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ESN INFORMATION BULLETIN

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This publication is approved for official dissemination of technical and scientific information of interest to the Defense research community and the scientific community at large

Commanding Officer ..... CAPT Terry J. McCloskey, USN
Scientific Director ..... James E. Andrews
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AERODYNAMICS

This Center (CEAT) is part of the University of Poitiers, France. The work being conducted in CEAT's aerodynamics laboratory is discussed under the topics of turbulence and numerical methods, hydrodynamics, acoustics and unsteady flows, rotating fluids, and reactive fluids and flow with mass transfer.

BEHAVIORAL SCIENCES

The assumptions methodology, and findings of the work of Gernot Kleiter and Kurt Schwarzenbacher in issues of error detection and the cognitive and physiological effects of errors are discussed. Knowledge of the processes involved is expected to provide important insights into the nature of cognitive self-monitoring and auto-control.

BIOLOGICAL SCIENCES

This conference, held in April 1988 in Lyon, France, was the fourth meeting of the European Cytoskeletal Club. Presentations given under 14 different topics are summarized. The author states that much progress has been made in recent years, and that development of techniques using monoclonal antibodies, recombinant DNA methods, cell culture, microinjection of cells, etc. has contributed greatly to research on the cytoskeleton.

CHEMISTRY

Although the emphasis in this meeting, held in April 1988 at Bristol, UK, was on zeolite catalysts and lyotropic liquid crystals, a full range of interfacial phenomena were covered. Selected presentations are reviewed.

COMPUTER SCIENCES

The purpose of the Kent study is to investigate engineering applicability of the transputer. This report covers the questions of node hardware and software, implications of load balancing, field of application, bearer network, management requirements, configuration problems, and infrastructure and interfacing requirements.

This is a review of the work at Liverpool University to analyze the performance of transputer networks as vehicles for finite element calculations and to provide OCCAM software tools to simplify the user interface with such a network.

MATERIALS SCIENCES

Ion irradiation studies are carried out at Padua, Italy, of glasses and ceramics, semiconductor materials, and of metal thin films. The surface compositional changes, and property changes are carefully followed. Surface hardening, antireflection coatings, wave guides, ion beam mixing, and gas incorporation are among the studies in progress.

PHYSICS

The Institute for Measurement- and Control-Technology of the West German Armed Forces University is conducting very broad-based research and development work in the area of intelligent ("smart") sensor systems. All aspects of the field (mathematics, physics, technology) are attacked. This article gives some typical examples of the Institute's approach and its achievements.

GRIN-optics and holographic optical elements are researched in the Optics Group of the Department of Applied Physics, University of Santiago, Spain.

SUPERCONDUCTIVITY

Work in superconductivity research at West Germany's University of Giessen, Technical University at Darmstadt, Hoechst AG, Siemens AG, Kernforschungsanlage at Jülich, Kernforschungszentrum at Karlsruhe, the Walter Meissner Institute at Garching, and the Max Planck Institute at Stuttgart is briefly noted. The authors give positive marks to West Germany for its well-planned and sustained effort in this area.

NEWS, NOTES, AND ABSTRACTS

AERODYNAMICS

The Laboratory in Aerodynamics at Centre d'Etudes Aérodynamiques et Thermiques

by Daniel J. Collins. Dr. Collins was the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He has returned to the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

The Centre d'Etudes Aérodynamiques et Thermiques (CEAT), located in Poitiers, France, is a part of the University of Poitiers. As with most research institutes in France there is a relatively complex infrastructure. Thus, of the four laboratories which form CEAT, three are Centre National de la Recherche Scientifique (CNRS) laboratories. The four laboratories, with the three relevant CNRS numbers, are:

- Laboratory in Aerodynamics (LA 191)
- Laboratory in Thermodynamic Systems and Energetics (LA 1098)
- Laboratory of Energetics and of Detonation (LA 193)
- Laboratory on Flow Measurements of Gases Under Pressure.

My discussion will mainly concern the Laboratory in Aerodynamics but I will also say a few words on the two other CNRS laboratories (the flow measurements laboratory is essentially a standards and test facility). CEAT's Laboratory in Aerodynamics forms only a part of the LA 191 CNRS laboratory, whose other sections include part of the mechanics of fluids faculty at Poitiers and another laboratory in aerodynamics at l'Ecole Nationale Supérieure de Mécanique et d'Aérotechnique (ENSMA). The ENSMA laboratory contains two wind tunnels, one devoted to enviromental aerodynamics and the other a large subsonic wind tunnel used in the study of turbulent flight (discussed below). The mechanics of fluids faculty of Poitiers works mainly in the area of rotating fluids, also discussed below. Some of the personnel of CEAT hold simultaneous positions as a professor at either the University of Poitiers or ENSMA. The total complement of CEAT is about 160, with 88 of this number classified as research staff. In a recent year some 150 diverse publications were produced by CEAT. Naturally enough all the internal publications are in French. Perhaps a third of the open literature publications are in English. Much of the research is done under contract. In this article I will only review the work done at CEAT.

Laboratory in Aerodynamics

The six research areas of the Laboratory in Aerodynamics as delineated in a report of their activities include turbulence and numerical methods, hydrodynamics, acoustics and unsteady flows, rotating fluids, reactive fluids and flow with mass transfer, and wind energy. The director of the laboratory is Dr. T. Alziary de Roquefort; my host for the visit was Dr. R. Leblanc. The research is a nicely balanced blend of both experimental and theoretical activity. Doctoral students form an integral part of the research staff, and in 1986 five students obtained their doctorates through work in the Laboratory in Aerodynamics.

Turbulence and Numerical Methods. Dr. J. P. Bonnet, head of this activity, indicated that all of the research connected with turbulence and numerical methods is supported by contracts from Direction des Recherches Etudes et Techniques (DRET) and industrial companies such as Aerospatiale and Airbus Industrie. The long-term purpose of the turbulence investigations is to develop the capability of calculating turbulent flows encountered in aerodynamics – with particular emphasis on detached flows. The investigations are divided into turbulence in compressible flows and turbulence in incompressible flows.

Supersonic turbulent wakes have been extensively investigated. Detailed hot-wire measurements of supersonic turbulent wakes have been compared with calculations which show that the average velocity and average temperature fields are satisfactorily predicted on the basis of incompressible results but that there is a sensible effect of Mach number on the turbulence profiles. The calculations permit a qualitative representation of the compressible terms not taken into consideration in the numerical model. This work is a continuation of investigations in 1984 reported on the structure of a high-Reynolds-number turbulent wake in supersonic flow. J. Bonnet and E. Chaput, reported on the visualization of the large-scale structure in turbulent wakes at supersonic speeds using Q-switched laser sheets (Bonnet and Chaput, 1986). As part of this investigation the digital treatment of images was explored and further work is in progress in order to improve and speed up digital imagery. A more interesting experiment is now in progress in which laser Fourier densitometry, a new technique for

wind tunnels, is being used to determine density fluctuations.

Another experiment with international cooperation, this one involving the University of Laval, Canada, and Cambridge University, England, is concerned with the effect of manipulators in the turbulent boundary layer within the region governed by the law of the wall. The manipulator is a thin airfoil or flat plate placed within the boundary layer. The effect of the manipulator on the turbulence profile, turbulent drag reduction, and the separation point may be measured. Work is now beginning on the problem of the change in turbulent conditions caused by the injection of a thermal perturbation from the manipulator. This latter work is more strictly included in the area of incompressible turbulence effects. The Hermes program has revived interest in hypersonics in France. Since CEAT has one of the rare hypersonic facilities in France Dr. D. Aymer, also a professor at ENSMA, has begun a program directed at the turbulent flow and heat transfer on the surface of Hermes at hypersonic speeds. As part of this program more fundamental investigation are to be made of shock/three-dimensional-boundary-layer interactions in the region of transition.

Work in incompressible boundary layers has involved manipulators as indicated above but the major experiment has been on the study of mixing layer turbulence (J. Deville et al., 1987). The experiment is that of a plane mixing layer with velocities of 42.8 meters/sec and 25.2 meters/sec respectively. Single-point measurements and two-point measurements in the time and spectral domain have been made. The strong three-dimensional character of the turbulence field is seen in the fact that different velocity components seem to behave in quite different ways. Work is now in progress on simultaneous measurements of flow conditions with a rack of 20 hot wires which will permit the relaxation of the quasi-steady hypothesis.

Numerical work has been based principally on a pseudo-spectral method, which results in the necessity of solving a series of Helmholtz problems (Farcy and Alziary de Roquefort, 1986) for the time-discretized incompressible Navier-Stokes equations. The solution is developed from a series expansion based on the Tchebytchev polynomials and requires that the boundary of the domain be along coordinate lines. To obtain an efficient solution one must therefore make a transformation of the domain to a nonorthogonal boundary-fitted coordinate system. This group is currently studying the application of multidomain solutions with a view to speeding up the solution process. This activity is mainly directed at the numerics of the problem, with less consideration of the fluid mechanics. Other numerical work is in the area of hypersonic flows, both viscous and nonviscous, and in hydrodynamic calculations, discussed below. The local computer facilities are equivalent to a Vax 780, but there is a network of computers available to CEAT, and all CNRS laboratories have access to a Cray 2.

Hydrodynamics. Laboratory personnel are conducting theoretical and experimental investigations, using the CEAT water tunnels, of unconventional ships such as multihull catamarans at high Froude numbers and at velocities of the order of 60 meters/sec. A new approach based on the method of singularities has been introduced which appears to be effective in handling the free surface. Further work on high-velocity jets used in a Pelton turbine will be done as part of a doctoral thesis with the support of a society of turbine manufacturers. This method of cooperation appear to be common at CEAT.

Acoustics and Unsteady Flows. The laboratory's work in acoustics is heavily applications-oriented; it involves the propagation of noise in ventilators and conduits and the refraction of sound waves by obstacles. Of the several ongoing investigations I would like to point out one in which there has been an effort to separate acoustic pressure fluctuation from that of the turbulence in the flow. This project is aimed at active acoustic absortion methods. Correlation measurements of two velocity and pressure measurements are being undertaken with a view, by means of the Taylor hypothesis, of obtaining instantaneous separation of the pressure and acoustic fluctuations.

Rotating Fluids. Most of the work in this area is carried out at the University of Poitiers with Professor J. Pecheux. Very sophicated experimental equipment permits the investigation of flows between flat plates and concentric spheres. The investigations use laser light sheets for flow-field visualization, and they have facilities available for image digitization and analysis. The work on rotation of heated concentric spheres which has astrophysics applications was the subject of a recent doctoral thesis (Ben Aissia, 1986). An interesting video permits the observation of Rossby phase waves between the spheres.

Reactive Fluids and Flow with Mass Transfer. Leblanc has several projects in this area which can be seen to be motivated by flows with combustion. One of the experiments consists of flow with strong blowing at the wall which is intended to model the fluid mechanics of a solid fuel combustion-chamber wall. Part of this program includes the combustion of a jet of propane in a crossflow. Another experiment concerns the mixing of two parallel streams of different velocities, as discussed before, but with emphasis on species mixing, which is obtained by marking one of the flows with a fluorescent dye. This latter work is in conjunction with digital image processing and is aimed at determination of the large, coherent structure of flow. Finally, work is also being conducted on the control of transition or laminarization of flow on a wing profile by means of boundary layer suction. Some col-

laborative work with the Von Karman Institute using dual-focus laser anemometry to detect transition in tansonic flows is also planned.

Conclusions

I was impressed particularly by the experimental work going on in turbulent flows. There is also a strong numerical effort devoted to spectral methods which require considerably less computer capability than brute force methods – i.e., integrate the equations directly. I would have a tendency to do direct integration but the investigation of spectral methods is certainly worth while. The CEAT laboratory complex is strongly supported by contracts from DRET and industry. There appears to be a good balance between fundamental research and applied research. Although some of the open literature publications are in English a lot of the work done at CEAT is reported in French. This may limit the utility of some of their research.

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BEHAVIORAL SCIENCES

Austrian Research on the Cognitive and Psychophysiological Consequences of Errors

by William Crano. Dr. Crano was the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office from June 1986 through to August 1988. He has returned to Texas A&M University, where he is a Professor of Psychology.

Typos, mislaid fountain pens, forgotten appointments, slips of the tongue, ear, and pen – "everyday errors" of this type have been of interest to psychologists at least since 1904, when Freud published his classic, *The Psychopathology of Everyday Life* (for some recent views of a more cognitive approach to understanding errors, see Cutler, 1982, and Fromkin, 1980).

Over the years, we have learned much about the social and clinical underpinnings of everyday errors. Now, cognitive and physiological psychologists have turned their attention to these issues, and this change of focus has resulted in even greater understanding of this issue. In this paper, I will discuss some fascinating work on errors undertaken by Gernot Kleiter and Kurt Schwarzenbacher of the University of Salzberg's Institute of Psychology. These cognitive psychologists have become interested in issues of error detection, and the cognitive and physiological effects of errors, because they are convinced that these processes will provide important insights into the nature of self-monitoring and auto-control.

Before beginning this discussion, let me set the context of the work by means of a simple example. Those who know how to type well usually know immediately after striking the wrong key that they have made a mistake. The question that psychologists following on the heels of Freud asked is, "*Why* was the wrong key struck? What is the psychological determinant of the error?" Contemporary cognitive and psychophysiological researchers are more concerned with the question, "How did the typist *know* that an error was made, and what are its consequences for subsequent performance?" Another example might help. Please consider the following analogies. Your task is to determine if they are true. (Hint: In both instances, the correct answer is yes):

See : Retina :: Hear : Cochlea

and,

Bread : Eat :: Fountain : Drink.

If you believed the hint and simply read through these analogies without thinking much, you might now feel somewhat ill at ease. Reconsidering the analogies would reveal the source of your apprehension. The hint was a

deliberate deception – the second analogy is not true. Why, and how, did your apprehension arise? The answer to this question lies at the heart of Kleiter and Schwarzenbacher's research program.

Some Working Assumptions

Before proceeding with a description of Kleiter and Schwarzenbacher's ingenious empirical research, let us first consider some fundamental assumptions that are implicit in their work. Consider first the question of how do we know (or suspect) after making a response, or giving an answer, that it was wrong? Kleiter and Schwarzenbacher assume that the brain continues task processing even after the response is made. In other words, we mentally reanalyze our responses immediately after making them. They term this process "post factum analysis." One important aspect of post factum analysis is that it occupies at least a part of our cognitive capacities. At times, such analysis is useful and important. If we have the luxury of time, post factum analysis can help us to improve future performance. At other times, however, especially when time is at a premium, post factum analysis can severely detract from ongoing performance.

For example, consider the mental processes of a chess grand master engaged in an important competition. To devote thought at move 40 to his decision at move 10 must detract from his performance. Wondering what might have happened if a different strategy had been pursued might prove very useful at the time of the game's postmortem, but to do so during the match cannot but adversely affect the quality of subsequent moves. The same might be said of a fighter pilot engaged in a dogfight. To expend cognitive energy in considering a mistake that took place 60 seconds earlier might prove fatal. Post factum processing is not goal directed, it detracts from attention and capacity at hand, and it is time-consuming. For all of these reasons, it is luxury that in many instances may not prove worthwhile or affordable.

Research evidence supports these views of the nature of post factum analysis. For example, Klieter (1986) asked subjects to judge the correctness of a series of verbal analogies, like those presented earlier in this report. He found that subjects needed more time to solve an analogy if they had made an error on the previous one. In other words, a mistake on the immediately preceding judgment increased the latency of the subsequent judgment. This result was obtained even though Kleiter gave the subject no feedback regarding the correctness of his response.

Rabbit and Rodgers (1977) showed that this effect operated even in very simple choice-reaction time tasks. In such tasks, the subject is asked to make a very simple discrimination as rapidly as possible. For example, one might be asked to press button A if a red display is activated, and button B if the stimulus display is green. Findings of this research demonstrated that reaction times suffered if the previous judgment was in error.

Empirical Study of Errors and their Effects

Methodology: Subjects and Variables. With this introduction, we are now in a position to consider an interesting, if complicated, experiment performed at the University of Salzberg by Kleiter and Schwarzenbacher. Subjects were 64 male undergraduates (average age, 22 years). They each were given 66 relatively difficult semantic analogies, of the type presented at the beginning of this report. Their task was to determine, as rapidly as they could, if the analogy was true or false. The first six trials were for warm-up purposes; the remaining 60 were the critical stimulus trials.

Thirty of the critical analogies were true, thirty were false. To maintain continuity with previous research, half of each set were structured such that the first term of the analogy was a noun (with the second term a verb); the remaining analogies were set up such that the verb was presented before the noun (i.e., the order of words in the noun-first analogies was reversed). Order of presentation of the analogies was random. The stimulus presentation was controlled by computer, and the measurement of response latencies – the critical variable – also was under computer control. The interval between a subject's response and the presentation of the next analogy was 1.8 seconds.

In addition to the response latency measure, each subject's heart rate also was monitored by EKG. The use of the data derived from this measure will be discussed later in this report.

Findings: The Basic Response Frequencies. Based on preliminary study, Kleiter and Schwarzenbacher chose verbal analogies of a relatively high degree of difficulty. Of a total of 3630 responses over all subjects, 757 (26.4 percent) were in error. Noun-first analogies produced 24.4 percent errors, while verb-first problems resulted in a 28.7 percent error rate. Table 1 presents the frequencies of correct and incorrect responses as a function of the validity of the analogy, and noun-verb order.

Table 1. Response frequencies as a function of noun-verb starting order and the validity of the analogy.

Order	Status of Analogy	Subjects' Response: True	False
Noun First	True	883	94*
	False	286*	676
Verb First	True	746	106*
	False	271*	568

Note: Starred values represent errors in subjects' judgments.

Four general approaches to the analysis of the data were employed (analysis of variance or covariance was

used in every case). The two most simple approaches investigated response latency or heart rate on each trial (we will term these measures "current response latency" or "current heart rate"). The two more complicated analyses investigated latency of response or heart rate in light of the validity of the subject's response on the previous judgment trial (we will term these variables "conditional response latency" or "conditional heart rate"). Description of the outcomes of these analyses follows.

The current response latency analysis:

- A result that replicates earlier findings (see Kleiter, 1986) disclosed that noun-first analogies were more rapidly solved than verb-first analogies. One interpretation of this result suggests that human thought processes assemble mental models, or schemas, around entities, and not around predicates, attributes, or process descriptions. In Greeno's (1984) "mental ontology," entities are expected to precede their qualities, and this result is fully consistent with his hypothesis.
- Another interesting result involving the current response latency data was that affirmative answers were made much faster than negative answers. The authors suggest that affirmative answers are based on the cumulation of positive evidence. For negative answers, a "time-out" period interrupts nonpromising activities, and this is followed by a brief period of nonresponse. This pattern would explain the difference in response latency between affirmative and negative answers. It is important to note that these results are not consistent with considerable earlier research which has suggested shorter response latencies for negative responses (e.g., Mulholland et al., 1980; Pellegrino, 1985). Conceivably, these between-study differences might be a consequence of the particular stimulus materials used. As noted, Kleiter and Schwarzenbacher purposely selected difficult analogies. If more simple stimuli characterized the studies reporting contrary results, this apparent contradiction might be resolved.
- Finally, the results disclosed that erroneous answers took much longer than correct responses. Overall, subjects spent approximately 3 to 5 seconds on each judgment. The latency of erroneous judgments was, on average, one-half-second longer than that of correct judgments. This indicates that errors were not characterized by wild guesses, perceptual errors, or haphazard responses. In Kleiter and Schwarzenbacher's words, subjects made "slow errors."

The current heart rate analysis:

- Overall, subjects displayed a relatively high overall heart rate (HR), 94 beats per minute (BPM), which suggests a state of high arousal. As the experiment progressed, HR progressively declined, suggesting an accommodation to the experimental arrangements.
- The HR was greater for positive than for negative responses. Apparently, discovering positive evidence – which gives rise to an affirmative response – is more activating (or less deactivating) than a conclusion, based on the rejection of multiple alternatives, that a negative answer is the correct response.
- Erroneous responses were accompanied by a deceleration in HR. Kleiter and Schwarzenbacher suggest that an inconclusive search for evidence that can give rise to a confident affirmative or negative judgment results in HR deceleration.

In the conditional response latency analysis, subjects' responses were analyzed as a function of the correctness or incorrectness of their preceding response. The central issue of this type of analysis is whether or not the validity of prior responses influences cognitive processing of present information, and physiological reactions that cooccur with this processing.

The conditional response latency analysis:

- This analysis disclosed that judgments made after a subject had made an error on the previous trial took on average 365 ms longer than those following a correct judgment. This statistically significant result suggests that subjects continue to process data even after they have made a judgment, if they are uncertain of the judgment's validity.

The conditional HR analysis:

- A relatively unambiguous picture of this data set may be had from the following description of the end points of the conditional HR distribution. The most rapid HR data were observed when subjects were judging affirmatively, on noun-first analogies, after having made a correct response on the previous trial. The lowest HR's were observed in the mirror-image conditions: on verb-first analogies whose correct answer was negative, immediately following an incorrect judgment.
- Perhaps the most interesting conditional HR finding is that after an error, HR decreases. Apparently, the feeling of uncertainty leads to an activation of the inhibitory system which suppresses conflict resolution strategies and results in a more focused information search.

The total picture of findings provides rich grounds for speculation regarding the linkage between somatic activities and basic metabolic processes. Earlier research and theory has pointed to the association between HR deceleration and orienting responses (see Lacey, 1968; Lacey and Lacey, 1974). In the Laceys' view, HR decelerates during perceptual "intake." If the autonomous error detection and response reanalysis evident in the present data may be viewed as a type of perceptual intake, then the HR data of this research may be seen as perfectly consistent with the Laceys' speculations.

Obrist et al. (1970; see also Obrist, 1982) speculate that decreased HR might be a result of the inhibition of ongoing, task-irrelevant activities. To respond efficiently to a new task, in other words, it becomes necessary to be in a quiet "state of readiness," as might be produced when the HR decelerates, and other somatic activities are inhibited. To maximize information processing

capabilities, all extraneous "background" activities must be stopped.

In the case of a continuous decision-making activity as typified in the multiple analogy task of Kleiter and Schwarzenbacher, such an hypothesis would foster the view that HR would decelerate during the interval between trials. However, as the present results suggest, subjects who feel uncertain about the correctness of their answers (or who become certain that they were incorrect) do not shut down their information processing machinery. In such a situation, it is not the inhibition of irrelevant activities that is associated with the HR effects in the present study, but the inhibition of relevant information processing activity. This would explain why latencies were greater when judgments were made following the production of an error. This result suggests a rethinking of Oberist's interpretation.

Concluding Observations

The results developed in Kleiter and Schwarzenbacher's research raise many questions, and call into question some commonly accepted interpretations of relatively well-established cognitive and physiological findings. This is a very positive aspect of the study. Substantively, the research suggests that current performance may be influenced strongly by judgments taken earlier. It is not shown here, but it is reasonable to hypothesize that the more important the earlier error, the greater its effect will be on future decision making or information processing. The increased latencies suggest the expenditure of greater cognitive and, if we are to accept Gray's (1982) speculations, emotional effort as well. These expenditures all carry a cost, and the cost is written in terms of diminished processing capacity.

The research carried out to this point is completely basic. Kleiter and Schwarzenbacher have made no attempt to relate their findings to more applied settings. However, it is clear that the results presented here might have important implications for a host of real-world problems, from the training of men who must continually make rapid decisions on the basis of ever-incoming information, to the clinical treatment of individuals whose perseveration on earlier problems renders them incapable of coping with the contingencies of everyday life.

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5/4/88

BIOLOGICAL SCIENCES

European Symposium on the Structure and Functions of the Cytoskeleton: Biological and Physiopathological Aspects

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1989 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Introduction

This conference was held at the Faculty of Medicine Alexis Carrel, University Claude Bernard Lyon, France from 13 through 16 April 1988. A well-focused and intensive meeting, it was organized by Professor Bernard Rousset with the aid of a committee of the European

Cytoskeletal Club, and represented the fourth meeting of this organization. There were 320 participants at this conference representing 10 West European countries and four East European countries as well as the UK, US, Israel, and the USSR.

The proceedings of the symposium will be published as a coedition INSERM-John Libbey Eurotext, 6, rue Blanche, 92120 Montrouge, France, within about 6 months. Partial support for the conference was provided by the Office of Naval Research, London.

The format of the scientific program was as follows:

- Structure and assembly of intermediate filaments and related proteins
- Assembly of microtubules and microfilaments: modulation by nucleotides
- Structure and Assembly of the cytoskeleton of erythroid cells
- Cytoskeletal proteins involved in cell-extracellular matrix interactions
- Expression of intermediate filament polypeptides in normal and tumor cells
- Actin and actin-binding proteins as differentiation markers
- Expression of tubulin and microtubule-associated proteins in health and disease
- Cytokeratins: gene expression and immune detection
- Involvement of the cytoskeleton in endocytotic and exocytotic processes
- Functions for microtubules, microfilaments and intermediate filaments
- Intracellular transport of organelles and axonal transport
- Regulation of microtubule and microfilament assembly by associated proteins
- Regulation of cytoskeletal protein assembly by post-translational modifications
- Regulatory role of calcium binding proteins and GTP-binding proteins on the cytoskeleton

The presentations at this conference consisted of 1-hour talks which gave an overview of a particular research area, oral communications ranging from 15 to 30 minutes, and 139 poster presentations related to the topics described above.

The cytoskeletal elements – i.e., microtubules, microfilaments and intermediate filaments – represent cytoplasmic structures which are involved in numerous specialized cell functions: cell shape, cell motility, cell division, distribution of intracellular organelles (lysosomes, mitochondria, secretory vesicles, etc), intracellular traffic of vesicles, cell-cell interactions, cell-intracellular matrix interaction, etc.

Basic research on the cytoskeleton has led to the development of general concepts on the spatial and functional organization of the cytoplasm in the animal cell. These concepts dealing with multiple aspects of the biology of the cell are now being applied to studies of the normal as well as pathological functioning of such differentiated cells at the molecular level.

The development of new techniques and methodologies in molecular biology (cloning and transfection of genes, etc.) and cell biology (cell microinjection, analysis of subparticle movement, etc.) have led to important discoveries on the structure, assembly, and functions of cytoskeletal elements. For example, axonal transport (indirectly approached for a long time) has now been visualized using the Allen video-enhanced contrast microscope. This new methodology offers the opportunity to study the forces generating molecular machinery for the transport of vesicles in neurons. The aim of this conference was to synthesize both fundamental findings and their application to human pathology such as hereditary disease of the erythrocyte skeleton, alteration of axonal transport, and the detection and classification of tumors using cytoskeletal markers.

There was an enormous amount of material presented at this cytoskeletal conference. Thus it is only possible to deal with selected papers in this relatively short report. However, as mentioned above, a book of the proceedings will be available within a few months.

Structure and Assembly of Intermediate Filaments and Related Proteins

A method for the preparation of neurofilament proteins (NF) in high yield was presented by R.A. Marugg (Institute of Anatomy, University of Zurich-Irchel, Switzerland). Marugg and his group found that the purification of NF constituent proteins from bovine spinal cords without the generally used flotation procedure resulted in a 10-fold increase in the amount of purified proteins. Homogenization and centrifugation in 0.85 M sucrose removed the myelin and resulted in a NF-enriched cytoskeletal fraction. Consecutive purification of the NF constitutent proteins was performed by disassembly-assembly cyles and by hydroxylapatite and ion-exchange chromatography (DEAE) leading to a pure NF-H (high molecular weight) fraction. NF-M and NF-L (medium and low molecular weight) were highly purified by electroelution from preparative sodium dodecyl sulfate-polyacrylamide (SDS-PAGE) gels into a membrane trap, whereas gel filtration and HTP chromatography did not completely separate NF-L from NF-M. The binding sites of various monoclonal antibodies (Mabs) were located on proteolytic fragments obtained by digestion with chymotrypsin or V8-protease GLU-C, which could, according to Marugg, provide some insight into the structure of NF's (common epitopes of the alpha-helical rod domain, head and tail domains, and chymotrypsin and V8-protease cleavage sites.

A study on the immunolocalization of bovine keratin no. 22 using synthetic peptides was reported by P. Rug-

gerio (Sclavo Research Center, Siena, Italy). Two polyclonal antibodies were raised by immunizing rabbits with synthetic peptide 1-9 (T-S-Y-S-T-R-Q-S-S) and 384-394 (G-Q-D-A-Y-F-N-D-L-S-L). The peptides were selected by computer analysis of the primary and secondary structure of bovine keratin no. 22, corresponding to the human keratin no. 19. After comparing this sequence with the other reported sequences of intermediate filaments and cytoskeletal proteins, Ruggerio and his group determined the best segments of non-homology giving the best characteristics of hydrophylicity and beta-structure prediction. In immunohistochemical staining of several bovine tissues, both antibodies reacted selectively with the epithelia reported to be positive for keratin no. 19 in human tissues. The immunohistochemical data were confirmed by Western blot of mono- and two-dimensional electrophoresis on bronchial and bladder epithelial extracts, showing a single band or spot corresponding to the bovine keratin no. 22.

Assembly of Microtubules and Microfilaments

A study of dynamic processes in steady-state microtubules by tubulin exchange kinetics was reported by M. Schilstra (National Institute of Medical Research, London, UK). GTP-tubulin within assembled microtubules does not exchange with free nucleotide: in an assembly system containing tubulin dimer plus an enzymic GTP-generating system, the only GTP present occurs as GDP-tubulin within the assembled microtubules. Schilstra said that sampling and high-pressure liquid chromatographic (HPLC) analysis allows monitoring of the GDP/GTP content as a function of time: parallel monitoring of assembly by turbidity showed that the GTP content of microtubules was below the detectable limit throughout assembly.

Schilstra reported that in separate experiments, in which tritiated GTP was added to steady-state microtubules (assembled with unlabeled GTP), the amount of tritiated GDP increased steadily with time due to addition of ^{3}H-GTP-tubulin at the microtubule ends, and the consequent GTP hydrolysis. According to Schilstra, the rate of appearance of ^{3}H-GDP reflects the rate of addition of ^{3}H-GTP-tubulin occurring under the conditions of constant polymer mass. The incorporation rate was shown to be a sensitive function of the initial steady-state microtubule length distribution, and is quantitatively accounted for by a dynamic instability model, according to Schilstra. It was found that the addition of the mitotic poisons podophyllotoxin or taxol suppressed this incorporation and hence, by inference, inhibits the dynamic processes of growing and shrinking occurring in the population of steady-state microtubules.

A presentation on the assembly properties of MAP2:tubulin microtubules was presented by R.G. Burns (Imperial College of Science and Technology, London, UK). The kinetics of subunit addition and of GTP hydrolysis of chick brain microtubule protein were examined using an assembly buffer supplemented with 67-mM NaCl to dissociate the MAP2:tubulin oligomers (MAP refers to microtubule-associated protein). The MAP2:tubulin consists of a 1:12 mol/mol stoichiometric mixture of MAP2 and tubulin. On assembly with 100-μM (γ^{32}P)GTP, a significant difference was found between the kinetics of subunit addition and those of $^{32}P_i$ release, indicating that elongating microtubules terminate in a GTP-cap, Burns said. He found that the initial burst of GTP hydrolysis is stoichiometric to assembled tubulin dimer, while the initial rate of $^{32}P_i$ release is directly proportional to the concentration of microtubule ends but not to the initial rate of subunit assembly. GTP hydrolysis, therefore, occurs as a vectoral wave. Following GTP hydrolysis it was found that the dissociation rate constant increases, giving rise to the behavior of dynamic instability and about 75 percent of the product GDP was displaced from the microtubule. The observed assembly and kinetic properties of the MAP2: tubulin protein in the NaCl-supplemented buffer lie midway between those of MAP2: tubulin microtubules and those of pure tubulin in unmodified buffers. The high association rate constant and the slow rate of GTP hydrolysis have permitted detection of the GTP-cap, according to Burns.

The effect of ATP removal and inorganic phosphate on length redistribution of sheared actin filament populations was discussed by P. Sheterline (University of Liverpool, UK). Sheterline and his group provided evidence that: (1) cytoplasmic concentrations of inorganic phosphate can significantly influence the constant for ADP-F-actin and (2) that the rigid length redistribution of filaments after shearing at steady state is probably due to end-to-end annealing.

The effect of inorganic phosphate (P_i) on the depolymerization of F-actin was measured. It was found that P_i inhibits disassembly of pyrene-labeled F-actin at steady state induced either by dilution or by shearing, suggesting that P_i decreases the off-rate constant, k, for dissociation. This effect of P_i is maximal at 20 mM, unlike the effect of P_i in reducing the critical concentration at the pointed end (maximal at 2 mM) as previously reported by Sheterline and coworkers. This difference in concentration dependence for the two effects was interpreted by Sheterline as different affinities of P_i for the barbed and pointed ends, presumably as ADP-P_i-actin species. The contribution of ATP/ADP phase changes at filament ends (i.e., "dynamic instability") to length redistribution in sheared polymer steady-state actin filament populations was determined by: (1) converting ATP to ADP in the system to prevent phase changes or (2) ad-

ding 20 mM P_i to the system to inhibit depolymerization. Sheterline said that the observed absence of effect of these treatments on length redistribution excludes all mechanisms which involve phase-change-driven disassembly or monomer exchange at filament ends and appears to constrain the mechanism to one of end-to-end annealing under these conditions.

Structure and Assembly of the Cytoskeleton of Erythroid Cells

The topic of new variants of human erythrocyte spectrin was discussed by J. Delaunay (CNRS UA 1171, Faculty of Medicine Grange-Blanche, Lyon, France). Human erythrocyte spectrin, a fibrillar dimer is probably the cytoskeltal protein for which the greatest number of genetic variants are known, according to Delaunay. The latter are often recognized in congenital hemolytic syndromes with abnormally shaped red cells. Delaunay and his group have recently discovered five new variants. Spectrin Tunis ($\alpha^{1/78}$) and spectrin Nice ($\beta^{220/216}$) are associated with elliptocytosis in the heterozygous state. Both are mutants of the head of spectrin (α1 and β1 domains respectively). Spectrin Tunis is manifested by the activation of a proteolytic site located no farther than 20 amino acid residues from the N-terminus, whereas spectrin Nice lacks a 4-kilodalton (kDa) fragment in its C-terminal region. Spectrin Oran ($\alpha^{11/12}$) generates a severe elliptocytosis in the homozygous state, but is virtually asymptomatic in the heterozygous state. The mutation is located in the "body" of spectrin, as indicated by profoundly modified peptide maps of the α11 domain. In these three mutants, spectrin tetramerization is disturbed, according to Delauney. He said that spectrin Saint-Chamond and spectrin Tlemcen are asymptomatic in the heterozygous state and, in contrast, leave unaltered the tetramerization of spectrin. The mutations lie in the "tail" of spectrin (βIV domain) that is known to interact with actin and protein 4.1. Delaunay said that not only do the above variants, as well as others, account for effective (or potential) genetic disorders, but also they help to answer more fundamental questions concerning the structure, function, and biogenesis of the red cell skeleton.

A study of fatty acid acylation of the erythrocyte membrane skeletal proteins ankyrin and protein 4.1 was reported by M. Staufenbiel (Max Planck Institute for Cell Biology, Ladenburg, West Germany). Ankyrin and protein 4.1 are peripheral membrane proteins mediating the attachment of the erythrocyte membrane skeleton to the plasma membrane. In this study, (^{3}H) palmitic acid was covalently incorporated into both proteins *in vivo*. Based on the pH sensitivity, the kinetics of release by hydroxylamine, and the sensitivity towards high concentrations of thiol reagents Staufenbiel concluded that the fatty acids are linked to the proteins via thioester bonds. The molar ratio of fatty acid to protein is higher for ankyrin than for protein 4.1. Fatty acid acylation of ankyrin and protein 4.1 was found to be independent of protein synthesis and assembly onto the membrane skeleton. It occurred predominantly on previously assembled proteins at the plasma membrane and its associated cytoskeleton. It also occurred in mature avian and mammalian erythrocytes. In these cells, covalent binding of palmitic acid to ankyrin and protein 4.1 was rapidly reversible. Staufenbiel said that the deacylation reaction was not due to a chemically labile linkage of protein and fatty acid but appeared to be physiologically induced (enzyme catalyzed). He said that the dynamic nature of palmitylation suggests that it may serve to modulate functions of the proteins.

Cytoskeletal Proteins Involved in Cell-Extracellular Matrix Interactions

The interaction of the cytoskeletal protein vinculin with membranes in intact cells was studied by V. Niggli (Department of Pathology, University of Bern, Switzerland). This was a collaborative project carried out with scientists from the Biocenter, Basel, and ETH (Institute for Biotechnology), Zurich. Vinculin, a putative actin-membrane linker, has been shown to be labeled *in vitro* by a lecithin-analogue carrying a photoactivatable group on its apolar portion (incorporated into liposomes). Niggli and her group had previously found that this process is critically dependent on the presence of acidic phospholipids in the liposomes. Thus, vinculin associates *in vitro* closely with phospholipid bilayers, possibly via ionic and also hydrophobic interactions, according to Niggli. In the present study, Niggli and coworkers presented evidence for such an interaction to occur also in intact chicken embryo fibroblasts. The cells were incubated for 2 hours with a ^{3}H-labeled photoactivatable fatty acid, followed by photolysis, cell fractionation, and immunoprecipitation of vinculin. Most of the label taken up by the cells copurified with membranes, partly as fatty acid, or incorporated into lipids. Vinculin was found in both in the cytosolic and in the membrane fraction. Twenty to 35 percent of total vinculin copurified with a crude membrane fraction, the rest being cytosolic. However, only labeling of membrane-associated vinculin was markedly increased by photolysis (3- to 5-fold). Moreover, upon photolysis, the membrane-bound vinculin contained about 15 times more label than the cytosolic vinculin, related to the same amount of protein. According to Niggli, these results suggest that the direct interaction of vinculin with acidic phospholipids observed *in vitro* may also occur in intact cells and may enable the protein to act as an actin-membrane linker in areas of cell-substrate and cell-cell contacts.

A study of vinculin-cytoskeleton interaction during platelet activation was reported by A. Horvath (University of Debrecen School of Medicine, Hungary). Vinculin is a protein of 130-kDa molecular weight which has been implicated in membrane-cytoskelton interaction in various cell types. Horvath and her group had previously verified its presence in platelets and showed that in resting cells it is localized submembranously and around the alpha-granules. In the present study, Horvath and her group showed by SDS-PAGE and quantitative immunoblotting technique that in resting gel-filtered bovine platelets, vinculin is not a cytoskeletal component. However, vinculin becomes incorporated into the cytoskeleton during thrombin activation. By increasing thrombin concentration as well as during the time course of thrombin activation, the assembly of main cytoskeletal components was found to proceed considerably faster than the association of vinculin to the thrombin insoluble residue.

When pseudopode formation was inhibited by cytochalasin B pretreatment but neither aggregation nor release induced by thrombin was prevented, the amount of vinculin in the Triton insoluble residue increased. Phorbol myristate acetate (PMA) which induces pseudopode extrusion but no contractile gel formation is a strong stimulus for aggregation but induced only a slight release of the granule content. In parallel, only a small amount of vinculin was recovered in the cytoskeletal fraction following PMA-induced aggregation. According to Horvath, the results clearly demonstrate that platelet shape change, pseudopode formation, and aggregation are not prerequisites for the incorporation of vinculin into the cytoskeleton. It starts with the release reaction but most of the vinculin becomes associated with the cytoskeleton after secretion has taken place.

Fibronectin and vitronectin regulation of the organization of their respective receptors was studied in cultured human endothelial cells (EC) by P.C. Marchisio (Institute of Pharmacological Research, "Mario Negri," Milan, Italy). This study was a collaborative project carried out with researchers in the Department of Biomedical Science and Oncology at the University of Torino, Italy. Human umbilical endothelial cells (EC's) adhere *in vitro* to proteins of the extracellular matrix, including fibronectin (fn) and vitronectin (vn). Specific receptors for fn and vn have been previously characterized in other cell types. These receptors belong to a family of membrane glycoproteins characterized (1) by being formed by a transmembrane complex of two noncovalently linked subunits and (2) by recognizing the tripeptide Arg-Gly-Asp (RGD) on their respective ligands.

In the present study, Marchiso and coworkers studied the biochemical properties of these receptors in EC's and investigated how vn and fn control their organization in the membrane of EC's. It was found that the clustering of individual receptors and the subsequent organization of focal contacts occurred only when EC's were exposed to the specific ligand and did not occur on the opposite ligand. The shape of clusters formed by different receptors was slightly different, and a superposition of the two receptors was found when EC's were cultured on a mixed matrix of fn plus vn. Adhesion could be inhibited by an RGB-containing peptide on different ligands – to a different extent, being more active on vn than on fn or fn plus vn. Adhesion was also selectively inhibited by vn or fn receptor antibodies on their respective substrates. Moreover, the association of either receptor with cell-to-cell contacts was independent of the ligand used to support cell-to-substratum adhesion. The clustering of both receptors preceded the association of vinculin with the focal contact and stress fiber formation. Also the vn receptor *per se*, in the absence of associated fn receptor, was capable of inducing the organization of the membrane-microfilament interaction complex. Overall, these results indicated, according to Marchisio, that individual matrix ligands induce only the clustering of their respective membrane receptors. The clustering of only one receptor is capable of supporting the subsequent formation of focal contacts and the assembly of related cytoskeletal proteins.

Expression of Intermediate Filament Polypeptides in Normal and Tumor Cells

A report on the tissue-specific expression of intermediate filament (IF) hybrid genes in transgenic mice was presented by F.R. Pieper (University of Nijmegen, the Netherlands). If genes are expressed in a tissue-specific way. Desmin is expressed only in muscle cells, whereas vimentin is found in cells of mesenchymal origin. Pieper said that an analysis of the regulation of the cell-specific expression of vimentin is hampered by the fact that nearly all cultured cells express vimentin. Therefore, Pieper and coworkers constructed vimentin-desmin hybrid genes and introduced these into the germ line of mice.

The first construct was composed of the 5′ region of the vimentin gene encoding the head and helical domain, and the 3′ region of the desmin gene encoding the tail domain. Transgenic mice expressed the hybrid gene at high levels in a developmental and tissue-specific manner. Immunohistochemical staining of fibroblast cultures derived from these mice with antibodies specific for vimentin and desmin demonstrated the intracellular colocalization of the hybrid protein with the endogenous vimentin filaments. A second construct, containing the vimentin promoter and the coding part of the desmin gene, was also expressed in a tissue-specific manner. According to Pieper, the impact of this finding is that forced desmin expression in all vimentin-expressing cells does

not interfere with normal mouse development. Furthermore, this is the first report describing the expression of an IF gene in a cellular context in which it is not normally expressed.

Actin and Actin-Binding Proteins as Differentiation Markers

The analysis of tropomyosin isoforms during the differentiation of human leukemia cells was reported by J. Marti (INSERM Unit 65, Institute of Biology, Montpellier, France). A number of tissue-specific tropomyosin isoforms have been described, several of them being specific to nonmuscle cells. Marti and coworkers isolated and characterized several tropomyosin complementary DNA (cDNA) clones from various tissue origins. Their sequential analysis allowed the classification of the isoforms and the analysis of the phylogenetic basis of their diversity. cDNA probes were used to analyze the messenger ribonucleic acid (mRNA) extracted from human leukemia cells (HL60,U937), either proliferating or induced to differentiate. Isoforms specific to the monocyte linkage were identified and the structure of the mRNA's analyzed by hybridization with specific cDNA probes.

A study on the accumulation of mRNA coding for β-isomyosin and αsk-actin in rat heart after aortic stenosis was presented by J.L. Samuel (INSERM Unit 127, Pasteur Institute, Paris, France). Samuels said that increased pressure loading of rat heart induces changes in the genetic expression of the heart. Previously Samuels and coworkers had found that there is a transition from α-myosin heavy chain (MHC) to βMHC isomyosin and an accumulation of transcripts from alpha skeletal muscle actin gene (αskA). The former is permanent while the latter is transient.

Using specific ^{35}S-RNA probes, the respective accumulations of βMHC and αskA mRNA were analyzed throughout serial sections of heart by *in situ* hybridization at defined times after aortic stenosis. Samuels and her group found that the accumulation of βMHC and αskA mRNA occur neither at the same time nor in the same region: the accumulation of αskA mRNA precedes that of βMHC mRNA by at least 12 hours and is distributed throughout the entire left ventricle, whereas βMHC mRNA accumulation is detected in the endocardium only 24 hours after surgery. Samuels said that these results demonstrate that the same initial signal, hemodynamic overload, induces in rat heart a pattern of myogenesis that is characterized by an uncoordinated reactivation of the fetal phenotype of two major contractile proteins.

Expression of Tubulin and Microtubule-Associated Proteins in Health and Disease

A study of the distribution of Tau proteins in the human central nervous syetm (CNS) in Alzheimer's disease was reported by A. Delacourte (INSERM Unit 16, Faculty of Medicine, Lille, France). Tau proteins are the major antigenic components of Paired Helical Filaments (PHF's), a landmark of Alzheimer's disease (AD). Using Western blots and a specific antiserum against PHF, Delacourte and his group carried out a quantitative and qualitative analysis of Tau proteins in various areas of normal human brains versus AD brains. In normal brain extracts, Tau proteins were strongly detected in the cortical gray matter while they were poorly detected in the cortical and spinal cord white matter. In AD brain extracts, the distribution of Tau proteins was identical, but two differences were observed: (1) a fairly high background, due to the partial dissociation of the lesions containing Tau aggregates, was present in the tracks corresponding to the gray matter of cortical areas and absent in the cortical white matter, in the spinal cord, and in the cerebellum; and (2) the immunodetection profile of Tau proteins was modified in AD, and there was a decrease of the dephosphorylated forms of Tau proteins (molecular weight between 45 and 55 kDa). Delacourte said that these results were also obtained with an antiserum against native human Tau proteins. He said that he and his group had thus demonstrated in a direct way that Tau proteins are abnormally phosphorylated in AD. Also, they observed that Tau proteins were not exclusively distributed in the axonal domain and are more abundant in the grey matter (particularly rich in cell bodies and nerve endings).

Finally, Delacourte and coworkers noted that Tau proteins in the normal human brain are abundant in the regions where histological lesion containing PHF (tangle and neuritic plaques) will develop during AD.

A study on isotubulin expression during neuronal cell differentiation in the mouse was presented by P. Denoulet (Collège de France, Paris, France). Denoulet and coworkers had previously reported that the highest level of tubulin polymorphism was found in nervous tissue and that the different isotubulins were expressed gradually throughout brain development. The use of cellular models of neuronal differentiation (neuroblastoma and teratocarcinoma cell lines) led to the demonstration that specific isotubulins appeared at crucial steps in neuronal differentiation such as early commitment and neurite outgrowth. In the present study, Denoulet described the expression pattern of isotubulins in long-term primary cultures of mouse brain neurons. Cells were isolated from 15-day fetal brain. Tubulin was extensively purified by taxol and analyzed by resolving isoelectric focusing. During the time course of culture, the patterns of isotubulins expressed by differentiating neurons were found to be similar to those present in the developing brain; after 4 weeks in culture, the level of tubulin heterogeneiety observed in neurons was as high as in the adult brain (8α and 12β). By contrast, glial cells exhibited

only a low level of tubulin polymorphism (5α and 4β), even after 1 month in culture. By pulse-chase experiments and *in vitro* translation of neuron RNA, two levels of control were found in neuronal cells in the synthesis of the diverse isotubulins: a transcriptional level for α1, β'1 and β3-5, and a post-translational level for the acidic α(α2-8), β'2 and the acidic β (up to β12) tubulin isoforms.

Involvement of the Cytoskeleton in Endocytotic and Exocytotic Processes

A report dealing with the assembly of the excitable membrane domain in *Torpeda marmorata* electrocyte during embryonic development was presented by J. Cartaud (Institute Jacques Monod, Paris, France). This was a collaborative project with scientists from the laboratory of J.P. Changeux of the Pasteur Institute in Paris. It had been shown previously that in the mature electrocyte, the acetylcholine receptor (Ach-R) molecules are assembled in paracrystalline arrays at the ventral pole of the cell and associated with a peripheral protein of 43-kDa molecular weight. This 43-kDa protein has also been found to be responsible for the immobilization of the Ach-R, perhaps by association with the subneural cytoskeleton. However, it is not fully understood whether the clustering of the Ach-R molecules and the assembly of the 43-kDa protein at the cytoplasmic face of the postsynaptic membrane are synchronous, interdependent events. To explore these questions, Denoulet and coworkers studied the subcellular localization of the Ach-R, the 43-kDa protein and a component of the basal lamina (laminin) using immunocytochemical methods in embryos before and after innervation of the electrocytes (stages 45 mm and 82 mm). The results showed that in the 45-mm embryos, Ach-R clustering occurred at the ventral membrane of the cell without concomitant accumulation of the 43-kDa protein. The latter appeared to be randomly distributed in the cytoplasm. Denoulet and his group observed that laminin and Ach-R distributions coincided transiently in 45-mm embryos, suggesting, Demoulet said, a critical role of the basement membrane in the differentiation of the electrocytes *in vivo*.

Functions for Microtubules, Microfilaments and Intermediate Filaments

A study showing a novel function for intermediary filaments was presented by K.Scherrer (Institute Jacques Monod, Paris, France). Scherrer said that at present, the function of the intermediate filament (IF) is hypothetical; novel data bearing on the PROSOME system indicate that they might have a role in gene expression. Prosomes were discovered as subcomplexes of repressed messenger ribonucleoproteins (mRNP) and characterized by electron microscopy as well as biochemical and cytological criteria. Composed of 85 percent protein and 15 percent small RNA (50 to 150 nucleotides) the individual particle is raspberry-shaped, with a diameter of 12 nm, according to Scherrer. There are about 25 peptide constituents of 19 kDa to 50 kDa and pI of 4 to 7, showing a characteristic two-dimensional electrophoretic pattern. The individual particle (600 kDa) may contain variable sets of RNA and proteins. Monoclonal antibodies (Mab's) constructed against duck erythroblast prosomes revealed, in dual label immunofluorescence, that prosome antigens are localized on the intermediary filaments, forming networks superimposable extensively onto the cytokeratin network in HeLa and PTK cells. Scherrer and his group also found prosomes are in the nucleus associated with pre-mRNA; the same Mabs also label the nuclear matrix and lampbrush chromosome loops. In embryonic tissue, individual prosomal antigens were found to be located in specific cells and developmental domains, in the nucleus or sectors of the cytoplasm, in configurations varying with the type and stage of differentiation. Scherrer proposed that specific prosomes accompany specific pre-mRNA and mRNA in a tissue- and differentiation-specific pattern from synthesis to expression, and that these carriers of information travel on the nuclear matrix and intermediary filaments.

Regulation of Cytoskeletal Protein Assembly by Post-Translational Modifications

A study of α-tubulin in the neuronal growth cone was presented by P.R. Gordon-Weeks (King's College, London, UK). Neuronal growth cones are able to navigate a precise route through the developing nervous system and to recognize the target site so that the correct synaptic connections can be made. To do this, growth cones are equipped with a variety of surface receptors to extrinsic guidance signals which, when activated, presumably influence motility through the cytoskeleton. Gordon-Weeks and coworkers have been studying the cytoskeletons of isolated neuronal growth cones from neonatal rat forebrain and have identified a large pool of soluble tubulin in the growth cone that is prevented from polymerizing. The mechanisms that maintain this pool of tubulin in the growth cone and control its polymerization onto the ends of the neurite microtubules (the plus ends) are not known. Gordon-Weeks and his group are carrying out a biochemical analysis of the tubulin and other cytoskeletal proteins in isolated growth cones by probing electroblots of growth cone cytoskeletons with well-characterized, specific antibodies.

They found that Triton X-100 insoluble extracts of isolated growth cones (cytoskeletons) contain large amounts of tubulin and actin. About 60 percent of total growth cone tubulin is in the Triton X-100 soluble fraction (soluble, cytoplasmic pool). The majority of the α-tubulin present in both fractions bound a monoclonal

antibody (YL 1/2) which only recognizes the C-terminal of tyrosinated α-tubulin. In contrast, very little of the tubulin in synaptosomes – the mature counterparts of the growth cone – is C-terminally tyrosinated. Gordon-Weeks said that although C-terminally tyrosinated α-tubulin polymerizes as efficiently as α-tubulin lacking the terminal tyrosine, phosphorylation of this tyrosine does inhibit polymerization and, according to him, this might form the basis for maintaining a large, soluble pool of tubulin in the growth cone.

Conclusion

This report contains only a sampling of the more than 200 papers presented during the focused and intensive conference dealing with the structure and functions of the cytoskeleton. It is apparent that much progress has been made in recent years in this difficult yet important area of research. The development of techniques using monoclonal antibodies, recombinant DNA methods, cell culture, microinjection of cells, etc. has contributed greatly to research on the cytoskeleton. It is also apparent that European scientists are making major contributions towards the understanding of the structure and functions of the cytoskeleton.

6/3/88

CHEMISTRY

Applications of NMR in Colloid and Interface Science An International Conference

by Henry A. Resing. Dr. Resing is the Liaison Scientist for Chemistry in Europe and the Middle East for the Office of Naval Research Branch Office, London. He is on leave until July 1990 from the Naval Research Laboratory, where he is a research chemist.

Professor Terrence Cosgrove of the University of Bristol, UK, arranged this superb meeting of the British Radiofrequency Spectroscopy Society (5 through 8 April 1988) in Bristol. Of the more than 100 attendees most were from the UK; the largest foreign contingent was from Sweden (about five) with representation from West Germany, France, Belgium, Denmark, Switzerland, the Netherlands, East Germany, and the US. Chemists, physicists, and chemical engineers made up the interdisciplinary group. Cosgrove intends that there be a symposium proceedings, to be included in a regular issue of the journal *Colloid and Surface Chemistry*.

Although zeolite catalysts and lyotropic liquid crystals comprised the two areas of of heavy emphasis, a full range of interfacial phenomena were covered by the conference, as this report reflects. Personally I am ever amazed at the constantly growing power of nuclear magnetic resonance (NMR) spectroscopy in surface chemistry; the power to analyze surface functional groups quantitatively and qualitatively, to measure dimensions of surface entities, to find the orientations of adsorbed molecules, to measure the kinetics of surface reactions, the power to say when microscopic regions are connected or not connected, and so on ad infinitum! Read on for but a sample.

Catalytic Surfaces

A first highlight of the meeting was the lecture by H. Pfeifer (Department of Physics, University of Leipzig, East Germany). His group has masterfully defined the state of the art for high-resolution proton magnetic resonance in the solid state, and in the process they have completely elucidated the acidic groups of the available rouge of zeolite cracking catalysts. Such catalysts are now the mainstay of the petroleum industry for cracking and reforming processes; the rate of the cracking process depends on the concentration of a certain one out of five types of acid groups Pfeifer's team has identified. Pfeifer and coworkers were able to use the spin-counting property of NMR spectroscopy (i.e., for any proton-containing functional group in the sample the signal intensity of its resolved line is proportional to its concentration) to measure the concentration of the crucial bridging hydroxyl group of the large cavities.

To do this, Pfeifer's group first had to resolve the proton NMR lines of the expected five groups, namely, of the (a) silanol, (b) extra-frame-work aluminate, (c) large cage Al-(OH)-Si bridging, (d) small cage bridging, and (e) ammonium groups. This involved the design and construction of "magic angle" spinning chambers in which each of the hundreds of zeolite specimens could be sealed under vacuum. No other laboratory in the world is able to do this on such a routine basis: this was technical advance number 1. Second, these researchers had to identify the NMR lines. This was done by a careful correlation of the NMR spectra with infrared spectra in the light of what was known about the histories of the zeolite samples (e.g., type, exchange degree, heat treatment, etc.). Third,

they had to identify the functional group (and its NMR line) that affected the cracking efficiency; it is the bridging hydroxyl in the large cages. Fourth, having found the responsible functional group they were able to correlate its catalytic effectiveness with the theoretical electronegativity of the zeolite lattice as a function of Si/Al ratio. The Si/Al ratio is the fundamental composition variable in zeolite science – i.e., it is under the industrial chemist's control, and, as a result, catalytic efficiency is also under his control.

The lecture and the research on which it was based were both "tours de force" and deserve greater exposure and acclaim than they are getting. No one from the Leipzig group has ever spoken in the US, although plans are under way to bring Pfeifer to the US for the Fifth International Symposium on Magnetic Resources in Colloid and Interface Science to take place in Delaware in 1989 – university and industrial laboratories please take note. (Write to: Professor Cecil Dybowski, Department of Chemistry, University of Delaware, Newark, Delaware 19716.)

J. Klinowski of the University of Cambridge, UK, reported that he was able to determine the molecular dimensions of this highly important aluminate bridge hydroxyl group. He reported also on his use of ^{29}Si NMR as a tool to measure the Si/Al ratio in zeolites.

B. Boddenberg (University of Dortmund, West Germany) has been able to find the orientation of molecules with respect to highly graphitized carbon surfaces, even if he used powdered samples. He notes (theoretically) the effect of the magnetic susceptibility on calculated powder NMR spectra: the known orientation of the susceptibility tensor with respect to the surface of graphite gives the index of surface orientation – a neat trick!

J.H. Strange (University of Kent, UK) reported on his study of the isothermal crystallization of cyclohexane enclosed with 90-Å pores of silica gel. He observed that freezing points were depressed, but the thermal and dynamical properties of the molecules proved similar to the bulk. He, along with T. Cosgrove (University of Bristol, UK), used quasi-elastic neutron scattering techniques – at the European Center for Nuclear Research (CERN) in Grenoble, France – in conjunction with NMR techniques. Said Cosgrove of their works on this project in France, "It's such a dream to go to CERN-Grenoble; everything works perfectly. All one has to do is bring the samples." (However, he added, very detailed planning is required in order to be productive.)

This "switch" to nuclear scattering is driven not purely by a desire to enhance scientific understanding, but, at least in some measure, is due to the unavailability of new magnetic resonance facilities for academic departments in Britain. For instance, Professor J. Luckhurst (University of Southampton, UK) mentioned that only $1.9 million are available for capital spending on university chemistry in the UK this fiscal year. On the other hand, the costs at Grenoble come from international agreements as well as from other pockets.

Cosgrove was able to achieve complementary results from both techniques from polyethylene oxide adsorbed from solution onto spherical silicon particles. Binding coefficients as well as mass distributions as function of distance from the surface were revealed.

Liquid Crystals

The second highlight of the meeting was the review by G. Lindman (University of Lund, Sweden) on oil/water microemulsions. In certain of these systems, stabilized by adding surfactants, one is able to go smoothly from a condition in which water is dispersed in oil to one in which oil is dispersed in water. This is revealed by the fact that when the water is dispersed – i.e., locked in micelles – it diffuses slowly, but when it encloses the oil in micelles it diffuses as freely as in the normal liquid. How this can happen without a phase change is quite mysterious, but happen it does. Lindman presented diffusion data for several systems; this data was obtained by the now familiar pulsed gradient NMR technique. The data require that at low water content only the oil-rich regions are connected but that at high water content only the water-rich regions are connected. At intermediate concentrations there is the bi-continuous region for which both the aqueous and oil phases appear to be connected. Lindman suggested a layer structure that would allow this. However, O. Soderman (also from Lund University) suggested that there were, instead, very unstable situations which went from one connectivity to the other quite rapidly. Lindman also discussed the NMR evidence for multiply connected cubic liquid crystalline phases.

N. Boden (University of Leeds, UK) presented a set of order parameters for liquid crystals composed of discotic micelles. S. Zumer (University of Ljubljana) discussed work he had begun at the liquid Crystal Institute in Kent, Ohio, on liquid crystal globules dispersed in polymers; here the goal was the practical one of making an optical switch. For small dispersed globules, order was imposed by the interface of the polymer with the globule, and was not "switchable." This was in contrast to switchable, larger globules.

Thus the meeting touched on solid-gas, solid-liquid, solid-solid, liquid-gas, and liquid-liquid interfaces. Quite a success!

5/9/88

COMPUTER SCIENCE

Feasibility Study of a Distributed Supercomputer Work in Progress at the UK's Kent University

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

Introduction

The feasibility study at the UK's Kent University for development of a distributed supercomputer is being conducted under the sponsorship of Britain's Science and Engineering Research Council and Department of Trade and Industry (SERC/DTI) transputer initiative. This initiative, which began in late 1987, is for the purpose of investigating engineering applicability of the transputer. (See *ESN* 40-9:306-309 [1986] and *ESNIB* 88-03:33-30[1988] for articles on the transputer and the transputer initiative.)

The purposes of this 6-month study are to:

- Investigate the technical feasibility of distributing computationally intensive applications over a national (or international) network of transputer-based supercomputing nodes
- Identify appropriate technologies to support such a facility together with their associated costs, performance capabilities, and timescales
- Identify parameters for the type of applications that would benefit from such a facility and identify specific examples
- Investigate problems associated with the management of such a distributed supercomputer (DSC) and to identify requirements for some of the software tools to support that management.

The transputer is the basic component in many machines under development or being marketed; for example, Meiko (UK), Parsytec (West Germany), and Floating Point Systems (US) are currently marketing such systems. Machines under development based on the transputer include the ESPRIT Supernode (Southampton), Alice (Imperial College, London), and the Alvey PARSIFAL. At the Edinburgh Concurrent Supercomputer Center a Meiko M40 computing surface module is being used for engineering applications (*ESNIB* 88-03:35-40 [1988]). The architecture of transputer-based systems allows open expansion of processing power through adding more processors to the system. Some of the installations, including the one at Edinburgh, will have as many as a thousand processors within the next year or so. The question is, to what extent will it be possible to harness these processors together to work on a common problem.

One of the many problems in harnessing the power of a large number of processors on a single problem is that of the communication bandwidth and communication control among the many processors. Many parallel processing systems have been built in the past in which the theoretical processing power could not be reached due to lack of intercommunication efficiency. The study at Kent is designed to find a balance between processing power and communications.

In a distributed system the allocation of individual sites to a global network should be dynamic and under the control of local sites. This would have advantages even when not being used for concurrent super-applications. Long-term computations could remain in the background network and exploit "slack-time" within individual nodes when local management made them available. Or local sites could pass on to other nodes noninteractive computationally intensive jobs when they become too highly loaded.

Node Hardware and Software

Nodes – geographically isolated computing resources – will be connected through local area networking (LAN's) or wide area networks (WAN's). Each node will contain a reconfigurable array of transputers to be allocated to the DSC together with other resources, such as disks and operating system hardware, to be shared with the local users and WAN/LAN networking hardware and software. Some of these resources could be supplied through an attached support processor such as a SUN-3 or a MicroVAX, but may be implemented by novel transputer-based systems.

Examples of organizations marketing transputer-based supercomputers suitable for a DSC node are Meiko with its Computing Surface running stand-alone with ERIX (or using a MicoVAX/VMS or SUN-3/UNIX as front-end processor), Floating Point System with its T-series using VAX/ULTRIX as a front-end processor, and Atari with the Perihelion Helios operating system kernel. Perihelion intends to make Helios available for Meiko

systems. In the future the ESPRIT supernode project 1085 (*ESNIB* 88-01:26-31 [1988]) may become a commercial product.

The Floating Point T-series uses the Weitek floating point vector processor with achievable performance of 8 MFLOPS (millions of floating point operations/second) to carry out computations passed to it by an Inmos T414 or T800 transputer.

Meiko is the company selling a user-selectable mix of transputer-based computing and peripheral resources, from which a wide variety of computer systems can be assembled. A DSC node could consist of one or more of Meiko's Computing Surface modules. The main computing resource of the Computing Surface is an electronically configurable (by the application) network of transputers. The application has total control over the application network. The operating system services, such as file stores and networking interfaces, are executed on a network of transputers physically distinct from any application network. Several distinct application networks may exist concurrently. An application network may be connected to the operating system network at several (but usually only one) points. Operating system services are accessed by an application through a procedural interface that manages the rapidly evolving operating system protocols that are defined for those connection points.

The DSC network interface could become sufficiently stable to be incorporated as a server within the operating system and accessed through the operating system spine. Alternatively, this interface may be directly installed as part of the application network. Then, the operation of the DSC would have no performance impact on the operating system and other users of the module.

In the Meiko Computing Surface the raw performance of transputers is made available to the user. High-level access to this performance is provided through the language OCCAM. Operating system services have no impact on an application except when required. Erroneous application software cannot corrupt the operating system or other applications.

The Perihelion Helios was commissioned by Atari to support its "add-on" boards and, ultimately, its stand-alone transputer-based workstations. Multiusers' systems are to be implemented through ethernet-connected workstations.

A parallel algorithm is not expressed as a single entity as in OCCAM. Instead, each sequential component of the algorithm is developed as a complete assembly program for the language C. Communication between components is by message-passing as in OCCAM. System procedures allow a component to pass a message plus its destination address to a Helios nucleus (about 70 kbytes) which is a separate process resident on every transputer. The nucleus automatically routes the message to the target component, possibly through other nuclei on other transputers. An application program, actually a collection of programs, need not know the topology of the transputer network on which it runs.

The performance overhead of passing messages through a third party seems very high. However, this may not be so crucial for some DSC applications, which may be coarse-grained parallelism with low communication bandwidth, similar to Helios applications. On the other hand, it would be useful to exploit fine-grained parallelism within a DSC node, as OCCAM and the transputer encourage.

The official Helios approach to supporting OCCAM is to expect OCCAM-placed par components to communicate not directly over links, but through Helios system calls to set up messages for the standard nucleus which will always be installed. They concede that some users may want to run on naked transputers and control the links directly. This is thought to be a minority interest, but it might make it usable for DSC.

Implications of Load Balancing

Balancing an application to make efficient use of the processing power of the DSC is logically the same problem as balancing an application across a directly connected transputer network. The parameters to the problem differ only quantitatively and the same methods of analysis and engineering of solutions may be applied.

The function of any node in a distributed application is continually to receive and transmit information, which may be data or coded instructions, and to perform computations. The communication function of the node is an unavoidable overload of the parallel implementation. To maximize the efficiency of such a system, the interruption to the computation function of each node must be minimized.

The INMOS transputer is thus far the only microprocessor with communication engines integrated on the chip along with a general- purpose processor. The transputer allows its communication to proceed mainly in parallel with its computations, apart from some initial and final signaling exchanges between the main and link processors. It is therefore possible to achieve nearly linear speed-up with a transputer network, by reducing the impact of the necessary communications on computation to near zero. The OCCAM programing language enables a simple expression of such parallel arrangements with a transputer. For a DSC node the same effect is possible. The computational function is performed by its main reconfigurable cluster of transputers. The communications function to and from the WAN/LAN is performed by separate hardware, which may include transputers, running concurrently with the main processing.

Applications suitable for worthwhile exploitation of a DSC are going to be large. With powerful processing

components, like T800's across the DSC, the minimal threshold of computational load distributed to each processor, below which inefficient use of the system will occur, needs to be some 100 times higher for DSC transputers than for a directly connected network.

A suitable application will need to be implemented by an algorithm that exhibits a high degree of parallelism. For flexible allocation of the algorithm across a DSC network with nodes of varying power, the extent of this logical parallelism needs to be much greater than the physical parallelism provided by the separate processing components in the system. Parallel algorithms of the event, geometric, or algorithmic varieties may be accommodated in the DSC. Consider a particular example of geometric parallelism: The main computation section of an algorithm for solving dense systems of n simultaneous linear equations (a parallel Gauss-Jordan elimination) consists of an nxn grid of processing elements. Data flows continuously from left to right and circularly up and down. The implementation projects each grid column down to a single cell and then groups equal length slices of the resulting logical pipeline on to a physical processor pipeline. The coefficient matrix of the left-handed sides of the equations are fed in from the left, each column going in logically in parallel. This is followed by an indefinite sequence of right-hand side columns. Solutions of the system for each right-hand side flow out on the right of the grid at an even rate.

The largest system for which the Kent researchers have figures is for a 64-equation system with 64-bit floating-point coefficients mapped on to eight T414 (15 MHz) transputers (each T414 managing eight columns of the logical processing grid). Solutions were generated every 50 microseconds, giving an interprocessor data flow rate of 10 kbytes/sec. The bandwidth of the T414 links was about 500 kbytes/sec; making the system compute bound. Distributed on a DSC of T414 components, the system would be slightly communications bound. For this application we could not use more than six T414's on a DSC implementation and achieve full use of their computational power.

With eight T800 (20 MHz) transputers, a factor of 10 increase was obtained in computing power. A solution was received every 5 microseconds, generating some 100 kbytes/sec link traffic. The system was still compute bound, by one order of magnitude. However, this application could not be effectively distributed over a DSC with 8-kbytes/sec bandwidth, since even a two T800 system would require 25-kbytes/sec traffic.

In the 64-equation system, each processor was managing 512 logical cells (eight columns, each of 64 cells). In a 4096-equation system distributed similarly over eight T800's each processor would have to manage 2024 k cells (512 columns, each 4096 cells). The cycle time to produce each solution will increase by a factor of 4 k, i.e., to about 20 seconds. This implies a data flow rate of only 1.6 kbytes/sec – i.e., compute bound by three orders of magnitude. Distribution over 40 T800's would produce a solution rate of one every 4 seconds and a communication load of only 8 kbytes/sec. This distribution is eminently worthwhile for a DSC application, if the 40 T800's are not available locally.

Analysis on the constraints on application parameters for the DSC will be generalized in the final report from Kent University.

Fields of Application

Parallel processing, at the high-performance end, may be an order of magnitude more cost effective than vector supercomputers. Ideally, a program runs n times faster on n processors than on a single processor, although the actual speedup is normally less. The design of algorithms to achieve this sort of speedup is an active area of research. Since the algorithm, programing language, and hardware are intimately connected, this exercise is difficult to carry out in general.

Compilers will not be sophisticated enough in the near future to map applications efficiently onto parallel hardware. In some cases the parallelism is obvious, as in most linear algebra problems, and for the simulation of physical systems with local update rules. In general the mapping is not so obvious, but three general strategies can be useful:

1. Independent tasks and event parallelism, in which each processor is executing the same program in isolation from all the other processors.

2. Geometric parallelism, in which each processor executes the same program on data corresponding to a subregion of the system being simulated and communicates boundary data to neighboring processors handling neighboring subregions.

3. Algorithmic parallelism, in which each processor is responsible for part of the algorithm, and all of the data passes through each processor.

There are many problems that might fit a DSC, and in the final report, Kent University will give details on them. They will include:

- Digital logic emulation
- Real-time expert systems
- Partial differential equations and fields
- Particle simulation
- Monte Carlo methods
- Matrix operation in basis set problems
- Energy minimization
- Coupled channel equations
- Fourier transforms and signal processing.

All of the above fields of application would be amenable to:

- Supercomputer facilities of power beyond a Cray
- Distributed array processing
- High-quality interactive graphics.

Careful analysis is required to determine whether the parameters for each size of each application can be carried out to fit the DSC constraints previously described.

Bearer Network

Given that the minimum speed to be used for the interconnection of the transputer sites is 64 kbytes/sec, four different technologies are possibilities for the bearer network. These technologies are X.25, provided by JANET/IPSS or PSS/IPSS, ISDN (either Basic Access or Primary Rate Access), digital leased lines (either British Telecom KiloStream, or MegaStream connection), and satellite links (e.g., British Telecom's SatStream service).

For each technology, the speed, characteristics, costs, and latency were investigated for the network. SatStream was discarded because, given the tariffs, it was difficult to conceive a topology in which SatStream would be cost effective. For comparing the others, nine potential transputer sites in the UK plus two in Europe were used, and the costs involved in interconnecting these sites were computed. For interconnection via digital leased lines, two possible, topologies were chosen. In both cases, the European sites were connected to each other, and then via a single link to the UK. For the UK, in the first option, the sites were connected as a ring (or loop), and in the second option, a mesh. Three levels of use of the interconnections were considered. These levels were 5, 10, and 15 percent.

When international as well as national traffic is considered together with 10 percent use, the order (cheapest first), for the recurrent costs of the options is as follows:

1. ISDN (Basic Access)
2. X.25 (JANET & IPSS)
3. ISDN (Primary Rate Access)
4. KiloStream (Ring Topology)
5. KiloStream (Mesh Topology)
6. X.25 (PSS & IPSS)
7. MegaStream (Ring Topology)
8. MegaStream (Mesh Topology)

Management Requirements

The necessary management functions identified were:

- When allocating resources deadlocking must be avoided. If several tasks attempt to collect resources until they can run, then there can be several tasks holding resources that each other are waiting for – hence deadlocking.
- To avoid users waiting on a constant negotiation for resources, some type of booking system would be useful; users can then negotiate use of the system in advance. This booking system could be distributed between the various nodes, or could be implemented as a single centralized booking server.
- User authorization may be needed for reasons of security. Problems may occur if user ID's and passwords are passed from one node to another – as this potentially enables "log-in" sequences to be copied.
- Some type of accounting system will probably be needed so that it is possible to identify who has been using the system, and for how long. If the system is heavily loaded, there may be need to control access – possibly in the form of allocation of slots of time.
- Task management will be needed at each node to control use of the local facilities. This management will need to manage use of local resources, such as disc space, and will also need to enforce job time limits.

As well as management functions, a certain number of facilities will need to be provided at each node to create an environment in which tasks can run.

- Some type of loading (and possibly dumping) mechanism will be need to be provided to load programs (possibly across the network) into the required nodes.
- Access to local filestore and standard operating system calls must be provided at each node. This has implications as to the node security.
- A configuration language will be needed to define how the tasks are distributed across the various transputers and sites (see the next section).
- A checkpointing facility may be useful to allow large programs to restart after failure.

Configuration Problems

In general, a DSC application may require a DSC network of arbitrary topology whose nodes are transputer clusters. The topological connections are assumed to remain fixed for the duration of any application. In practice, a DSC may offer only a particular topology for its nodes to which each application has to conform. This study deals with the general case.

There are some weaknesses in the existing configuration language. The OCCAM language lets us describe a closed network made out of a flat collection of transputer processing nodes and transputer communication links.

In reality, transputer applications are never closed but have some interaction with the outside world. Frequently, these interactions take place through transputer links, the outside world may be another transputer application or some more conventional architecture mapped onto a transputer link. Currently, such interactions are not openly declared in the top level configuration code, but are buried in local declarations within the code for the processor that manages the external interface.

Transputer applications also have structure at the hardware level. A sub-network might have responsibility for a particular subsystem such as flight control, matrix inversion, or an operating system spine. Sub-networks may have sub-sub-networks. At the lowest level, there

will be a flat collection of transputers with external links. At higher levels, there will be a flat collection of sub-networks, also with external links.

The DSC is an example of a transputer application with at least two such levels of structure. From the DSC application designer's viewpoint the intersite WAN links may be modeled by transputer links or by OCCAM first-in/first-out processes.

The two weaknesses, closedness and flatness, are different manifestations of the same problem. A configuration language that allows description of open connections will give hierarchical structure as well. This capability is relevant to the DSC for properly describing each component of an application that runs on a particular site. Such components will run on a local cluster of transputers and will require external connections to other sites. The designer of the application is free to multiplex or de-multiplex OCCAM channels onto the limited number of transputer links that local site provides to the DSC cluster.

The capability to allow description of open connections removes a source of mistakes in the ordinary programing of transputer networks that need access to operating system services that execute on their own transputer such as the INMOS TDS and the Meiko ERIX. Link numbers are very difficult to get right when these connections are defined deep in the application.

Arbitrary levels of configured networks can be described by the above scheme but the processor line describing the kind of processor on which the code is to be placed must be generalized. At higher levels, in each component of a placed par, code is being placed into a structured multiprocessor, not a single transputer. The Kent group's final report will give a discussion of some of these problems.

Infrastructure Requirements

Infrastructure requirements that have been identified as necessary or useful for the implementation of a DSC environment are:

- Programs should be loaded into the DSC nodes in one of the standard transputer loader formats. All types of nodes must then be able to accept the selected format.
- File transfer should be provided to allow programs or data to be loaded into the nodes in advance of operation; this will allow the DSC to spend all of its time running tasks rather than performing file transfer. The file transfer should be implemented using standard file transfer protocols.
- File store and system access should be provided using the standard system access facilities available on each node. A standard library interface must be defined, such that the system access is identical, no matter which type of node is being used.
- A "Grey Book" mail service should be provided to allow users of the various nodes to coordinate use of the DSC resources.
- The provision or not of checkpointing within a program should be left to the user. The system would need to be told if – and how – a program can be restarted after being interrupted.

Interfacing Requirements

The interface to the long-haul links should operate through the operating system in order to provide security and insulate the user from details relating to the underlying network. It is relatively straightforward to incorporate such software into the Meiko system.

Facilities requirements include: circuits for transfer of load images and initial data; circuits for use during the running of an application; those to handle booking for resources; and those needed for diagnostic facilities.

The basic rate ISDN appears to be a good choice for the network. Since the circuits are dynamic, the network topology may be adapted to the problem. However, it is likely that a star or ring topology will handle most problems. The ring structure has the advantage of not requiring any one site to have more than two circuit end points and makes no site vital to operation of the service.

Realization of the ISDN interface is expected to be achieved using existing or projected products. British Telecom is developing two circuit cards intended for IBM-PC clones. One offers an X.21 interface providing access to ISDN through network terminating equipment. The second card attaches directly to the NTI interface of ISDN and offers I.430, Q.921, and Q.931 facilities. It is unclear as to whether these cards offer two circuit end points as required for the Kent configurations. The IBM-PC will act as a front-end processor and booking server. Interfaces exist to connect the PC to a hardened transputer link.

Conclusions and Comments

This report is based on a preliminary report prepared by Kent University for the Transputer Initiative Seminar, held at Rutherford-Appleton Laboratory on 26 April, 1988. A final report to be available later will contain firm conclusions and recommendations.

A recommendation of the study thus far is that if the minimum speed for a connection into a site is to be 64 kbytes/sec then Basic Access ISDN is the best solution to access. It is stated, however, that JANET could provide an alternative. This alternative is second choice because the proposed configuration includes sites in Europe, and the JANET circuits would therefore have to be supplemented by use of IPSS at additional cost. Also,

to guarantee JANET bandwidth it is probable that additional JANET lines to each site would be required.

The study concludes that there is merit in linking transputer facilities with a medium-speed ISDN network, but the major benefits arise from the ability to queue and distribute complete tasks to idle nodes in parallel, rather than to execute one task on the whole distributed facility. The operation of a single DSC is applicable only to a few carefully selected very large problems. The total real time to wait in the queue for the DSC and execute the problem on it must be less than the time to execute it on a single node.

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7/3/88

Development of Finite Element Software for Transputer-Based Parallel Processors

by J.F. Blackburn.

Introduction

As part of the UK's Science and Engineering Research Council/Department of Trade and Industry (SERC/DTI) Transputer Initiative to promote engineering applications of the transputer, Professor R. Wait of the Center for Mathematical Software Research at Liverpool University is leading an investigation to analyze the performance of transputer networks as vehicles for finite element calculations and to provide OCCAM software tools that simplify the user interface with such a network. (For more on the transputer and the OCCAM program, see the preceding article.)

The three main parts of the work are:

- Development of finite element software to generate element stiffness matrices, and assemble the global matrix, on a transputer array
- Development of numerical linear algebra software for sparse matrix problems on a transputer array Linking the two sets of software tools into a computational environment for finite element calculations.

Algorithm Development

A complete finite element system would include a preprocessing phase incorporating automatic mesh generation, and a postprocessing phase including stress recovery and graphical output. Since the time allotted was short and there was not graphics hardware on the transputer systems used for the software development Professor Wait assumed these two phases were outside the scope of the project.

Matrix Assembly

With an array of k transputers available, the problem domain can be partitioned into k subdomains. When each transputer has received a definition of the geometry of the associated subdomain the element stiffness matrices can be generated without further interprocessor communications. This method of element matrix generation is called "data partitioning," as identical processes are loaded into each processor which then performs the same operations on a different subset of the data. The data for the element matrix assembly are the geometries of the elements in the form of arrays of nodal coordinates and arrays of element node numbers. A complete list of the OCCAM 2 procedures used in the generation of the element matrices for a processor subdomain will be included in the report by Wait and Brown (1988). The computation does not involve any communication after the loading of the code and the data, so this phase is largely independent of the array topology if the subdomains are large enough. If the problem partition is into very small subdomains then the loading of the processors can dominate the computation.

Numerical Linear Algebra

One aspect of the work has resulted in a report on overlapping block Jacobi methods, including the numerical results given in the report by L.M. Delves (Delves, 1988) on a 16-transputer Meiko Computing Surface. Full details of this work are given in Wait and Brown (1988). The banded systems used for the experiments in Wait and Brown's report were based on a simple finite difference scheme on a regular grid.

The test problem implemented was defined on a regular rectangular grid which leads to a block tridiagonal system of algebraic equations. The algorithm implemented to solve this test problem is a method based on Block Cyclic Reduction, a block iteration method of solution. This is an interim provision, and there is a need for a more robust linear solver appropriate to finite element systems. Three possible methods have been identified:

1. A direct solution based on the partitioned subdomain. This can be viewed as a one-way dissection or multifrontal method; assuming there is no need for backing store, the computation is essentially the same for each. The drawbacks are that the final stages of the elimination/factorization are difficult to efficiently carry out in parallel on an array with more than a few processors. It is important that when a transputer network is used as an MIMD parallel machine, it does not experience severe degradation of performance on finite element type sparse matrix calculations. One function of this project is to investigate fully the problems associated with synchronization delays and with transferring large amounts of data in realistic finite element calculations using a network of powerful computing elements with limited local memory.

2. An iterative solution of the full system of equations, probably based on the preconditioning conjugate gradient method is a well-tried alternative to direct methods. In view of the results given in Delves (1988) and Wait and Brown (1988) a few cycles of a block Jacobi iteration could be used as a preconditioner. This form of iteration reduces the amount of storage required on each processor for a given size of problem and it greatly reduces the problems of load balancing.

3. If each processor is loaded with the equations corresponding to a subdomain then the nodes in the interior of the subdomain appear only in equations of the processor associated with that subdomain. On each processor it is possible to eliminate the interior nodal degrees of freedom in terms of the remainder, prior to any interprocessor communications. This is the first stage in the direct method proposed in paragraph 1, above. However, as an alternative to a complete forward elimination it is possible to complete the solution by an iteration with the reduced system. This avoids the need for an algorithm with a complex tree structure for completing the later stages of the elimination. This approach has been successfully implemented on other highly parallel architectures (Wait, 1988). In this approach the choice of the preconditioner is crucial to the efficiency of the method. Both types of iteration are more easily done in parallel than is the direct method, but the communication costs vary and the iterative methods are not as robust as the direct methods. These general strategies constitute an area for future work.

Global Assembly

Both direct and iterative solvers are needed so the data structures selected should be compatible with any of the above-described solvers, given a specified domain decomposition. The global assembly phase is the link between the element matrix generation and the linear solvers. At this stage decisions concerning the form of the global matrix have to be implemented. To be answered are such questions as: Where is the space provided for the fill-in with a direct solver, or What is the best form of compact storage for an iterative method.

Implementation

In view of the large number of level 0 routines necessary to build a complete finite element program, there was no attempt to provide comprehensive error handling facilities at this time. In a finite element environment the user may manipulate a processor topology that reflects the problem domain. Although this strategy is often advocated, particularly for electronically reconfigurable arrays, it is not obvious that it provides a realistic computational model. The demonstration software is arranged as a process farm so that the same procedures, containing all the library routines for assembling the matrices, are loaded onto each slave transputer in the array. The equation solver runs on the local host as a separate code fold. This strategy is not optimal but it was adopted in order to provide an identifiable structure to the demonstration software, given the short time scale of the contract. This method of static loading the complete library code on to all slave processors severely reduces the memory resource (Delves, 1988). An efficient alternative implementation of a finite element library would be to use dynamic loading (Brown and Delves, 1988).

Conclusions

This project has verified the suitability of transputer arrays for finite element programs. The next logical step is to provide software to deal with more general domains. The procedures for generating the element matrices is independent of the topology outside the individual processor subdomain, and so this part of the software is already available for arbitrary regions. Interprocessor communication is only necessary: (1) to load the geometry, if it is not generated locally; (2) to exchange element data at the subdomain interface to complete the global assembly (both steps involve one-way communication); and (3) as an integral part of the equation solver.

The provision of general purpose linear equation solvers is the next major objective.

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7/4/88

MATERIALS SCIENCE

Ion Irradiation Studies at Padua, Italy

by Louis Cartz. Dr. Cartz was the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He has now returned to Marquette University, College of Engineering, Milwaukee, Wisconsin, where he is a Professor of Materials Science.

Introduction

There are two institutes in Padua where research studies on ion irradiation of materials are being undertaken. These are at the Department of Physics' "Galileo Galilei" of the University of Padua and the Instituto Nazionale di Fisica Nucleare, Laboratori Nazional: di Legnaro (LNL); they are within about 10 kilometers of one another. The LNL laboratory is at the disposal of the various universities of Italy. My visits to the university and LNL were made possible with the aid of the university's Dr. A.V. Drigo and LNL's Professor P. Mazzoldi.

This review is mainly concerned with the irradiation studies on glasses and ceramics, and with the work in surface mechanical properties being conducted at both institutions.

Laboratori Nazionale di Legnaı. The LNL laboratory is well set up in modern buildings, located at Via Romea 4, I-35020, Legnaro, Padua, Italy; it is under the direction of Professor Piero Dalphaz. The principal items of equipment consist of two Van de Graaff (2 MV, 7.5 MV), a tandem XTU (16.3 MV), and an ion implantation facility. There are several instruments under construction including a recoil mass spectrometer and associated detectors. All of the equipment is well maintained and being upgraded as appropriate.

The laboratory is used by faculty from many Italian universities (among others, those at Padua, Genoa, Naples, Trieste, Milan, Trento, Bologna, Modena, Firenze, Bari, Messina, Torino, Rome, Parma, Pisa, Catania, Verona, Lecce) and by workers from the US, West Germany, France, Hungary, the UK, Chile, and Turkey. Studies pursued at the laboratory cover topics in experimental and theoretical nuclear physics, biology, mammography, environment, and archeology, as well as those in materials science and solid-state physics. Over 200 LNL scientific publications appeared in 1987, most in English.

University of Padua, Department of Physics. The faculty of the university's Department of Physics benefits considerably from the proximity of LNL (with its accelerators and implantation facilities). Studies at the university are concerned with glasses and ceramics and with semiconductor materials as well as with ion beam mixing and film adhesion.

Irradiation in Glasses and Ceramics

Many of the irradiation studies on glasses and ceramics have been carried out by Mazzoldi and colleagues (Mazzoldi, 1987; Mazzoldi and Arnold, 1987). These have been concerned with the chemical durability and leaching of glasses (related to their use as host materials for radioactive waste), ion exchange for waveguide formation, optical properties (in conjunction with the glass industry of the island of Murano, Italy), and the adhesion of metal films to glasses.

During ion irradiation, alkali depletion occurs at the surface region of the glasses, either by alkali preferential sputtering or by radiation-enhanced diffusion. Soda-lime silicate glasses ($73SiO_2$, $14Na_2O$, $6.8CaO$, $1.8Al_2O_3$, 3.9-MgO weight-percent) have been implanted with H, N, O, Ne, and Kr ions of fluence 10^{16} to $2x10^{17}$ ions/cm^2 at energies from 20 keV to 300 keV, using current densities of 0.3 to 3 μA/cm^2 under 10^{-6} to 10^{-7} torr. The Na profile is determined by nuclear reaction analysis (NRA) and by Rutherford backscattering (RBS), and the surface examined by Auger electron spectroscopy (AES) and x-ray photoelectron spectroscopy (xps). (An advanced secondary ion mass spectrometer (SIMS) was installed in 1987 in the Department of Physics at Padua as a complementary analytical tool; this extends the sensitivity of the techniques at Padua to the ppm and ppb range.) The degree of depletion tends to a limit dependent on the ion energy (range) and on the ion current density. Other studies of glasses have been concerned with the leaching of Zn-containing glasses, and of the ion beam mixing of Fe/SiO_2 by Ar (100 keV) ion irradiation. Depth profiles have been determined of glasses irradiated by 4.5-keV electrons, and by Xe ions of 250 keV, of glasses containing Li, Ca, or Na cations during which the surface compositional changes are followed. The thickness of the modified layer, due to the irradiation, is greater than the incident ion range, and this effect increases with the mass of the incident particle. The compositional changes in the surface region are considered to be due to an electric-field-

assisted diffusion due to the deposited charge of the irradiated ions.

Surface Mechanical Properties

Surface swelling and surface stresses of glasses after irradiation have been measured by step-height technique, as well as by hardness testing measurements. Irradiations have been carried out of alkali silicate glasses, fused silica, and borosilicate glasses by H, He, O, Ne, Ar, and Xe ions of energies up to 250 keV at fluences up to 10^{16} ions/cm^2. Surface compression, microcracking, swelling, and thermal stability have been studied by fluence, ion mass, and energy. It is believed that it will be possible to develop surface hardening effects in glasses by ion implantation (Mazzoldi, 1987).

Optical Changes in Glasses and $LiNbO_3$. The refractive index (RI) of glasses is in general reduced by ion implantation while the RI of fused SiO_2, α-quartz and $LiNbO_3$ crystals increases with ion implantation of N, O, B, He, Ne (Mazzoldi and Carnera, 1987). Optical slab waveguides can be formed when ion implantation gives rise to lower RI outer layers. The surface reflectance is modified with implantation energy, so that ion implantation can be as effective as vacuum-deposited antireflection coatings.

Surfaces of Ceramics. Since surface flaws play a very important role in determining the mechanical properties of ceramics, implantation can give rise to increased surface hardness and toughness by inducing compressive stresses and reducing flaws. Surface hardness measurements are carried out using a specially designed ultralow load system. Ions of N and Ar are being implanted into ceramics based on Al_2O_3, MgO, ZrO_2, SiC, Si_3N_4, and TiB_2 (Mazzoldi, 1987).

Semiconductors. *Self-annealing effects have been* studied of P and Si implanted into Si (Berti et al., 1986b). It is known that annealing of Si by ion or electron beams occurs at temperatures below those required for thermal anealing, and studies are being carried out to determine the mechanism of this lower temperature self-annealing. Crystalline, and also some pre-amorphized Si samples have been irradiated with P (100 keV), at 60 to 500 μA/cm^2; RBS and transmission electron microscopy (TEM) studies have been carried out of the damaged surfaces. The ion-induced crystalline regrowth rates have been determined, and the activation energy is found to be $\sim$0.32 eV. This activation energy is comparable to that for the migration of neutral vacancies, indicating a mechanism dependent on the migration of point defects by elastic displacements.

M. Berti et al. (1986a) have studied superlattices of $In_xGa_{1-x}As/GaAs$ as deposited by molecular beam epitaxy (MBE) and by metal organic chemical vapor deposition (MOCVD); the electrical properties of such epitaxially grown semiconductors are very interesting. Strains are introduced due to lattice mismatching in the epitaxial plane; $a_{\parallel}$ (in plane) can be 1 percent different from $a_{\perp}$ (perpendicular to plane). RBS is used to observe the crystal direction changes induced by this "tetragonal" distortion.

The incorporation of gas by pulsed laser annealing of Si in a range of gaseous atmospheres has been studied by Berti et al. (1986c). The gas incorporation occurs during the μs following the ns laser pulse. NRA and RBS have been used to determine the composition profile. Significant incorporation of gas occurs only for very high irradiation densities (>3 J/cm^2), when surface melting occurs.

Another study has been concerned with magnetron-sputtered amorphous silicon (α-Si:H) films, relating the physical properties of such films to the hydrogen concentration (Della Mea et al., 1988). RBS and NRA have been used to determine the film composition and hydrogen profiles with depth, and these have been related to the optical and electrical properties of the films.

Other Studies

Ion beam mixing experiments have been carried out on Fe-Pt and Ni-Pb bilayers, using 200-keV Kr (doubly charged) ions, and 600-keV Ar ions. When the surface layer consists of 60 nm of Pt. RBS and grazing incidence x-ray diffraction (GIXD) studies have shown the alloy $Fe_{0.4}Pt_{0.6}$ to form (Battaglin et al., 1988).

Adhesion studies have been carried out of thin films of Fe on glass of Si surfaces, irradiated by 1-MeV protons (Carbucicchio et al., 1986).

Comments

The work undertaken at Padua – at the university and the research institute, LNL – are of a very high standard, equal to that observed in any of the better laboratories of Europe or the US. There are a very large number of international collaborative studies with a wide range of US laboratories (such as those at Sandia, IBM, and Bell Laboratories), Orsay in France, and at other European laboratories in Karlsruhe, West Germany, and Guildford, UK. The equipment is well maintained, with first-rate facilities giving rise to exceptionally good research opportunities. This seems to be the case for many universities and research institutes in Italy, which must be considered to be in the forefront of scientific endeavors.

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7/4/88

PHYSICS

Intelligent Sensors in Neubiberg

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.

The rather new Institute for Measurement and Control Technology is a self-managed unit of the Electrical Engineering Division of the West German Armed Forces University of Munich. The University's modern and pleasant campus is in Neubiberg, a southeastern suburb of Munich. The Director of the institute is Professor Dr. H.R. Tränkler. He has only about nine research associates, but receives much technical support by the institute's close cooperation with industrial research labs, including those of Siemens and Karl Thomae. In addition to undergraduate and graduate level teaching and fundamental and applied research, the institute also maintains a technology-transfer and advisory function, cooperating with the appropriate Bavarian governmental agencies.

The institute's work in the area of metrology focuses on intelligent ("smart") sensor systems. The main research targets are as follows:

1. Drafting and testing algorithms for sensor-specific signal processing and data evaluation. This work concerns linearization of sensor characteristics and static error correction; dynamic error correction and adaptive sensors; and finally, recognition of complex measurement signals (this includes pattern recognition, both spatial and temporal).

2. System design studies of microelectronic measuring systems. The research in this subfield comprises not only the integration of diverse sensors, electronic and logic components, and data fusing, but also the system-aspects and problems of both the "process"- environment (from where the measurands and other data are taken) as well as of the human interface (at the final level of the entire system).

3. There is additional research done to invent, design, and fabricate prototypes of new sensors and partial sensor-systems (transducers). This work has entailed, so far, only electromechanical devices (not optical, optoelectronic, or microelectronic-semiconductor sensors), but a broadening of scope is in progress.

The research and design laboratory of the institute has very fine equipment and instrumentation. This includes a DX990/10 computer (dedicated to microprocessor programing), development systems for Intel microprocessors, IEEE-bus-controlled test and calibration tools (for a wide variety of measurements, ranging from mechanical entities through electrical data to gas-chromatography, density and concentration measurement instruments), as well as a number of personal computers and peripheral calculation equipment.

General Considerations about Intelligent Sensors

In the true tradition of German academia, Tränkler approaches the institute's program from a philosophical viewpoint. Physics and technology, he explains, determine the quality and applicability of sensors and transducers. Theory of measurement produces the algorithms which are necessary for static or dynamic correction of sensor signals – similar algorithms are needed to

devise intelligent measuring systems. The physics, technology, and mathematics aspects are so interwoven that only a well-focused, well-directed, concentrated research program has the chance to come up with widely applicable, properly accurate, and relatively inexpensive systems. Contrary to often-heard overoptimistic promises, Tränkler believes that the ideal physical effect (on which a sensor is based) is generally not realizable on the level of design and manufacture, not even if intolerable fabricating expenses are taken into account. Instead of stable linear and influence-free characteristics of measuring components, we get, in the output, unwanted arithmetic operations and combinations with external perturbing influences. Tränkler, following other pioneers in "smart" microprocessor-controlled measurement systems, says that, instead of "fighting" the inevitable, one must use "brains." For example, by application of reference input signals (or by a separate measurement of the perturbing influences) the static characteristic of a sensor can be corrected. In practice, this requires the systematic use of algorithms, as well as a knowledge of the approximation-model function.

Here is where intelligent sensor systems (IS) become the "operative idea." Even though the field is still in a formative period, Tränkler finds it important to coin precise definitions. He emphasizes that all IS's are based on sensor-specific measurement-signal processing. He distinguishes between IS's in the broader sense and in the narrower sense. IS's in the broader sense simply enhance the usable information-content to a required level. IS's in the narrower sense gain usable information stemming from a number of individual informations which – taken by themselves – have only a small, and hence insufficient, information content.

IS's in the broader sense may be used, for example, to improve static or dynamic transference characteristics. But for the determination of complex measurands (such as recognition of spatial or temporal patterns), IS's in the narrower sense must be used.

Thus, IS's allow the determination of quantities almost entirely free from physical or technical sensor-quality limitations and from perturbing external influences; moreover, they permit the determination of complex features which previously could not be measured by sensors at all. In addition, it is now possible to combine smart sensors with sophisticated evaluating processors on one chip, and these "single chip sensors" are becoming increasingly important. The single chip IS can be considered as a natural outgrowth of elementary sensors in the classical sense, through stages of the transducer and digital sensor. This is illustrated in Figure 1. Even more impressive is the graphical representation of the historical development of "sensors," showing how, gradually, the sensor element, analog signal preprocessing, converter, and microcomputer components of a measurement system became integrated (Figure 2).

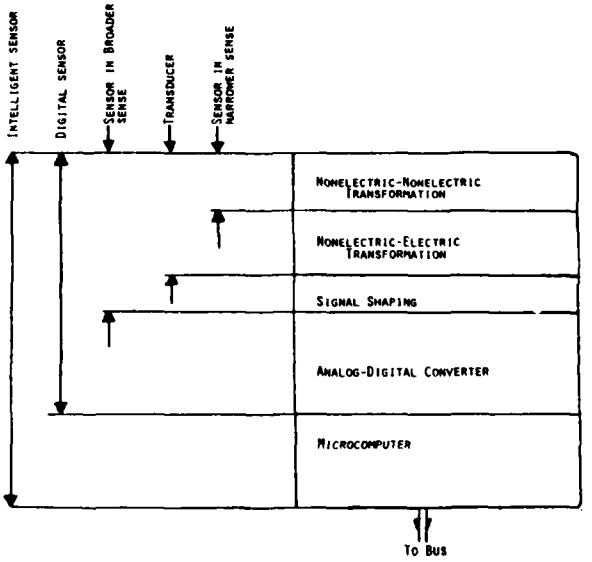

Figure 1. Scheme of an intelligent single-chip sensor.

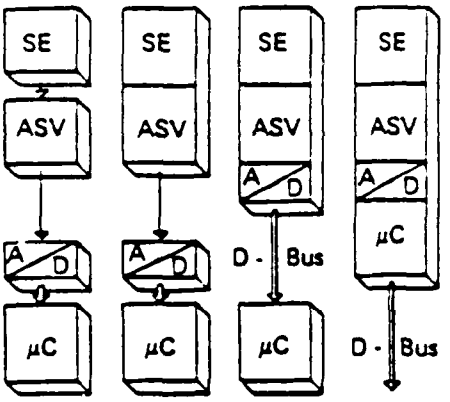

Figure 2. Development of modern measuring systems. (SE = sensor element; ASV = analog signal preprocessing; A/D = analog/digital converter; mC = microcomputer; D-Bus = data bus.)

Tränkler emphasized that, in his opinion, for the realization of high-performance intelligent sensors it is absolutely necessary to assign a dedicated microcomputer to each sensor path. These permit both the computation of static, adaptive, and dynamic corrections, as well as the determination of complex features. Furthermore, in order to increase the integrity of the signal transmission, and also to increase clarity and economics of the system, it is necessary to use sensor-specific signal forms and serial bus systems.

Tränkler concluded the interview with sketching his vision of an entire microelectronic system of the future

(see Figure 3). On one side, we have the "process" which is monitored by sensors and acted upon by actuators. On the other side, we have the "human operator," who receives output from the huge system and can influence or control the process by appropriate inputs. In between we have the intelligent sensor systems and intelligent actuator systems, with appropriate signal-specific processing. To each microperipheral component there is assigned a dedicated microcomputer. The individual components communicate through a digital data bus. For successful operation, it is necessary to employ specific signal processing procedures (adapted to each element), so as to minimize data traffic on the bus.

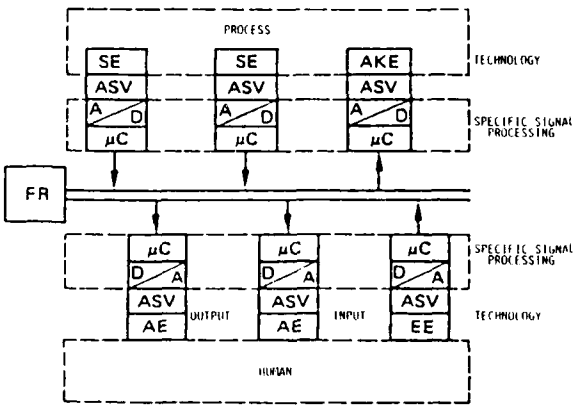

Figure 3. A complete microelectronic system of the future. (SE = sensor element; ASV = analog signal preprocessing; A/D = analog/digital converter; µC = microcomputer; FR = controlling computer; D/A = digital/analog converter; AE = output interface; EE = input interface.)

Examples of Current Research

Tränkler's philosophy is well illustrated by an industrial multisensor system, recently designed, built, and tested at the institute (and transferred to users). The multipurpose system is symbolized in Figure 4. A coil spring or a printed coil sensor element or some other micromechanical sensor element (not shown) responds to force, displacement, pressure, mass flow, or liquid level values in the "technical process." Temperature in the "process" is also sensed (by locally developed spreading resistance-effect sensors) – but of course, temperature parameters also influence and perturb the reading of the other measurand. The inductive sensor controls the frequency of an inductive-capacitive oscillator that operates at around 1 MHz. The temperature sensor controls a resistive-capacitive oscillator. The signals of the oscillators are electronically multiplexed together, and transmitted (via a two-wire line, a coaxial cable, or a fiber-optic link) to a demultiplexer at some distance away. Frequency-analog mode of transmission is used. After frequency-digital conversion, a microcomputer linearizes the sensor output and corrects for temperature perturbations. The processed output of the intelligent sensor is calibrated by the program when the system is installed, and the calibration results are stored in the microcomputer's memory. The microcomputer has a keyboard/display peripheral, and is connected to a "sensorbus" by a suitable interface. The sensorbus combines data from a large number of intelligent sensors. Incidentally, the microcomputer (in each IS path) can also easily be its own watchdog and report any sensor problems.

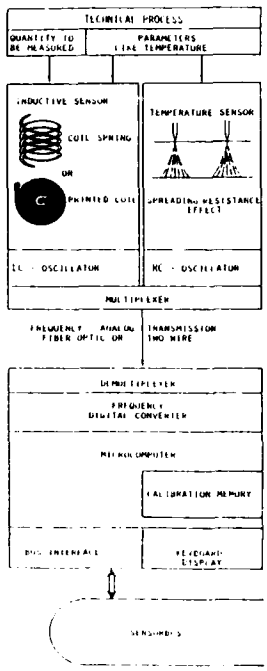

Figure 4.
Microcomputer = oriented intelligent sensor system scheme.

A second project, recently concluded at the institute, illustrates the algorithm-designing activities of the researchers. In the past, one did not have inexpensive sensors that could selectively determine the individual component-concentrations in a gas mixture. The reason is that, for any individual sensor for a particular component, there always is some cross-sensitivity to the other components. Hence, the individual component-concentration values can be ascertained only by using several sensors for each component – any single one has, naturally, a different cross-sensitivity to the "alien" gas components. With such a multisensor system a multidimensional analysis can be performed, provided that with the use of sensor-specific signal processing one succeeds to determine the n measurands $x_1, ..., x_n$ from the m sensor output signals $y_1, ..., y_m$. This is what the scientists of the institute did. The coefficients of the system of equations were determined by a regression proce-

dure, based on a large number of measurements on systems with known composition. However, the equations with the established coefficients allow an easy solution for an unknown set of concentration values only if the system is linear. (Then, for $n = m$, matrix inversion gives the answer.) In real life, the system is nonlinear, so that the superposition principle does not apply. The scientists developed stochastic-deterministic search procedures and also, on an even more sophisticated level, they developed algorithms for pattern recognition. With these methods, quick solution of the equation system – i.e., efficient and simultaneous determination of the individual gas component concentrations – became feasible.

After developing the algorithms, the researchers also did the experimental and construction work: they built a complete workstation with elaborate and flexible calibration and testing facilities and used it to develop prototype gas analyzers. Later, these were transferred to governmental and industrial users.

A third aspect of the institute's research profile is exemplified by the development of signal processing and algorithmic methods for use with intelligent sensors designed for recognizing complex features. Using only simple IS methodology, it is now possible to discover and map faults with ultrasound echo analysis in bulk matter samples. But to improve the distance resolution up to an acceptable level it is necessary to separate very clearly the partial echoes. The institute's researchers achieved this by using convolution algorithms that calculate and display correlations. Figure 5 illustrates the success of this research. The top line shows the actual echo-profile, as captured by the sensor (piezoelectric transducer). The second line is a norm-echo, automatically produced by the measuring system. The bottom line shows the result of convolution: the resolution of the echoes is now excellent.

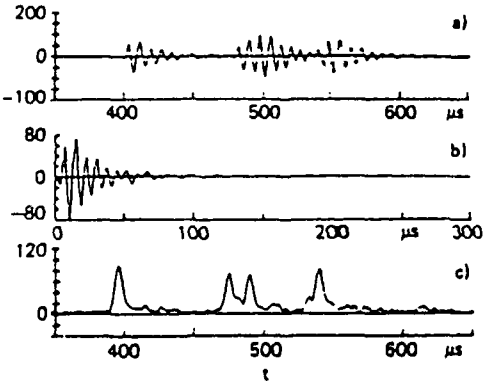

Figure 5. Separation of partial echoes by convolution.

Some Data-handling Research

This sketch of the institute's research and development profile would be incomplete if I did not describe also activities which, in a way, go beyond the strict domain of sensorology – but which are facilitated in the institute because of its embedment in the Electrical Engineering Division.

As is obvious from the introductory discussion, in modern microelectronic measuring systems the sensor signals must be available in a digital form. However, up to now, only in very few cases do we have sensors which give directly a digital output. Therefore, one must be satisfied (for the time being) with "digital-friendly" sensors. Among these, Tränkler thinks, sensors with a frequency-output are foremost, allowing a simple digitalization of the raw output. One reason is that sensors of this class can be manufactured with high accuracy and inexpensively, and the use of expensive analog-digital converters becomes unnecessary.

Frequency-analog sensors or control sources are well known. They range from the tuning fork quartz oscillator to resistive sensors (Si or Pt resistance thermometers, or magnetosensitive field-plates), capacitive sensors, and inductive sensors. (I already mentioned their use in connection with the first example of the institute's research activities.) Tränkler notes that even voltage-outputting sensors (such as modern Hall-elements) allow for an easy conversion of voltage to frequency.

Here, then, is the first research in this area which was tackled successfully at Neubiberg. For efficient use of frequency output sensors, it is important to have extremely good oscillators. This is so because the Q-value of, let us say, an inductive sensor element is usually low and, in addition, varies with the measurand. In order to have a multipurpose oscillator with extreme frequency stability, the institute developed a modified Franklin oscillator (see Figure 6). Here the needed 180° phase-rotation is achieved not with passive components, but via a second amplifier stage which has a high input resistance, a low output resistance, and a low and widely frequency-independent input- and output-capacitance. In this way, the output frequency of the oscillator coincides to great precision with the resonance frequency of the oscillating circuit. Apart from high stability, this also reduces substantially the usual warm-up time. Using this modified

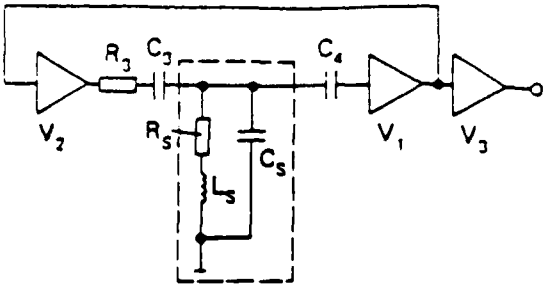

Figure 6.
Circuit diagram of the modified Franklin oscillator.

Franklin oscillator with inductive sensors, in the particular case of a conical spring displacement sensor a resolution of 9 Hz/μm was achieved in the entire range from 1.3 MHz to 2.2 MHz. The standard deviation of the output signal was below 2 Hz. Current experiments study the use of the oscillator with capacitive sensors. As a matter of fact, the institute went beyond this oscillator development work, and has now developed an even more stable modified Pierce oscillator.

Once a good-quality frequency signal is obtained, the next step is to combine it (using locally developed logic-circuits) with the output of a standard RC-oscillator that is linked to the output of a temperature sensor which monitors the temperature of the environment. (This point was discussed earlier). Figure 7 shows a typical multiplexed output, which is then sent to the processing electronics by a two-wire, coaxial cable, or fiber optic transmission link (also mentioned earlier).

Figure 7. Typical output signal.

Eventually (after demultiplexing), the frequency-digital conversion (i.e., frequency measurement) must be taken care of. For this step, the researchers of the institute developed known counter techniques to suit the specific requirements of IS's. They found that by using a microprocessor, one can effectively arrange for a synchronized gating time. As Figure 8 shows, three counters are used in the Neubiberg converter-system. Z1 (in Figure 8) captures the pulses at the input, Z2 measures the synchronized gating time, and Z3 is used as a programmable time-divider supplying the gating time. The quality of this converter system is illustrated by the experimental result that using, for example, a 10-MHz reference frequency, a 10-ms gating time setting guarantees a resolution of about 16 bits, completely independently of the input-signal's frequency. In the conceptual framework of IS work, a further advantage of the Neubiberg-converter is that the gating time can be automatically adjusted so as to suppress system-induced perturbations. In other words, the counter "contains" an integrated filter.

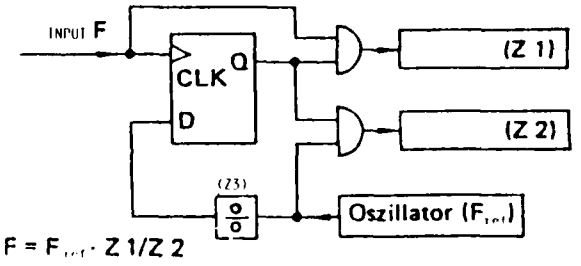

Figure 8. Block diagram of the frequency/digital converter.

Concluding Remarks; Plans for the Future

The broad spectrum of activities at the institute – ranging from IS systems theory, through technical realization of all stages, to the development of sensor elements – impressed me strongly, especially because I admired the spirit of sincere philosophic considerations combined with practical work and user-oriented activities. The institute's future plans continue the present preoccupation with sensor-specific methods for measurement-signal processing, and the development of IS systems that allow for high-demand requirements while aiming for price-effectiveness, ruggedness, and simplicity as well.

In addition to these general lines of planning, the institute recently beame a partner in several specific federally funded research projects. One of them is a crush-project to develop MOSFET gas sensors. (Apart from three Fraunhofer Institutes, the Physics Institute of the Bundeswehr University is also contributing to the project, the latter by using the unique capabilities of their in-house molecular beam epitaxy (MBE) facilities (see *ESN* 39-6:276-281[1985]). A second federal project, supported by the DFG (the West German equivalent of the NSF) is aimed at the study of creep-correction and hysteresis-correction methods for intelligent sensors. In this pioneering basic research effort various models are put into advanced algorithms, and detailed computer-controlled programs test actual experimental evidence provided by simple typical test systems. Being an outsider, I was surprised to learn that the modeling of the rather simple physical systems of creep and hysteresis require a stunning amount of computer memory utilization. But work is progressing well also in this new enterprise.

Optics Research at Santiago

by Paul Roman.

There is a small, but promising optics research group within the Department of Applied Physics at the University of Santiago de Compostela, in northern Spain. The group is led by Professor C. Gomez-Reino, and it consists of 12 members (including doctoral students). The group's activities concentrate on two areas: (1) tapered

gradient-index (GRIN) optics and (2) holographic optical elements. In addition, and in cooperation with Professor C. Righini at Florence (Italy), the theory of geodesical micro-optical components is also pursued.

The work on GRIN optics is purely theoretical research and concerns topics of optimizing GRIN-based optical couplers, connectors, and collimators. There are maturing plans underway to devise computer algorithms for automatic GRIN design.

The work in holographic optical elements concentrates presently on tools for alignment of interferometers and on the design of other optical tools, such as holographically produced zone plates. Future plans involve development of holographic components for integrated optics, including spectrum analyzers.

I have a collection of recent papers of this optics group, and, if definite areas in the above-outlined fields are specified, I would be glad to supply copies to qualified requestors.

SUPERCONDUCTIVITY

Summary of a Report on High Temperature Superconductivity Research in Selected Laboratories in West Germany

by Donald H. Liebenberg, Low Temperature Physics Program, National Science Foundation, and Alan F. Clark, Office of Naval Research. Dr. Clark is the Liaison Scientist for Superconducting Materials and Electromagnetics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until March 1989 from the National Bureau of Standards in Boulder, Colorado, where he is Group Leader of the Superconductor and Magnetic Measurements Group.

Introduction

At the invitation of H. Dr. Hans Donth, Deputy Assistant Secretary, Federal Ministry for Research and Technology (BMFT), we, the authors, were invited to visit laboratories in West Germany to discuss research in progress on the high temperature superconducting materials. Fr. Dr. Magdala Gronau, Verein Deutscher Ingenieures (VDI), acted to arrange the visits and accompanied us on several of them. The visits occurred early spring following by about a month the announcement of the BiCaSrCuO – another of the high temperature superconductors. The laboratories visited included those of universities at Giessen and Darmstadt, those involved in industrial research at Hoechst and Siemens, and the federally supported laboratories at the Walther Meissner Institute at Garching, the Max Planck Institute at Stuttgart, the Kernforschungsanlage (KFA) at Julich, and the Kernforschungszentrum Karlsruhe (KfK) at Karlsruhe. The research capabilities observed and the results discussed for high temperature superconductivity during those visits are described in detail in a special ONR report 8-011-R.

In this brief summary of that report some general comments can be made regarding the German response to the opportunities in this area of high temperature superconductivity. Then brief descriptions of the eight labs visited are given which are followed by some general conclusions about the current position of the research we observed relative to what we know is in progress in the US.

General Comments

Some research groups in Germany, such as KfK, Darmstadt, and Giessen, have a long history of research and development of superconductivity and, not surprisingly, these groups have developed quickly in high temperature superconductivity research. Government support of superconductivity research from the BMFT had been tapering off, from DM4 million/year to 1-2 million/year (~$2.5 to $0.6 - $1.2 million [at current rate of exchange $1.00 = DM1.58]).In FY87 the level was stepped back up to DM4 million with some additional new funds and reprogramed funds. This included DM0.8 million made available very early in 1987 for equipment purchases by existing groups. The expected level in FY88 is DM16 million that will be mostly new funds provided by separate legislative action. Planned support for FY89 is anticipated to be DM35 million with a further increase hoped for in FY90 to DM45 million.

The BMFT program consisted of four major thrusts: (1) development of superconducting magnets, (2) cryogenics, (3) development of practical superconductors including new materials, and (4) new applications of superconductors. While BMFT support of university/in-

dustrial collaboration is normally 50 percent, support for high T_c materials will be provided at 50 percent to industry and 75 percent to university, thus reducing the industry support and product-oriented influence on the initial university studies. Such a plan would remain in effect for 4 to 5 years.

In addition to the research and development funds in superconductivity there is specific support in medical applications and for an electric generator construction at DM25 million/year each. Applications in accelerator physics are funded by other mechanisms also.

Brief Summaries of Laboratory Research

University of Giessen. The group at Giessen has been developing superconducting electronics with classical superconductors for some years and is producing some of the best and quickest results as part of the development of new superconductor circuit elements.

Technical University at Darmstadt. Based on a long history in low temperature superconductivity research, the Darmstadt group has developed a number of experimental techniques for determining the fundamental properties of the new superconductors.

Hoechst AG. The Hoechst company's recently acquired businesses in ceramics have produced a substantial and long-range commitment to the development of the new superconductors, including the recent BiCaSrCuO compound.

Siemens AG. Extensive experience in conventional superconductors, which are being marketed and further developed, has placed Siemens in a very strong position with expertise and commitment to develop the new superconductors, including the BiCaSrCuO materials.

Kernforschungsanlage Jülich. The current research in high temperature superconductors extends over the 10 KFA institutes, with reorientation and strengthening planned in the area of thin films of both superconductor and semiconductor materials.

Kernforschungszentrum, Karlsruhe. The long-term commitment to superconductivity research at KfK has produced recent significant advances in the conventional superconducting materials, NbN and $PbMoS_8$. The wide range of expertise and planned long-term future effort seems certain to yield substantial gains in fundamental understanding and in technological developments in the new materials that will keep KfK at the forefront.

Walther Meissner Institute, Garching. This institute's contributions to fundamental physical properties of the new materials have been carefully accomplished with limited resources combined with capable expertise.

Max Planck Institute (MPI), Stuttgart. At MPI Stuttgart excellent optical measurements and advanced materials preparation has produced seminal work in understanding the lattice vibrational properties and chemistry of the new high temperature superconducting materials, including prompt work with BiCaSrCuO.

General Conclusions

The eight university, federal, and industrial laboratories that were visited represent a small, but high-quality, set of laboratories in Germany doing research in high temperature superconducting materials. We observed that long-term, steady support of superconductivity in each setting has provided both significant expertise in individuals and marketable products. The fast pace of developments stresses the existing mechanisms of communication, and we saw evidence where improved communications would be helpful; this situation is not dissimilar from that in the US. The future prospects are being nurtured with increased federal funding and corporate commitment on a time scale that appears to be consistent with the expectations for improved fundamental understanding closely followed by the development of applications. This also has a positive effect on the careers of young scientists where this commitment will provide opportunities to establish their professional stature in this field.

7/3/88

NEWS, NOTES, AND ABSTRACTS

Staff Changes at ONRL

By the time this issue is received, Drs. William Crano and Paul Roman will have completed their tours at ONRL – Dr. Crano, on 1 August, and Dr. Roman, on 12 September. Crano returns to Texas A&M where he is a Professor of Psychology. Roman is retiring, but, I suspect, will use the freedom that it brings to pursue those creative activities of most interest to him.

In August we welcomed four new liaison scientists: Dr. Marco S. Di Capua, who will report on physics, comes to us from Lawrence Livermore National Laboratory, Livermore, California, where he is a physicist in the Pulse Power and Diagnostics Group, Nuclear Energy Systems Division. Dr. Richard H. Franke, whose field is mathematics, is from the Naval Postgraduate School, Monterey, California, where he is a Professor of Mathematics. Gerald S. Malecki, who has

been a Scientific Officer and Assistant Director (Research Psychology), is from the Life Sciences Directorate, Perceptual Sciences Directorate, Perceptual Science Program of ONR in Arlington, Virginia. Dr. Dean L. Mitchell, whose field is device physics, will be on sabbatical from his own company, Mitchell Associates, in Reston, Virginia.

C.J. Fox

A New All-European Computer Network for Research

The ever-increasing number of European scientists and other researchers who use computer systems has created a great need for international means of online communication facilities between the various computer systems. It was realized that existing networks must be harmonized, enlarged, combined, and standardized, and that new services must be set up. This demand led to the formation of the COSINE (Cooperation for Open Systems Interconnection Networking) project.

COSINE is actually a EUREKA enterprise, in which all EUREKA partner-states, the European Community organization and its member-states, as well as a number of other countries (including Austria, Switzerland, Sweden, Finland, Turkey, etc.) participate. Yugoslavia expressed an interest; but no Iron Curtain countries are involved. Recently, negotiations were initiated to involve also the US, via transatlantic links.

The major idea is to supply data services and telecommunication facilities for the European community of academic and industrial researchers. The building of an effective infrastructure would also lead to economic advantages, because of the necessary new technologies that will go into the networking system. Finally, the effort to normalize several, so far independent national networks within the frame of unified European standards is expected to improve political cooperation.

In order to avoid high costs and inefficient network-interfacing between incompatible networks, it has been decided to employ the international standards for open systems (OSI) for communication, to utilize existing postal teleservices, and to realize COSINE with commercially available products.

Common application services of COSINE, already available, are:

- Interactive data communications infrastructure
- File transfer and access management
- Message handling
- Directory services
- Accounting services.

Future planned services are:

- Screen-oriented dialog
- Remote job entry
- Graphics
- Virtual terminal support
- Broadband communications.

The final implementation phase of COSINE just started, and it involves a shift of emphasis from international and centralized activities to national and decentralized activities.

Detailed information on COSINE can be obtained directly from Nicholas K. Newman or John Beale, Commission of the European Communities, Directorate-General XIII, Office A25-7/13, Rue de la Loi 200, B-1049 Brussels, Belgium. Telephone: (011-32-2)235-0655.

Paul Roman

The First Center for Microperipherals-Systems Research

By combining existing areas of concentration and new institutes, the Technical University of Berlin (West Germany) established the world's first dedicated research and development center for studies and instruction in the area of technologies of microperipherals. The current focal areas of research are:

- CAD and simulation methods for design of microperipherals systems and components
- Methodologies for fabrication and connection technologies
- Sensor research.

Typical research projects pursued at this time are:

- Tape-automatic bonding for VLSI circuits
- Microwave-oriented integrated microelectronic system design and fabrication
- Photo-induced metalorganic metal-film deposition
- FET-gas sensors (based on both heteropolysiloxan and heterogen-catalitic devices)
- Integrated intelligent sensors.

Technology transfer is also a concern of the center.

It appears that the financial future of the center is well secured. Almost all of the budget comes from sources outside of the Technical University. The Federal Ministry of Research set aside DM23.65 million (about $13.36 million [currently $1.00 = DM1.77]), the Land of Berlin, DM10 million – these sums are to be used for building up the infrastructure (including construction of a spacious, modern building on the grounds of the new Technology and Innovations Park of Berlin.) An additional DM10 million has already been appropriated from industry commitments for initial operational costs.

For more information, please contact directly Herr H. Griese, Fachbereich Elektrotechnik, TU Berlin, Einsteinufer 17, D-1 Berlin 10, West Germany. Telephone (011-49-30) 314-3555.

Paul Roman

Research for Advanced Robotics – A New UK Collaborative Effort

A broadly based group of 16 UK organizations responding to an initiative from the Department of Trade and Industry (DTI) have agreed to develop jointly the technologies required for a revolutionary new generation of robots that will eventually be able to work independently of human intervention in hostile and unstructured environments.

The proposal has been spearheaded by Salford University Business Services Ltd. (SUBSL), who were selected by DTI as the result of an open competition.

The work is now planned to take place at the Advanced Robotics Research Center (ARRC), to be established especially for the venture at Salford. The center will have a budget of £15.8 million (~$26.9 million) over its first 5 years, of which the DTI will provide £5 million (~$8.5 million). After 5 years the center is expected to become self-financing.

The center will take a long-term attitude towards robotics research. Its goal will not be a particular product but the refinement of the key enabling technologies to a point where individual companies can begin commercial exploitation. The research effort required to overcome

the technical hurdles is beyond the scope of any single company. The DTI has therefore encouraged the collaboration of UK-based organizations with an interest in robotics who have agreed to pool their talents and resources. Each of the collaborating organizations will be seconding a highly qualified researcher to the center. Organizations involved include representatives of small and large companies, an academic institution, and a government research establishment. The ARRC will thus spread the financial burden of development, as well as providing a broad range of skill to the project team.

C.J. Fox
7/14/88

More UK Backing for EUREKA's HDTV Project

The UK's Department of Trade and Industry (DTI) announced that it will be providing £1.7 million (~$2.9 million) financial support for participation by the UK's Quantel Ltd. and Philips Research Laboratories in a major EUREKA project to develop a high-definition television (HDTV) system. This takes the total DTI support to UK participants in the HDTV project to £4.8 million (~$8.2 million).

Quantel will develop a range of high-definition editing and image manipulation equipment and Philips will be making a major contribution to research into picture analysis and coding techniques associated with the transmission and display of high-definition signals.

The aim of the EUREKA HDTV project, which involves some 30 European industrial companies, broadcasters and research institutes, is to define a standard for HDTV which is compatible with the Multiplexed Analogue Components (MAC) transmission system being introduced for Direct Broadcasting by Satellite (DBS) services in Europe. The project will develop and demonstrate, by 1990, a complete prototype production and transmission system for MAC-compatible HDTV.

A major demonstration of the EUREKA system will take place at the International Broadcasting Convention in Brighton, UK, in September this year. Further demonstrations will take place in 1989, with the objective of having the EUREKA system adopted as a world standard by the CCIR (the international radio standards body) in 1990.

Further information about the EUREKA HDTV project may be obtained from Mr. H. Wessels, EUREKA HDTV Directorate, Philips International BV, Building SK 7, Eindhoven, the Netherlands.

C.J. Fox
7/14/88

Conference on the Structure and Properties of Dislocations in Semiconductors

This conference, to be held in Oxford, England from 5 through 8 April 1989, will be the 6th international conference held on this topic. The earlier meetings were in Moscow (1986), Aussois (1983), Krynica (1980), and Hunfeld (1978).

Sessions will be held on:

- Structure of grain boundaries and dislocations
- Electronic and optical properties of dislocations and associated point defects
- Dislocation mobility
- Dislocation plasticity
- Grown-in and process-induced dislocations and their effects in devices
- Fracture.

Further details can be obtained from Sir Peter B. Hirsch, F.R.S., University of Oxford, Department of Metallurgy and Science of Materials, Parks Road, Oxford OX1 3PH.

Louis Cartz
7/14/88

High-Speed Room Temperature HgCdTe Detectors

Some time ago (see *Science Newsbrief*, Vol. 3, No. 52, [November 1985]) I reported the availability, through a UK distributor, of Polish-developed HgCdTe infrared detectors that operate efficiently at room temperature. Recently I learned that a West German company (Vis-Tek, Prinz Karl Str. 52, D-813 Starnberg) also distributes these products in the western world. Moreover, I now have some technical details that characterize the latest devices:

Wavelength ranges	8-12 or 3-3.5 μm.
Active area	up to 1x1 mm
Peak D*	10^5 to 10^9 cm $Hz^{1/2}$ W depending on model.

Currently, five models can be supplied off the shelf. Power supplies are also available.

Further information should be requested directly from Vis-Tek, attention: U. Weiszer.

Paul Roman

Hot-Spot Detector

The UK Atomic Energy Authority, in consultation with several other British agencies, has developed a heat-sensing early warning system which can provide a cost effective and reliable scan of the complete volume of a space. The unit, which can be optionally linked to a computer, was originally developed to constantly monitor for an errant laser beam in high-power laser machining stations. The high-speed precise performance of the system is, however, widely applicable to many other situations, providing an early warning indication before a dangerous operating temperature is reached. The system consists of two main elements (plus an optional computer): the scanning head, which is typically located in a ceiling or wall, and the control unit. One computer system can serve up to eight scanners. The screen provides a thermal map of the complete volume being scanned. The instrument detects thermal radiation in the 3- to 5-micron wavelength region and will scan an entire space wall-to-wall and ceiling to floor approximately 180° vertically by 360° horizontally at one of three speeds: 1, 3, or 10 scans a second. It can operate with scanning head and control unit alone, or in conjunction with a computer and monitor screen, in a variety of modes.

At the most sensitive of its six settings available, 1-cm- and 15-cm-diameter objects at 500°C can be consistently identified at a range of at least 3 m and 54 m respectively. This range is strongly dependent on the size of the minimum hot spot to be monitored and on its temperature. The system detection reliability is designed for less than 1 failure occurrence

every 100,000 years. In tests, the production system has correctly spotted more than 100,000 artificial hot-spots without a single failure. The computer program enables the scanner to ignore those heat sources which should exist within the area being scanned but, as soon as an errant source is found, the alarm is sounded, and if a power source is involved it can be instantly shut down.

CDR J.P. Simpson
7/13/88

French Center For Marine Meteorology

The French Centre de Meteorologie Marine (CMM) of the Etablissement d'Etudes et de Recherches Meteorologiques (French Meteorological Office) was formed in 1971. The center, located in Brest, is staffed with 10 permanent meteorologists with strong maritime interests. The permanent staff can be augmented by French and foreign scientists wishing to do course work or to use the computing facilities.

Work at CMM is geared primarily toward national requirements in the areas of marine meteorology and synoptic oceanography. Emphasis has been on the study of ocean-atmosphere interactions and on the setting up of a program of meteo-oceanographic buoys. The buoy program has concentrated on development and construction of "optimal" buoys, both drifting and anchored, capable of measuring wind speed and direction, pressure, sea-surface temperature, air temperature, and water temperature at various depths from the surface. A wide variety of buoys with various capabilities have been developed and deployed over the years. The buoys have been used extensively in both national and international programs. As an example, since 1971 CMM has carried out an extensive sea-surface temperature measurement program in the eastern Atlantic which has resulted in both improved fisheries information and improved acoustic forecasts for the military. Temperature data from these buoys is processed every 10 days and published regularly in *Met-mar* and *Satmer* magazines.

CDR J.P. Simpson
7/13/88

World's First Superconducting Motor Presented to the British Science Museum

Twenty-two years to the day after its initial tests began, the world's first superconducting motor was presented to the British Science Museum. On 1 June 1966 in Newcastle-upon-Tyne, England, Dr. A.D. Appleton of the International Research and Development Co. led his research team in testing the world's first superconducting electric motor. It had been designed and built under contract from the Marine Engineering Division of the British Ministry of Defence, Navy. Exactly 22 years later, on 1 June 1988 in London, Rear Admiral R.A. Isaac, Director General Marine Engineering, presented this superconducting motor to Dr. N. Cossons, Director of the British Science Museum, the largest and most comprehensive science museum in the world.

The first superconducting motor developed 37 kW (50 hp) at 2000 rpm. It was of the homopolar configuration where the current is distributed radially in a rotating disk with brush contacts at the axis and the rim. The disk rotates in a solenoidal field generated by a superconducting magnet wound from an early niobium-zirconium wire. It was followed by a larger machine in 1970, also developed by Dr. Appleton's team, which produced 2400 kW (3250 hp) at 200 rpm. This machine was tested by pumping cooling water at the Fawley power station near Southampton, UK. Further superconducting motor and generator systems of a wide variety of configurations have been developed by the UK, Japan, the USSR, and the USA.

Now, the world's first superconducting motor has been incorporated in a display in the British Science Museum's Hall of Electricity and Magnetism. This display also outlines some of the major developments in superconductivity, including the new high critical temperature superconductors.

Alan F. Clark
6/30/88

Major New Industrial Consortium Formed in Europe – Superconductivity One of its First Focuses

The recently formed European Institute of Technology (EIT) is a major new industrial consortium for scientific and engineering research and education. EIT was organized by leading European international corporations with the founding members being AT&T, EniChem, IBM Europe, Montedison, and Philips. Based in Paris, it was created to help European industry take full advantage of its own scientific and technological resources by forging a more effective industry-university partnership. EIT is funded by industrial contributions from its members, and its activities are focused on direct, precompetitive research in materials technology, information technology, and biotechnology. The address of EIT is Tour Franklin, Cedex 11, 92081, Paris.

One of EIT's first activities was to organize and sponsor a 3-day conference, "European Symposium on Advanced Materials: Their Role in New Technologies," which was held in Madrid, Spain on June 27-29, 1988 and hosted by AT&T Microelectrónica de Espãna. The symposium emphasized research related to functional materials and brought together speakers from industry, academia, and public research centers. Subjects covered were superconductors, semiconductors, composites, molecular electronics, optoelectronics, magnetic materials, surfaces and interfaces, and nondestructive evaluation.

Other activites of EIT include establishing networks of researchers and funding of projects selected from competetive requests. Announced at the meeting were the final six in this year's selection, and two of those were in superconductivity, with the winners each receiving 250,000 ECU (~$350,000) per year for 3 years. One, from Professor Franco, University of Madrid, was a systematic search for new superconductors and the other, from Professor Lumley, Cambridge University, was a study of the weak links that cause low critical currents. Other winners were in composites, integrated circuits, laser processing, and nondestructive evaluation.

Alan F. Clark
7/10/88

ONRL REPORTS AND MAS BULLETINS

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.

Computer Science

EUREKA Program Update, by Dr. J.F. Blackburn. **(8-009-R)** The EUREKA Program is brought up to date in this list, with descriptions of the 165 EUREKA projects. Also identified are the participating/interested countries, the cost, duration, and status. The topics under which these projects fall are: information technology; robots, manufacturing, and process control; biotechnology; new materials; environment; telecommunications; transportation; energy; and lasers.

Physics

The XII European Conference on Few-Body Physics, by Dr. Michael I. Haftel. **(8-012-C)** The contributions to this conference, held in September 1987 at Fontevraud, France, are discussed under three general categories: the nuclear force problem, including the possible effects of quark structure; properties of few-nuclear systems, especially as probes of the nuclear force; and atomic and molecular few-body problems and calculational methods.

Superconductivity

High-Temperature Superconductivity Research in Selected Laboratories in the Federal Republic of Germany, by Dr. Alan F. Clark. **(8-011-R)** The superconductivity work at eight West German laboratories is reviewed. The laboratories are (or located at): the University of Giessen; the Technical University at Darmstadt; Hoechst AG; Siemens AG; KFA Julich; KFK, Karlsruhe; the Walter Meissner Institute, Garching; and the Max Planck Institute, Stuttgart.

MAS Bulletins

The following *Military Applications Summary (MAS) Bulletins* were published by ONR, London, during July and August. 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.

45-88 Solid-State Angular Rate Transducer (START)
46-88 Oceanology '88
47-88 Underwater Sandblasting with Compressed Air
48-88 Deep Escapex '87
49-88 European Naval Forecast Conference
50-88 Polyphem-German/French Fiber Optic Guided Missile Development
51-88 Hot-Spot Detector
52-88 Tactical HF Loop Antenna System
53-88 GIRAFFE Search Radar
54-88 SIMRAD LP7 Handheld Laser Range Finder
55-88 LORIS Range Finding Optical Sniper Sight
56-88 SIMRAD LP100 Laser Rangefinder
57-88 Pyrocool Charging Unit for Thermal Imaging

REPORTS ON EUROPEAN SCIENCE AND TECHNOLOGY FROM OTHER COMMANDS

Reports

Information on the reports listed below was furnished by the activity identified by the abbreviations for that office. Report numbers are given in brackets after the titles. Requests for copies of or information about these reports should be addressed to the appropriate office:

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

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

Chemistry

Chemistry at the Weizmann Institute of Science, by LTC LaRell Smith, EOARD. (21 pp) [EOARD-LR-88-42]

A recent visit to the Weizmann Institute uncovered several projects which have definite overlap with Air Force interests. Dr. Steve Weiner is a pioneer in using biotechnology to investigate and engineer structural materials. Recent work has uncovered some of the biological processes which produce composites at the molecular level. This work has great relevance to the possibility of producing materials with the hardness and order of crystals but without their normal brittleness. Professor M. Lahav and Professor V. Krongauz both have projects which deal with organic nonlinear materials. Professor Lahav has shown that it is possible with the assistance of tailor-made additives to control both the growth and dissolution of organic crystals – particularly with regard to controlling their symmetry for nonlinear properties. Professor Krongauz has pioneered work in ordered and self-organizing polymers. The quasi-liquid crystals he works with can be engineered to have either second or third order nonlinearities, and a recent group of compounds show promise for imaging technologies as they can be revers-

ibly changed from red to blue to yellow through irradiation and temperature changes. Finally, Dr. Yehiam Prior works in the field of four-wave mixing. He has been responsible (along with Professor A. Levine, CUNY) for developing a unified theory of resonances in four-wave mixing. The full report gives more detail on each of the programs and provides a few selected reprints and excerpts.

Fluid Mechanics

Unsteady Aerodynamics in Turbomachinery in Switzerland, by LTC Bob Winn, EOARD. (2 pp) [EOARD-LR-88-35]

The Swiss Federal Institute of Technology at Lausanne is one of two federally funded technical institutes in Switzerland. This report describes the work underway in one of the labs in the institute, the Laboratory of Applied Thermodynamics and Turbomachinery. Particularly impressive is their work in the Non-Rotating Annular Cascade Test Facility. The ability to supply continuous, uniform, supersonic flow to an annular blade ring makes this facility unique in the world.

Materials

Mullite Fibers Via Sol-Gel, by LTC Jim Hansen, EOARD. (7 pp) [EOARD-LR-88-36]

The British company Clinotherm Ltd. is sponsoring development of mullite ceramic fiber produced via a sol-gel, process. Chemistry of the precursor has been carried out at the University of Manchester Institute of Science and Technology (UMIST), UK. Homogeneity of the precursor is excellent. Precursor chemistry eliminates the need for an organic polymer, coagulating baths, water, reagents, and accelerators. (Distribution of this report limited to US government agencies only.)

Multidiscipline

Review of Portugal's Technical Universities, by COL Phil Conran, EOARD. (2 pp) [EOARD-LR-88-49]

This report covers an orientation visit made to the three technical universities in Portugal: the Instituto Superior Tecnico in Lisbon, the University of Coimbra, and the University of Porto.

Italian Strategic Defense Research Capabilities Survey, by Dr. Vince Donlan. (16 pp) [EOARD-LR-88-48]

A survey of Italian companies was performed in the period 26 April through 6 May 1988. Some 21 companies were contacted to discuss their capabilities applicable to the SDI program. With few exceptions, the companies contacted have ongoing research, current interests, or past experience applicable to SDI research needs. In several cases, companies have innovative ideas that are of immediate interest. This report gives a summary of these applicable capabilities, interests, and innovative concepts for eight major research areas relevant to the SDI program.

Physics

Molecular Cluster Work at Heidelberg, by Dr. Stacey Lazdinis, EOARD. (3 pp) [EOARD-LR-88-40]

Professor F. Trager of the Physikalisches Institut of Heidelberg University in West Germany is performing research in the physics of gas phase clusters, in the physics of atomic clusters adsorbed to solid surfaces, and in the thermoelastic behavior of solid surfaces irradiated with pulsed laser radiation. His work in generating neutral cluster beams of specified mass is detailed.

Semiconductors

Silicon on Insulator Workshop, by Dr. Eirug Davies, EOARD. (7 pp) [EOARD-LR-8847]

A recent Silicon on Insulator Workshop shows that competitive European efforts exist for producing IC-compatible, isolated films of silicon. The innovation of higher furnace annealing with oxygen-implanted "Simox" material originated in France's Grenoble area laboratories. Probably the most advanced work on porous silicon currently pursued is in the UK and France. Island dimensions vary with circuit layout to provide sidewall isolation. For zone melt recrystallization, the tendency is to configure three-dimensional structures around seed openings and defect regions within the recrystallized material. This is in common with the Japanese approach, and the work has not produced subgrain-free material for single layer use, as is currently becoming available in the US.

THE EMBASSIES: TECHNOLOGY ROUNDUP

France

For further information on French items, contact Dr. Allen Sessoms, Office of the Science Counselor, American Embassy, APO New York 09777.

Oceanographic Research in France—The Laboratories at Villefranche sur Mer. The seaside village of Villefranche sur Mer lies just west of Nice on the Cote D'Azur. Its sheltered harbor and very steep coastal gradient make it an excellent location for marine research. As a result, Villefranche hosts a number of laboratories devoted to oceanography which are supported by the Centre Nationale de la Recherche Scientifique (CNRS). These include the Laboratory for Marine Physics and Chemistry and the Laboratory for Ocean Geodynamics (both associated with the Université Pierre et Marie Curie [Paris]), the Laboratory for Plankton Ecology, the Laboratory for Marine Cellular Biology, and the Jean Metz Laboratory for Cellular Physiology (a collaboration with the French Atomic Energy Commission). Approximately 20 US national researchers are currently working at the various laboratories. The Laboratory for Ocean Geodynamics works closely with USGS, NASA, NSF, and NOAA and is a participant in the US-led international deep ocean drilling program. In addition, these laboratories collaborate with the Woods Hole Oceanographic Institute, Scripps Institute for Oceanography, and various US university-based research groups. Laboratory researchers strongly

expressed an interest in expanded cooperation with the US, especially hosting US postdoctoral-level scientists for extended periods of time.

The complex at Villefranche is impressive. Some of the buildings are old (old is a historical monument dating back to slave trading days), but there is obviously money for renovations since the lab spaces are easily up to US standards. Given the already excellent ties to the US, this group of laboratories might be a useful showcase for the mutually beneficial aspects of collaboration with the US. This could be an important exercise in view of mounting pressures in France to look more towards European research with the approach of the single European market in 1992.

The Laboratory for Marine Physics and Chemistry, directed by André Morel, consists of 35 Ph.D. researchers (9 from CNRS) and 12 technical and administrative staff. The foci of research are:

- Ocean currents at mid-depths (focusing on the Mediterranean)
- Interaction of solar energy and oceans
- Satellite remote sensing (temperature, sedimentation, and biomass)
- Carbonic gas cycles in the ocean
- Geochemistry of metallic trace elements (atmosphere/ocean/sediments)
- Organic molecules as tracers of processes or origin.

The Laboratory of Ocean Geodynamics is directed by Gilbert Boillot. Consisting of 15 researchers (8 from CNRS) and 13 support and technical staff, the laboratory has extensive research contacts with the US. Active in very deep ocean studies, frequent use is made by laboratory researchers of the French deep-sea submersibles Nautile and Cyana, which belong to the the Institute for Research and Exploitation of the Oceans (IFREMER). Extensive use is also made of other French and international oceanographic research vessels. The laboratory also participates in the US-led Deep Ocean Drilling Program. The major research lines are:

- Slipping along continental shelf boundaries
- Continental/Ocean transitions along divergent boundaries
- Sedimentation in deep ocean trenches
- Structural effects of continental shelf subduction
- Ancient continental boundaries

The Laboratory of Plankton Ecology has a number of very active research programs underway and probably benefits most from Villefranche's setting. Abundant quantities and varieties of plankton live in the very deep sea areas within 4 km of the laboratory. This year-round source of ocean microorganisms makes this laboratory an international magnet for researchers. Consisting of 17 researchers (10 from CNRS) and 16 support staff (directed by Paul Nival), the laboratory focuses its efforts on:

- Spatial distribution of plankton
- Plankton development
- Metabolic studies
- Plankton growth in tropical environments
- Microzooplankton
- Gelatinous plankton
- Population dynamics.

Efforts are underway to model the life cycle of plankton under varying circumstances, focused on attempts to explain the fluctuations in abundances of various species and their effect on the fishing industry. Efforts are also underway to understand the complex, and apparently profound, interaction between plankton abundances, ocean pollution, ocean temperature, atmospheric ozone depletion, etc.

I was able to observe first hand the development of a research project by Sordet. The discussion included a senior American and a senior German cellular biologist. Both scientists were extremely impressed by the array of state-of-the-art equipment (funded partly by the European Community). They were also impressed by the quality of the research and probably will spend the summer collaborating on the project (which relates to the cellular and intracellular movements of eggs before fertilization in simple, multicellular marine organisms).

Christian Sardet, the director of the laboratory, is anxious to expand his already strong collaboration with the US. He is interested in receiving both researchers and research grants from US entities.

The Laboratory for Marine Cellula. Biology, consists of 12 researchers (8 from CNRS) and three support staff. It also currently has three graduate students. Other areas the laboratory researches, besides that mentioned above are:

- Fundamental fertilization processes and the rapid development of embryos
- Mechanisms of development
- The intra- and intercellular pathways and control of the movements of ions.

The Jean Metz Laboratory is located in a spacious new building paid for by CEA through its biology department. The codirectors of the laboratory are R. Motais (CEA) and F. Garcia-Romeu (CNRS). The focus of research is cellular physiology and so is only tangentially related to marine research. The staffing levels are seven researchers (four from CNRS), nine support staff, and five visiting scientists. The laboratory's efforts are directed towards:

- Elaborating transepithelial transport mechanisms
- Studying mechanisms which regulate the permeability of cellular membranes
- Mechanisms for the transduction of energy in bacteria.

I discussed the work on transepithelial transport with the key researcher in this area, who turned out to be British. He noted the easy access to needed equipment and comfortable working conditions as his principle reasons for joining CNRS. He also argued that the research he was conducting there was unique and possibly of the best in this field in Europe.

The Laboratory for Condensed Matter Physics at the University of Nice. This laboratory is located on the science campus of the University of Nice, a complex which supports about 6000 students. The university itself is relatively new and has benefited from significant local philanthropic support. It is housed on the grounds, and, partially, in the buildings of a turn-of-the-century chateau built by a wealthy industrialist. The laboratory itself is housed in several buildings on campus, some of which are a bit cramped and in poor repair. This situation will be remedied when the group moves in September to a new building constructed just for it.

One of the peculiar aspects of the funding of French higher education is that there is little money for building maintenance but substantial funds for new construction. It seems that buildings are allowed to fall into disrepair and are replaced when the situation deteriorates to the point where it becomes a hindrance to research.

The laboratory itself is well funded with essentially all of its funds coming from CNRS (vice the Ministry of Education). Headed by Dr. Nicole Ostrowski, it consists of 33 Ph.D. researchers and 16 engineers, technicians, and administrative

staff. In addition, there are approximately 15 doctoral students and 8-10 other students.

There are five major research programs. These are in the areas of liquids and suspensions (viscoelasticity of molecular liquids, behavior of suspensions under sheer stress, etc); interfaces (especially quasi-two-dimensional surfaces) including liquid/solid metallic aggregate phase changes, transport and propagation in porous materials, liquid crystal polymers, and fiber and nonlinear optics. The lab prides itself in conducting both basic and applied research.

The work in liquid crystals, both theoretical and experimental, seems excellent, with the largest group of researchers devoted to it. For samples of recent work see, for example, A. Ten Bosch and P. Sixou, *Journal Chemical Physics*, 86, 6556 (1987), and M.J. Sevrin and P. Sixou, *European Polymer Journal*, 23, 77 (1987). Another clearly excellent area is in interface studies, both liquid/liquid, liquid/solid, and quasi-two-dimensional 2D. For examples of recent work on quasi-2D thin films see, J.P. Laheurte, et al., *Physics Letters A*., 123, 101 (1987), J.P. Desideri, et al., *Physics Review B* 35, 6725 (1987), and M. Papoular and C. Vanneste, *Europhysics Letters*, 3, 839 (1987).

In addition, in the area of fiber optics, a small pilot plant for producing exotic fibers from preformed glass tubes is currently being inaugurated. This is the first such facility at a CNRS-associated laboratory. It is a collaborative effort with French industry. In nonlinear optics the lab has conducted good and novel work on nonstationary stimulated brillouin backscattering and spontaneous Raman scattering, focusing on controlling damage produced in optical fibers. They have also measured nonlinear effects in lithium niobate and mercury-cadium-telluride optical materials.

This laboratory has an enthusiastic and capable staff, among whom number at least two Americans. They are very open to foreign participation having, for example, seven foreign postdoctoral students, three of whom are from China. The quality of the work is high and, with its new facilities, there should be ample space for expansion. The lab appears to enjoy close collaboration with a few US universities, most notably Boston University and the University of Massachussetts at Amherst. In the areas of liquid crystal polymers and interfaces, the lab appears to be among the best in France. It is more difficult to judge its standing in other areas although clearly the work on nonlinear optics is of high quality.

Italy

For further information on Italian items, contact Dr. Gerald Whitman, Office of the Science Counselor, American Embassy, APO New York 09794-0007.

Telespazio to Handle Japanese Satellite Data. The Italian communications company Telespazio, in a recent agreement signed with ESA within the framework of the Earthnet Program, will process data from the Japanese Marien Observation Satellite (MOS-1). The satellite was launched in February 1987 for remote sensing of the oceans.

ESA Finances Development of Gallium Arsenide Photovoltaic Cells. European Space Agency (ESA) has allocated funds to CISE, (The Research Laboratory of ENEL, the National Electric Company), and to the Italian Company FIAR for the development of second-generation gallium arsenide photovoltaic cells. The ESA Project is intended to challenge US and Japanese leadership in this area, producing lighter weight cells at a lower cost for use in future European satellites.

SGS-Thompson and Catania University Form Consortium for Microelectronics Research. SGS-Thompson, one of the principal manufacturers in Catania of microelectronic circuits, and Catania University's Department of Physics of Matter have agreed to cooperate in microelectronics research. The university will make their research results available to SGS-Thompson; the company will provide fellowships and training for young graduates.

Italy Increases financing for Environmental Protection. Italian financing for environmental protection has increased substantially, reflecting growing public sensitivity over environmental issues. Recent government financing totals 2970 billion lire (about $2.38 billion), distributed, inter alia, as follows: 106 billion for high environmental risk areas; 725 billion for the Po River basin and other polluted rivers; 1700 billion for the disposal of urban solid waste; 60 billion for national parks; and 75 billion for the general reclamation of water supplies.

Florence University Reorganizes Its Scientific Activities. Florence University has obtained 117 billion lire (about $98 million) financing to relocate all its scientific activities to a new 80,000-m^2 research park in the northeastern part of the city. The area, expected to be completed in 4 years, will also house all the CNR Research Centers in Florence, as well as the National Institute of Optics, the Florentine Section of the National Institute of Nuclear Physics, and the Institute of Nonlinear Spectroscopy.

Computerized System to Monitor Etna's Activity. The Italian National Research Council's Institute of Volcanology has ordered from a Milan Company, SDI, a computerized seismic monitoring system, "SAMES." The system's 70 seismometers will continuously analyze seismic activity around Mount Etna; in addition to seismic studies, the system will warn area inhabitants of pending eruptions.

FORMEZ Highlights Results of Its Exchange Program for the South. FORMEZ, the government organization responsible for the development of the South, presented the results of its 3-year exchange program for Italian and foreign students and scientists. Under the program, which ended in December 1987, FORMEZ sponsored 219 research projects of Italian scientists and 74 from foreign scientists. Of these, 26 percent were for economic development, 25 percent for informatics, and 19 percent for biotechnology and genetic engineering. Sixty-nine fellowships were given to Italian students and scientists to study abroad and 29 fellowships were awarded to foreigners to study and work at universities in southern Italy. Over 43 percent of these fellows were from the US.

West Germany

For further information on items, contact Edward M. Malloy, Office of the Science Counselor, American Embassy, APO New York 09777.

High Temperature Superconductivity Research: Hoechst, AG. Embassy personnel visited the Hoechst Chemical Concern, Frankfurt, to inquire about the state of superconductivity research. Response was guardedly positive. Hoechst is following closely developments in other labs and attempting to draw upon in-house expertise in ceramics

to develop new materials which would operate at the 120-150 Kelvin range. Hoechst has a patent pending on one powder compound and continues to experiment with a variety of substances and fabrication processes.

High temperature superconductivity research is sponsored by Hoechst's Central Research Division. This group supports projects with no immediate commercial application but of possible eventual interest. A team of 14 physicists and chemists has been assembled to search for alternatives to yttrium-barium-copper oxide, or 1-2-3 compound, as a high temperature superconducting material in the 120 to 150 Kelvin range. Bismuth-strontium-calcium-copper oxide has shown potential and the Hoechst team is working closely with the Max Planck Institute in Stuttgart to develop a substance which is patentable. Along with the search for the proper mix of elements is development work on fabrication processes, including the preparation of powders, fibers, extrusion with organic binders, sol-gel, melt-spinning, screen printing, and spray coating. Both thick and thin films using sputtering techniques show potential for eventual use in electronic circuits, though initially such circuity would be relatively simple, e.g., sensors.

As for the prospects for Future Developments, Hoechst believes its real technical strength lies in its technical ceramics division, called Hoechst Ceramtec AG, a wholly owned subsidiary which was acquired from the Rosenthal group. This division already produces substrates for both thick and thin film circuits and a variety of packaging materials for integrated circuits. With high temperature superconducting materials Hoechst would seek similar product development lines. Hoechst would like to discover the correct mix of raw materials to produce compounds with controlled properties in a semifinished state. These would then be sold to other firms such as Siemens for use in circuit applications. The research team offered little hope for early progress in such areas as cables or magnetic motors, but rather sees progress in high temperature superconductivity in developing thick or thin films, possibly ceramic or ceramic on silicon, as a research area where slow but steady progress is likely to occur in the next 5 to 10 years. Along with other German research establishments, Hoechst is cautious in its assessment of overall progress in the field.

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