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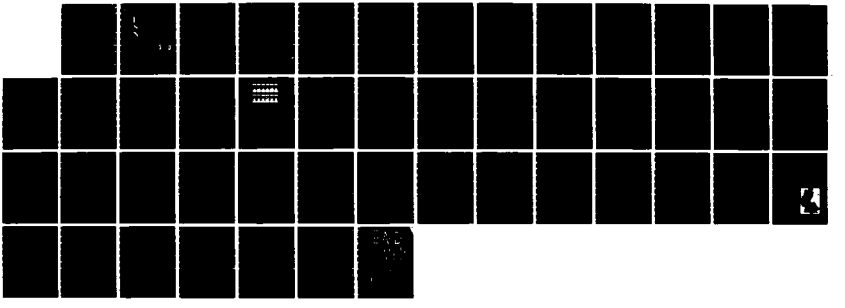

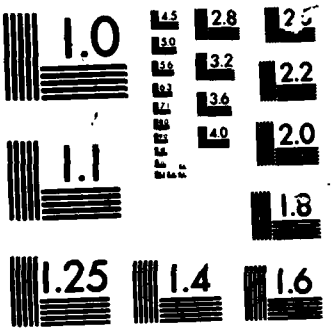

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European Science Notes (ESN) is a monthly publication with brief articles on recent developments in European scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the US Army Research, Development and Standardization Group. Qualified US scientists travelling in Europe may also be invited to write an ESN article.

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Biological Sciences

Neurobiology research in Belgium is of high quality and is innovative even though the laboratory groups are small as compared with those in the US. Research being done at the Free University of Brussels and the Unversity of Antwerp is described.

Plant Genetics Systems is the only genetics engineering company in Belgium with a direct and continuous relationship with university laboratories. The company's work in soil microbiology, genetic engineering, and genetic engineering of plants is reviewed.

Environmental Sciences

This article provides a brief summary of the presentations, giving an insight into the kinds and nature of research being done in the areas of flow of granular materials and nonflowing granular materials. The workshop appears to be the first to bring together a diverse group of researchers concerned with both basic and applied aspects of granular media.

Material Sciences

The Fraunhofer Institute for Material Mechanics is doing work in fracture mechanics, cold compaction of powder materials, elastic-plastic fracture mechanics, and application of fracture mechanics principles to cutting brittle materials. This article highlights research projects from these areas that are relevant to US Navy needs.

Most of the research at the Institute de Soudre is applied research and is often focused on solving immediate problems in the field. Topics under investigation are limited to the offshore, transportation, and aviation industries. Many of their research programs are of interest to the US Navy.

Mechanics

New Laser Doppler Anemometry (LDA) developments and applications which have produced data contributing to the understanding of basic fluid mechanics phenomena are the focus of interest in this article. Topics include application of fiber optics, multipoint LDA measurement techniques, LDA-based particle-size measurement, and measurement of turbulence quantities in the near-wall region.

The third meeting of UK scientists and engineers concerned with turbulent flow was held in Cardiff, Wales, on 9 January 1986. This article reports on papers in turbulence modeling, particle-sizing measurement, measurement of turbulence parameters in a negatively buoyant jet, and modeling of industrial spray dryers.

A wide diversity of papers was presented at the Seventh INRIA Conference. This article, which is concerned primarily with the presentations in the field of fluid mechanics, concludes that finite element methods are playing an increasingly important role in computational fluid dynamics.

Physics

FIAR is a private-stock, independent R&D small-to-medium scale manufacturing company in Milan, Italy. This article surveys some current work at FIAR's electro-optics section. Powerful laser rangefinders, laser designators, and eye-safe laser development is highlighted.

This article reviews the work done in three leading modern optics research centers of Florence, Italy: The Research Institute for Electromagnetic Waves, the Quantum Electronics Institute, and the National Institute of Optics. Some of the highlights are: Integrated optics, color center research, remote sensing, nonlinear effects in fibers, quantum optics and chaos, and some practical optics applications.

Science Policy

Many European countries are using the concept of collaborative government-industry research to focus the research toward the specific needs of that country. Fraunhofer-Gesellschaft, organized to serve that function for West Germany, is an outstanding example.

News and Notes

* * *

ESN Invites Letters to the Editor

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Biological Sciences

NEUROBIOLOGY RESEARCH IN BELGIUM

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 1987 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, Univereity of Hawaii School of Medicine.

Although neurobiology research in Belgium is not carried out at centers such as exist in the US, there are several neuroscience laboratories in Belgium in which innovative, high-quality research is being done. In this article, research by scientists at the Free University of Brussels and the University of Antwerp is described.

Laboratory of Neuropathology and Neuropeptide Research, Free University of Brussels

J.J. Vanderhaegen and his group at the Erasme University Hospital, Free University of Brussels, have been engaged in research on neuronal cholecystokinin for several years. The first demonstration that peptides previously found only in the digestive tract were also present in the central nervous system (CNS) was realized by the discovery of the gastrin-cholecystokinin family (G-CCK) peptide in the CNS of several vertebrates by Vanderhaegen et al. in 1975. It was later shown by Vanderhaegen et al. and other groups that the G-CCK peptides are mainly present in the CNS as the carboxy terminal octapeptide of cholecystokinin (CCK-8) in its biologically activated, sulfated form (CCK-8(s)).

Other molecular forms of CCK are also present in the brain, including CCK tetrapeptide and CCK-39. CCK-8(s) has been shown to be synthesized in the brain and to share properties with chemical neurotransmitters and releasing factors. Receptors for CCK peptides have been shown to be present in the CNS. Their distribution has been studied in detail by immunohistochemical and radioimmunoassay (RIA) methods. CCK has also been reported by Vanderhaegen and others to be involved in various neurological (Parkinson, Huntington, epilepsy) and psychiatric disorders (bipolar depression, schizophrenia). The neuroanatomy of CCK combined with a large body of neuropharmacological, behavioral, and electrophysiological data indicate that CCK may be involved in several neurobiological functions related to, for example, pain perception, regulation of feeling, lactation, control of water balance, stress, thermoregulation, some emotional behaviors, motor function, and the hypothalamo-hypophyseal axis.

The close relationship of CCK peptides with some of the dopamine pathways and the limbic system had suggested a putative role for these peptides in the pathophysiology of neuropsychiatric disorders such as Parkinson's disease, manic-depression, and schizophrenia. Using RIA methods, Vanderhaegen, et al. found a significant decrease in CCK immunoreactivity in the cerebrospinal fluid (CSF) of patients with bipolar manic-depression and untreated schizophrenia in comparison with control subjects. Further studies involving larger sample size are being carried out to characterize more fully these observations.

Vanderhaegen et al. have recently carried out a detailed immunohistochemical mapping of seven peptides, including CCK in normal human spinal cord. At present, the main advantage of the immunohistochemical techniques for peptide localization is to provide neuroanatomists and neuropathologists with additional markers of individual neurons and neuronal systems. This is of cardinal importance in human studies in which the improved methods used in animals for mapping CNS pathways--such as anterograde or retrograde labeling of neurons or their processes--cannot be applied. Once the physiologic roles of the neuractive peptides are better understood, chemical morphology can improve anatomoclinical condition correlations, notably in spinal cord disorders.

Vanderhaegen et al. using immunohistochemistry have investigated the presence in rat irises of three important neuropeptides: vasoactive intestinal polypeptide (VIP), peptide HI, and CCK. These peptides were all originally isolated from porcine duodenum and later found also to be present in the CNS. The mammalian iris is richly innervated by a number of different types of nerves, and recently several biologically active neuropeptides such as substance P have been localized to nerve fibers in the iris. However, the detailed localization study carried out by Vanderhaegen and his group is the first study to show the origin and distribution of VIP, peptide HI, and CCK.

In another study of CCK, Vanderhaegen et al. determined the content of CCK in the posteriointermediate lobe of the rat pituitary in several experimental conditions using RIA. Their results showed that, in addition to sex difference (CCK higher in males than females), factors affecting the vasopressin and/or oxytocin levels in the posterior pituitary and external median eminence also affect CCK immunoreactivity in the same regions. Vanderhaegen et al. conclude that CCK may, therefore, be of importance in functions related to these hormones, and they are carrying out further studies to evaluate their hypothesis.

Vanderhaegen et al. have also been studying the enkephalin neuropeptides and precursor form, proenkephalin. They recently investigated the processing of the precursor protein proenkephalin in two different bovine tissues, the hypothalamus and adrenal medulla. The high molecular weight enkephalin-containing peptides that accumulate in these two tissues were found to be different, indicating the existence of two processing pathways for this neuropeptide precursor. The processing pathway of proenkephalin in brain tissue has not been described previously. The major obstacle in characterizing such a pathway has been the lack of a brain region in which the processing intermediates accumulate as they do in the adrenal gland. However, Vanderhaegen et al. had found previously that the high molecular weight enkephalin-containing peptides were present in the bovine hypothalamus where the enkephalins and oxytocin are localized in the magnocellular neurons of the supraoptic nucleus. Thus, these findings, in addition to the well characterized anatomy of the hypothalamic magnocellular neuronal system projecting to the neurohypophypis, enabled Vanderhaegen and his group to carry out the study described above.

J. Wybran and colleagues at the Department of Immunology, Hematology, and Transfusion, Erasme University Hospital, Free University of Brussels, have been studying some immunological effects of the neuropeptide methionine-enkephalin (met-ENK) in man and its potential for therapeutic use. In recent years, several studies have been reported which narrow the relations existing between the CNS, the endocrine system and, more recently, the immune system. It appears that one of the links between these systems is the endogenous opioid peptides. A few years ago Wybran et al. demonstrated suggestive evidence for the presence of MET-ENK receptors on human Tymphocytes. Recently they have found that the supernatant of MET-ENK-treated cells also enhances the natural killer (NK) activity of human cells isolated from peripheral blood.

In a series of experiments, Wybran et al. have investigated whether MET-ENK can influence various surface antigens of human lymphocytes. They used the following monoclonal antibodies: OKT9 (transferrin receptor), OKT10 (activated T cells, immature T cells, NK cells, monocytes), OK1A1 (DR antigens), Leu 11 (NK cells belonging to the large granular lymphocytes), and Tac antiserum, which recognizes the interleukin-2 receptor (Il-2). Their results showed that MET-ENK acts directly on T cells. Furthermore, since T10 positive cells are also found in the NK population, these results indicate that the T10 increments were not due to NK cells since the Leu 11 cells were not increased using a pure T cell population. Finally, since cells with Leu 11 phenotype were not increased in the T cell population, Wybran et al. believe that MET-ENK probably recruits non-T pre-NK cells rather than T pre-NK cells.

Wybran et al. have investigated the influence of MET-ENK upon the production of Il-2 and found that it was indeed enhanced by MET-ENK. They also studied the *in vivo* effects of MET-ENK in humans, using lung cancer patients and AIDS and pre-AIDS patients. The results indicated that MET-ENK induces *in vivo* the same immunological changes as the ones observed *in vitro*. Taking into account both the *in vitro* and *in vivo* data, Wybran et al. postulate that MET-ENK is able to influence the immune system through a chain of events. MET-ENK is recognized by T lymphocytes through a specific opiate-sensitive surface receptor. Such recognition leads to an induction of various T cell receptors like the sheep red blood cell receptors (active E rosette), the T10 receptors and the interleukin-2 receptors. In the presence of a T cell mitogen, interleukin-2 production is enhanced. MET-ENK per se augments NK function probably by recruiting non-T, pre-NK cells and acting directly on NK cells. All these mechanisms are observed *in vitro* and appear to be operative *in vivo*. They suggest that MET-ENK may act as molecules of lymphocyte activation. Wybran et al. are investigating the following questions of the potential roles for MET-ENK:

1. At very low concentrations MET-ENK is able to trigger multiple mechanisms related to T cell activation as well as to NK function. Does MET-ENK play a physiological role in the immune response?

2. In patients with cancer, pre-AIDS, and perhaps AIDS, MET-ENK appears to be able to trigger mechanisms related to T cell and NK cell activation. Can MET-ENK be used as a therapeutic agent (immunomodulator, modifier of the biological response) in diseases with primary or secondary immunodeficiencies?

3. Stress induces the release of a variety of hormones with opposite immunologic activities like cortisol (which suppresses some immune responses) and MET-ENK (which enhances some immune functions). Can immune mechanisms be responsible (pathophysiology) for stress-related diseases including psychosomatic diseases?

4. MET-ENK provides a new hormonal link by which the endocrine system, the nervous system, and the immune system communicate. Is MET-ENK an integral part of a network system necessary to the communication between the three major systems? Wybran et al. believe it is.

Laboratories of Neurochemistry and Neuropathology, Born-Bunge Stichting, University of Antwerp

J. Gheuens and his colleagues who have extensive experience in the production of monoclonal antibodies (Mabs) have been using this technique to study nervous system diseases such as Alzheimer's disease and tumors. They have recently been able to produce Mabs specific to paired helical filaments (PHF) by a novel *in vitro* immunization procedure developed in their laboratory to study nervous system diseases. Neurofibillary tangles (NFT) are alterations in the neuronal cytoskeleton found in a number of conditions including Alzheimer's disease. Senile plaques and NFT are among the light microscopic pathological hallmarks of Alzheimer's disease, a form of presenile dementia of unknown etiology. At the electromicroscopic level NFT's are described as paired helical filaments, probably of the intermediate filament class. The relation between PHF of Alzheimer's disease and the normal intermediate filaments of neurons, the neurofilaments is not known.

To study NFT in different disorders, their relation to other filament accumulations, and their relation to the normal neuronal cytoskeleton, Gheuens et al. developed Mabs directed to a purified preparation of PHF by their *in vitro* immunization technique. The advantages of their procedures include the use of a very small amount of antigen and short immunization time. Since PHF is difficult to purify and thus yields only minute amounts of purified antigen, Gheuens' method is extremely useful for producing specific Mabs when only limited amounts of antigen (protein) are available. They were able to obtain a Mabs specific to PHF.

Gheuens et al. have also produced specific Mabs to glial fibrillary acidic protein (GFAP) and γ-enolase (neuron-specific enolase) to study nervous system tumors. They found that GFAP is limited to glial or mixed neoplasms. Although γ-enolase had been reported previously by other groups (using polyclonal antisera) to be a neuronal marker in tumor biopsy material, it was found by Gheuens et al. (using their specific Mabs) to be present in non-neuronal as well as neuronal tumors. Therefore, γ-enolase can no longer be considered a neuronal marker in tumor biopsy material. In their study, Gheuens et al. used a two-site immunoradiometric assay with their specific Mab for human γ-enolase. With this method they were able to detect nanogram amounts of γ-enolase.

Gheuens et al. (are also using recombinant DNA (rDNA) technology as a tool to study the basic defect in Alzheimer's disease. Progress in rDNA technology allows the tracing of heritable diseases without the precise knowledge of the molecular origin of the disease. Examples of this approach are the detection of linked restriction fragment polymorphisms (RFLP) to the disease locus of Huntington's chorea, and more recently to cystic fibrosis. Observation of large pedigrees by Gheuens et al. have led them to the hypothesis that in the families studied, Alzheimer's disease is inherited as a single-locus autosomal and dominant trait. Genomic DNA is digested with a selection of restriction enzymes, blotted and hybidized with single copy DNA as a hybridization probe. Although chromosome-specific libraries for almost all chromosomes are now available, there is as yet no confirmed association of Alzheimer's disease with a defined chromosome. For this reason, Gheuens et al. are testing randomly selected clones from the Maniatis human gene library for linkage.

2/28/86

PLANT GENETICS SYSTEMS/UNIVERSITY/INDUSTRY COLLABORATION

by Claire E. Zomzely-Neurath.

Plant Genetics Systems (PGS), established in 1982, is the only genetic engineering company in Belgium with a

direct and continuous relationship with university laboratories. This collaborative arrangement provides the company with the scientific basis for its industrially applicable technologies.

PGS applies its technology primarily to agriculture, the food and feed industries, and the food and fish processing industries. PGS was established as a joint venture with funds supplied by three companies in Belgium and one in Sweden. Their Scientific Board includes some of the world's leading specialists in the fields of molecular biology, biochemistry, plants, and soil bacteria (Table 1). Professor Marc van Montagu is the Scientific Director and is also Professor at the University of Ghent and at the University of Brussels. He is a member of the management group listed in Table 2.

The laboratories of PGS are located in facilities rented from the University of Ghent. Almost $2 million was spent to build new laboratories and to provide advanced scientific equipment. The company has opened a second laboratory at the University of Brussels; it houses the molecular graphics activities of the Protein Engineering Program of PGS. At present, PGS has 60 employees, including 14 Ph.D. scientists, with expansion anticipated in the near future.

The research and development activities of the PGS laboratories are centered around three major themes: genetic engineering of plants, soil microbiology, and genetic engineering.

Genetic Engineering of Plants

Because of the close association with the research activities at the Laboratory of Genetics at the University of Ghent (Professors J. Schell and M. van Montagu), PGS is particularly well suited to tackle the challenging field of plant genetic engineering. The Laboratory of Genetics has developed efficient gene vector systems for plants which allow the transfer and expression of genes into plant cells and the regeneration of the engineered plant cells into normal and fertile plants. These systems are based on an adaptation of the Ti plasmid of *Agrobacterium tumefaciens*.

The current objectives of the plant genetic engineering program are to construct:

- Insect resistant plants producing proteins which are toxic to insects; for example, the *Bacillus thuringiensis* endotoxins
- Leguminous plants with higher nutritional value through the expression in the seeds of high sulfur-containing storage proteins
- Virus resistant plants which produce antiviral agents that block the proliferation of viruses

In 1985, PGS announced the successful engineering of plants for insect resistance. The present activities involve the construction of tissue-specific expression vectors in order to limit the synthesis of the new compounds to either the roots, the leaves, the fruits, or the seeds of the engineered plants.

Besides development of improved vectors, the research is centered around the identification of the plant genes which give advantageous properties to particular cultivars, such as growth in adverse conditions, better plant development, disease resistance, and improved nutritional value. Although the strategies vary from case to case, the approaches are based on the capacity to tag chromosomes and plant-movable DNA elements with antibiotic resistance genes by means of the T-DNA vector system.

A third focus of activity is aimed at introducing and expressing in plant cells specific bacterial genes which may influence plant cell development. It has been shown that this approach can be important for the improvement of the regenerative capacity of some plant species by altering the level and composition of secondary metabolites in plants. PGS believes that this activity will lead to the commercialization of new classes of highly valuable secondary metabolites from medicinal plants.

Soil Microbiology

It is now well documented that a variety of soil micro-organisms play an important and beneficial role in plant growth. In particular, it has been shown that certain bacteria isolated from the rhizosphere (hence called rhizobacteria) are beneficial because they colonize the plant roots and protect them from the invasive proliferation of minor pathogenic micro-organisms.

Because of their previous experience with the genetic engineering of *Agrobacterium* and *Rhizobuim* strains, the PGS scientists have acquired the expertise to transfer new genes into gram-negative bacteria. Recently, this expertise has been extended to gram-positive organisms for which novel multicopy cloning and expression vectors are presently being developed, as well as methods for plasmid conjugation and mobilization between different types of gram-positive bacteria.

One of the main objectives of the research program is the identification

Table 1

Scientific Board of Plant Genetics Systems, Belgium

Dr. John R. Bedbrook--Scientific Director, Advanced Genetics Sciences, Plant Science Center, Berkeley, California

Professor Lawrence Bogorad--Maria Moors Cabot Professor of Biology, Harvard University, Cambridge, Massachusetts

Professor Nils Olaf Bosemark--Director of Research and Development, Hilleshög S.N., Landskrona, Sweden

Professor Howard Goodman--Chief, Department of Molecular Biology, Massachusetts General Hospital, Boston, Massachusetts, and Professor of Genetics, Harvard University, Cambridge, Massachusetts

Dr. Paul Maliga--Science Director, Ags Plant Science Research Center, Manhattan, Kansas, and Section Head, Institute of Plant Physiology, Biological Research Center, Szezed, Hungary

Professor Marc van Montagu--Science Director, Plant Genetics Systems Laboratory, and Co-Director, Genetic Research Laboratory, University of Ghent, Belgium

Professor Jozef Schell--Director, Max Planck Institute for Plant Improvement, Cologne, West Germany, and Co-Director, Genetic Research Laboratory, University of Ghent, Belgium

Professor Milton N. Schroth--Professor Plant Pathology, University of California, Berkeley, California

Table 2

Management Group, Plant Genetics Systems, Belgium

Mr. Joseph Bouckaert, Chief Executive Officer, is a lawyer with long-standing experience in setting up new companies in high-technology fields. He has been responsible for the organization and capital structure of Plant Genetics Systems.

Professor Marc van Montagu, Scientific Director, is Professor at the University of Ghent and at the University of Brussels and has gained worldwide acknowledgement for his research work on *Agrobacterium Tumefuciens* and Ti-plasmid.

Dr. Marc Zabeau, Laboratory Director, has been a group leader of a scientific research unit at the European Molecular Biology Laboratory (EMBL) at Heidelberg, West Germany. His specialization concerns different aspects of gene manipulation in bacteria. He is also part-time Professor at the University of Brussels.

Dr. Jan Leemans, Coordinator Plant Engineering, has gained international acknowledgement for his research on vector systems as a means of transferring foreign DNA into plant cells. His main responsibility is the setup and organization of the plant engineering activities of the company. Prior to joining Plant Genetics he was on staff of the University of Ghent.

Dr. Shoshana Wodak, Consultant Protein Engineering, heads the molecular modeling Laboratory of Plant Genetics Systems at the University of Brussels and coordinates the research program of the company in the field of protein engineering.

of efficient root colonization bacteria which would be engineered genetically and used as vehicles for the engineering of genes that determine properties beneficial for plant growth. In this program, the identity and properties of the major groups of bacteria which colonize the ecto- and endorhizosphere of some major crops are being evaluated. The extent of seasonal and geographical variation is monitored. Among the efficient colonizers, those which are most accessible to gene transfer manipulation are being examined in most detail.

A second program involves the isolation and characterization of bacteria which produce antifungal compounds that inhibit the growth of major plant pathogenic fungi; the aim is to develop systems for controlling fungal diseases in major crop plants. In certain cases it has been shown that this antifungal activity is due to the synthesis and release of small molecular weight compounds. Progress has been made in identifying and transferring to the appropriate rhizobacteria the genes which are involved in the biosynthesis of these antifungal compounds. Study of the molecular basis for the beneficial action of some plant growth-stimulating rhizobacteria is likely to identify a further set of genes which can be transferred to efficient plant colonizers.

Protein Engineering

The protein engineering activities aim at the modification of industrially important enzymes so as to improve their catalytic properties and to optimize their use in industrial processes. In the long run, the goal is to exploit this knowledge to design novel enzymes tailored to catalyze reactions that now

Table 3

Laboratories Participating in Plant Genetics Systems' Research Program for Protein Engineering

- Molecular Modeling Laboratory (Dr. S. Wodak), PGS and University of Brussels, Belgium
- Nuclear Magnetic Resources Laboratory (Professors Jeener and Reissi), University of Brussels, Belgium
- Laboratory Biological Dynamics (Dr. Y. Engelborghs), University of Leuven, Belgium
- Laboratory of Micro-colorimetry (Professor Jaenicke), University of Regensburg, West Germany
- Laboratory of x-ray Diffraction (Professor J. Janin), University of Paris, Orsay-Lure, France
- Laboratory of Enzyme Technology (Professor D. Thomas), University of Technology of Compiegne, France
- Laboratory of NMR Analysis (Professor K. Wütrich), Swiss Federal Institute of Technology, Zürich, Switzerland
- Plant Genetics Systems (Professors M. Zabeau, M. van Montagu), Ghent, Belgium

can only be performed chemically. Such modified enzymes will have very large industrial applications in the food and feed industry, the food and feed processing industry, and the chemical industry.

Protein engineering requires a complex, multidisciplinary approach involving several scientific disciplines and techniques. PGS has taken a double initiative in this rapidly developing field of genetic engineering techniques. The company has opened a second laboratory at the University of Brussels, establishing a unit of molecular modeling. The laboratory houses a powerful computer facility composed of a 32 bit minicomputer, a PS 300 color graphic system from Evans and Sutherland, and a raster graphics system. The research team is headed by Dr. S. Wodak of the University of Brussels.

PGS is presently executing two important industrial projects in protein engineering and has also established a research program and budget for protein engineering. This program covers all technical and scientific aspects of the integrated approach to protein engineering; it also coordinates some of the most important laboratories in Europe in this field. Participating laboratories are listed in Table 3.

Conclusion

Plant Genetics Systems is a new high-tech company dealing with genetic engineering of plants, is a prime example of liaison between academia and industry, and is the only such company in Belgium. It was founded in 1982 by Professors Schell and van Montagu, Co-Directors of the Laboratory of Molecular Genetics, University of Ghent, Belgium. They both act as consultants, and van Montagu is also Scientific Director of the company. However, both retain their university appointments. Plant Genetics Systems utilizes the best research information from the university for application to biotechnological processes in a collaborative arrangement. The scientists at the company also carry out basic research.

2/28/86

Environmental Sciences

EUROMECH 201:APPLICATIONS OF THE MECHANICS OF GRANULAR MATERIALS TO GEOPHYSICS

by Chiang C. Mei. Dr. Mei is a Professor of Civil Engineering in the Department of Civil Engineering, Massachusetts Institute of Technology.

EUROMECH 201:Conference on Applications of the Mechanics of Granular Materials to Geophysics was held 13 through 18 October 1985 at Interlaken, Switzerland. The meeting was organized by Dr. K. Hutter of the Swiss Institute of Technology (ETH) and Dr. S.A. Savage of McGill University of Montreal. There were nearly 50 presentations, of which greater emphasis was on flowing than nonflowing granules. Since it is the policy of EUROMECH not to publish proceedings, some of the presenters devoted their sessions entirely to motion pictures.

Granular materials are relevant to a large number of fields in technology and natural sciences. Examples from daily life include the stability of soil foundations under static and transient loading, the transport of grains in bins and chutes, and the falling of rocks in

landslides. If the eventual strain is small, the mechanics is dominated by sliding and deformation of the particles in continued contact. Problems of this kind are at the core of soil and rock mechanics. At the other extreme, the particles are in flowing motion; the mechanics is then dominated by intermittent collisions. In either case the presence of air or water or both transforms whole material into a three-phase medium. Examples may include the movement of sand particles in rivers or deserts or on beaches, and the transport of coal slurries in pipes.

The mechanics of nonflowing soils or rocks is a discipline of long history; the number of workers is large and conferences are frequent. In contrast, the study of flowing granules is comparatively new and involves many fewer investigators. Workers in the latter area do not often interact with those in the former; the two groups are also separated from each other by professional boundaries. Thus far there have been few meetings and workshops on the fundamental aspects of granular flows. The EUROMECH 201 workshop appears to be the first to bring together a diverse group of researchers concerned with both basic and applied aspects of granular media.

Flow of Granular Materials

To predict the large-scale motion of a granular medium the investigator is ultimately interested in the macroscopic description of the field in which the dynamical quantities--velocity, density, stress, etc.--are represented by averages over length and time scales considerably larger than the particle diameters or interparticle distances. For example, he needs continuum equations expressing the conservation of mass, momentum, and energy. To complete the formulation, constitutive relations such as those between stresses and strains are also needed. Furthermore, he needs information on the transport coefficients of viscosity and heat diffusivity. (The concept of heat and granular temperature refers to energy associated with the random motion of granules in collision.)

One approach, started by Goodman and Cowin for dry granules, is to hypothesize the form of constitutive laws based to a certain extent on heuristic guesses. These laws must obey certain criteria in general continuum mechanics but the details must otherwise be supplied by experiments. Therefore, for the theory to be useful it is necessary in principle to perform enough experiments not only to confirm the form of these laws but also to yield the values of the transport coefficients. This line of approach has been expanded in recent years by others, including Savage and D.F. McTigue who have scrutinized available experiments with care. However, only a small number of papers at this meeting took that approach.

J. Goddard of the University of Southern California cast existing formulations into elegant general forms and gave new extensions for dissipative media. H.W. Buggish of Germany showed laboratory experiments in shear cells for relatively low shear rates. One of his conclusions was that the stress-strain relation consists of a Coulomb friction part and a Newtonian part. Quite coincidentally, Shibata and Mei of the Massachusetts Institute of Technology proposed a similar formulation and worked out several examples of simple gravity flows in one dimension.

On both theory and applications, there were more papers on microscopic theory. Here, one starts from the basic level by examining the collision process between particles and then obtaining continuum equations by taking statistical moments. Models are needed for the collision processes. Perhaps the most sophisticated are those by Savage and associates who assumed the collisions to be binary. To date they have incorporated such factors as particle elasticity, rotation, and friction. Some hypothesis is introduced for the probability distribution of collisions. In particular, this theory has succeeded in confirming Bagnold's experimental result for rapid shear flows that shear stress is proportional to the square of the strain rate. Further progress was reported by Savage on the stress tensor under general strains.

Intricacies of the collision process were given a vivid treatment by H.P. Rossmanith of Austria who showed his photoelastic study of stress patterns in colliding spheres. P. Haff of the California Institute of Technology described his "spash" function, which is a novel idea related to the impact frequency of saltating grains on a boundary. Hayley Shen of Clarkson College described her own version of kinetic theory and its application to the rheology of broken ice in the Artic.

Aside from analytical theories, C. Campbell of the University of Southern California summarized a comprehensive computer simulation of dry particle collisions. This involves the computation of the detailed motion of a large but finite number 0(100) of particles of specified geometric and mechanical properties in a box or in a period domain under boundary conditions typical of a

Couette flow. Statistical averages are taken to calculate the averaged momentum transfer so as to obtain the macroscopic stresses and strains. Such an approach does not require any hypothesis on the probability density. This tour de force confirmed a number of key results by Savage and associates (Jenkins and Savage 1984). Related efforts were also reported by C. Thornton of England. An application of the Jenkins-Savage theory was described by Hutter and F. Szidarovszky through a simple example of a one-dimensional parallel shear flow. The equations are very complex and possess singular behavior at the boundary. Additional refinements are introduced to regularize the boundary condition. The amount of ingenuity and effort needed to treat this example appears to be daunting, and suggests that the future for applying this kind of theory to practical cases will not be smooth.

Relevant geophysical phenomena which received extensive coverage at this meeting were landslides, snow avalanche motions, and sediment transport. The physics of large-scale landslides was described by H.J. Melosh of the University of Arizona. He advocated a theory whereby acoustic noise within the rock debris fluidizes the rock debris. T.H. Erismann of Switzerland, however, gave a different explanation: fused material provides lubrication which enables rocks to slide. D. Bozzlo and R. Pamini of Switzerland presented an impressive film showing the falling of rocks. The information gained from the film has helped to build a mathematical model which accounts for the slip, roll, impact, bounce, and flight of the rocks. (This research has even been used to design a highway.) Savage and Hutter showed several laboratory experiments in which rocks slide off the side of a mountain and fall into a large lake. Simple and semiempirical continuum models were described for the shallow layer of rocks. For a one-dimensional lake the water waves generated are nonlinear and dispersive. Computations according to the Boussinesq approximation are confirmed by experiments.

Snow avalanches are understandably a topic of high priority among Swiss workers. H. Gubler reported radar measurements of flow-speed distributions of snow layers. Avalances were initiated artificially by a mortar. Volumes from a few hundred to several tens of thousands of cubic meters were released. B. Salm described a theoretical model based on a recent theory of Haff, who applied combined arguments of the kinetic theory with an order-of-magnitude analysis without getting involved in heavy mathematics. T. Schewiller and F. Hermann reported computations and laboratory simulation of powder snow avalanches. In the latter, polystyrene particles and water were used to represent snow and air. Numerical techniques were presented by Szidarovszky for the model of Jenkins and Savage.

Aeolian transport of sand was the subject of R. Andersen of the University of Washington: he has incorporated Owen's theory of saltation with the turbulent diffusion model of suspension. Haff showed some experimental results of spheres in saltation. B.B. Willets and A. Rice of the UK presented a comprehensive documentary of wind tunnel tests. Trajectories were observed and the effects of grain size and shape studied. A probability density of ricochet angles was found empirically. As a related subject, T. Davies of Switzerland described the awesome power of destruction in mud flows. A pulsating phenomenon in mud flows was shown to resemble roll waves in open channels.

A fascinating film on simulated broken ice flowing on the surface of river water was shown by Hutter. The phenomenon of jamming behind a bridge pier is particularly striking. J. Hogan of the UK described underwater observations of a vertical circular cylinder towed through a layer of floating ice (pieces of polyethylene). Ridges at the bottom of the simulated ice layer were noted in front of the cylinder.

Nonflowing Granular Materials

The second major part of this workshop was concerned with topics normally associated with soil or rock mechanics. Theoretical works represented here were all based on continuum formulations with only phenomenological constitutive relations; i.e., without use of microscopic theory.

E.G. Prater of Switzerland gave a review of the major approaches in the literature. L.W. Morland and A. Sawicki of the UK discussed their model for the compaction and hysteresis of saturated material under cyclic loading. A three-phase (ice, water, and gas) mixture theory for melting snow was also described by their colleagues, R.J. Kelley, Morland, and E.M. Morris. Numerical techniques have been developed for one-dimensional problems with a moving surface. D.F. McTigue of Sandia Laboratories gave a linearized theory for the thermal-elastic response to a heat source in a saturated porous matrix; there is good agreement with experiments. This problem is of interest for nuclear waste disposal in rocks. R. Nova of Italy extended the theory of

plasticity to account for many properties found in rocks, such as the brittle ductile transition and anisotropy. Prager's consistency rule has been applied to consider the effect of temperature on yielding and failure.

Arthur and Wong of the UK described their experiments on the effects of rotating principal stress directions in sand under cyclic loading. Bozzolo and Pamini showed a film describing their experiments on the impact of a concrete sphere falling on a layer of gravel. Measurements were taken of the forces on the container base and the acceleration of the sphere as well as the impression of the gravel face. Schmieg and Vielsack of Germany considered the mechanics of pile driving by vibration and found a one-dimensional differential equation with nonlinear restoring force and damping to fit the experiments.

There were also papers on gravity currents. R. Simpson of the UK focused attention on the interfacial instability between two fluids. A. Butler of Switzerland described an integral model of two- and three-dimensional turbidity currents. These studies appear to be closer to ordinary fluid mechanics research and lack the special characteristics of granular flows.

3/3/86

Material Sciences

FRACTURE RESEARCH AT THE FRAUNHOFER-GESELLSCHAFT FUR WERKSTOFFMECHANIK

by Kenneth D. Challenger. Dr. Challenger is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until May 1986 from the Naval Postgraduate School, where he is Associate Professor of Materials Science.

The organization of the Fraunhofer-Gesellschaft (FhG) is described in my article beginning on page 183, following. I recently visited the FhG's Institute fur Werkstoffmechanik (Material Mechanics, MM), Freiburg, West Germany. I confidently report that the research ongoing at this institute is superb, the facilities excellent, and the results germain to the US Navy's current and future needs in these areas.

The topics worthy of specific comment (and the principal investigators) include dynamic fracture mechanics (Kalthoff), cold compaction of powder materials (Prümmer), elastic-plastic fracture mechanics (Blauel), and application of fracture mechanics principles to cutting brittle materials (Sommer and Döll).

The institute is directed by Professor E. Sommer, one of the early researchers in the field of brittle fracture. The 80 employees are distributed quite uniformly among five sections of the institute: metallic materials (J.G. Blauel), nonmetallic materials (W. Döll), experimental stress analysis (J.F. Kalthoff), numerical/theoretical stress analysis (W. Schmitt), and surface properties (R. Prümmer). The annual budget for the institute is about DM6 million (~$2.5 million) of which about 20 percent comes directly from the Ministry of Research and Technology (BMFT) and 80 percent from industry.

The following paragraphs highlight the research projects ongoing at the institute which are related to US Navy needs.

Fracture Mechanics Testing

Dr. J. G. Blauel and his coworkers are involved with several research projects that are particularly noteworthy: fracture toughness testing of welds and correlation of fracture toughness results of small test specimens to large structures.

Specimen Size Effects. The most widely used fracture assessment method for components loaded into the elastic-plastic regime is based on the J-integral as the controlling parameter. The critical value of J_I (e.g., J_{Ic}) is determined experimentally and the J-applied for the component compared to J_{Ic}; if J-applied $\leq J_{Ic}$, failure should not occur. This is a very conservative approach because it is based on the load required to cause crack initiation. In reality, the load-carrying and deformation capacity of a component will be much greater than predicted by this approach because stable crack growth can, and normally will, occur.

Blauel and his coworkers have evaluated two different approximate assessment procedures, both of which account for some stable crack growth. These are the Engineering Approach by Shih (1980) and the Failure Assessment Diagram method developed by Milne (1979), UK Central Electricity Generating Board Laboratories (see, *ESN* 38-8:432 [1984]).

Small (2T) laboratory compact tension specimens were used to generate the J-resistance curve and stress-strain curve for the material to be analyzed--a reactor pressure-vessel steel. The results were used to predict the failure load of very large specimens that have been designed to simulate the characteristics of a full-scale engineering component. Single-edge notched specimens 200 mm thick by 700 mm wide were tested at the Fraunhofer MM institute, and 200-mm-thick compact tension specimens were tested by another German institute, MPA (see *ESN* 39-4:152 [1985]). The actual failure loads of the large specimens were compared to those predicted by the two separate approximation methods.

The conclusion reached from this study is that generally good agreement between the predicted and actual failure loads occurred for both methods. The loads at component instability are dependent on some input material property data that are normally only poorly known; hence, the accuracy of the predictions is poor for the instability analysis. And finally, a judgement on the relative merits of the two approximate methods cannot yet be achieved.

Research of this type is required in order to develop reliable design methods for the failure assessment of ships and other large engineering structures. Most of the research in Europe to date has been in support of the nuclear power programs, but this research is directly applicable to other materials and structures. West Germany has some very excellent testing facilities to perform these large-scale component-like tests.

Fracture Toughness of Weldments. The fracture toughness of multipass submerged arc (SAW) and shielded manual metal arc (SMAW) weldments of a C-Mn steel has been investigated by Blauel and W. Burget. Crack tip opening displacement (CTOD) is often used to screen fracture toughness properties and to assess the structural integrity of engineering components. By its very nature CTOD is a local parameter; e.g., it indicates the resistance to crack initiation in a small region surrounding a crack tip. Serious difficulties with this method should be anticipated if anisotropy and inhomogeneities exist in the material under evaluation; welds certainly produce these complicating difficulties.

Blauel and his coworkers have investigated the effect of notch location in the weldment, the effect of residual stresses, specimen geometry size effects, welding procedure and process parameters, and testing techniques on the critical CTOD for multipass weld metal and heat affected zones. They conclude that it is very difficult to obtain reproducible CTOD results on welds unless careful control of all the welding procedures and the testing procedures is maintained. A much more careful approach is required for welds than for base metal if any usable results are to be obtained. Blauel's work on weldments points out a serious difficulty in measuring the fracture toughness of welds by a local approach such as the CTOD. Much larger scatter and test results should be anticipated for welds than base metal, and the interpretation of the measured CTOD values should take into account the fact that local brittle regions may give frighteningly low values of the CTOD where, in reality, the weldment as a whole will exhibit good fracture toughness.

Dynamic Fracture Toughness

Dr. J. F. Kalthoff has been a pioneer in the applications of the shadow optical method of caustics to stress strain analysis, a method originally introduced by Manogg (1964). Stress in a solid will alter the optical properties of the solid--tensile stresses reduce the thickness and the refractive index, compressive stresses have the opposite effect. These changes in a material under stress can be utilized in the shadow optical method of caustics to visualize stress distributions. Figure 1 illustrates the various light distributions that would be observed for tensile and compressive loading using the transmitted light (for transparent materials) and reflected light (for either transparent or opaque materials).

Kalthoff has developed the appropriate mapping conditions to interpret these caustic images in terms of a stress distribution. For the reflective case, the Young's modulus and Poisson's ratio must be known for the material that is being analyzed. The stress intensity factor, K, is shown to be a function of the diameter of the crack tip caustic. Relationships for all three modes of loading for cracks have been developed (Mode I, tension; Mode II, in-plane shear; Mode III, anti-plane shear). These relationships have been used to evaluate the development of the stress intensity factor at crack tips under dynamic loading. Elastic-perfectly plastic behavior has also been analyzed, but for strain hardening materials the stress fields become more complicated and the caustics cannot be calculated analytically. Kalthoff has used numerical calculations of the deflections of

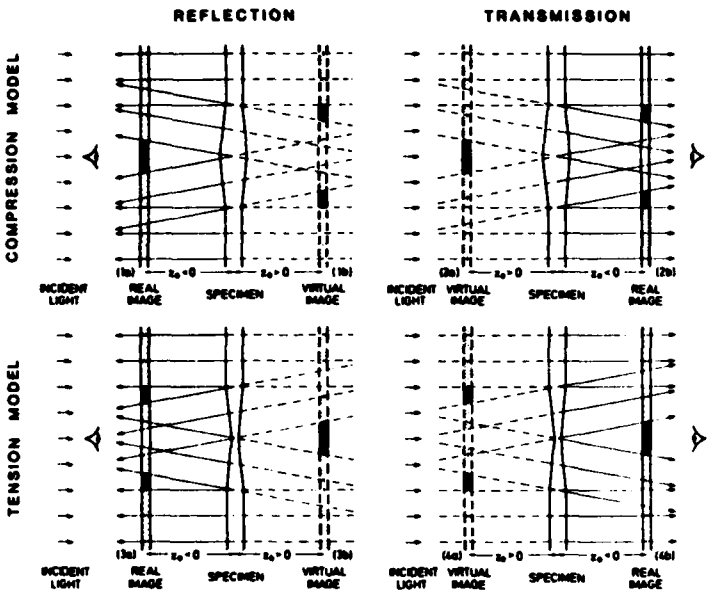

Figure 1. Shadow optical light distributions for different registration arrangements (schematically).

the rays of light around the crack tip in these materials. When the strain hardening exponent, n, is unity (perfectly elastic material) the caustic obtained is identical to that observed experimentally for a perfectly elastic material. When n is set equal to 25, the caustic appears as that which would appear for the elastic-perfectly plastic case (Kalthoff 1986, in press).

In my opinion, one of the best applications of this technique is Kalthoff's work on dynamic fracture toughness. By using a 24-spark Cranz-Schardin high-speed camera in an experimental apparatus similar to that shown in Figure 2, crack initiation and crack arrest behavior have been studied. Figure 3 illustrates the changes in the caustic image as a function of the time elapsed from impact for a three-point bend specimen of a high-strength steel. With this information, Kalthoff calculates the stress intensity factor as a function of time for this test. An impact response master curve is created by using different heat treatments of the material and/or a different notch tip acuity in order to vary the conditions for crack initiation. These experiments are done with a constant testing condition; i.e., the same impact hammer mass, velocity, specimen geometry, and material with the same chemical composition (the principal material parameters to be held constant are the elastic constants, Young's modulus and

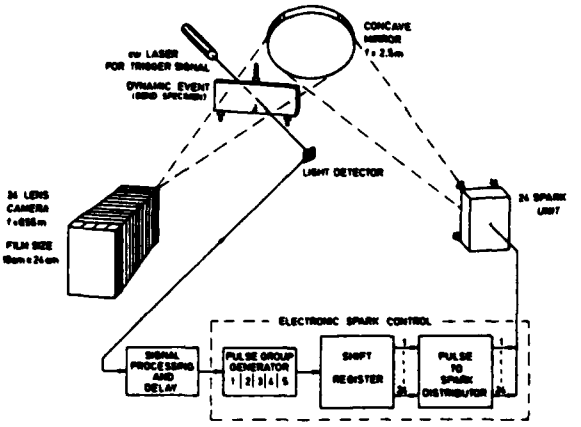

Figure 2. Complete experimental configuration.

Poisson's ratio). The impact response curve consists of a plot of the dynamic stress intensity factor, K_{Id}, vs time. Since most steels have essentially the same elastic constants, this master impact response curve can be used to establish K_{Id} for any steel sample where the time to fracture has been recorded under the same impact conditions as those used to establish the master plot. Thus, once having established the master plot, high-speed cameras or caustic methods are not required.

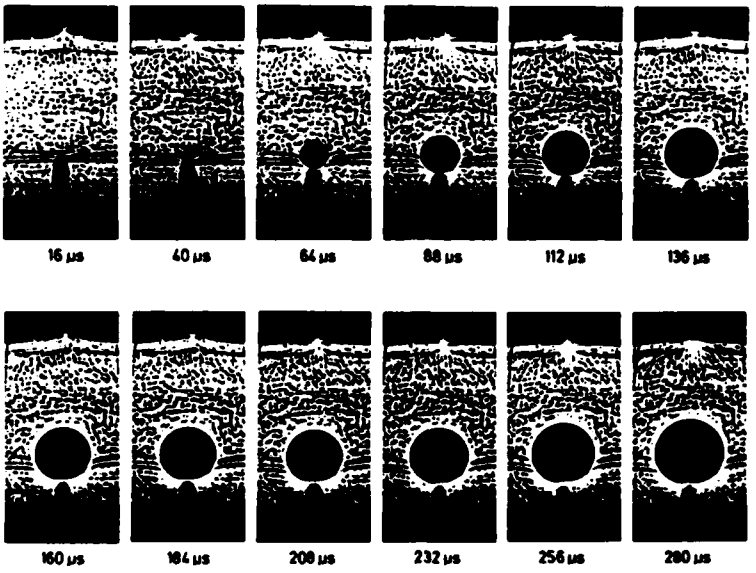

Figure 3. Series of shadow optical photographs for a crack under impact loading (virtual images photographed in reflection with a high-strength steel specimen).

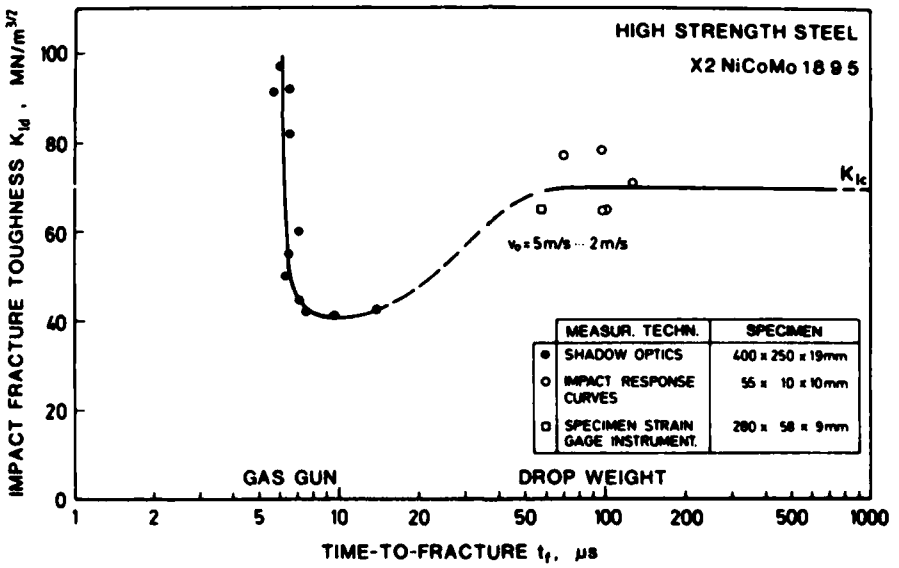

Figure 4. K_{Id} as a function of the time to fracture.

Kalthoff has successfully applied this method for determining K_{Id} to a range of impact conditions varying from standard instrumented Charpy v-notch tests to ultra-high loading rate experiments using a gas-pressure-propelled projectile (this method uses a projectile to create an elastic stress wave in the specimen that causes a rapid pulse loading at the crack tip). This impulse loading results in a loading rate that is twice as fast as a Hopkins-bar apparatus and can result in crack tip loading rates, $\dot{K}_I$, in excess of 10^7 $MNm^{3/2}s^{-1}$. This can cause the onset of crack propagation within a few microseconds.

The ability to load the crack tip at such high rates has allowed Kalthoff and his colleagues to develop an

explanation for the fact that K_{Id} will normally decrease with increasing loading rate to some minimum value whereupon further increases in the loading rate cause an increase in K_{Id} (see Figure 4). He explains this phenomenon on the basis of an incubation time for crack initiation, [Kalthoff (1984)]. That is, the crack tip has to experience a super-critical stress intensity factor greater than a critical stress intensity factor for a specific length of time before a fracture will initiate. If K_{Id} vs time is very steep, the K_{Id} achieved during this incubation time will be much higher than for a test where the K_{Id} vs time is less steep. Thus, a higher K_{Id} at fracture will be measured for the high loading rate test. The exact connection between this incubation time, on the order of 5 to 6 μs for the steel shown in Figure 4, and any physical mechanisms involved in the fracture have not been discussed but it is likely that it is related to the rate of dislocation movement.

Another important result from Kalthoff's research is that he, working in conjunction with D.A. Shockey (SRI-International, Menlo Park, California), has developed a testing method for K_{Id} based on the master impact response curve for the instrumented Charpy v-notch tests. This impact response curve method is applicable to testing conditions that cover a much broader range of loading rates than the method proposed by the American Society for Testing and Materials (ASTM). The ASTM method uses the time record of the load at the tip of a striking impact hammer to determine the load at the onset of crack propagation. This load is then used to calculate K_{Id} using conventional static stress intensity factor formulae. The major difficulty with this technique is that vibrations in the hammer caused by the impact produce oscillations in the load-time history; this causes uncertainties in the actual fracture-load, particularly when the time to fracture is short. Thus, the technique produces meaningful data only if the time to fracture is greater than three times the period of these load-time oscillations. The period of these oscillations will vary with the starter crack length, but will be on the order of 50 μs. Thus, the technique cannot be used reliably for initiation times less than about 150 μs. The application of the impact response curve method overcomes this difficulty because only the time-to-fracture needs to be recorded, the K_{Id} is then determined from the master curve.

Kalthoff is extremely active in the field of dynamic fracture for both crack initiation and crack arrest (not discussed in this article). His research is leading to the development of novel experimental methods to study the complex but real situation of fracture under impact conditions. Some of his work has been sponsored by the US Army, and because he is working closely with researchers at SRI-International he is well connected with the US community interested in this topic. He will be organizing a workshop on dynamic mechanics for the US Army (Dr. Fritz Oertel, USARDSG, London) sometime in 1986. Details of this workshop will be announced in the *ESN* when they become available.

Surface Properties and Explosive Rate Powder Compaction

Dr. R. Prümmer has established an excellent facility for the determination of residual stresses by x-ray techniques. The facility has several computer-controlled x-ray diffractometers with complete computer data acquisition and analysis capabilities. This system has been used to measure residual stresses in welds and residual surface stresses in order to characterize the effect of these surface stresses on fatigue and fracture. He has developed a unique (patented) method to thermomechanically treat the surface of cylindrical shapes. Any cylindrical shape is heated by an induction coil and rotated against a roller that applies a specific load to the surface, thus causing deformation. The combination of deformation and thermal cycling can be carefully controlled during both heating and cooling. Following the thermomechanical treatment the sample can be cooled by a gas blast or water spray. Substantial improvements in fatigue life have been created by precisely controlling the residual stress at the surface and refining the surface microstructure by these thermomechanical treatments.

Prümmer, using explosive compaction methods at room temperature, is also investigating ways to produce, from powders, materials with 100 percent of their theoretical density. Metallic glasses, rapidly solidified metals, and conventional metallic and ceramic powders are under investigation. With metals, the theoretical density of the explosively compacted material (IN-100, a nickel-base superalloy, for example) is approached, but for ceramics, the maximum attainable density has been 95 percent of the theoretical density. Adiabatic heating due to friction at the particle-to-particle interfaces during compaction causes local melting during the high rate compaction. Local melting and the subsequent very rapid cooling of

the interface regions produces a perfect metallurgical bond between adjacent particles and rapidly solidified microstructures at the interface regions. However, since the compaction occurs from the outside-in, the outer regions of the cylindrical samples must undergo severe plastic deformation in order to transmit the pressure wave to the central regions of the cylinder. Hence, the larger the diameter, the more difficult it becomes to produce densification uniformly throughout the cross-section of the cylinder. Attempts to produce IN-100 as 20-mm-diameter rods have almost succeeded. Prümmer feels that with more development, this is feasible.

Explosive compaction appears to hold great promise for the conversion of the new amorphous metals and other rapidly solidified materials into useful shapes without losing their unique properties. This is in contrast with conventional powder metallurgy techniques, which involve sintering steps at elevated temperatures to produce the densification of the powders; such treatment destroys the unique properties of rapidly solidified materials.

Prümmer wants to build a bunker for his experiments on the Freiburg site, (at present they are performed by another laboratory) but the FhG presently rents the entire facility for the Institute of Material Mechanics and is not prepared to invest in this addition to the facility until the FhG purchases the property. The purchase of this property is currently under negotiation and, if successful, Prümmer's program on explosive compaction will expand, and I would expect the development to proceed at a much more rapid pace.

Glass Cutting

Professor E. Sommer, Institute Director, and W. Döll have developed an excellent practical use of fracture mechanics. They use a thermal gradient to produce controlled cracking in glass. This cracking, under controlled conditions, is now used by some of the optical industries in West Germany for glass cutting because the cut surface is almost flawless and requires much less grinding and polishing than conventionally cut glass.

Summary

It is my understanding that Dr. J. Gudas, David Taylor Naval Ship Research and Development Center, Annapolis, Maryland, will be working at the Institute for Material Mechanics in Frieburg for one year. I am certain that this will prove to be a mutually satisfying year and that the US Navy will benefit substantially by his interaction with the investigators at Frieburg. The Fraunhofer institutes are specifically focused toward applied research, but the work at Frieburg also includes some excellent basic research. The facilities and expertise at Frieburg are a valuable resource to West Germany in particular, but also a valuable resource to the fracture mechanics community as a whole.

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2/27/86

INSTITUT DE SOUDRE: THE FRENCH WELDING INSTITUTE

by Kenneth D. Challenger.

The Institut de Soudre (IS) is the French equivalent of the British Welding Institute (*ESN* 39-6:255 [1985]). IS is making an extremely valuable contribution to French industries involved with welding. Consulting and training, rather than research, are the main activities; however, a significant research effort does exist at IS--approximately 16 percent of a total expenditure of FF142 million (∿$20 million) is spent on research. A new facility for welding research is currently being developed and constructed. Several brazing furnaces, one laser (5 kW), and two electron beam welding machines (30 kW and 100 kW, SCIAKY) have been purchased and a new facility is under construction to house this equipment at their Centre André-Leroy site located near Metz. The primary reason for this investment is to provide the facilities and expertise to help French industries decide if they want to use laser beam welding (LBW) or

electron beam welding (EBW) in their operations. The funding for this facility has come directly from the government.

IS employs about 550 people with almost 300 solely committed to service (welding problems, nondestructive testing [NDT], qualification of weld processes, and qualification of personnel). Many of the service people are semi-permanently assigned to a contractor's site.

The research staff is located at IS headquarters in Paris (welding processes and metallurgy) and the Centre André-Leroy in Metz (fatigue, fracture, NDT and--in the near future--LBW and EBW).

Paris

The research activities both at Paris and Metz are directed by M. Evrard. My hosts for the visit in Paris were M. Dadian, head of the Metallurgy and Mechanical Testing Section, and E. Charoulet, Director of the Paris Laboratories.

M. Dadian has produced a superb summary of the research at IS on weld solidification and how this research has benefited the field of metallurgy in general. At present this report is only available in French, but if sufficient interest exists, I believe Dadian will publish an English version. The report is an excellent metallographic study of weld pool solidification structure and the subsequent solid-state phase transformations that can occur during the cooling of a weldment. Dadian has interpreted the results of this metallographic examination with respect to process parameters such as cooling rates, thermal gradients, and weld pool shape.

The observation of traces, or "ghosts," of previous metallurgic states can be observed by metallographic techniques. This method has been used to study in detail the complex metallurgical phenomena that take place during welding. These ghosts of the prior structure are caused by local inhomogeneities in the chemical composition that often exist at prior grain and interphase boundaries. By careful etching techniques it is possible to follow the solidification and allotropic transformations that occur as a function of time in the weld pool and surrounding heat affected zone (HAZ).

Armco iron (pure iron) and plain carbon steels (0.04- and 0.06-percent C) have been studied and compared. The microstructural history of Armco iron during welding is much less complex to follow than that for steel. Therefore Armco iron has been used to collect some information that has proven useful in the understanding of the effects of thermal gradients on the nucleation and growth of the solid phase from the liquid phase and the subsequent allotropic transformations in steel. Grain orientations and interphase relationships have been deduced from these metallographic observations. Chemical etchants were developed to reveal characteristics of the microstructure, including the "ghosts" of the prior microstructure.

The metallographic techniques that M. Dadian has developed will be very useful to anyone involved in the study of steel microstructures. And further, his results on the various phase transformations that occur in welding provide some insight into the relationship between the thermal cycle of welding and the complex phase transformations that occur as a result of this thermal cycle. His published work is required reading.

Dadian's research is important because the dominant parameter that controls the mechanical properties of a weldment is the microstructure. The evolutionary changes in the microstructure that occur during the thermal cycle caused by welding are complex and are influenced by many different parameters. In many instances, the exact effect of these influential parameters on the final microstructure is unknown. Research like Dadian's is necessary to achieve the understanding required to reproducibly control the weld process in order to produce a desired final microstructure.

The Paris laboratory has several other research programs either in progress or recently completed. They indicate the range as well as the focus of the topics of interest to the laboratory. Briefly mentioned, they are as follows:

- The IS has initiated a project to develop new brazing methods for aluminum alloys because they believe that brazing will increase as a joining method for these alloys in France.
- The development of welding procedures for several nickel-base super-alloys is in process; pulsed tungsten inert gas (TIG) and EBW are being evaluated. Joining methods for Alloy 718, Waspaloy, IN-100, and Astroloy are being evaluated. In addition to the pulsed TIG and EBW, friction welding and brazing are also being studied. To date, the only method capable of avoiding fusion line cracks in the highly alloyed nickel-base alloys uses a very slow welding velocity and a large included angle for the weld preparation. Many studies have been completed, but they did not reveal

exactly what causes the cracking. These researchers have apparently determined that Alloy 718 can be more successfully welded if the welding is done with the alloy in an overaged condition.

- A potentially big pay-off program, but in my opinion unlikely to succeed, is the use of acoustic emission techniques to control, or really monitor, weld cracking in multipass welds. Presently, weld cracks are found during inspections that normally take place after many weld passes have been completed. Defects, such as cracks, must be repaired by removing all weld metal that was deposited subsequent to the cracking. If cracking could be detected as it occurs, as would be the case if acoustic emission techniques are successful, then the weld could be repaired immediately following the pass that suffered cracking.
- A program designed to eliminate (or at least reduce) the requirements for preheating steels prior to welding is in process. The principal aim is to improve the welder's working environment, but the metallurgical implications, such as an increase in hydrogen-assisted cracking, are controlling the required preheating temperatures.
- A computerized welding guide designed to prescribe the welding conditions that should be used for hyperbaric welding (down to 1000 m) is under development.
- IS researchers have evaluated the effect of Cu on hot cracking and fracture toughness of low alloy steel welds and find that in a range of 0.4- to 1.3-percent Cu the ductile-to-brittle transition temperature is only slightly increased (and is only slightly detrimental) but that hot cracking has not been a problem. The details of this research program may be of use to the researchers involved in the Navy's high-strength low-alloy steel development program that is now in an advanced stage at David Taylor Naval Ship Research and Development Center (DTNSRDC). If anyone wants more information, write to me and I will attempt to get what I can.
- IS has an excellent program on resistance welding where a method to closely monitor the welding conditions has been developed; this method is based on an IS-developed correlation between the weld integrity and the displacement of the electrodes that occurs during welding.
- The residual stresses in orbital pipe welds (0.8-m diameter) and the complicating influences of a longitudinal weld in these pipes are under investigation.
- Guidelines and standards have been recently developed on the subject of the health hazards of the welder's exposure to welding fumes.

Centre André-Leroy, Metz

As I mentioned earlier, a new facility to demonstrate the practicality of welding with very high energy density heat sources (EBW and LBW) is under construction at the Metz laboratory. The fact that this is going to be located here seems to indicate an intent to slowly eliminate the research activities in Paris and move them to Metz. While it makes sense in my opinion to keep the headquarters in Paris, the Paris facility is really not suitable for modern research and, further, there is no room for expansion. So, perhaps in the next decade, all the research activities of IS will take place in Metz.

My host in Metz was the laboratory director, M. Payet. The annual budget for this laboratory is small (FF16 million [~$2.2 million]) compared with the Paris facility but it is growing rapidly. Three years ago there were only eight employees in Metz. Today there are over 50. The research business is prospering at Metz; for example, they cannot accommodate any more contract research on fatigue or fracture for at least 1½ years. They have all their facilities and manpower committed to projects for the offshore oil and gas industry, the French railway system, and the French aviation industry.

The other main research topic at Metz is nondestructive testing (NDT). These two research areas (fracture and NDT) are combined in an excellent research project designed to assess the significance of defects in welds. NDT will be used to characterize over 100 different types of defects in welds and then this material containing a defect will be tested and the results compared to the predictions made by various fracture mechanics methods. This is a new program at Metz and is just entering the experimental stage. The past year was spent performing a thorough review of the literature on this subject.

This research program is funded by a group-sponsored system similar to that used by the British Welding Institute. A group-sponsored project is one where the laboratory develops a research program that it feels is required to meet the future needs of a given industry. It then "sells" this program to individual companies in that industry, hence the term group-sponsored project.

Because the members of the group may actually be competitors, the topics for the research are generally either fundamental or generic in their scope. The results of the research are only available to the individual sponsors. This is a new method of funding research in France, but it appears to be the trend for the future.

Summary

There are many research programs at the IS that are of interest to the US Navy. My general impression is that the IS is performing applied research on a level, albeit on a smaller scale, equal to that of the British Welding Institute. Topics under investigation are limited to the offshore, transportation, and aviation industries. Sponsorships by industry causes most of their research to be applied and it is often focused on solving immediate problems in the field. The British Welding Institute has both more flexibility and discretionary funds with which to pursue research of a longer term nature than does the IS.

2/28/86

Mechanics

THE FIRST INTERNATIONAL CONFERENCE ON LASER ANEMOMETRY

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

The First International Conference on Laser Anemometry was held on 16 through 18 December 1985 at the University of Manchester, UK. The conference was organized by Dr. J.T. Turner of the Department of Mechanical Engineering of the University of Manchester on behalf of the UK Laser Doppler Anemometry (LDA) Users Group. It attracted over 100 participants, the majority of whom were from England and Scotland. Germany, France, Ireland, Spain, Italy, and Japan were also represented.

The papers presented at the meeting were divided into several sessions including fiber optics, three-dimensional measurements, two-phase flow measurements, engine-flow applications, and signal processing. In reporting on this conference I will concentrate on those papers which described new LDA developments or described applications which produced data that contributed to the understanding of basic fluid mechanics phenomena. A proceedings volume containing all papers except those presented in the Open Forum (held at the end of the conference) was distributed at the meeting.

Fiber Optics Applications

Fairly recently, the LDA community has begun using fiber optics; this was described by L.M. Fingerson (TSI Inc., St. Paul, Minnesota). Several of the exhibitors illustrated commercial adaptions of this technology to their products. One of the great advantages is that by conducting the laser beam through a fiber (rather than air) the Laser Doppler Velocimetry (LDV) probe can be moved independently from the laser. This greatly facilitates traversing the LDV probe in a flow field, and, in principle, would even make it possible for a single, centrally located laser to serve a number of experiments. In this report (just as in practice) the terms Laser Doppler Anomometry and Laser Doppler Velocimetry and their abbreviations (LDA and LDV) will be used synonymously.

Through the use of bundled optical fibers, a single cable carries the two intersecting transmitted beams in fine (six micron) polarizing preserving, single mode (PPSM) fibers wrapped around a central core consisting of a larger diameter (50 to 100 micron) graded index, multimode fiber which serves as the receiving optics. This allows a modular probe a few millimeters in diameter to be constructed, effectively permitting an LDA system to be operated in a "point-and-shoot" mode. In addition, with such a design the probe can be inserted directly into a flowing fluid, thus avoiding the problem of window interference. An example of an LDV fiber-optic probe is shown in Figure 1.

The Japanese have developed a two-color, four-beam LDV probe, one prototype of which even contains Bragg cells. Its development and use for making two-dimensional, mean velocity, turbulence intensity, and sheer stress measurements in a laminar, pre-mixed flame were described by K. Hishida (Keio University, Yokohama). His measurements, like many others presented at this conference, were made simply to check out the operation of the system rather than to provide new insight into fluid mechanics.

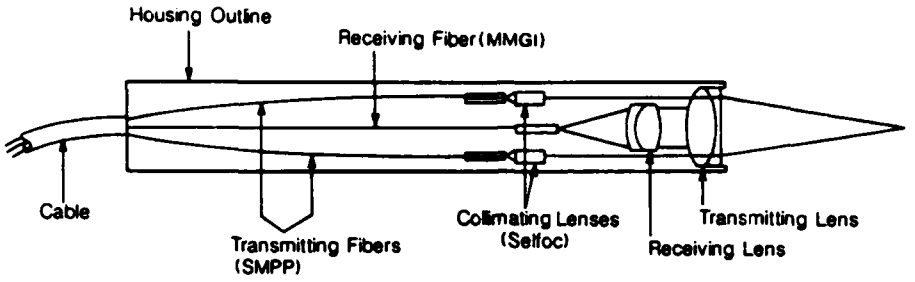

Figure 1. Example of a small LDV probe.

For this reason such measurements will not be further reported here.

An interesting development was the use of a strained optical fiber to, in effect, produce an optically integrated Bragg cell. Fiber modulators permit more rapid modulation frequencies than can be achieved by Bragg cells. In addition fiber modulators are more compatible with fiber optics than Bragg cells since the additional optical components which are required to couple the input beam from the fiber into the Bragg cell or from the Bragg cell back into the fiber are avoided.

Fiber modulators are produced by altering the polarization state of the fiber by physically straining it. In work described by J.D.C. Jones (University of Kent) this was accomplished by wrapping the optical fiber around a piezo-electric cylinder to which a ramp voltage was applied (see Figure 2). Within the linearly rising voltage region, a constant rate of change of optical phase was generated and during flyback the optical phase was rapidly returned to its original value. In the experiments which were described, a ramp voltage of 170 V and a frequency of 43 Hz were used with 100 fiber turns on the piezo-electric cylinder. This combination produced a phase modulation amplitude of approximately 750 radians and resulted in a pseudo-frequency offset of 5.2 kHz. A 5-mW helium neon laser was used as the light source.

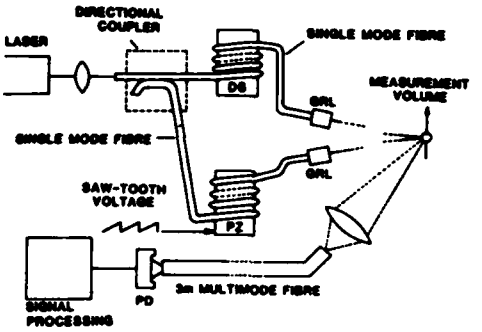

Figure 2. Compact optical fiber laser velocimeter.

Multipoint LDA Measurements

Another promising technological advancement is the use of multipoint LDA measurements. This is best accomplished by inserting a phase-type diffraction grating into the optical path following the beam splitter. One approach using this concept was described by N. Nakatani (Osaka University). He constructed a six-point LDV system using a signal processor consisting of an electric scanner, frequency counter, and a personal computer. The maximum measurable frequency of the velocity fluctuations was 7 kHz. To exclude the influence of the intensity decreases caused by beam splitting, he used a high-power argon ion laser. Except for the diffraction grating, the system was a conventional LDV system. In order to increase the width of the measurable spatial range, two additional beam splitters were used to provide a total of four beams which were then incident on the diffraction grating.

Multipoint LDA is particularly useful in measuring unsteady flows such as exist in the combustion chambers of reciprocating engines. In these cases, a knowledge of the instantaneous flow velocity at a number of points is required in order to analyze the complex flow patterns which are present. A conventional LDV system can only furnish the instantaneous velocity at a single point in a fluid and to obtain the complete flow pattern, the measurement has to be repeated throughout the flow field. Unless the flow is reproducible, there is no way to reassemble these repetitive measurements to produce a valid instantaneous map of the flow field. For

example, it is well-known that there are significant aperiodic events which exist in internal combustion engines; thus, the only way of producing reliable combustion chamber flow-field maps is by some sort of multipoint measurement.

Nakatani used six individual photo detectors whose outputs were multiplexed by a scanner and processed by a single counter. Titanium dioxide particles of 0.3-micron diameter were used. These experiments were first carried out to demonstrate the steady-state performance of the system. In these experiments, a turbulent air jet was used and measurements made to confirm that integral length scales could be measured. For this purpose the spatial correlation coefficient was measured from which the integral length scale was determined. From the integral length scale, the extent of coherent motion--and therefore the size of turbulent eddies--can be approximated. In these measurements it was concluded that a mean integral length scale from 0.89 to 1.4 mm was representative of the flow.

The second experiment featured the time evolution of a turbulent jet at a Reynolds number of 3600. Velocity measurements were made from the moment that flow was initiated in the jet and were continued through the laminar/turbulent transition until 120 milliseconds had elapsed. In these measurements, which exercised the transient capabilities of the method, the instantaneous integral length scale (depending on location and time of measurement) varied from 0.69 to 1.66 mm. In general, smaller length scales were measured at earlier times--and in the core of the jet--as might be expected.

Multipoint LDV research was also reported by B.C.R. Ewan (University of Sheffield). He was principally concerned with the effect of the particle size and the spatial extent of the measuring volume on signal quality. He used a signal collection arrangement which employed a linear array of five 1-mm single-core fibers.

His first experiments were with a line-crossing method using a 500-mW argon ion laser. Using particle sizes ranging from 30 to 40 microns down to 1 to 2 microns, he covered the particle range from that encountered in two-phase flow measurements down to the particle sizes used in seeded gas flow measurements. The test setup consisted of a 6.3-mm-diameter orifice connected to an air supply. By regulating the supply pressure, exit velocities from 70 to 330 m/s could be produced. Adequate signal quality was achieved for particles down to approximately 7 microns. For the smallest particles (1 to 2 microns), the signal quality was marginal. Permissible line extensions ranged from 120 mm for the large particles down to 25 mm for the small particles.

Greater efficiency in the use of the light power can be achieved if the light is concentrated at the measuring points. This can be achieved if a diffraction grating is placed close to the intermediate focus as shown in Figure 3. Using this technique it was found that measurements with the 1- to 2-micron particles were possible out to the fifth diffraction order. This would give a coverage of 11 point-wise measurements. Using a second diffraction grating produced a two-dimensional array consisting of fifty points. It was clear, however, that the additional depletion in intensity produced by the second grating would limit the measurable points to second order.

To permit multipoint measurements to be made in two dimensions, the use of a pulsed laser was explored. Only operation of the laser in non-Q switched mode was considered because only in this mode of operation is a pulse of sufficient length (approximately 10 μs) produced. A JK 2000 pulsed ruby laser was used in these experiments. Although no flow measurements were reported using the pulsed laser, pulse widths and repetition rates seemed to be appropriate for the intended applications.

LDA-Based Particle-Size Measurements

L.E. Drain (Atomic Energy Research Establishment, Harwell) set the stage for several papers on LDA-based particle-size measurements by giving an overview of the available techniques and the problems encountered in their implementation. Measurement of particle size in sprays is, of course, an important problem in studying the combustion of liquid fuels. Such measurements are complicated by the fact that sprays are

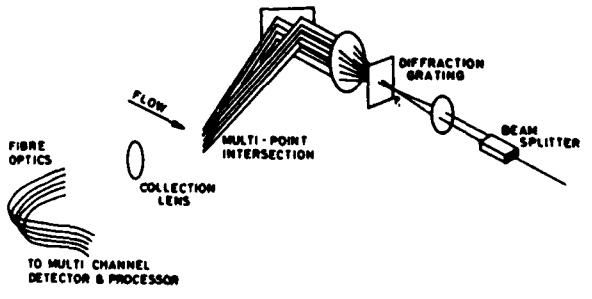

Figure 3. Multi-point LDA using diffraction grating.

often exceedingly dense. This introduces the problem that more than one particle occupies the probe volume at a time and some procedure must be devised to untangle the multiple signals which are thus produced. This is called the multiple occupancy problem. A second problem lies in the fact that many sprays are exceedingly heterogeneous in terms of their particle size distributions. This imposes severe dynamic range requirements on any particle-sizing technique. In addition to this, in any LDA-based technique the radiation received by a detector is a combination of refracted and diffracted light. An appropriate receiving angle must thus be found which corresponds to the predomination of one of these two modes since the determination of the particle size is strongly dependent on the origin of the light received.

The technique which provides the greatest freedom from these and other particle-sizing difficulties is the phase technique. This employs two or more detectors to determine the phase difference between signals received at two (or more) angular positions. Because the phase difference is related to the difference in optical-path length through the particle, this measurement can be used to determine the particle diameter.

Dantek (formerly Disa) markets a commercial system which operates on this principle. It operates in the side-scatter mode to reduce the multiple occupancy problem. It uses three detectors to extend the dynamic range of the device and, in addition, uses discrimination logic to determine whether or not the particles are spherical.

An application of the phase technique was described by K. Bauckhage (University of Bremen). He measured simultaneously both particle size and velocity with his system. The experiments were conducted with a water fan-spray atomizer which produced a flat spray cone in quiescent air. Particle sizes from 3 to 300 μm and velocities from 0.1 to 100 m/s were measured with this system. He compared the results of his LDV measurements with a double-flash photographic technique and found both the particle size and velocity to be in good agreement.

Low-Velocity Measurements

Some special problems arise in attempting to measure flows at low velocity, particularly those with high turbulence levels such as are encountered in natural convection problems. P. Betts, University of Manchester Institute of Science and Technology (UMIST), described his measurements of mean and turbulence velocities in an air column contained between two differentially heated vertical walls. Since the velocities were so small (5 to 20 cm/s) smaller particles than those which would otherwise be desired had to be used in order to keep the particles in suspension. As a result, the signal-to-noise ratio was poor and conventional counter equipment had to be abandoned in favor of a transient recorder. In addition, the high turbulence levels (well in excess of 100 percent of the mean velocity at some points) required significantly more than the usual amount of Bragg-cell frequency shifting. The measured vertical velocities and temperatures agreed reasonably well with the predictions of a finite volume, k-ε calculation of the flow.

Measuring Turbulence Qualities in the Near-Wall Region

It is well known that polymer additions can cause reductions in pressure drops (and therefore pumping power) on the order of 40 to 60 percent. What is less well known is the mechanism responsible for this. This requires measurement of the turbulence quantities in the near-wall region. Special problems arise in attempting to make LDV measurements near walls. As was pointed out by F. Durst (University of Erlangen-Nürnberg), this requires, first of all, the use of a probe volume that is properly suited for the wall region. He suggested a probe diameter of less than 60 μm. It is worth pointing out that most commercial systems produce probe volumes that are anywhere from 100 to 200 μm in diameter. In addition, sufficient sampling time must be provided if smooth measurements are to be obtained. Attention to the integral scales indicates that for suitable number of samples, say 1000, 100 seconds per point are required. Finally, because of the curvature of the inner and outer walls, special problems arise in attempting to make measurements (even away from the wall) in the circular glass pipes which are used for these studies. This is because of the refraction of the beam which occurs as it leaves the air, enters the glass, reaches the fluid within the pipe and is transmitted back through the glass and the air on its way to the receiving optics. In such cases it is difficult to know where the probe volume is located. In addition, such large beam reflections may be produced that it is geometrically impossible to carry out the measurements.

To overcome these effects, Durst immersed the test section in a rectangular channel containing an oil-based fluid whose refractive index was matched to that of the glass. He also used the same mixture as the working fluid. (The index-matching product which Durst found to be most effective was Palatinol C produced by BASF.) In this way the test section was rendered optically transparent. The only refraction which remains is that associated with the air/glass interface where the beam enters and leaves the rectangular channel containing the test section.

This technique, which has been used in studying chemical mixing processes and the flow through rod bundles, requires extremely careful temperature control since the indices of refraction must be matched to the fourth significant figure, and viscosity-matching fluids are notoriously temperature sensitive.

Durst described experiments in which he used a 2-inch-diameter glass pipe and a traversing mechanism which could be positioned to an accuracy of 10 μm. With this equipment he was able to make velocity measurements within 0.5 y^+ units of the pipe wall. With the polymer present in the flow (he used polyisobutylene in the concentration of 800 wppm) he found a significant reduction in the rms levels of both streamwise and cross-stream turbulence velocities in the near-wall region.

Durst also measured the Reynolds shear stress, $-\overline{u'v'}$, and found that the measured shear stress became negative, particularly for low Reynolds numbers. (Reynolds numbers of approximately 9000, 12000, and 15000 were tested.) Additional polymer increased both the magnitude of the negative shear stress and the extent of the region in which it occurred. Durst provided a theoretical rationalization for the appearance of negative shear stress, including its dependence upon Reynolds number.

Conclusion

For me the highlight of the conference was the multipoint LDV work described by Nakatani and Evans. The simultaneous flow-mapping capability which it offers may well lead to significant increases in the level of understanding of complex unsteady flows such as in three-dimensional shock-wave/boundary-layer interaction problems and internal combustion engine flows. Developments in this area should be closely watched and, if possible, supported.

3/1/86

INFORMAL TURBULENT FLOW MEETING

by Eugene F. Brown.

I attended the third meeting on Experimental Measurements in Turbulent Flow on 9 January 1986 at University College, Cardiff, Wales. The Turbulent Flow Group was organized 18 months ago, and this was its third meeting. The purpose of these meetings (held every 6 to 9 months) is to provide an opportunity for UK scientists and engineers to discuss both problems and successes in an informal workshop atmosphere. The group was organized by Dr. R.T. Szczepura of the Berkeley Nuclear Laboratories, Berkeley, Dr. M. Yeoman of the United Kingdom Atomic Energy Authority (UKAEA), Harwell, and Dr. C.J. Bates of University College, Cardiff (UCC). At present, the membership consists of individuals from these organizations, as well as representatives from British Gas, The National Engineering Laboratories (Glasgow), the Central Electricity Research Laboratories, Rolls Royce, General Electric Corporation (GEC), the University of Manchester Institute of Science and Technology (UMIST), and the University of Oxford.

This group was originally organized as an industrial laser Doppler anemometry users group but it was soon realized that limiting the scope of the meetings in such a way would soon leave very little to be discussed and the meetings would, therefore, be very infrequent. Consequently, during the second meeting it was decided to broaden the scope to include turbulence modeling, with the intent of stimulating exchange of information between the experimental and computational turbulence communities. The program of this meeting was a reflection of the new direction taken by this group. A total of seven papers were given at this meeting and three were related to turbulence modeling. No proceedings will be published, but informal minutes will be distributed to the participants. I would be happy to supply a copy to anyone who is interested.

The first presentation was particularly appropriate considering the expanded scope of the meetings. It concerned turbulence modeling and was given by Dr. N. Wilkes and Mr. S.K. Martin, who are both from UKAEA, Harwell. After presenting a brief review of zero-, one-, and two-equation models and a brief consideration of wall treatments they described their calculations for flow in a sudden expansion using the k-ε turbulence model. Near the expansion, the results were in reasonable agreement

with experiment, although there was some difficulty in predicting the velocity profile in the recirculation zone. Further downstream, results both in the recirculation zone and in the core flow were not very well predicted. Typical for this turbulence model, the recirculation length was underpredicted. As far as the turbulence kinetic energy was concerned, the calculations overpredicted the experimental results in the recirculation region and underpredicted the experimental results in the shear layer. They then presented their results for the flow in a transversally ribbed channel which was a model of the heat exchanger of a gas-cooled reactor. (They had previously presented these results at the Conference on Laser Anemometry--see my article, preceding.) Similar to the sudden-expansion calculations, the length required for the flow to reattach downstream of the ribs (reattachment length) was too short and the turbulence parameters were poorly predicted. In addition, the transverse fluctuating velocity component was poorly predicted.

The industrial orientation of the group was well represented by the presentation by Professor N. Syred of UCC. His interest is in the design of vortex collection systems for particle separation. Such devices are used in steam power plants to remove the fly ash which is produced by the burning of coal. The vortex devices have the advantage of being much smaller than conventional fly ash removal systems and they are remarkably efficient. Syred discussed a LDV study which he had undertaken to characterize the flow, and his student, Mr. S. Dolbear, described the modeling which he had done using both differential and algebraic two-equation and algebraic four-equation turbulence models. The results provided a reasonably accurate qualitative model of the behavior of such devices.

Mr. D. Hemsley (UKAEA, Harwell) described some work which he had done on particle sizing using Fraunhofer diffraction theory. I had also seen some of this at the Manchester meeting. He described a small-aperture, off-axis collection system which significantly (by a factor of 5) increases the range of visibility-type particle-sizing measurements. There is some difficulty, however, if extremely small particles are to be detected. For this he suggested using two aperture sizes, a large one for the small particles and a small one for the large. Although off-axis collection was thought to present some difficulties compared with on-axis collection in terms of accommodating particles of irregular dimension (nonspherical), experiments were conducted which showed that the off-axis collection system operated reliably for both regular and irregular particles. In addition, he discussed a three-beam, two-color particle-sizing method for intensity-type particle-sizing measurements. The purpose of the third beam is to assure that measurements are only made for particles which pass through the center of the measuring volume. Unless this is done it is impossible to accurately measure the particle size. This is because a large particle passing through the edge of the beam will produce the same intensity change as a small particle passing through its center. An interesting feature of this method is that it allows measurement of particle velocity to be made simultaneously with particle size. A single measurement therefore suffices to determine the volumetric flow rate of the particulate.

Mr. M. Ross (GEC) presented some of his results obtained with a dual focus (two-spot) laser system. This uses the so-called transient (time-of-flight) technique in which the time required for a fluid particle to pass between two beams is measured. He presented results of velocity measurements made near the leading and trailing edges of a cascade and around a submarine fitted with a shrouded propeller. The submarine flow measurements were made on the hull, in the wake, and within the shroud of the propeller. Both time-averaged and fluctuating velocity and flow-angle measurements were made. Many of the results, particularly the submarine measurements (made in the 30-ft water tunnel at the Admiralty Research Establishment, Teddington) were proprietary and not much detail was given.

Mr. Ron Cresswell (UKAEA, Harwell) used a conventional LDV system to measure the turbulence parameters in a negatively buoyant jet. This situation occurs in a liquid-metal, fast-breeder reactor when a hot jet is directed downwards into a cold pool. To simulate this situation he used a heated water jet flowing through a 1.5-cm tube with a velocity of 0.13 m/s. The Reynolds number based on the pipe diameter was 5000, and the tube was sufficiently long to produce fully developed turbulent flow. Ordinarily, LDV measurements in such flows are difficult because of the large differences in index of refraction which occur between the heated jet and the pool. Because of the highly turbulent nature of the injection process, the jet interface is in constant motion which causes troublesome diffraction effects.

To overcome this problem, a Bragg cell was used to sweep the fringes through the control volume at a rate which was much higher than the diffraction-induced motion of the beams. Using this technique, no difficulty was encountered in making measurements in this highly turbulent flow. It was found that the negative buoyancy resulted in an enhancement of the turbulence. Future plans call for making temperature/velocity correlations with the use of a thermocouple array. These results will be used by Professor B. Launder at UMIST to refine his turbulence model for buoyant jets.

The last presentation was by Dr. J. Goldberg of the University of Oxford. He reported on his attempts to model industrial spray dryers for which the experimental data had been obtained by Bates (UCC). The typical problem of k-ε models relative to underprediction of the extent of the recirculation zone was encountered. As a consequence, algebraic stress models were adopted. This produced significant convergence difficulties and a number of "fixes" had to be introduced in order to get converged results. Possibly as a result of this, the algebraic stress calculations produced results which were no better than those obtained with the k-ε model. Part of the difficulty might also be due to the fact that the calculations were begun with a very incomplete knowledge of the particle size distribution at the inlet.

I was invited to remain in Cardiff following the meeting for a tour of the laboratories of the Department of Mechanical Engineering and Energy Studies at UCC and a discussion of their fluid mechanics research. My hosts were Dr. C.J. Bates and Professor N. Syred. Bates' interest is in velocity measurement and particle sizing in two-phase flows. Bates has been working in this field for a number of years and has close relationships with UKAEA, Harwell, where he directs a group which is involved in making such measurements. His contracts with UKEAE have supported many of his research and technical staff. At the present time, 10 individuals are receiving such support. In addition, UKEAE has employed many of his doctoral students. His relationship with UKEAE is a very close and productive arrangement.

Bates has been involved in the development of visibility methods for particle sizing for many years. This work was described by Hemsley (a former student of Bates) the previous day. Bates is currently developing a portable version of his two-color, particle-sizing equipment. The two-color method has the advantage over commercial, phase-Doppler particle-sizing equipment in that it is simpler and more easily adapted to making *in situ* industrial measurements. Bates is currently working on a beam deflection device which combines Doppler and time-of-flight measurements and is particularly well adapted to velocity and particle-sizing measurements of larger particles.

Much of Syred's work on centrifugal-type particle collection systems has been experimental; however, he has begun a computational effort aimed at predicting the flows in such devices which will undoubtedly benefit from the experimental data which has been collected. Of particular interest to me were some experiments and proposed modeling of the flow of the outlet of a centrifugal burner where a large precessing, kidney-shaped vortex and an associated secondary vortex have been identified. This is responsible for flame-flapping in industrial burners. This can result in significant structural damage to the boiler. Syred's work is largely supported by the Central Electric Generating Board (CEGB).

1/23/86

INRIA CONFERENCE ON COMPUTING METHODS IN APPLIED SCIENCES AND ENGINEERING

by Eugene F. Brown.

The Seventh INRIA (Institut National de Recherche en Informatique et en Automatique) International Conference on Computing Methods in Applied Sciences and Engineering was held 9 through 13 December 1985 in Versailles, France. It attracted more than 300 attendees, the majority of whom, as might be expected, were from France. The conference is held every two years. This year the emphasis was on vector and parallel computing, compressible flow calculations, semiconductor modeling, combustion, and turbulence. Additional sessions were held on semiconductor theory, numerical logic, and numerical methods for geophysics and solid mechanics. Because of the broad scope of this meeting I will be reporting on only a few of the 51 papers which were presented, primarily those in the fluid mechanics area. Only about half of the papers were available at the meeting. Unfortunately, discussion of the work presented was almost

nonexistent. In my opinion, the failure to allow sufficient time for discussion was a serious oversight on the part of the session organizers. The proceedings of this conference will be published by North-Holland.

Many of the papers presented employed finite element calculations. A. Hauguel (Laboratoire National d'Hydraulique) reported on some work which his group had done on turbulent calculations in complex geometries using a finite element method. Such calculations tend to converge rather slowly. They succeeded in finding a way around this with a preconditioning procedure which used the local value of the eddy viscosity. Two additional problems arose from the use of the k-ε turbulence model. One of these problems had to do with the need to revaluate the coefficients in the discretized momentum equations at each time step due to the change in the viscosity field. This was overcome by using a semi-explicit treatment of the diffusive terms. The CPU savings on the Cray 1S of about 50 percent was achieved when this technique was used. The other difficulty arose from the manner in which the wall boundary conditions were treated. Use of the law-of-the-wall couples the velocity components together. He was able to uncouple the velocity components again by writing Dirichlet conditions for the velocity and determining the pressure by solving a minimization problem involving a quadratic functional.

The calculations by N. Satofuka, (Kyoto Institute of Technology) departed from what seems to be an increasing trend toward the use of finite element methods for fluid mechanics calculations. Satofuka's calculations are similar to Jameson's work in that both used Runge-Kutta methods. Satofuka, however, uses conventional finite difference discretization; whereas Jameson uses a finite volume approach. His calculations were accelerated with the use of local time stepping and residual averaging. Both inviscid and viscous calculations were shown. For the inviscid calculations, second and fourth order artificial viscosity was added in order to assure stability for shock-containing flows. Satofuka's calculations done on a symmetric NACA 0012 airfoil at Mach number 0.8 and an angle of attack 1.25 degrees predicted the shock jump quite well, avoiding the undershoot experienced in Beam-Warming calculations. A viscous calculation was shown which corresponded to the A.2 test case of the recent GAMM Workshop (*ESN* 40-2:74-75 [1985]). The Mach number was 0.8 and the Reynolds number was 500 based on the cord length. A 257×65 grid was used. For this same case, a turbulent calculation was made at a Reynolds number of 1×10^6. For these calculations a Baldwin-Lomax algebraic turbulence model was used. Several other airfoil calculations and a NACA 65(12)10 cascade case were shown. Satofuka made a special point of mentioning that no artificial viscosity was required in his inviscid calculations. His calculations were made on a Fujitsu VP-200 super computer.

It is well known that external flow calculations which impose the static pressure of the free stream as the downstream boundary condition exhibit very slow convergence to steady state. S. Abarbanel (Tel-Aviv University) described a small perturbation analysis which was used to obtain a new downstream boundary condition for the problem of the flow over a flat plate. Attention was focused on the long-wavelength behavior because the poor convergence characteristics of Navier-Stokes calculations have been traced to the slow decay of relatively long-wavelength disturbances. The basic idea was to perturb the Navier-Stokes equations around some approximation to the steady state in the downstream region. The resulting linear partial differential equations for the perturbed quantities are then attacked using a modal form for their solution. The resulting equations represent an eigenvalue problem which is solved in the very long-wavelength limit. This eigenvalue problem yields the decay rate for long wavelengths and the value of the phase velocity. With these two quantities, as functions of the Mach number and Reynolds number, one can use the results of the perturbation problem to obtain the desired boundary conditions. The resulting downstream boundary condition is a linear function of the pressure and the stream-wise pressure gradient.

The usefulness of this new boundary condition was tested by implementing it in a Navier-Stokes program which used a version of the MacCormack scheme. The problem was a Mach 0.4 flow over a flat plate at a unit Reynolds number (per ft) of 3.0×10^5. An exponentially stretched, 17×31 grid system was used. A number of runs were made to verify the performance of the program with respect to convergence rate and its robustness with respect to changes in the coefficients contained in the outflow boundary condition. Although a direct comparison with alternative propositions for boundary conditions which accelerate the solution of Navier-Stokes equations is difficult, indications are that a reduction in computing time by a factor of from 2 to 4

can be achieved. Although a thorough test has not been made, the method seems to be fairly robust in terms of modifications of the constants contained in the boundary condition formulation.

The topic of domain decomposition (perhaps the term "zonal methods" is more familiar) was brought up several times during the meeting. An intriguing idea was suggested by V.I. Agoshkov (Soviet Academy of Sciences) in a paper entitled "Domain Decomposition For Boundary Value Problems of Hydrodynamics" which was concerned with the calculation of ocean circulation. He proposed that with the advent of array processors, domain decomposition would allow the various zones to be solved independently in the array processors and later brought together in a central processor.

Although domain decomposition is a popular technique for handling problems with complex geometry and problems in which it is desired to model the flow using, for example, Euler equations in one region and Navier Stokes equations in another, there is some doubt about the proper manner for exchanging information between the various zones. I was, therefore, pleased to see that in December of next year INRIA will be sponsoring a meeting on domain decomposition. The meeting will be organized by Dr. J. Periaux of INRIA.

C. Basdevant (Laboratiore Météorologie Dynamique, Paris) described a new subgrid-scale turbulence model for use in large eddy simulations (LES). The problem here is that the statistical treatment of the virtual scales (that is, the unresolved small scales) is crucial. The intent here is to represent as exactly as possible the statistical effect of the virtual scales on the large scales which are resolved by the solution of the Navier-Stokes equations.

The most popular subgrid scale model (SGM) is based on the eddy viscosity concept. Basdevant pointed out that the major drawback of this formulation is that instead of simulating the enstrophy (square of the vorticity) cascade through the turbulence scales, from the large scales which are calculated by the Navier-Stokes equation to the small scales which are represented by the SGM's, these models create an artificial small-scale dissipation range. This contradicts the properties of two-dimensional dynamics. Spectral formulations for SGM have also been proposed; however, the validity of such modeling for two-dimensional turbulence is still open to question. Basdevant's method avoids the defects of both types of SGM. The approach is called the Anticipated Potential Vorticity Method (APVM).

The APVM observes the generic properties of two-dimensional turbulence; in particular, it simulates the enstrophy cascade from large to small scales while assuring that the energy flux toward the small scales is asymptotically vanishing. In addition, the extraction of enstrophy from the deterministic solution occurs in an energy-conserving fashion. The second important property retained by APVM is the locality in physical space of the cascade process. Namely, it assures that the modeling acts only where the flow exhibits singularities (for the model resolution) without directly disturbing the large-scale flow features.

The objective of APVM is to evaluate a correction term to be added to the time derivative in the explicit scale calculations (Navier-Stokes) to account for the subgrid scale effects. The method is called "anticipated" since the filter used to suppress the development of small-scale structures in the Navier-Stokes solution anticipates the vorticity. The anticipation time is scale dependent. It vanishes at large scales and increases rapidly in the vicinity of the cutoff up to the mean eddy turn-over time.

In numerical experiments consisting of a simulation of two-dimensional incompressible turbulence in a square periodic domain, APVM was shown to be significantly different from other SGM's for simulations of decaying turbulence, forced turbulence, and transition. The main advantage of APVM was claimed to be the use of all the explicit scales of the numerical modeling. The calculations were illustrated by means of an impressive color film and a video which illustrated the evolution of the turbulent structures. A proposal for the extension of APVM to three-dimensional turbulence was given.

B. Larrouturou (INRIA, Sophia-Antipolis) presented his work on an adaptive, explicit, finite-difference method for the computation of unsteady, one-dimensional, laminar flames propagating in premixed gases. A two-step adaptive mesh procedure was used, composed of dynamic and static re-zone stages. The static re-zone was based upon the leading order terms of the truncation error. The calculations exhibited the well-known spikes indicating the thermodiffusive instability of the flame front. The solution featured the use of a method of lines and an explicit time integration scheme. An extension of this procedure to two-dimensional calculations was also presented. For these

calculations a finite element calculation was used. The calculations appear to be quite simple and inexpensive. This method looks like an economical approach for the solution of multidimensional flame front problems.

The theme of affordable combustion calculations was continued in the presentation by S. Galant (Bertin and Co.). Bertin, being a large-scale consulting firm (*ESN* 40-4:133-136 [1986]), has need for computational methods for a wide variety of industrial situations. Gallant talked about three problems: propellant combustion, chemical laser mixing, and large-scale flame fronts. Reflecting on the results of those calculations, he suggested two areas where improvements were needed: a self-adaptive and time varying grid scheme based on considerations of stability and error propagation and novel techniques to improve the capabilities for solving sets of stiff differential equations.

Given what I felt was some unjustified criticism of his calculations at the GAMM Meeting in Göttingen in September (see ONR London Report C-1-86, *GAMM Conference on Numerical Methods in Fluid Mechanics*) I was glad to see A. Rizzi (FFA, Sweden) discuss the matter of inviscid separation. It is necessary to address this issue because separation is generally thought of as a viscous phenomenon. Thus, in the solution of the Euler equations where viscosity is absent, one would not expect separation to arise. Nevertheless in Rizzi's calculations separation is clearly present.

The first question which arises is whether the separated zones in some way violate Kelvin's vorticity theorem. Rizzi concluded that they do not. Only if a closed contour could be identified in which the circulation changed with respect to time would a violation of Kelvin's theorem take place. Rizzi demonstrated that although contours could be found containing the separated zone where circulation changed with respect to time, these contours were not closed. This substantiates the fact that zones of separated inviscid flow are theoretically possible.

What then is the numerical mechanism which produces these zones? Rizzi believes there are two mechanisms at work here. The first is truncation error. The proposition here is that the discretization which takes place in the solution of the Euler equations produces an artificial viscosity which produces viscous effects in what would otherwise be an inviscid calculation. He substantiated this point of view by showing a coarse and fine mesh calculation which he had done for the flow over a circular cylinder. When he used a coarse mesh there was a loss of total pressure produced by the numerical viscosity and he obtained the asymmetric separated-flow configuration that one associates with a solution of the viscous equations. However, for the fine mesh he found the symmetric solution which one would expect from the solution of the inviscid equations.

Also contributing to separation was the nonlinear build up of shear waves into vortex sheets. He demonstrated this by showing the calculations of the flow over a delta wing. The delta wing was of finite thickness, at a Mach number of 0.7 and an angle of attack of 10 degrees. He used 620,000 mesh cells in the calculations to practically eliminate truncation error as a source of separation. With this number of mesh cells he was able to get a calculation of exceptional fineness. What he found was a zone of separated flow which occurred on the leading edge of the wing approximately half way back from its apex. The vortex generated by the shear layers resulting from the separation was clearly visible.

Having demonstrated the theoretical possibility of inviscid separation and exploring the mechanisms by which it might occur the question remains: Is the separation real? At the present time this is very much an unanswered question.

M. Mallet (Stanford University) was the first of several speakers to describe his finite element calculations. The significant feature of his work was the use of the entropy variables based on the work of Hughes. He showed a number of calculations obtained by solving the Euler and Navier-Stokes equations with Petrov-Galerkin methods. The cases were an oblique shock reflection at Mach 2; a Mach 8 bow shock; flow over a circular cylinder; a NACA 0012 airfoil at a Mach number of 0.85; a Mach 7 elevon cove calculation; inviscid flow over a flat plate at a Mach number of 3; and a viscous, Mach 8, flat-plate calculation at a Reynolds number of 1000. Although it was difficult to judge from the figures which were presented, good agreement was claimed with both experiment and theory in all cases.

O.C. Zienkiewicz (University College, Swansea) claimed that improved accuracy, more general purpose codes, ease of handling of complex shapes, and a base for adaptive grid refinement are some of the reasons that finite element codes are becoming popular. In his talk he emphasized the last feature and showed some of his calculations for both compressible and incompressible Euler

and Navier-Stokes calculations. His grid refinement technique splits coarse mesh into finer and finer elements. Alternatively, he completely redefines the grid, resulting, for example, in grids of high aspect ratio where large gradients are detected. In this fashion very good results are produced on quite coarse meshes.

The last paper, entitled "Towards The Computation of the Flow Past a Complete Airplane," was given by A. Jameson (Princeton University). Jameson announced what he called his "conversion" to finite element methods as a result of the difficulties which he perceived in using zonal methods such as those suggested by MacCormack. His program is now in its debugging stage (not an insignificant undertaking since the code presently contains 8,000 lines with an estimated 250,000 characters). The triangularization which is required to produce the mesh over complex shapes (particularly those involving concave regions) is not trivial. Jameson encountered a problem with the generation of spurious off-surface elements. This he said resulted in an airframe geometry which more resembled a hedgehog than a streamlined aerodynamic shape. He believes that once the problem with the mesh generation is solved, a solution will be quickly obtained. He intends to use a multigrid, adaptive-grid technique to solve the Navier-Stokes equations. He has already made such calculations on an isolated ONERA M-6 airfoil and it showed excellent convergence properties, requiring only 10 cycles for convergence.

It is difficult to formulate any conclusive impressions from the meeting because of the diversity of the papers which were presented. The one lasting impression which I have, however, is that finite element methods very definitely are playing an increasingly important role in modern computational fluid dynamics. This is especially true for calculations involving complex shapes. For this reason, the upcoming INRIA meeting on Finite Element Methods in Flow Problems to be held 16 through 20 June 1986 in Antibes, France, might turn out to be one of the most important fluid mechanics meetings of the year.

2/10/86

Physics

MILITARY APPLIED LASER RESEARCH AT FIAR OF MILAN

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 1987.

Powerful and fast tactical range finders, eye-safe erbium lasers, plans for laser designator development and for slab configuration lasers are the highlights of current activities at Fabbrica Italiana Apparecchiature Radioelettriche (FIAR), the Italian Factory for Radioelectric Appliances. FIAR is a growing private company, dedicated almost exclusively to research, development, and small-to-medium-scale manufacturing of products for the military market. The main stockholder is Ericson. FIAR has 1200 employees working at three plants in the northern industrial zone of Milan. While total sales amounted last year to approximately $50 million, research and development activities were supported by FIAR at the high level of $5 million. Modern engineering laboratories, sophisticated instrumentation, highly qualified workforce, and remarkably strict quality control put FIAR among the most esteemed suppliers in Italy for defense (80 percent of FIAR's work profile), space and automation systems (16 percent), and logistic support (4 percent). The profile includes the following areas:

- Avionics (radar and optical fire control; Doppler, weather, and search radars)
- Heavy military systems (precision radars; approach systems; sonars)
- Air defense systems (NATO programs)
- Electro-optics (TV systems for ground and naval applications; laser range finders; TV trackers; fire control systems; fire training simulators; thermal imagers)
- Space technology (telecommunications; power supplies/conditioners; power amplifiers; local oscillators)
- Automation and Artificial Intelligence (protection, alarm and safety systems; process controllers; data acquisition systems; robotics; sensor fusion)

This article, in which I review selected activities, is based on a recent visit to the Electro-optics Section, a part of the Defense Division,

directed by Professor M. Zorgno and managed under the stimulating supervision of G. Vigo. It is interesting to note that the laser group is only five years old, yet, as the following will indicate, it can already look back at significant achievements. So far, after the completion of the research and development phase, some components have been manufactured at FIAR, but some others have been subcontracted. Current efforts aim at producing all electro-optic systems and subsystems entirely within the FIAR facilities.

Laser Rangefinders

In addition to its work on more conventional battlefield range finders, FIAR recently completed its most prestigious product: a tactical high-power laser range finder with up to 20-km range and capable of tracking fast-moving targets. Thus, the system is particularly suited for naval applications.

The transmitter is a compact Nd:YAG laser with close-coupled flashlamp pumping. It delivers over 20-MW pulsed output power (this accounts for the long range). The repetition rate is high and is variable up to 15 Hz (this permits tracking high-speed targets). Pulse length is 8-10 ns only, and beam divergence is currently around 2.3 mrad.

The receiver uses a silicon avalanche photodiode, which allows for a minimum of 2-nW detectable power. The fieldview is 2.5 mrad.

The entire system is computer controlled, data being handled in a 12 bit serial form. More work is at present directed toward improving the electronics and thermal dissipation in the processor system.

The present model has an accuracy of ±5 m and a resolution of 30 m. The range capability is illustrated in Figure 1. (Here At stands for target area and ρ for target reflectivity.).

The developers of this system feel that it is particularly efficient for such targets as sea-skimmer missiles. The laser beam propagates better in the vicinity of the water surface than radar beams since it has less divergence. Target acquisition well beyond 20 km would still have to be done by radar; the attached communication system would then automatically pass on the target to the laser rangefinder, allowing much better precision. In any case, the FIAR engineers believe that this current long-distance model is already better than a similar system devised by Marconi.

Nevertheless, FIAR is still at work to implement further improvements. One of their problems is optimizing size and weight versus cooling requirements. Good cooling (effected by a forced circulation of fluorocarbon liquid) is necessary for increasing repetition rate (needed for fast data acquisition on fast targets); for eliminating heat-induced mechanical changes of the lasing rod (tilt, misalignment); and, last but not least, for the achievement of a good Gaussian beam profile. In general, improvement of beam quality is very much in the focus of current development attempts. For detailed testings the FIAR scientists developed a sophisticated

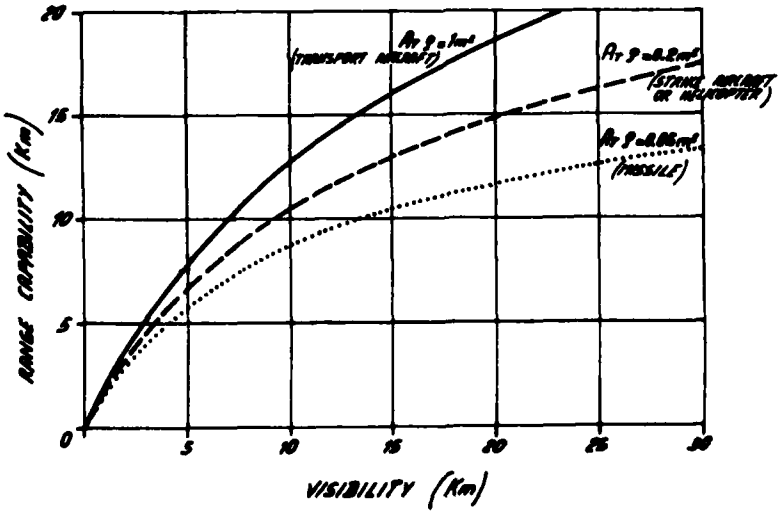

Figure 1. Range capability of FIAR range finder.

system consisting of a CCD camera and a grid.

Another research line is aimed at drastic weight reduction. The present system weighs little (38 kg, not counting the power supply, which is 16 kg), but it is hoped that weight may be further reduced to a level that will enable deployment on aerial platforms.

Laser Designators

This work is still in the stage of intensive development. The aim is to keep the beam on target with high precision and a high (at least 20 Hz) repetition rate. The beam divergence will be about one-tenth of that for the range finder: FIAR aims at 0.2 mrad. Unlike many designators available on the market, the model under development will not use an unstable laser cavity configuration.

Much of the design work focuses on the repetition rate. Not only should this be high, as explained above, but also it is desirable to arrange for its variability. This would impede enemy detection.

Furthermore, the FIAR scientists are developing a methodology which permits one to use the variable repetition rate to "code" part of the information--this would allow for the simultaneous guiding of several missiles to several targets, designated by different laser systems.

Eye-Safe Lasers

The proliferation of laser equipment on the battlefield necessitates the development of infrared laser sources which have a wavelength that will not damage the human eye. Researchers found that the ideal wavelength in the near IR range is 1.54 μm. At this wavelength the corneal damage threshold is considerably increased, and retinal damage is actually prevented by both the high absorption of the ocular media and the reduced focusing capability of the corneal and crystalline lenses.

One laser (discovered long ago but rejected later for a variety of reasons) that operates in the 1.5-1.6 μm range is the Er^{3+}:Glass laser. Cost effectivity, simplicity, ruggedness, and compatibility with well-known Nd:Glass technology all speak in favor of an erbium (Er)-glass laser system, used in pulsed operation. However, although FIAR (and other) experiments demonstrated that short-pulse MW power operation is possible, they also found a list of difficulties that their scientists, under the leadership of Forgno and Dr. C. Tarenzi are currently attempting to surmount. To start with, repetition rate is too low, and so is the efficiency. Very strong flashlamp pumping is needed. Finally, Q-switching is difficult to achieve because a customary Pockel cell does not work (except if it is made with $LiNbO_3$, but this requires an extremely high operating voltage). Nevertheless, the FIAR researchers succeeded in constructing several pre-prototypes.

In all cases the laser rod is pumped by a single linear flashlamp in a close-coupled configuration. The cavity length chosen is less than 10 cm. The best Q-switching mechanism so far found used a prism rotating at a rate of 20,000 rev/min. Of course, this arrangement adversely affects the ruggedness of the system. Another Q-switching mechanism under experimental study is the use of a special dye saturable-absorber. The ideal would be a polymerized disk of the dye--but this does not exist yet. (Even for the Nd:Glass laser wavelength, only polymerized dye films, but not disks, exist presently.)

The results that FIAR publicized refer to the Q-switching variant with the cumbersome, only temporary, polarizer-Pockel cell combination. In this version, 25-ns pulse duration and less than 5-μrad beam divergence was achieved. With a threshold of 20-J energy input, a slope efficiency of 0.1 percent was found; the maximum output observed (at 50-J pumping) was near 30 mJ per pulse (i.e., the average power was over 1 MW).

Based on this intermediate model, an eye-safe laser rangefinder is already under development. For a visibility of 20 km, the expected range would be 5 km.

FIAR scientists also consider another way of producing eye-safe IR laser radiation: by Raman shifting of the output of a Nd:YAG laser in pressurized CH_4 gas. The "wrong" wavelength will have to be filtered out, and they do not expect more than 0.1 percent overall conversion efficiency. In addition, there are doubts about the ruggedness of the device.

Concluding Remarks

The electro-optics group at FIAR has several other research programs going, beyond those I reviewed. For example, they just initiated work in developing novel IR solid-state lasers, including slab configuration models. Ruggedness and portability are the major objectives here. Atmospheric studies of laser and microwave propagation are likewise a long-term concern. Finally, plans are underway to initiate in the future far-infrared-laser (FIR) research and development.

In summary, I have seen a vigorous center with good research capabilities and a fine record. Of course, FIAR is product-oriented so that short-term development is emphasized. On the other hand, they have caught the interest of the Italian government, NATO, and several Asiatic customers. I understand they are seriously interested in broadening and deepening connections to the American research and development community.

12/3/85

OPTOELECTRONICS, QUANTUM OPTICS, QUANTUM ELECTRONICS AND INSTABILITY RESEARCH IN FLORENCE

by Paul Roman.

Florence, the magnificent capital of renaissance Europe, has a longstanding tradition in optics--suffice it to recall the memory of Galilei Galileo and his school. Today, many-faceted research in modern optics and its quantum theory/electronics-related versions still occupy an important part in the city's life. In November 1985 I visited three research centers: the Research Institute for Electromagnetic Waves, the Quantum Electronics Institute, and the National Institute of Optics. Major topics that caught my attention were in the areas of integrated optics, color center physics, remote sensing, four-photon mixing in optical fibers, instabilities in lasers and other nonlinear systems, and practical holography. In the following, I select a few highlights for description, grouped according to their home institutes.

Research Institute for Electromagnetic Waves

This large, multidisciplinary research center (Istituto di Ricerca sulle Onde Elettromagnetiche [IROE]) belongs, as does the Quantum Electronics Institute (see below), to the National Group for Quantum Electronics and Plasma Studies, which is sponsored by the government agency Consiglio Nazionale delle Ricerche (National Council of Research [CNR]). The director of the Integrated Optics and Micro-optics Group, Professor G.C. Righini, explained to me that CNR no longer funds institutes by unrestricted budgets but, rather, supports special projects and cooperatives. Therefore, there is some uneveness in the level and balance of current activities at IROE.

Integrated Optics. Righini first described his years-long results in signal processing by integrated optics circuitries. His major concern is the improvement of a microwave frequency analyzer. (A very good review of the topic, with emphasis on Righini's and his associates' work, has been given by him in the volume "Integrated Optics, Physics and Applications," NATO ASI Series, Series B: *Physics*, Vol 91.) The general layout of the device is shown in Figure 1. The laser source has a single transversal and longitudinal mode; the first waveguide lens expands and collimates the beam. An interdigital finger-electrode-array transducer is driven by an incoming one-dimensional signal, such as a radar signal, which is mixed with a local oscillator output and then amplified. Thus, surface acoustic waves (SAW) are excited and traverse the waveguide, creating moving corrugation gratings at the interfaces. (The index grating is the dominant mechanism for the Bragg diffraction of the incident optical beam.) The portion of the beam which fulfills the Bragg condition will be deflected by an angle proportional to the acoustic frequency and with an intensity proportional to the applied signal power. This diffracted beam is then focused by the second lens onto a photodetector array at the focal plane. Each pixel acts as a frequency channel. The best way to achieve a good serial readout of the signal power-density spectrum contained in the detector is to couple it to a charge-coupled device (CCD). (A similar, effective, but less integrated device has been recently developed at Siemens, see *ESN* 39-12:568 [1985].)

Several versions have been experimented with. Righini pointed out that

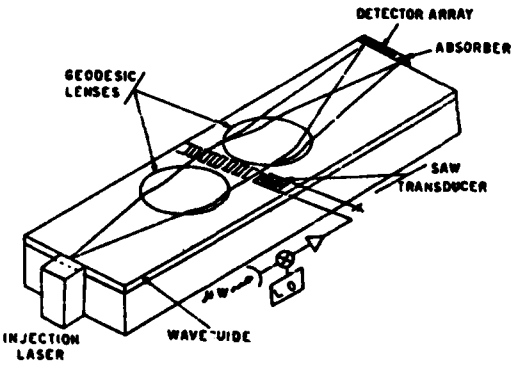

Figure 1. Sketch of integrated optics spectrum analyzer.

the major problem is the implementation of highly efficient, diffraction-limited lenses. Currently, so-called geodesic lenses are used (see below). These work well, but their fabrication technique is difficult and makes the device too expensive for practical applications. Fresnel lenses, also tried, have reasonable apertures but low efficiencies. Conventional grating lenses, on the other hand, have a too small aperture. Righini now experiments with novel grating lens structures that are directly introduced into the glass substrate. One approach uses direct laser-beam writing; another, holographic methods. One could, for example, store a grating in a photoresist and then transfer it by a mask. The latest attempt actually consists in the use of a chalcogenide glass, on which direct laser writing with a blue beam can easily be done. (This part of the work is carried out in cooperation with an industrial group and is therefore protected at present by proprietary silence.)

An extension of this research line consists in the replacement of the SAWs by magnetostatic waves. In this case, the transducer is just a conductor line; no conversion of the microwave signal is needed. But Righini's researchers ran into a technical problem. The waveguide structure consists of an Y-Fe-garnet film on GaCd-garnet, and it is difficult to optimize the thickness of the film, which must act as a single-mode guide.

Now a few words on geodesic lenses, used in the standard spectrum analyzer. These have been "invented" by one of Righini's most accomplished associates, Dr. V. Russo. She suggested this clever system in 1972, but because of lack of response, work began on more general versions only in 1980. The great advantage of hemispheric geodesic lenses is that they can be focused wherever desired, and can join discontinuities smoothly. Spherical profiles are the most common forms, but aspherical profiles can also be fabricated; these are useful for beam direction changing and even for beamsplitting. A good survey of some aspects of geodesic lenses (with references to the literature) can be found in the *AGARD Conference Report* (Preprint Collection #383) of the 1985 Istanbul Conference on Guided Optical Structures in the Military Environment, where, in addition, a new potential application for constructing a spherical waveguide multiplexer-demultiplexer is described. Russo proposes more general work in the future on passive optical components in integrated optics.

Research on Color Centers. The future of tunable color center lasers is still not clear; therefore, I was particularly interested in the persistent efforts of Drs. P. Fabeni, G.P. Pazzi, and their younger associates in their search for new doped alkali halide crystals which are possibly suitable for color center lasers.

The scientists created color centers in CsI and KI by doping with heavy elements, especially positive Tl, In, Pb, and Ag ions. They investigated optical amplification in the ultraviolet and visible region, and are planning experiments in the infrared. In all cases they paid special attention to the study of gain (if any) at room temperatures--an important practical consideration.

The technique the researchers use for studying the luminescence intensity as a function of either the pumping intensity or of the pumped sample length is the method of amplified spontaneous emission (discovered by Marowsky et al., *Applied Optics*, 19 [1980], 138).

Particular success was obtained with the Tl:CsI system (0.2 mole percent dopant in the melt). They observed a gain factor of 1.4 at room temperature, with fluorescence at 406 nm (fast component) and at 540 nm (slow component). On the other hand, In:CsI showed no amplification. The biggest disappointment came with Ag:KI; here the gain was only 0.7, in contrast to reports by other researchers who, at liquid He temperatures, registered very high gain and amplification.

Most experiments used a homemade N_2 laser for irradiation, but the researchers are now turning to a XeCl excimer so as to utilize more efficiently the absorption band.

At this moment, the IROE research group feels that there is reasonable hope of constructing room-temperature visible and UV color center lasers by using doped alkali halides--provided crystals with good optical quality can be grown. But further work with new materials, and also amplification measurements with different pumping wavelengths, must be done soon.

Remote Sensing. Even though I did not find in this area such intensive research as, for example, at the German DFVLR Centers, I want to list activities in the so-called "geo-cosmo-physics group" because I understand that the IROE's group is probably the best in Italy.

Dr. L. Pantani explained that (apart from geodesic observations from satellites and high resolution atmosphere-spectroscopy) the focal points of their work are optical remote sensing of land and sea and lidar work. In the lidar work, stratospheric sounding is

the most developed activity. Differential propagation and differential reflectance technology is also advanced at IROE. A fluorescence lidar system for maritime applications has been developed and tested. They have plans to construct a lidar suitable for satellite basing. One of the recent successes of the group was the prototype development of a battery-operated, rugged, compact XeCl excimer, suitable for lidar applications.

Quantum Electronics Institute

This relatively small research center, also a CNR institute, is only a couple of blocks away from IROE, and all credit must be given to its suave, scholarly director, Professor R. Pratesi, for succeeding in running dedicated research under incredibly hard housing and supply-support conditions. The major activities of the institute can be summarized as follows:

- Applied physics (development of various laser sources, such as flashlamp-pumped 200-W dye lasers and compact XeCl excimers; slab-configuration Ne:glass lasers; four-photon mixing in optical fibers; initial work on metal vapor lasers)
- Molecular physics (collision-induced light scattering in very dense gasses; laser-assisted collision energy transfer)
- Theoretical physics (laser theory; FEL theory; solitons in one-dimensional structures; magnetic excitations)
- Biomedical research (photobiological studies and surgical lasers)

In the following I will report on only one research line. It was rather new to me, and I found it particularly unusual.

Nonlinear Frequency Conversion in Optical Fibers. About two years ago Dr. R. Salimbeni and a few young associates, including R. Pini, initiated an experimental program for the study of frequency shifting by Raman amplification in multimode optical fibers. The impetus for this research was the fact that silica fibers with relatively low losses in the ultraviolet spectral region were first announced around that time. This, observed Salimbeni, may significantly extend frequency conversion experiments using nonlinear effects in fiber propagation from the traditional infrared and visible domain into the ultraviolet. This is exciting, says Salimbeni, because the Raman cross-section is high at UV frequencies and, as long as good coupling to the fiber is provided, a simple excimer laser can easily pump in MW-order of power. These considerations more than compensate for the fiber losses which, even today, are relatively high.

In their first experiments on fiber Raman amplifiers the researchers pumped a highly multimode silica fiber with the 351-nm output of XeF excimer. For input angles much smaller than the numerical aperture of the fiber, they observed not only substantial Raman amplification of the weaker XeF line at 353 nm, but also anti-Stokes and Stokes spectra generated by stimulated four-photon mixing (SFPM) at 348.9 and 355.5 nm, respectively. The Stokes peak at 355.5 nm had 1 kW peak power.

Follow-up research led to the spectacular observation of SFPM up to four Stokes orders in a 300-m long, low-loss, large core multimode silica fiber. The fiber was now pumped by a dual-frequency dye laser (one, the pump, in the red with fixed frequency, and the other, the signal, tunable in a range of higher frequencies). The phase matching condition for SFPM was achieved in the fiber in a nonmarginal way, so that, by varying the frequency separation of the two laser lines, it was possible to tune continuously an intense line generated by SFPM under the Raman-gain curve in the range of 350 to 495 cm^{-1}. To conclude: the scientists demonstrated that the combination of SFPM and Raman amplification by stimulated Raman scattering (SRS), excited by a pulsed laser in a multimode silica fiber, generates efficiently multiple lines of coherent radiation. Figure 2 shows the output spectrum of the fiber which was pumped with 300-kW power in both the pump and signal lines.

These successes led the Salimbeni-Pini group to think of practical applications in absorption spectroscopy. This goal will demand an optimization of the scheme which produces the tunable, equally spaced multiline spectrum. They

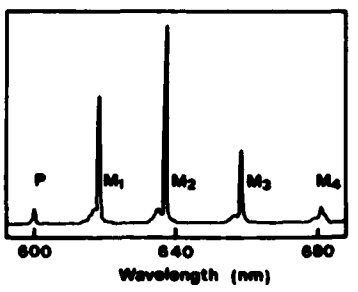

Figure 2. Output spectrum.

realized that optimal performance demands the separation of the Stokes generator and the power amplifier function. In a paper just submitted for publication to *Applied Optics*, the group (in cooperation with A. Haider, University of Dhaka, Bangladesh, and Chinlon Lin, AT&T Bell Laboratories, Holmdel, New Jersey), describes a high conversion efficiency ultraviolet fiber Raman oscillator-amplifier system. The system consists of a first piece of fiber which acts as a Stokes generator and a second piece of fiber which plays the role of a power amplifier. Figure 3 shows the experimental arrangement. The multimode fiber was pumped by the 308-nm line of a XeCl excimer with 150-mJ energy and 7-ns pulse-length. Remarkable conversion efficiencies (up to 80 percent) have been observed. Preliminary experiments demonstrated that the method can be extended to amplify weak and tunable lines in several UV regions. For example, at 250 nm a conversion efficiency higher than 50 percent was seen. The authors are convinced that the present amplification results can be scaled up to reach energy conversion up to tens of millijules, employing fibers with larger cores. Now they plan to use the amplifier part only, replacing the generator by a frequency-doubled dye laser. Potential applications may involve, besides spectroscopy, areas of material processing, photochemistry, and biomedicine.

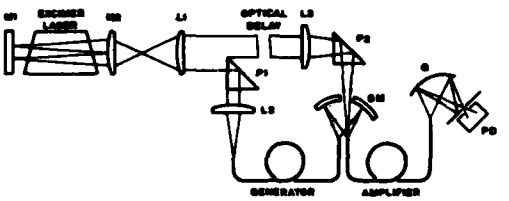

Figure 3. Generator-amplifier experiment.

National Institute of Optics

This institute (Istituto Nazionale di Ottica [INO]), is housed in Florence University's old Physics Department building, south of the Arno river. It is a public research institution operated directly by the Ministry of Public Instruction, and enjoys partial support also from CNR and the national agency for atomic and innovative energy resources (ENEA). It has 20 professionals, many of them sharing university positions. The ratio of doctoral students to permanent employees is higher than at the other two institutes described above. Apart from advanced basic research and training, technical inspection and certification is also a mandated activity.

There are four areas of concentration:

- Quantum optics (fundamental and applied laser physics, mostly theoretical; studies of instabilities in nonlinear systems, both theoretical and experimental)
- Electro-optical systems (design of devices for industrial purposes)
- Optical metrology (interferometry, holography, analog optical processing, optical design)
- Science of vision (physics of visual perception)

The institute is directed by the very energetic, active, and internationally mobile Professor T. Arecchi, who is also the group leader of the best known work-division, the one in quantum optics.

Research in Quantum Optics. The work of the quantum optics group, which was brought into existence in 1978, focuses almost exclusively on research relative to order and chaos in quantum optics. Problems related to phase transitions in nonequilibrium systems (bistability and multistability) led to the study of the stochastic time approach to transitional phenomena. Apparently, Arecchi's group was the first to show evidence of low dimensional chaos in quantum optics and noise-induced jumps between different basins of attraction. This work opened INO's area of chaos-studies both in quantum optics and fluid dynamics. Today, very general studies of nonlinear dynamic systems occupy the group. These are rapidly growing activities, hotly contended, and I am in no position to make value judgments--the less so because, due to technical reasons, I did not report at all on related work of high quality done at the University Physics Institute in nearby Milan (*ESN* 40-3:104-107 [1985]). But I want to put it on record that present and planned nonlinear dynamics studies at the INO include the following:

- Chaos in CO_2 laser operation
- Oscillations in light polarization in a sodium cell
- Time dependent structures in fluid dynamics
- Optical chaos in solid-state systems (InSb driven by a CO laser)
- Analog simulation of nonlinear systems

I will comment on the first three topics.

A group of scientists, led by Dr. A. Poggi, assert that recently they measured the fractal dimensions and the Kolmogorov entropies of periodic and chaotic attractors for a CO_2 laser system with modulated losses. Besides the expected usual increase of the fractal dimension in the chaotic region, they also found an increase in dimension near the accumulation point of the periodic cascade. Quantitative agreement between a theoretical model and experimental results seems established.

Another recent work in laser dynamics concerned experiments with a CO_2 ring laser, where a single longitudinal mode was propagating in each direction. Dr. Tredice and his colleagues found a variety of stable, periodic, and aperiodic phenomena, which depend on gas pressure, cavity detuning, and relative excitation. Three distinct low-frequency time scales were observed, and it is asserted that they correspond to numerical solutions of an elaborate theoretical model. The importance of chaotic behavior in ring lasers is, of course, important from the "practitioner's view" in that it determines the ultimate limits for laser gyroscope operation.

The research on intrinsic oscillations in the polarization of light transmitted by a sodium-vapor-filled Fabry-Perot cell is conducted by Dr. S. Cecchi. His group reports that these oscillations occur if the interferometer is near-resonant with the incident D1 line radiation and if no magnetic field acts. In the experiments, no buffer gas was used. Actually, as the laser frequency scans across the resonance line, two different oscillatory instabilities can be observed. Hopf bifurcations, evidence of periodic doubling and of intermittency, are, apparently, verified.

Dr. S. Ciliberto is the leader of the experimenters who study time-dependent structures in Rayleigh-Benard convection. With a new experimental technique he measured the spatial distribution of temperature in the time-dependent states. He evaluated the spatial dependence of local signal spectra, and characterized the spatial distribution of temperature with time-resolved spatial Fourier analysis. This allowed for the measurement of the energy distribution among the spatial modes. The fluid used in the experiments was silicon oil with Prandtl number 30. The most difficult part of the experiment was to achieve a 1-m°C temperature stability on the bottom and lower plates of the cell.

Practical Optics. The frontier-level atmosphere of the chaos group at INO is balanced to some extent by varied optical engineering studies which lend themselves to immediate use in industry.

Dr. G. Molesini acquainted me with two new results. A few months ago he and F. Querioli developed a two-step approach to white-light holography. The first step produces a so-called light-in-flight hologram (discovered in 1972). The second step consists in classical recording of the real pseudoscopic image across a new holographic plate. Reconstruction can then be provided in white light. In fact, a color-coded representation is obtained which has a rainbow appearance and which encodes the actual contouring of the object.

The second, somewhat older research of Molesini, led to a patent concerning a focus-wavelength-encoded optical profilometer. The principle of action is focus multiplexing by wavelength encoding. Decoding is then achieved by using a lateral achromatic lens. A detector array shows up a signal distribution whose features accurately monitor the surface position of a sample under test.

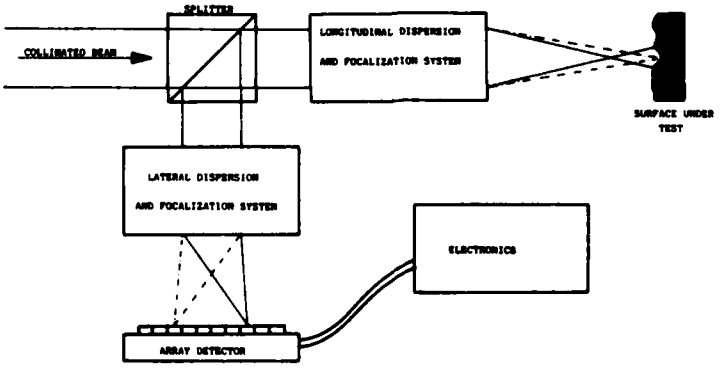

Figure 4. Block diagram of profilometer.

The block diagram of the profilometer is shown in Figure 4.

Concluding Remarks

The broad variety of topics in modern optics, tackled by several lively research institutes in a town that used to be more known by tourists than by scientists, testifies to the vigor and enterprising spirit of a new, young generation of physicists. It may be well to note two additional points: first, most scientists I met in the three institutes are natives of Florence who will not yield to the temptations of the large open world; and second, Florence has no famous university and, especially, there is not much going on in the natural sciences and engineering faculties. Thus, the research institutes are rather self-sustaining entities. This perhaps explains the somewhat high level of travel; it also calls for our extending substantial cooperation to this well proven, active, capable group of colleagues working in many frontier and applied areas.

12/6/85

Science Policy

FRAUNHOFER-GESELLSCHAFT

by Kenneth D. Challenger. Dr. Challenger is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until May 1986 from the Naval Postgraduate School, where he is Associate Professor of Materials Science.

The Fraunhofer-Gesellschaft (FhG) is the powerful applied research arm of the West German government and industries. Immediately following the war (1949) the West German Ministry of Defense (MoD) founded a few institutes in order to directly support the needs of the MoD. When the Department for Research and Technology (BMFT) became interested in applied research in the 1960's it was decided to expand the FhG to accommodate these needs. Now the BMFT sponsors a large part of the FhG's budget in conjunction with industry. At present there are about 30 institutes, only six of which are funded by and operated for the MoD.

Those institutes that are part of the BMFT receive an average of about 25 to 35 percent of their funding from the FhG via the BMFT and the remaining funding from industrial projects. All of the facilities and the equipment are purchased and maintained by the FhG. Normally about half of the industrial project funding originates from government sources but it does not come to the institutes directly from the BMFT.

The charter of the FhG specifically limits the type of research performed by its institutes to that which has direct social and economic significance. Thus, the FhG institutes form a link between basic research organizations, such as the Max Planck Society, and the industrial users of research; transfer of basic research to practical applications is the primary objective in the FhG.

The institutes of the FhG are located all over the country, as shown in Figure 1. In 1984 over 3400 people

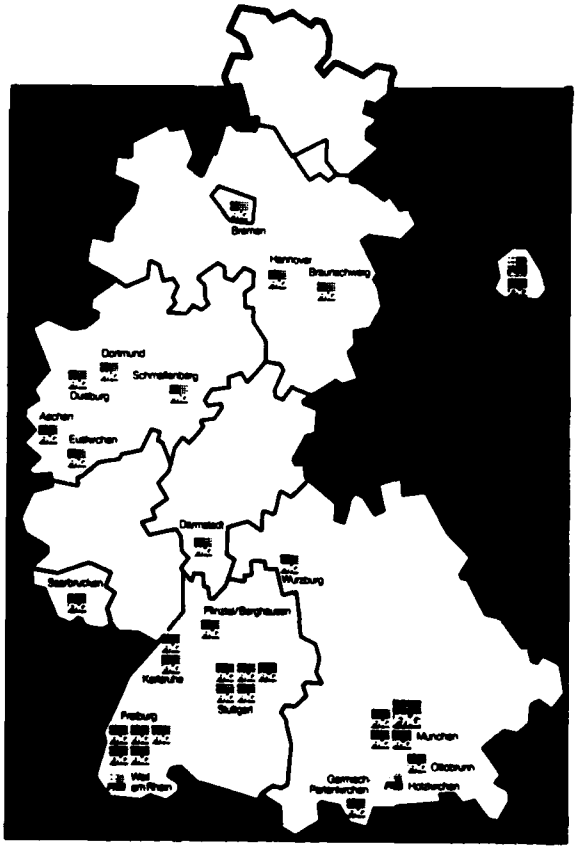

Figure 1. Location of the Fraunhofer Institutes in West Germany.

were employed by FhG, including over 1000 qualified scientists and engineers. The budget for 1984 was about DM340 million (~$140 million). The six defense institutes of the FhG that operate directly for the MoD carry out research in the fields of ballistics, materials, acoustics, and solid-state physics. The remaining institutes perform contract research directly for business associations and industry, and project research for government departments in fields where high risk exists or in areas that are not directly profit oriented. Normally up to 50 percent of the funding for these government-supported projects originates from industry; in this way, the government makes sure that all of the research satisfies the current and future needs of West German industry.

Companies with annual budgets less than DM500 million (~$200 million) are eligible for some federal and state subsidy for the research contracts they give to the FhG. This subsidy can amount to about 50 percent of the total cost.

The following section describes the major fields of research incorporated within the FhG institutes and identifies those institutes active in each field.

Material and Building Component Behavior
Institute for:
- Structural Fatigue Strength, Darmstadt
- Material Mechanics, Freiburg
- Applied Material Research, Bremen
- Nondestructive Testing, Saarbrucken
- Silicate Research, Wurzburg
- Short-time Dynamics, Freiburg
- Hydroacoustics, Ottobrunn (near Munich)

Process Engineering
Institute for:
- Fuels and Explosives, Pfitztal (near Karlsruhe)
- Timber Research, Braunschweig
- Silicate Research, Wurzburg
- Interface Technology and Biotechnology, Stuttgart
- Food Technology and Packaging, Munich

Production Technologies
Institute for:
- Production Technology, Aachen
- Material Mechanics, Freiburg
- Applied Material Research, Bremen
- Production Technology and Automation, Stuttgart

Energy and Construction Technology
Institute for:
- Solar Energy Systems, Freiburg
- Construction Physics, Stuttgart
- Timber Research, Braunschweig
- System Technology and Production Research, Karlsruhe
- Fuels and Explosives, Pfitztal (near Karlsruhe)
- Short-time Dynamics, Freiburg

Environmental Research
Institute for:
- Toxicology and Aerosol Research, Grafschaft and Hannover
- Fuels and Explosives, Pfitztal (near Karlsruhe)
- Atmospheric Environmental Research, Garmisch-Partenkirchen
- System Engineering and Production Research, Karlsruhe

Technical-Economic Studies
Institute for:
- System Technology and Innovation Research, Karlsruhe
- Scientific-Technical Trend Analyses, Euskirchen
- Information Center for Space and Construction, Stuttgart
- Patent Office for German Research, Munich

Microelectronics and Sensor Technology
Institute for:
- Solid State Technology, Munich
- Applied Solid-State Physics, Freiburg
- Microelectronics, Duisburg
- Scientific-Technical Trend Analyses, Euskirchen
- Physical Measurement Technology, Freiburg
- Information and Data Processing, Karlsruhe

Information Technology and Production Automation
Institute for:
- Information and Data Processing, Karlsruhe
- Production Facilities and Construction Technology, Berlin
- Transport Technology and Goods Distribution, Dortmund

A brochure describing the specific research programs and facilities at any of the institutes can be obtained by writing to: Department of Public Relations, Fraunhofer-Gesellschaft, Leonrodstr. 54, D-8000 Munich 19, West Germany.

Summary

Many of the European countries are using the concept of collaborative government-industry research in order to focus the research toward the specific needs of that country. However, West Germany is probably better organized for this purpose because the Fraunhofer-Gesellschaft is specifically organized to serve the needs of West German industry. Research is prospering in the two

Fraunhofer institutes that I have visited (the Institute for Structural Fatigue Strength and Material Mechanics, at Freiburg [see page 157 for a description of the activities at the Institute for Material Mechanics]). If this is an indication of the success of these applied research laboratories, it appears that both the West German government and industry are satisfied with the results.

2/28/86

News and Notes

EMPHASIS ON BIOTECHNOLOGY

Increasing emphasis on biotechnology is clearly in evidence in governmental programs and initiatives in the Netherlands, Ireland, and the UK.

The Dutch government is taking an active role in stimulating the development of the biotechnology industry in the Netherlands. The government offers tax and other financial incentives to emerging biotechnology companies. (These incentives have already led Centocor and Molecular Genetics--US companies--to establish operations in the Netherlands.) Other government initiatives include the Biotechnology Research and Feasibility Studies, in which companies can qualify for subsidies of up to 50 percent of their investments in basic research projects. The Innovation Stimulation Scheme enables firms to apply for subsidization of R&D wage costs. Businesses can obtain government loans to support the development of new products, technologies, or services through the technological Development Credits Program. High-technology grants can total 20 percent of a firm's investments in fixed assets.

Biotechnological research in the Netherlands emphasizes human and veterinary health care, the food and beverage industry, and agricultural applications. Dutch companies active in these fields include Gist Brocades, Heineken, and Akzo-Pharm. In addition, the Netherlands Industrial Commission maintains three offices in the US to assist American companies in entering the Dutch market. Finally, the biotechnology Innovation Research Program, a joint effort of the Dutch government, industry, and academia, seeks to promote the application of research projects in academic institutions to aid the Dutch economy.

In Ireland, the government, in association with the National Board of Science and Technology (NBST) and the Industrial Development Authority (IDA), is creating a $10 million fund to support the establishment of four centers of excellence in biotechnology. The centers' areas of emphasis will be immunodiagnostics and mammalian reproduction of cells, food and plant technology, molecular genetics, and microbial fermentation. The centers will be based in universities and supported with funds from industry and government. The centers are expected to eventually become self-financing through contract research.

Under their cooperative R&D Grant Program, NBST and IDA cosponsor up to 50 percent of the cost of cooperative university-industry projects. Their strategic Research Grant Program supports basic and applied research programs in academic institutions. In addition, IDA sponsors international programs aimed at obtaining research contracts for scientists in Irish universities and attracting foreign industry.

The Irish government offers a variety of tax and other financial incentives to entice new businesses, including a maximum 10 percent tax on corporate projects through the year 2000.

In the UK the Science and Engineering Research Council (SERC) has created a Biotechnology Directorate to coordinate research and training programs in biotechnology and to promote biotechnological research through partnerships between universities, polytechnical institutes, and industry. SERC plans to increase its research support in the fields of fermentation, enzyme and immobilized cell technology, separation and concentration technology, product processing, waste treatment and by-product utilization, and feedstock development for biological processes.

Leicester University in Leicestershire has been recognized by the government as a center of excellence in biotechnology. With support from the county council, the university's industrial partners in this venture include John Brown Engineering, Dalgetz Spillers Ltd., Gallagher Ltd., and Whitebread Co. The biocenter will offer consultancy services, contract research facilities, and courses and seminars in an effort to promote technology transfer between the university and industry. The Core Research Program of the Biocenter is as follows: molecular biology of yeast

plasmid replication, plant gene expression in yeast and bacteria, and protein segregation in yeast.

The Liverpool city government has taken steps to strengthen the region's biotechnology industry base, including the construction of a $13.5 million high-technology park in the heart of the city. The park is linked to Liverpool University and Liverpool Polytechnic. The former's collaborations with local chemical and pharmaceutical companies have already led to the formation of two companies that supply materials and services to the nuclear biology industry.

The north of England has biotechnological research activities at Newcastle University, Durham University, Sunderland Polytechnic, and Teeside Polytechnic. The four institutions have joined to create a program entitled Higher Educational Support for Industry in the North. The North East Biotechnology Center, a consortium of Teeside and Sunderland Polytechnics, was developed to promote biotechnology. Designated as a national Center for Development, the organization oversees biotechnological activity at the two schools and biotechnology education in the region. The Yorkshire and Humberside Development Association is actively promoting the health care and biotechnology industries. There are about 120 companies in the region that emphasize pharmaceuticals, hospital and medical supplies, dental equipment, and biotechnology.

Claire E. Zomzely-Neurath
3/3/86

THE NATIONAL QUANTUM ELECTRONICS AND PLASMA RESEARCH GROUP OF ITALY

Changing patterns of research have interesting effects on the science-infrastructure of all nations. This is well illustrated by the history of the government-sponsored research cooperative Gruppo Nazionale di Elettronica Quantistica e Plasmi (GNEQP) of Italy which, from a loose structure of the 1970's and an insignificant budget of about $250,000 in 1977 grew to a well focused, extensive nation-wide entity that operates today on a budget well over $1 million, and is still growing. The main reason for the change is that the CNR (rough equivalent of our National Research Council), which provides Italian research funds, no longer wishes to support "general research" and drastically reduced its unrestricted research funds to university departments, rechanneling its resources into goal-oriented, often, perhaps, overly practical-minded research of obvious national priorities. This type of research is, of course, best conducted in the frame of more closely knit specific-purpose research centers; many are located on the premises of universities and polytechnics.

The GNEQP consists of a core of 13 specific full-title member institutes; six research groups whose CNR-sponsored work is coordinated by GNEQP; and four additional industrial, private, and government institutions which are cooperating in some activities. Best known among the core institutes are, probably, the Quantum Electronics Institute (Florence), the Quantum Electronics and Electronic Instrumentation Center (Milan), the Plasma Physics Institute (Milan), the Research group on Quantum Electronics (Rome), the Research Group on Optics and Interactions (Naples), and the Research Group on Nonlinear Optics and Spectroscopy (Bari).

The current Director is Professor G.C. Righini (who also leads a research group at the IROE institute in Florence--see page 178, preceding). He is assisted by a Scientific Committee of 21 internationally known scientists (perhaps too many).

The main research activities coordinated by GNEQP are:

- Quantum electronics (laser sources; free electron lasers; laser physics; laser theory; radiation-matter interactions; nonlinear spectroscopy; light scattering; optoelectronics, including fiber optics and optical signal processing; laser metrology; industrial, photo chemical, biomedical applications)
- Plasma physics (plasma generation; magnetic confinement; plasma heating; materials research and plasma physics applications; beam diagnostics; basic theory)

This powerful organization has good working relations with other European cooperatives and individuals, and I was told that GNEQP wishes to increase its interaction with American scientists. Interested colleagues may receive contact-addresses by writing to me at the ONR London Branch.

Paul Roman
12/3/85

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David L. Venezky
3/12/86

A NEW BOOK--COMPOSITE MATERIALS DIRECTORY: EUROPEAN RESEARCH, 1985

Over 400 different researchers from nine countries can be identified and a general impression gained about their work from this new composite materials directory. Edited by A.R. Bunsell and A. Kelly, it is available (£60) from Butterworth and Co. Ltd., London. Although it is somewhat incomplete--the information was obtained by questionnaire--it is a vital addition to the bookshelf of every researcher in the composite materials field.

Kenneth D. Challenger
2/26/86

ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

The Interaction of Molten Salts and Metals: Current Understanding of Hot Corrosion and New Approaches to Practical Problems, York, UK, 2-4 July 1986.

International Optical Computing Conference, Jerusalem, Israel, 7-11 July 1986.

Naval Applications and Environmental Chemistry of Organotins, Padua, Italy, 11 September 1986.

Sixth International Symposium on Gas Flow and Chemical Lasers, Jerusalem, Israel, 8-12 September 1986.

Fractals and Chaos, Centro A. Volta, Como, Italy, 18-19 September 1986.

Aerodynamics at Low Reynolds Numbers, London, England, 15-17 October.

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FEBRUARY AND MARCH MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during February and March. The *MAS Bulletin* is an account of naval developments in European research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

MASB Number	Title
8-86	European Aerospace Update
9-86	Supersonic Anti-Air Warfare Target Developed in the UK
10-86	Radar Receiver Protection Developments from EEV in the UK
11-86	French Ocean Thermal Analysis--Update
12-86	Foreign Weapons Evaluation (FWE) and NATO Comparative Test (NCT) Programs
13-86	Remote Sensing Yearbook 1986
14-86	A United Kingdom Study on Visual Detection Thresholds for Simulated Sonar Signals
15-86	Course-Corrected 76 MM Projectile
16-86	First French Remote Sensing Satellite Launched

SCIENCE NEWSBRIEFS FOR FEBRUARY AND MARCH

The following issues of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during February and March. *Science Newsbrief* provides concise accounts of scientific developments or science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

Science Newsbrief Number	Title
4-3	Seminars in Fluid Mechanics at the University of Cambridge, UK
4-4	International Conference on Fluctuation Phenomena in Underwater Acoustics

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ONRL REPORTS

To request reports, indicate the report number on the self-addressed mailer and return it to ONR, London.

C-1-86 *GAMM Conference on Numerical Methods in Fluid Mechanics*, by Eugene F. Brown. Presentations on aero-acoustic modeling, transition control, vortex shedding, domain recomposition methods, LDV calculations, viscous/inviscid interaction, and Euler solutions are reviewed. Papers dealing with methods (in contrast with applications) were stressed at this meeting.

C-2-86 *Turbulent Shear-Layer/Shock-Wave Interaction*, Eugene F. Brown. Presentations given at the September 1985 symposium of the International Union of Theoretical and Applied Mechanics (IUTAM) are reviewed. This report concludes that calculation of two-dimensional shock-wave/boundary-layer interaction problems is advancing well. For three-dimensional flows, accurate numerical calculation needs more experimental data to clarify the mechanisms and flow structure involved. Of greatest priority in this area is obtaining accurate unsteady measurements so that the mechanism of shock oscillation and its results on the flow field can be better understood.

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