted with  $NH_2X$  and  $NHX_2$  alkene additions to produce *vicinal* aminohaloalkane compounds. This laboratory is also applying its UDMH process development expertise to a new method of monomethyl hydrazine (MMH) synthesis for industrial-sized scale-up, in which previous fundamental reaction characteristics of  $NH_2Cl$  studied by this group has proved helpful. MMH is a possible candidate fuel for future ESA rocket systems.

### Energetic Materials

*The Norwegian Defense Research Establishment (NDRE)*, by MAJ Scott Shackelford, EOARD. (4 pp) [EOARD-LR-87-73.]

The Norwegian Defense Research Establishment (Forsvarets Forskningsinstitutt) Kjeller, Norway is actively involved with in-house and contractual energetic materials development and missile propulsion. Their work is expanding in this area to address Penguin missile follow-on modifications and the ASRAAM missile systems. This work is being conducted in their Weapons and Materials Division. They have a flat-type organizational structure with effectively only one level between the NDRE Director and the hands-on Project Leader. They have a very flexible technical manning system which permits them to rapidly regroup for new technical projects as former ones close or as needs vary. Several different projects are being conducted jointly with the US, the UK, and the Netherlands as well as with several other Western European countries.

### Material Sciences--Surface Structure

*Second International Conference on the Structure of Surfaces*, by LTC LaRell Smith, EOARD. (17 pp) [EOARD-LR-87-93.]

This conference covered fundamental research on surface structure. Topics of particular interest were: surface melting and reconstruction, new instrumentation for surface investigations (STM and modifications of LEED), and theory of surface melting and rearrangement. Also reported is a new catalog/database for surface structures. This report contains a full list of papers, a report on the general conference themes and findings, and abstracts of several important papers.

### Semiconductors

*Sixth International Workshop on Compound Semiconductors for Room Temperature X-ray and Nuclear Detectors*, by LTC LaRell Smith, EOARD. (21 pp) [EOARD-LR-87-94.]

This was a basic research conference which focused on the new solid-state detectors of mercuric iodide ( $HgI_2$ ) and cadmium telluride ( $CdTe$ ). Substantial progress in these detectors has been made and there are already commercial products available. There are still many problems, however, and this was the focus of the conference. The report contains a full list of papers, a report on the general conference themes and findings, and abstracts of several important papers.

### Structural Materials

*Research at the Institute of Metal Forming, Aachen, West Germany*, by LTC Jim Hansen, EOARD. (4 pp) [EOARD-LR-87-97.]

Research pertains to forming processes for iron and non-iron metals. Finite element computer models simulate plastic forming processes with global, local, and microscopic analyses. Results of experiments for measuring flow stress and local friction are used to correct models. A computer-driven incremental forging process is being developed, especially for use with aluminum lithium.

Physics

*Continuous Optical Discharges*, by Dr. Stacey Lazdinis, EOARD. (3 pp) [EOARD-LR-87-84.]

Dr. Uhlenbusch and his colleagues at the Second Physics Institute of the University of Düsseldorf in Germany are applying sophisticated laser gas diagnostic techniques to measure plasma parameters in hollow cathode discharges and TOKAMAK fusion devices. In addition, they are investigating continuous optical discharges, high-power CO<sub>2</sub> lasers, and plasma-wall interaction phenomena.

*Interplanetary Particulate Matter*, by Dr. Stacey Lazdinis, EOARD. (2 pp) [EOARD-LR-87-96.]

The Space Unit of the Physics Laboratory of the UK's University of Canterbury is a major European center for the study of interplanetary particulate matter. Not only has it designed space-borne instrumentation and experiments for ESA and NASA, but it also possesses unique laboratory facilities to simulate and analyze particle-target interactions at hypervelocities.

SCIENCE NEWSBRIEF FOR JANUARY

The following issue of *Science Newsbrief* was published by the ONR, London, Scientific Liaison Division during January. *Science Newsbrief* provides 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

6-1 Composite Materials Meetings in Europe 1988 by Louis Cartz.

JANUARY AND FEBRUARY MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during January and February. 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.

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| 06-88 | Oil-Absorbent Coatings                                                     |
| 07-88 | Technical Catalog of French Oceanographic Instrumentation                  |
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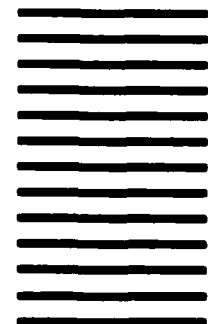


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