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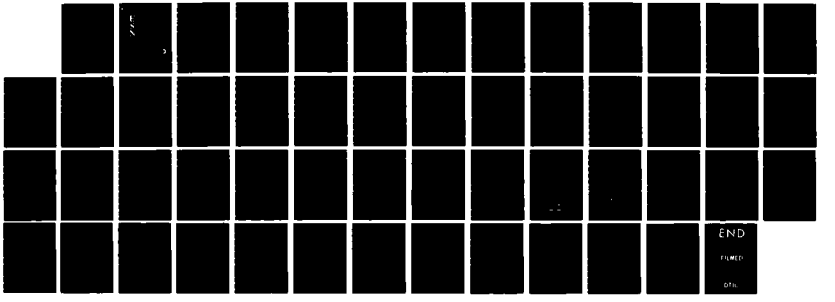

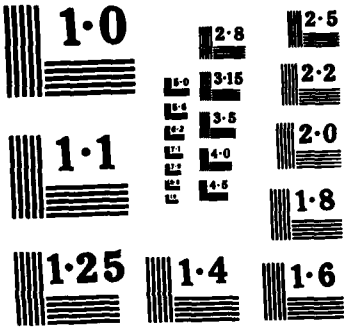

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European Science Notes (ESN) is a monthly publication with brief articles on recent developments in European scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to 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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August 1985
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Behavioral Sciences

A review of the literature on left-handedness suggests that a more systematic search for and analysis of cognitive and psychomotor tasks that show superior performance for some types of lefties may be fruitful for both basic and applied US Navy research.

Biological Sciences

The Third International Low-Temperature Biological Microscopy and Analysis Meeting was held at Cambridge University, UK, from 1 through 4 April. Presentations dealt with topics such as metastable water, processing of quench-cooled samples, scanning electron microscopy, cryomicroscopy, low-temperature microanalysis, molecular microscopy, and radiation damage.

The North Atlantic Treaty Organization's Advisory Group for Aerospace Research and Development held in April a series of lectures on the impact of proposed and existing radio frequency (RF) radiation standards on military operations. This article discusses presentations on RF energy, long-term exposure, accidental exposure, epidemiological studies, effects of power-line frequencies, very-low-frequency and medium-frequency hazards, exposure standards, and measurement problems.

Switzerland's Brain Research Institute has a multidisciplinary program in neurobiological research, an approach that is unusual in Europe. This article examines work on the ultrastructure of excitable membranes and the research of the electrophysiology group.

Computer Sciences

The conference Advances in Command, Control, and Communication Systems was held last April in Bournemouth, England. This article discusses presentations on modeling, communication systems, human factors and man-machine interface, and expert systems.

Material Sciences

The Soete Institute is the center for materials testing and welding development in Belgium. This article examines work on strain measurement, weldability, and fracture mechanics.

Mathematics

The Oxford Study Groups With Industry encourage academic applied mathematicians to address problems in industry. This article examines the objectives of the study groups and discusses some of the problems treated at a March meeting.

Mechanics

An active program of research on surface waves and ship resistance is being carried out at Tel Aviv University and at the Technion in Israel. The new feature of this work is the concentration on nonlinear wave interactions utilizing digital solutions of the Zakarov equation, a wavenumber description of the fluid dynamical processes involved.

Physics

High quality and vigorous basic research is performed in various areas of optoelectronics at the Hirst Research Center of the General Electric Company of the UK. This article focuses on diode lasers, multiquantum wells, and a real-time optical data processing system using degenerate four-wave mixing.

The laser research group in the Applied Physics Department, University of Hull, conducts worldwide-respected pioneering activities in x-ray laser studies high-power CO_2 lasers, diode lasers, laser applications in microelectronics, and other related areas.

Space Sciences

To allow the scientific community to respond to the European Space Agency's *Horizon 2000* report, a workshop on future missions was held from 30 April to 3 May. This article concentrates on discussions of the CLUSTER and SOHO missions.

News and Notes

* * *

ESN Invites Letters to the Editor

ESN publishes selected letters related to developments and policy in science and technology in Europe and the Middle East or to interactions between the US and Europe and the Middle East in science and technology.

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Behavioral Sciences

NOTES FOR A PSYCHOLOGY OF LEFT-SIDEDNESS

by Richard E. Snow. Dr. Snow is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September from Stanford University, where he is Professor of Education and Psychology.

The neuropsychology of cerebral hemispheric asymmetry and dominance has been a rapidly rising field of interest in the past two decades, and many books on the subject are now pouring forth. For some of the best of these, see Corballis and Beale (1983), Hellige (1983), and their review by Springer (1984), as well as Geschwind and Galaburda (1984) and its review by Gazzaniga (1985).

Research on asymmetry has in turn focused scientific attention on left-sidedness, because its understanding will inform theories of cerebral laterality and dominance. Thus, the psychology of left-sidedness, though long neglected, is becoming an important field of inquiry in its own "right." This article reviews some background and some new efforts by British, French, and Italian scientists in this field.

Over the ages, left-handedness has been regarded not only with suspicion, but with derision and dread. The Latin word for "left" is "sinistra," which is also the root for the English word "sinister." In Christianity and some other religions, it is a sign of the devil, worthy of burning or banishment. Only in very recent Western history have schools stopped forcibly changing left-handed children to right-handed, and such children and even adults can still face ostracism in many parts of the world--even in relatively developed countries such as Ireland and Japan. Subtle discrimination even remains in our own language; in English a "gauche" person is "tactless, awkward, lacking in grace," but the word is borrowed from French, where it also means "crooked, ugly, clumsy, uncouth"--and "left." In the design of equipment, from scissors, butter-knives, and desk-arm chairs, to bolt-action rifles, discrimination against the long-suffering lefty remains universal.

Criminality and insanity have long been associated statistically with left-handedness, and this probably underlies the age-old prejudice. But left-handedness has also been associated with creativity and excellence in some artistic and athletic pursuits, especially where visual-spatial skills seem required. Thus sinistrality may sometimes be an advantage, not a handicap. Unfortunately, the psychology of these phenomena has been difficult to develop, because they are difficult to study. The proportion of left-handed persons in the US population has apparently been increasing, but it is still estimated as roughly between 10 and 15 percent. And there are subcategories of lefties that may have psychological significance--inverted-hand writers may differ from straight-hand writers, and indices of handedness, eyedness, earedness, and footedness may not correlate highly. Most research in cognitive psychology as well as in personality psychology has simply ignored this aspect of its human subjects.

Hemispheric Specialization

The popular theory of cerebral hemispheric specialization today holds that logical-analytic and linguistic processes are primarily left-brain functions, whereas figural and spatial processes are primarily right-brain functions, at least in right-sided persons, from whom the bulk of the supporting evidence comes. The sidedness variable has most often been controlled, e.g., by choosing only right-handed, right-eyed subjects for experiments. But readily available measures useful for this purpose, such as Oldfield's (1971) questionnaire developed at the University of Edinburgh, or Annett's (1972) battery from Coventry, are also useful for identifying the several kinds of left-sidedness and could be routinely included in studies of any subject population. There is reason to hypothesize that lefties may be quite different psychologically, and may have distinct performance advantages in some kinds of cognitive and psychomotor tasks, including tasks of great interest to the US Navy. However, attempts to estimate the numbers of lefties in different Navy classifications have not always been in agreement (see, e.g., Briggs and Nebes, 1975, and Schlichting, 1982).

The late Norman Geschwind of Harvard was a pioneer in the study of cerebral dominance. His theory of left-sidedness, developed with Peter Behan of Glasgow University (see Geschwind and Galaburda, 1984), argues that lefties display a higher incidence of visual-spatial skill, but also of such apparently unrelated syndromes as autoimmune

disorders, migraine, epilepsy, dyslexia, and other learning problems, because of overproduction of testosterone during gestation. This retards left-hemisphere growth, thus favoring development of the right hemisphere (and left-sidedness). Hence, the spatial functions of the right brain are enhanced, and it turns out that many more artists, architects, mathematicians, and certain kinds of athletes are left-handed than would be predicted from the general population. Also, however, suppression of left-brain growth produces linguistic processing problems such as dyslexia, particularly in males, and slower growth of the thymus, making autoimmune disorders more likely. There is the further hypothesis that testosterone overproduction is genetically based; there appear to be familial patterns, and different distributions by gender, for left-handedness and dyslexia, and also gender differences in mathematical versus linguistic abilities. Behan adds an interesting anecdote regarding the Kerr Clan in Scotland, which was well known for its sinistrality over the centuries. Unlike other medieval castles, which have right-spiraled staircases to favor the right-sworded defenders on upper steps, the Kerr Castle stairs are left-spiraled to favor the left-handed Kerr defenders.

The theory is controversial, but it fits many statistical facts about left-sidedness. Geschwind and Behan recently established the Rodin Foundation to pursue the needed further research (Rodin was left-handed, and dyslexic, as well as a great artist). There has also been much new interest in this development shown by both the scientific and the popular press in Britain (see Dixon, 1985; McKie, 1984; and Bradshaw, 1985).

Annett's (1972) research in Britain starts from a different premise. Her theory posits two features of asymmetry: a normal distribution of relative efficiency of the two sides applying to all species subject to lateral differences, and a particularly human factor that induces a shift of the distribution toward dextrality. The human shift to the right is seen as a product of both cultural and genetic influences. Right-handedness may be inherited, whereas left-handedness may not.

Annett and Kilshaw (1982) have demonstrated mathematical superiority of left-handers in a large sample of school and college students and teachers in England. Differences were clearer for males than for females. The conclusion was that the incidence of left preference and skill is higher for mathematicians not because there is intrinsic advantage for left-sided persons but because extreme right-sidedness is disadvantagious for mathematical thinking. A double dose of the genetic base for left-hemisphere language specialization could be understood as impeding the sort of left-right coordination of cognitive processes thought to be needed in mathematics. This reasoning remains consistent with Annett's right-shift theory of handedness.

Excellence in Sports

The work of Guiard (1982a, 1982b, 1983; Guiard and Athenes, n.d.) in France has been attempting to delineate the possible kinds of task performance advantages associated with different forms of left-handedness. His review suggests that some types of left-handers are distinctly advantaged in some sport tasks; tennis and fencing seem to offer particularly good examples. It seems clear, furthermore, that degree of lateralization is more variable in sinistrals than in dextrals, but that the direction of hemispheric specialization for cognition in sinistrals may be opposite to that of dextrals in only a minority of cases. In further studies of inverted versus noninverted left-handers, the French reseachers have called into question previously reported US findings suggesting that left-handed inverters were faster in reaction time to target stimuli in the contralateral visual field. The French data do not show this effect. The results argue against theories positing peculiar neurological organization among left-handed inverters.

A team of Italian researchers has been investigating for some years the nature of hemispheric specialization, particularly in relation to the nature of the stimulus and the kinds of processing to which it is subjected, using purely right-sided subjects (see, e.g., Simion, Bagnara, Bisiacchi, Roncato, and Umilta, 1980). In collaboration with a team of French investigators, Bisiacchi has now brought the handedness variable and its relation to athletic excellence into this line of work as a central focus (see Bisiacchi, Ripoll, Stein, Simonet, and Azemar, 1984). The question is: Why is there such a disproportionately high number of left-handed players in such sports as tennis and fencing, and why do they excel?

Azemar, Ripoll, Simonet, and Stein (1983) have reported, for example, that in one French sport population studied the incidence of left-handedness was only 6 percent in general, but in tennis and fencing it was 15 percent and 39 percent, respectively. Table 1 shows further that when a world championship

Table 1

Percentage of Left-Handed Fencers in a World Championship (after Bisiacchi et al., 1984)

	All Competitors			Entrants to Finals			Quarter Finalists		
	Total	Lefties	%	Total	Lefties	%	Total	Lefties	%
Males	127	44	35	8	5	62	4	4	100
Females	102	33	32	8	5	62	4	2	50

in fencing is considered, the proportion of left-handers becomes higher and higher as the finalist matches are reached.

The high incidence of left-handed tennis and fencing champions has been attributed to a surprise effect for the usually right-handed opponent (Corballis, 1983). Another possibility would be some peripheral motor advantage for lefties, but this would require that the left-handed advantage appear in a variety of other motor tasks; existing evidence does not bear this out. In contrast, the Bisiacchi et al. (1984) hypothesis is that the advantage is in spatial attention--fencers have trained spatial-attentional abilities; if such ability rests mainly on right-cerebral-hemispheric processes, then left-handed fencers should be faster and better than right-handed fencers.

Of the 24 male students obtained from a sports institute for study, 12 were fencers and 12 were specialists in other sports such as swimming or judo. Each group of 12 consisted of six purely left- and six purely right-handers. The task required binocular fixation on a marker window with head immobilized. Four redlight diodes were arrayed horizontally 24 degrees and 8 degrees left and right of the fixation window. Markers flashed in this window to indicate one of the four locations where a light would appear (cued conditions), or that a light could occur in any location (uncued condition). On some trials the light actually appeared in a location opposite to that indicated (contrary condition). Subjects indicated the presence of a light by button press, alternating which hand was used. Simple reaction time and errors provided the performance measures.

The overall results are shown in Figure 1. The left-handed fencers displayed faster performance than right-handed fencers and left-handed other sportsmen; the right-handed others matched them in speed but committed more errors. The left-handed fencers thus showed by far the best speed-accuracy trade-off.

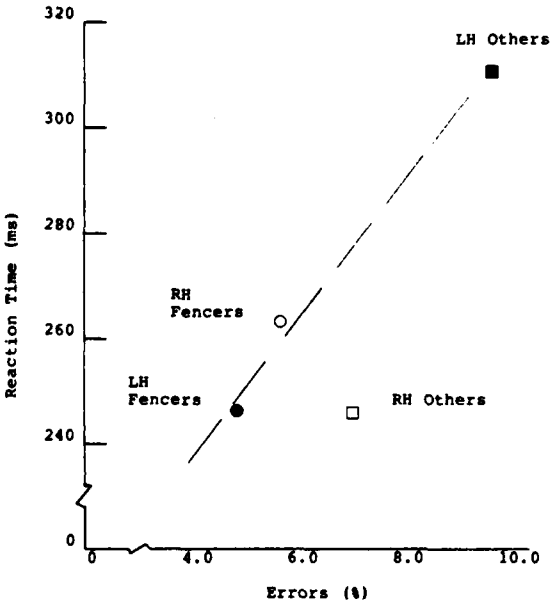

Figure 1. Reaction time and errors in a spatial-attention task for four groups of sportsmen: left-handed (LH) fencers and others; right-handed (RH) fencers and others.

Since error rates were low, only the reaction-time data could be broken down into separate experimental conditions. Figure 2 shows the curves for the four groups, when only data for the preferred hand are considered and data for cued and uncued conditions are averaged. (There was a preferred-hand effect. Separate curves for cued and uncued conditions did not differ markedly from those shown.)

These more detailed results are not entirely clear. Left-handed fencers show faster reaction time than right-handed fencers throughout the visual field; the differences appear greater in the left visual field (i.e., the right hemi-field) than in the right visual field (i.e., the left hemi-field), but not strikingly so. The differences between

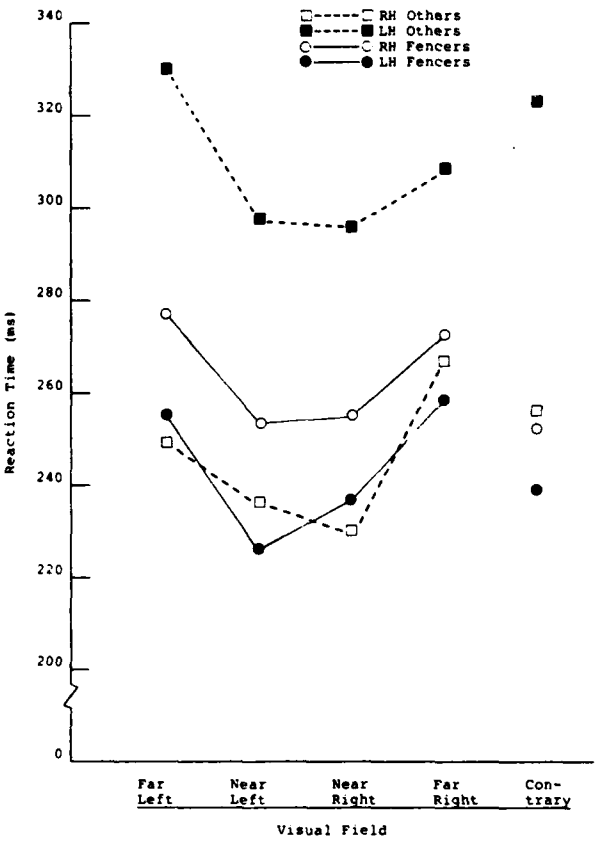

Figure 2. Reaction time with preferred hand for stimulus identification in four locations of the visual field, with cued and uncued conditions averaged, and in a contrary cuing condition for four groups of sportsmen: left-handed (LH) fencers and others; right-handed (RH) fencers and others.

left-handed fencers and right-handed others are consistently small, though there is indeed cross-over between near-left and near-right fields. The contrary condition gives the largest difference in reaction time for these two groups. The performance of left-handed others is consistently the slowest.

Fencers are presumably trained for accurate and rapid shifts of attention in space and to be ready for unexpected stimuli or purposely contrary cues. Clearly, the left-handed fencers are superior to right-handed fencers in this task. But the link to right-hemisphere superiority for these lefties is not clearly demonstrated here. There is other evidence that hemispheric representation of functions in lefties may not be opposite to that of righties, as noted above, but rather may be bilateral; that is another complication for this sort of research. Finally, the fact that right-handed others match the left-handed fencers, in speed if not in accuracy, and are far superior to left-handed others in both speed and accuracy, is perplexing and needs further study. In further research, it would seem to this writer, more needs to be made of the speed-accuracy trade-off and of performance under contrary cuing conditions. Also, the task needs to be recalibrated to include a wider difficulty range, so that error data as well as reaction time can be analyzed in detail.

Conclusion

This collection of notes identifies some features of the terrain to be studied in depth in this field. It cannot at this early date be used to sustain or reject various competing hypotheses. It does suggest, however, that a more systematic search for and analysis of cognitive and psychomotor tasks that show superior performance for some types of lefties may be fruitful for both basic and applied Naval research.

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13/85

iological Sciences

TERNATIONAL LOW-TEMPERATURE BIOLOGICAL CROSCOPY AND ANALYSIS MEETING

Patrick Echlin and Thomas C. Rozzell. . Echlin is University Lecturer in tany in the School of Botany, Camidge Univereity. Dr. Rozzell was the aison Scientist for Biological Scices in Europe and the Middle East for e Office of Naval Research's London anch Office. He is now with the fice of Naval Research, Arlington, Virginia, where he is Program Manager for Bioelectromagnetics.

The Third International Low-Temperature Biological Microscopy and Analysis Meeting was held at Cambridge University, UK, from 1 through 4 April. Approximately 180 people from 17 countries attended; 75 papers were presented on a wide range of cryomicroscopical and cryoanalytical techniques. The format and direction of the meeting allowed a free and in-depth discussion of the wide range of low-temperature techniques used for the preparation, examination, and analysis of biological material primarily--but not exclusively--in electron beam instruments. The meeting was supported by funds from the Royal Society, the British Council, and the US Office of Naval Research, London.

Metastable Water

Much of the discussion on the first morning centered around the chemical physics of metastable water. F. Franks (Cambridge) opened with an account of metastable undercooled aqueous glasses which contain unfrozen water, with particular reference to their role in drought- and freeze-resistant organisms. E. Mayer (Innsbruck) gave further details of the process of vitrification and showed that we must now consider two forms of vitreous water based on their density differences, depending on whether the vitrified water was formed from the liquid or vapor phases. In a discussion on the relative merits of different cooling rates, W.B. Bald (Cranfield) emphasized that nitrogen in its supercritical state should give one of the fastest cooling rates. Rapid cooling methods--plunging, dipping, slamming and jetting--were themes in other papers. It is encouraging to find that the high-pressure cooling technique pioneered by H. Moor (Zurich) is now a practical and commercial reality (see *ESN* 39-7:307-310 [1985]) and that the theoretical predictions by Bald on the use of supercritical nitrogen are borne out in work from the Zurich group. C.A. Angell (Purdue) spoke on the process of crystal nucleation in supercooled liquids which favored using 6-nm sized emulsions in a nonaqueous phase as a way to vitrify at slow cooling rates. In all these deliberations on rapid cooling, the same old message, dictated no doubt by the immutable laws of physics, showed that in order to obtain good spatial resolution in frozen specimens, small samples, rapid cooling, and low temperatures were vital prerequisites.

Processing

Attention then turned to some of the methods of processing samples once they had been quench cooled. R.A. Steinbrecht (Seewiesen) and M. Muller (Zurich) showed that freeze-substitution is particularly useful, provided care is taken to have ultradry fluids during the final stages of dehydration. P. Bridgeman (Saint Louis) showed how this method could be used for preparing material for high-voltage microscopy. Freeze-fracturing continues to provide useful morphological information about samples. M.J. Costello (Durham, North Carolina) emphasized the usefulness of complementary replicas, particularly with reference to recognizing artifacts related to contamination and thermal radiation. H. Gross (Zurich) showed how one can take advantage of decoration artifacts and demonstrated a procedure of positive staining of surfaces using metal vapors. Differences in surface charge and hydrophobicity allow the preferential staining of different regions. R. Rachel (Martinsried) emphasized the importance of keeping freeze-dried samples absolutely dry following the initial sublimation of ice. Such samples appeared less sensitive to radiation damage than their fully hydrated counterparts. M. Fotino (Boulder) and J.B Pawley (Madison) demonstrated how freeze-drying of whole cell mounts could be used to prepare samples for high voltage electron microscopy.

SEM

Several papers outlined the use of the scanning electron microscope (SEM) at low temperature to examine and analyze bulk frozen samples. While there appeared to be little improvement in the type of spatial resolution of morphological studies, other than the high-resolution coating methods suggested by K.R. Peters (Yale), there were advances in the procedures for quantitative microanalysis of bulk frozen samples. Although this mode of analysis is unlikely to ever have the high spatial resolution associated with the analysis of sections, papers by P.T. Marshall (Melbourne), P. Echlin (Cambridge), and A. Boekestein (Wageningen) showed that the resolution would approach 1 to 2 μm, and that the peak/background-ratio approach is a reasonably accurate method of quantitation. Marshall described some elegantly simple experiments to measure spatial resolution in bulk samples. He also demonstrated, using a windowless oxygen x-ray detector, that the Kα oxygen x-ray signal can be used to measure the water concentration in a sample. S.E. Taylor (Richmond) showed how the peak-to-background analytical method could be applied to the highly convoluted cellular components of leaves.

Cryomicroscopy

Attention then focused on the area of light microscope cryomicroscopy. In a series of very impressive papers, J.S. Morris (Cambridge), Ch. Korber (Aachen), and K. Diller (Austin, Texas) showed how this technique could be used to follow the process of freezing in living cells and tissues. By using microcomputers to control the rate of cooling and video recorders and image entrancement techniques to analyze the images, these workers have been able to accurately follow the process of ice crystal formation first outside and subsequently inside cells. Much time was taken up by a discussion on cryosectioning. The question about whether one can section below 163K remains unsolved, and the answer seems to center more on being able to define what is meant by sectioning: is it a discontinuous microfracture, a continuous cutting process, or (heaven forbid) a pressure-induced regelation? There appeared to be general agreement that the faster the tissue is cooled, the smaller the ice crystals and the easier it is to cut thinner sections at lower temperature. This was shown by A.W. McDowall (Heidelberg) and H.K. Hagler (Dallas), and P.M. Frederick (Maastricht).

A. Saubermann (Houston) addressed the problems associated with preparing sections for microanalysis and showed that these thicker and larger sections were more difficult to cut at the lower temperatures. One came away from this session with the feeling that no one was absolutely right in their approach, and no one was wrong. In spite of some convincing sections from microcrystalline samples, each and every material appeared to require a different approach, and the actual cutting temperature was probably irrelevant as no one could measure it. In this respect Saubermann is correct in trying, through an analysis of the mechanical and material properties of frozen samples, to better understand the process of cryomicrotomy, for this may be the only way to improve the quality of the end product. In spite of all the discussions about cryomicrotomy, in spite of the assembled expertise, and in spite of claims of being able to routinely cryosection plant material (as it turned out, roots and seeds), no one reported being able to cut cryosections of leaves. Perhaps the large internal surface area of these predominantly vacuolate tissues hinders proper quench cooling, and in turn

ate cryopreservation, so that fro-
ections cannot be cut.
The alternate approach of low-tem-
ure embedding was expounded by E.
malm (Basel), who, after reiter-
the advantages of Lowycryl, gave
ls of two new resins--K11M and HM
hich work at 213K and 203K respec-
y. Both Carlemalm and Müller
sized the advantage of combining
e-substitution and low-temperature
ding, and showed a series of high-
ution images to prove their point.
rik (Maastricht) finished the ses-
with details of a process of encap-
ing macromolecules and viruses in
films and showed how these ultra-
layers were stable enough to be
ned by low-dose microscopy at ambi-
emperature.

emperature Microanalysis

The talks then turned to low-tem-
ure microanalysis. The discussion
less on major advances than on re-
ents to the technique and on a more
cal awareness of some of the prob-
Thus T.A. Hall (Cambridge) empha-
the importance of correctly meas-
the background when analyzing
n sections. Both he and K. Zierold
mund) considered the now-accepted
us problem of radiation damage.
the results and approaches were to
extent ambiguous. Zierold, in his
ssion of the problems of low con-
in frozen hydrated sections, pro-
using dark field contrast as an
ng system. This process seems to
advantages in thinner sections. But
then went on to show that the mass
due to etching was greater in
er than thicker sections. Clearly
promise is needed. Saubermann pro-
convincing evidence that the well-
lished procedure of using periphe-
tandards in x-ray microanalysis may
e as fault-free as hitherto expec-
Unless great care is taken, the
us standards can quickly influence
the water content and local elemen-
concentration of the tissues which
standards encapsulate. In some in-
es these peripheral standards can
rate intercellular spaces. T. Bar-
(Oslo), and other speakers, inde-
ntly made the interesting observat-
that poorly frozen, poorly section-
and poorly cytotransferred sections
r to have lower sodium and chlorine
s than that expected from physio-
al studies. This may well prove to
useful guideline for good cryopre-
tion--at least of animal tissue.

ular Microscopy

A series of papers showed how
emperature techniques have given an
impetus to molecular microscopy. Using a simple device constructed from a particular New Zealand hardwood, S. Bullivant (Auckland) was able to show that plastic deformation in freeze-fractured yeast plasma membranes could be reduced by fracturing at *higher* temperatures. The same device was used to study the non-complementarity of the extracellular face and protoplasmic face assays. Bullivant concluded that this may be due to shielding by adjacent particles referred to as volcanoes. The term "volcanoes" seems singularly and thermally inappropriate, perhaps pingos would be more appropriate. (Pingos--a geomorphological term--are mounds that form when water is trapped between the permafrost, which inhibits drainage, and the surface of the ground. As this water freezes, it expands and heaves the ground upwards, making a conical hill of soil and ice up to 100-feet high.)

Several speakers eloquently demonstrated how vitreous ice is the ideal embedding medium for the electron microscopy of biological macromolecules. E-M. Mandelkow (Heidelberg), R.A. Milligan (Stanford), J. Trinick (Langford), J. Lepault, and earlier J. Dubochet (both from the European Molecular Biology Laboratory [EMBL], Heidelberg) all showed how vitrified samples retained enough contrast in the electron microscope to give details of microtubules, ribosomes, muscle actin, viruses, proteins, and lipid vesicles at 2- to 3-nm spatial resolution. The real success with this technique seems to be the ability to embed the particles to be examined in a layer of ice slightly thicker than the particles themselves. Although thinner layers give better resolution, the slightly thicker layers prevent any chance of dehydration. The formation and existence of these very thin layers of vitrified water were questioned by Frederik, who considered that some surfactant would be necessary to maintain the structure. Vitrification, which retains the natural water and entirely avoids chemical fixation, appears to be the major advance in cryomicroscopy, provided the processes of crystallization can be avoided. A.W. McDowall (EMBL, Heidelberg) showed that if the specimens are cryoprotected, it is possible to cut vitrified cryosections from vitrified samples. This only seems to work with very small samples, and we are still some way from being able to cut vitrified sections from larger samples which are not cryoprotected.

Radiation Damage

The meeting concluded with somber warnings about the problems of radiation

)sophy and technical detail behind levelopment proving of the PTARMIGAN :t switching network.

R.H. Davies and T.R. Davies (RSRE) ıssed the design philosophy of the Packet Radio System for the forward battle area. Although a number of :t radio systems have been developed ıte, most notably one by the Defense ıced Research Projects Agency in the the proposed RSRE system is the : to be specifically designed for forward area.

Another communication-based session : with the special topic of interop-ility. Two systems are interconnec-if there is an identifiable physical between them that provides a trans-ion medium. If, in addition, there meaningful exchange of data between :ies across the interconnection, the entities are said to interoper-

Paul Kennedy of ARE discussed roperability issues as a result of ating in an international environ-. For interoperability to occur, able technical standards must be sed to enable the information ex-ge between systems. There must be a on representation for information, rstood by all systems. J.M. Fowler cicon discussed a virtual-database oach to achieving these goals. G.E. nall and R. Greenway discussed pro-res for interoperability testing, n should be conducted to minimize roperability problems before systems placed into service. Three levels esting were identified: requirements uation, implementation tests, and ational tests.

n Factors--Man Machine Interface

My overall impression is that these ions emphasized human operator-ine interface rather than commander-ine interface. A.J. Gundry of Elec-ic Facilities Design Ltd. discussed application of human factors consid-ions in the various stages of a C^3I em development. His company has ntly written--for the British Royal nent Research and Development Estab-ment--a document entitled "Code of tice for the Application of Human ors to the Design of Military ADP ems." It is intended to provide a s for these considerations. C. an of the Defense and Civil Insti-of Environmental Medicine discussed Interactive Spatial Information Sys-project for studying the interaction umans with map-like data for deci-aiding. J. Wild of Marconi Radar ems Ltd. discussed the development the universal workstation for the DGE. According to Wild, Marconi has been able to implement a large, cost-effective, multilevel system with work-stations that are identical from a hard-ware and software operational viewpoint.

Expert Systems

A small session on expert systems concentrated on applications to tracking and classification problems in naval command and control. W.L. Lakin and J. Miles of ARE-Portsdown discussed their research program to introduce expert systems to the multisensor data fusion problem. Most current expert systems deal with the case where all symptoms (observations) belong to one patient (target). ARE is sponsoring SPL Inter-national to design a general-purpose blackboard framework to be called Multi-ple Exert Architecture.

In another talk, F.A. Anderson dis-cussed the plans and objectives of a ARE-Portland project, begun in 1984 and still in the design phase, to provide an expert system to help in the task of classifying contacts from information from a submarine's sensors. This system is called Aided Sonar Detection Integra-tion and Classification System. As one part of this work, a system was devel-oped by Yard Company for ARE to advise sonar users on the best use of equipment in given situations.

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4/29/85

Material Sciences

THE SOETE INSTITUTE FOR STRENGTH OF MATERIALS AND WELDING TECHNOLOGY, UNIVERSITY OF GHENT, BELGIUM

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

r defense laboratories. Noticeably ab-ent was any participation by university cientists.

This was a conference not a work-iop--there were no parallel sessions, id every talk was given to the entire udience. Except for one or two ques-ions at the end of each talk, there was o discussion. Many of the talks sum-arized recent systems under development nd, in some sense, were sales pitches bout various projects. Thus, this con-erence had an entirely different char-cter from the annual US Office of Naval esearch/Massachusetts Institute of echnology (ONR/MIT) Workshop on C^3 Sys-ems, which tends to concentrate more on esearch issues. That workshop has a ealthy, interdisciplinary interaction mong system theorists, cognitive psy-hologists, and weapons analysts. (The ighth annual workshop was held from 24 hrough 27 June at MIT.)

This article provides brief summar-es of many of the talks. Given the verall content of the conference, the ajor purpose of this article is to lert US Department of Defense personnel o the British philosophy of designing imilar C^3 systems.

odeling

P.D. Morgan of Scicon Ltd. discuss-d his research on modeling the decision aker within a command system. His cur-ent approach to the decision-making rocess is based on a control and esti-ation theory rather than information heory. His research incorporates Boet-cher and Levis's work at MIT (supported y ONR) on interacting decision makers ith bounded rationality and Minsky's oncept of artificial frames. Morgan rgues that such modeling is helpful in he preliminary design of hierarchical ommand and control systems and stated hat this modeling process is being used n the new North Atlantic Treaty Organi-ation Frigate 90 design.

D.G. Galley of System Designers resented an overview of the C-process eing developed at the Admiralty Re-earch Establishment's (ARE) Commercial ystem Laboratory, which is a simulation odel of a command system to support the orce-level command of antisubmarine arfare. A.S. Georgiou of Plessey De-ence Systems discussed the use of sys-ems dynamics (SD) modeling techniques or studying the effectiveness of vari-us C^3 systems. SD techniques, devel-ped by J.W. Forrester at MIT in the ate 1950s, rely on influence diagrams epresenting the interactions between arious factors. To do realistic simu-ation, however, one must come up with ctual quantitative measurements--and this seemed extremely difficult to get in Forrester's model.

G.B. Wilson of Ferranti Computer Systems Ltd. dealt with the problem of data fusion. Fusion refers to the prob-lem of combining information from vari-ous sensors to obtain a single picture of the environment: position, identity, and behavior of the various targets. This paper was tutorial in nature.

T.G. King and A.F. Martin discussed the problem of the modeling of communi-cation networks. Specifically, they dis-cussed a particular hardware emulation of communication networks, the experi-mental packet switched network developed at the Royal Signals and Radar Estab-lishment (RSRE).

Communication Systems

The two sessions on communication systems contained eight talks. In the first presentation, D.F. Bird (Computers Ltd. of General Electric Company, UK) examined a number of aspects of communi-cation systems in the military environ-ment. A central problem is interopera-bility between computer systems; the problem arises when one tries to imple-ment a system of intercommunicating ap-plications in host systems. Bird dis-cussed some potential solutions that may be provided by international standards and the organizations responsible for the standards.

For the most part, the sessions on communication systems concentrated on systems under development for the Brit-ish and Australian defense forces; five talks were given by representatives from Plessey Defence Systems Ltd. E.C. Phil-lips gave an overview of the defense integrated secure communications network (DISCON); its aim is the provision of a secure, survivable, communications net-work for the Australian defense forces. J. Heaney discussed the British IUKADGE-DDN System--the Improved UK Air Defence Ground Environment C^3 system. The IUKADGE system is physically dispersed over 24 sites around the UK and offshore islands, and the distributed data net-work (DDN) subsystem provides the neces-sary intercommunication facilities.

Two talks by Plessey personnel dealt with aspects of the British PTARMIGAN System, a tactical area com-munications systems to support British land forces in a mobile environment in West Germany. The first talk, by C.S. Warren, B. Wells, and B. Symons, dealt with enhancements of the PTARMIGAN net-work to provide a range of data communi-cation facilities to support existing and evolving C^2 systems sharing the same tactical area. The second talk, by P.K. Smith and J.R. Bartlett, examined the

olecular weight from the Pons nuclei of ıe rat *in vivo*. Previous studies to ıcertain whether glutamic and aspartic :ids might be neurotransmitters re-ıased in response to stimulation of the ıner cortical and afferent cortical ıthways were inconclusive. Therefore, ıey have turned to the examination of losely related molecules which in pre-lminary experiments showed promise as timulating transmitters. These re-ıarchers had found that the extracell-lar concentration of 2-aminoethanol ethanolamine or EA) in the optic tectum f the pigeon is increased during optic timulation. They also recently found a timulation-dependent release of EA. The ıbcellular origin as well as the func-ional significance of the release of EA re unknown at present. It has been hown, however, that membrane phospho-ipids are involved in the mechanisms of ynaptic transfer and EA as a polar com-onent of phospholipids could partici-ate in these reactions. They are now rying to determine other polar compon-nts in order to find out a possible onnection between them--i.e., base xchange reactions.

P. Streit and collaborators have ecently set up a tissue culture labora-ory. The first major product under-aken was the production of monoclonal ntibodies against the neural cell-adhe-ion-molecules (N-CAM). The two best ybridoma cell lines are suitable for ffinity purification of the embryonic ut not the adult form of this molecule. hey are now being used as well, for the roduction of monoclonal antibodies gainst the adult form. Recently, a earch was initiated to obtain monoclon-l antibodies which are able to distin-uish the cell types in the retino-ectal system, and some antibodies have lready been obtained. These will be of reat value for the continuing studies n the morphological examination of the eveloping retinal afferents to the ptic tectum. These researchers have een able thus far to label these grow-ng nerve fibers using horseradish per-xidose and detailed studies are under ay to improve the methodology for use t the level of electron microscopy.

onclusion

The Brain Research Institute is an ntegrated organization in which the ap-roach to neurobiological research is ultidisciplinary. Thus, a particular esearch problem can be studied at many evels--i.e., morphology, physiology, hemistry, etc. This system facilitates ollaboration among the scientists and s also of value for the research fel-ows and students in learning a unified approach. The institute also is self-contained, having facilities for maintenance and repair of equipment, central labs for preparation of solutions used in the tissue culture laboratory and for other programs, and computer facilities. Some of the scientific staff as well as some students and research fellows come from other European countries to spend a few years at the institute so there is an international aspect as well. The Brain Research Institute has excellent facilities for research in neurobiology and has achieved an international reputation in the field.

3/21/85

Computer Sciences

ADVANCES IN COMMAND, CONTROL, AND COMMUNICATION SYSTEMS: THEORY AND APPLICATIONS

by Charles J. Holland. Dr. Holland is the Liaison Scientist for Applied Mathematics/Computational Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until December 1985 from the Office of Naval Research, Arlington, Virginia, where he is the Deputy Division Director of the Mathematical Sciences Division.

The international conference Advances in Command, Control, and Communications Systems: Theory and Applications was held from 16 through 18 April 1985 at Bournemouth, England. This conference had 34 talks in its sessions on Operational Viewpoint, Human Factors--Man Machine Interface, Modeling and Methodology, Communications Systems, Interoperability, Applications and Techniques, and Expert Systems. The meeting was organized by the Computing and Control Division of the British Institution of Electrical Engineers, from whom the proceedings of the conference are available at a price of £30.

While the meeting was advertised as an international conference, it was mainly British in attendance and content. Thirty-three of the 34 talks were from British attendees, with the remaining talk from a Canadian. Most of the British attendees were personnel either from British industries or from military

cortico-collicular pathway. The reason for this emphasis was a discrepancy in the literature. Neurochemical experiments in the rat had been reported pointing to glutamate-aspartate as the transmitters in this nerve pathway. Histological studies in the cat, however, showed no retrograde labeling in the cerebral cortex after injection of tritiated D-aspartate into the superior colliculus--although this substance did show a transmitter-specific retrograde labeling in other systems. The experiments done by Matute et al. in rats and rabbits showed a convincing retrograde labeling into the cortico-collicular pathway, and experiments are in progress using cats as the test animal. Interesting but unclear is the finding that after injection of tritiated GABA (γ-aminobutyric acid), several weakly labeled neurons could be found in the cerebral cortex. They found that when D-aspartate was used as well as GABA, many other afferent nerve pathways to the superior colliculus were retrograde-labeled. These investigators are now carrying out a detailed comparative analysis of the labeling pattern.

In a collaborative project with Wiklund and M. Persson (University of Lund, Sweden), Matute et al. have also been studying the afferents to the Nucleus Raphé Magnus (NRM) of the rat selectively labeled with D-(^{3}H)-aspartate. The NRM, which lies in the medulla oblongata, is an important part of the pain system. The nerve cells whose fibers go to the NRM were examined using a general retrograde-labeling substance, radioiodized wheatgerm agglutinin (WGA) and a selective retrograde-label--i.e., tritiated D-aspartate (D-[^{3}H]-Asp.). After injection of tritiated D-asparate into the NRM, nerve cells were retrograde-labeled in the following structures: (1) cerebral cortex (cells of the fifth layer), (2) precentral areas, (3) the dorsal agranular cortex, (4) the medial preoptic area, (5) the dorsomedial hypothalamic nucleus, (6) the central grey cavity (small cells), (7) the reticular formation of the midbrain, (8) the lateral pontine tegmentum, and (9) the spinal trigemenius nucleus. After injection of ^{125}I-WGA in the NRM, the above structures were also retrograde-labeled. Additionally, labeled nerve cells were also found in the following areas: (1) the nucleus of the stria terminals, (2) the large cellular part of the nucleus basalis, (3) the N. parafasciculoris prerubralis, (4) the nucleus of the posterior commissure, (5) the N. cuneiformis, (6) the superior colliculus, (7) the pontine reticular formation, and (8) the deep cerebellar nuclei. These results show that a part of the afferents to the NRM have a selective affinity for D-aspartate, which has a bearing on the use of amino acids as transfer-substances.

K. Qu and her group have recently initiated a project to study neuroactive substances using high-pressure liquid chromatography (HPLC), gas chromatography, and mass spectrometry. Morphological, physiological, and biochemical studies point to the fact that amino acids such as asparagine, glutamic acid, GABA, glycine, and proline play a role as neurotransmitters in the central nervous system. However, the question as to whether these amino acids liberated *in vivo* and *in vitro* are transmitters in themselves or are degradation products of the real transmitters is still open. These investigators are, therefore, trying to answer this question by examining the endogenous excretion of neuroactive substances using the above-mentioned highly sensitive methods which permit the characterization of small molecules such as amino acids and peptides. In addition, the laboratory is now set up for peptide syntnesis.

M. Wolfensberger and his group are investigating a possible neurotransmitter role for chinolinic acid (2,3-dicarboxypyridine)--a metabolite of the amino acid tryptophan--using HPLC, gas chromatography, and mass spectrometry for detection of this compound in extracts of brain tissue. Since cholinic acid in direct application to the striatum and hippocampus of rat brain leads to axon-sparing degeneration of neuronal elements, these investigators are studying the possible role of this finding in the etiology of neurological disturbances such as Huntington's chorea and temporal lobe epilepsy.

In the rat brain, these researchers found regional differences in the concentration of chinolinic acid with the highest values found in the frontal cortex. On the other hand, no regional differences could be found in human autopsy material. In order to examine a possible neurotransmitter role for chinolinic acid *in vitro*, techniques for trace analysis of this substance in brain perfusates were developed. Chinolinic acid was converted into the respective dimethylester, which, after extraction, was analyzed by gas chromatography and electron-push ionization or by chemical ionization. They are studying the influence of depolarizing stimuli on the liberation of chinolinic acid.

H. Perschak and his collaborators are investigating the release of endogenous neuroactive substances of low

examinations. Pharmacological studies have shown that the parallel fibers of the cerebellum as well as the climbing fibers release a transmitter similar to glutamate. In order to find out which substance would be released by these synapses, extracellular leads were applied to Purkinje cells. Various glutamate antagonists were iontophoretically applied, and the effect of applied antagonists upon the iontophoretically and electrically evoked activity were compared. The results showed that aspartate-induced stimulation and parallel fiber-evoked effects as well as glutamate and climbing fiber-evoked effects together are influenced by means of certain antagonists. It appears, therefore, that aspartate is the parallel fiber transmitter and glutamate the climbing fiber transmitter. Further studies are being carried out to confirm these findings.

Cochran et al. are also studying synaptic transmission in the central vestibular system. The isolated brain stem of the frog can be maintained alive for several days *in vitro* for electrophysiological studies. This fact allows the transfer of studies begun on the synapses of the peripheral vestibular apparatus to synapses of the central nervous system. At the present time, they are dealing with the synaptic transmission of vestibular afferents. Application of glutamate antagonists (e.g., Kynuric acid) reversibly blocks this transmission effect without influencing the presynaptic potential. Similar blocking effects were observed in other central nuclei: (1) bulbus factorius, (2) tectum opticum, and (3) trigeminus nucleus. While glutamate agonists show a blocking effect, the Ach antagonist, curare, does not influence the synaptic transmission on the first central vestibular synapse. These studies form the basis for the hypothesis that a glutamate-like substance plays a role as neurotransmitter in the central nervous system and further studies on this problem are in progress.

M.C. Hepp-Reymond and his group are carrying out studies to examine the role of various brain regions in the control of isometric strength in monkeys. They use single-cell leads on the awake monkey with learned finger motions with emphasis on the neuronal activity in the somatosensor brain cortex. This cortical area represents, next to the motor thalamus, one of the most important pathways to the motor cerebral cortex. These investigators have found that the neurons correlated with motility parameters, as well as the neurons in the motor cortex, are characterized by phasic and/or tonic modulations of their release frequency, which follows the temporal course of the strength of the finger motions. However, they have found some notable differences in the distribution of the release patterns between somatosensor and the motor cerebral cortex. In the somatosensor areas, a greater percentage of the neuron is characterized by transient increase of activity (36 percent in somatosensor, 16 percent in motor cortex). These transient releases occur at different times of the strength level as short, high-frequency releases. It remains to be explained how these are caused by the sensory qualities of the neurons, or correlated with the motor task with certain motility parameters. Furthermore, in the tonic-modulated neurons, the majority show an increase, and only a few a decrease, in the release frequency with strength, in contrast to the motor cerebral cortex. In the latter, both types of neurons are equally strongly represented. Hepp-Reymond et al. are doing a quantitative analysis with the possibility of delineating whether the observed tonic modulations are related to the strength or with the qualities of the receptive fields. Recently, there have been further developments by the groups in techniques and methodology which will aid in this research. In addition, a lab computer for on-line experiments has been installed.

Neurochemistry

L. Wiklund and his colleagues are investigating transmitter-specific retrograde marking of nerve pathways. This study was undertaken after finding that experimental models by which the question of a possible functional significance of transmitter-specific retrograde transport appeared to be feasible. These investigators found after extensive experimental testing that the systems of lumbar-motorneurons/nervous ischiadicus and hypoglossus-nucleus-nerve were unsuitable systems. Therefore, they have been studying the model systems, ciliaganglion-eye. Preliminary studies showed that in this cholinergic system a retrograde labeling in the cell bodies following the intraocular injection of tritiated choline could be seen by autoradiography. These investigators are now searching for the reason for the specificity of this labeling and are continuing research to develop this promising model for *in vitro* testing.

C. Matute and his group are studying transmitter-specific retrograde labeling in afferents to the superior colliculus. The main emphasis of their research has been on the labeling in the

of albinos. Experiments to clarify this question are being conducted.

N. Dieringer and his colleagues are investigating the oculomotor unit in the frog. The neuronal organization of optokinetically released, reflectory, eye follow-up movements shows a series of species-specific specialization. In frogs, for example, a certain network (velocity-collector) is nonfunctional, but another network (position-integrator) is exceedingly well developed. The different release models of extraocular motorneurons, which are observed after an optokinetic stimulus, allow three types of motorneurons to be recognized: (1) the largest motor units respond only with an eye-velocity signal, (2) the smallest motor units respond only with an eye-position signal, and (3) units with qualities between (1) and (2) respond with a release mode which contains velocity and position signals. Parallel to these studies, immunohistochemical and histochemical studies of the extraocular muscle fibers showed that in the frog, as in mammals, besides the slow tonic fibers, at least two groups of "twitch" fibers exist. The connection of the various motorneurons with these different muscle-fiber types are now being examined.

B. Hess and his group are trying to identify the vestibular sense organs in the frog which are responsible for the release of maculo-ocular reflexes. The role of the various maculo organs of the vestibular apparatus (Macula urticuli, M. sacculi, M. lagenae) in the stabilization of the view axis during passive motions of the head has been largely neglected. Registration of the eye position (in two motion planes) in the frog with fixed head has shown that linear acceleration stimuli in the vertical in the dark release no eye motions (correlated with the stimulus), while linear motion in the horizontal plane dependent on the direction of the acceleration with respect to the body axis causes small vertical or torsion motion of the eyes (so-called maculo-ocular reflexes). In order to determine which of the receptor organs are involved in the release of these reflectory eye motions, Hess et al. examined the reflexes, whose frequency characteristics they had already studied in the intact animal, in animals after bilateral cutting of the branches of the eight cranial nerve. Comparisons were then made with the reflex behavior of the intact animal. The following lesions were performed: (1) bilateral sectioning of the anterior branch (contains all fibers of the Lagena), (2) the lagena branch, and (3) the sacculus branch. The results of these experiments showed that the M. retriculi but not the M. sacculi or the M. lagena was responsible for maculo-ocular reflexes.

J.M. Annoni and his group are studying synaptic transmission in the vestibular labyrinth. The investigations have been carried out *in vitro* on the isolated frog labyrinth. Spontaneous synaptic potentials as well as action potentials can be generated by means of intra-axonal leads of different fibers in the proximity of the hair cells. These potentials are generated by release of transmitters from the hair cells. Pharmacological studies of these potentials have shown that the transmitter which is released by the hair cells is probably glutamate or a substance similar to glutamate. The vestibular hair cells are also directly provided by different synapses whose original cells are located in the brain stem. If one applies acetylcholine antagonists (Ach) in the bath solution as well as leads at the same time from different fibers, one often finds an increase in the frequency, but not of the amplitude of the synaptic potentials. This means that via Ach, an increase in the release of transmitter from the hair cells is elicited. Direct postsynaptic effects of Ach could be excluded. Electrical stimulation of the nervous vestibularis and the afferent fibers also led to an increase in the frequency of the EPSPs and action potential--i.e., to an increased release of transmitter. The effects which are pharmacologically released by means of Ach as well as the electrically evoked effects are blocked by the Ach antagonist, curare. Intracranial section of the nervous vestibularis--2 weeks before the lead--led to the disappearance of the electrically released effects but allowed the Ach antagonists to persist. These findings show that the effects of electrical stimulation are transmitted through the efferent fibers which exert their effect via the release of Ach, directly on the hair cell membrane. Occasionally, after application of Ach antagonists or electrical stimulation, there is a decrease of the postsynaptic registered effects. However, this blocking itself can be obliterated by curare and is, therefore, obviously transmitted via Ach. The question as to the genesis of these dual effects is currently under investigation.

S.L. Cochran and his group have been investigating synaptic transfer in the cerebellum. The cerebellum of the frog can be kept alive for up to 2 weeks *in vitro* for electrophysiological

slower increment of the speed to the end phase. The initial jump is clearly smaller than in primates. The slow increment of the eye velocity shows a strong nonlinearity, which probably originates in the retina. If the stimulus is offered for a sufficiently long period of time, it does not achieve saturation even with high stimulus velocities. The incremental factor (open loop) depends on the stimulus velocity. Also, the cat shows a marked post-nystagmus. This can best be modeled with a dampened sinus wave--i.e., the optokinetic system behaves like an underdampened second order system. In sinus-formed stimulation, strong nonlinearities appear--i.e., the increase factor correlates best with the acceleration of the stimulus.

Additional experiments, using rats, on the possible significance of the cerebellum for the optokinetic reflex showed that the initial increase in eye velocities was controlled by the vestibular cerebellum. Examination of the neuronal organization of the optokinetic reflex path in the rat showed that pretectal neurons which form the first shadow image have a direct projection to the Nc. praepositus hypoblossi. This pathway probably transmits optokinetic signals to the vestibularis nuclei and motorneurons. It could also be shown that the Purkinje cells of the cerebellar flocculus receive optokinetic signals which converge synergistically with vestibular ones. These researchers found that brainstem regions which show eye-movement-correlated releases also project to the flocculus. Since the flocculus projects to the vestibular nucleus, it can influence the optokinetic brain-stem switch paths. While the study of the neuronal organization of the optokinetic system of the rat is far advanced, these researchers could make only a few definitive statements on optokinetic eye movements since their measurement posed many problems. However, recently the scientists have developed a very sensitive method for measurements which is based on electromagnetic principle. If the eye, on which a microspool is fixed, rotates in a rotating magnetic field, one obtains a tension which denotes the absolute change in eye position. With this method, they are able to quantitatively analyze optokinetic and vestibular induced eye movements.

Plasticity in the vestibular system is being studied by J.H. Courjon and his group. Examination of the vestibulo-ocular reflexes of the cat (after unilateral removal of the labyrinth) have shown that the spontaneous nystagmus which occurs immediately after the lesion, disappears almost completely within the first post-operative week. This new equilibrium in the oculomotor innervation can be explained by a return of the resting activity of the vestibular nuclear neurons adjacent to the lesion. If this mechanism were solely responsible for the new equilibrium, one would expect a symmetrical vestibular reflex of smaller amplitudes after stopping of the spontaneous nystagmus. These investigators found, however, that the vestibular reflex is asymmetrical even after many months. This persisting asymmetry finds its neuronal expression in a great reduction of rotation-sensitive vestibular cells adjacent to the lesion. How this disturbance originates is not clear. At any rate, it is not caused by neuronal degeneration in the vestibularis nucleus. Aside from this asymmetry, the incremental factor also remains reduced for a long time. This is surprising because intact animals can modify their vestibular reflex within hours as they are plastically adaptive. Courjon el al. have asked if unilaterally labyrinthectomized animals have lost this capability. They have found, however, that this is not the case. If one "pendulates" the animals passively for a few hours with a motion-stimulator before a contrasting background, the incremental factor of the vestibular reflex can be increased significantly. Presumably, in the animal left to itself, this adaptation of the vestibular reflex does not reset because other systems (optokinetic and proprioceptive) are called into action for stabilization of the eye during motions of the head, thereby avoiding other motions which lead to a dislodgement of retinal pictures.

These investigators have shown in the rat that the relocation of the position of the head as well as the spontaneous nystagomus is independent of the site of the lesion of the vestibular entrance--i.e., the course of the compensation time after a peripheral section or lesion of the scarpal ganglion is nearly identical. Also, ganglion cells, after peripheral lesion, show no further rest release, although they do not degenerate and also retain the capability for conduction and synaptic transmission. The ganglion transfer, therefore, contributes to compensation following peripheral lesion. While albino rats, after initially good compensation, show after a few days partial decompensation of head position, this is not the case in pigmented rats. The difference might be correlated with the deficient visual system in generations

able to obtain morphological correlates for chemical as well as for electronic transmission, in support of electrophysiological data of the research group of Yasargil and Greef. Surprisingly, these researchers also observed a heretofore unknown kind of cell contact (specialized interneuronal junction). These junctions showed symmetrical membrane densities and a regularly widened tissue split resembling, therefore, the "intermediate junctions" to which are ascribed adhesion functions. These contacts exhibit, at the postsynaptic side, a characteristic organelle, which consists of a reticular arrangement of microtubules penetrating into the axoplasma with a fine calibrated granular matrix. The functional significance of this structure is unknown at this time, but these investigators in collaboration with other groups at the Brain Research Institute are searching for the function.

H. Künzle et al. have been carrying out studies on the innervation of the M. retractor bulba in monkeys as part of comparative hodologic studies in vertebrates. In comparison with other vertebrates, monkeys have only a very small musculus retractor bulbi (synonym for M. rectus lateralis accessorius). This muscle is not found in man; the question posed by these researchers was whether this muscle had regressed during the course of primate development or had become integrated into the M. rectus lateralis as proposed a few years ago by other scientists. Using staining procedures for the detection of acetylcholinesterase, Künzle et al. showed that the retractor bulbi muscle in monkey, in contrast to the real M. rectus latera, consists of singularly innervated muscle fibers. Using ^{125}I-labeled wheat germ agglutinin, they showed that the retractor motorneurons are not mixed with the motorneurons of the abducers nucleus, but form an independent cell group, the so-called Nc. abducers accessorius. This arrangement in monkeys corresponds to that in nonprimates. Künzle and his group believe that the lack of the M. retractor bulbi in humans can probably be explained by the fact that the deep orbit gives sufficient protection so that the reflex retraction of the eye bulbus offers no advantage for humans.

Künzle and his group have also been studying the nervous system of the turtle. One study is concerned with the retinopetal system of the turtle. Although the eye of the turtle belongs to the most differentiated and best examined vertebrate eyes, it has not been clear, thus far, if there is a centrifugal innervation of the retina in this species. Using ^{25}I-labeled wheat germ agglutinin and horseradish peroxidase, it was shown that retinopetal cells occur in the isthmo-mesencephalic tegmentum. Its number, however, is small (about 50) compared to more than 10,000 in birds. In rats, such cells could not be shown clearly with the present technique.

Using anterograde transported labeled material it was shown that in turtles, as well as in mammals, retinal and spinal pathways end in the ventral and dorsal thalamus. Furthermore, the relevant part of retinal pathways, which end in the ventral and dorsal thalamus, was found to be the same in turtles and mammals. The relevant part is different, however, with respect to spinal input. Spinal projections to the dorsal thalamus are extended in mammals, but only moderate in turtles. The reverse situation occurs with respect to the spinal input to the ventral thalamus, being minimal in mammals but very prominent in turtles (in the so-called ovalis complex). In the ovalis complex, one finds a convergence of retinal and spinal paths.

Künzle et al. have also been studying the spino-cerebellar system of the turtle. Using retrograde-transported horseradish peroxidase, it was shown that in turtle, compared to mammals, there are relatively few cells of spinocerebellar origin. There are indications for the existence of nuclear groups similar to those of the Nc. cervicalis centralis of mammals. Anterograde transportation with ^{35}S-methionine showed that the spinal paths end in the cerebellar granular layer. The endings, however, are not equally distributed over the anterior four-fifths of the cerebellar cortex, but form zones of differentiated ending density. In contrast to the extensively folded cerebellum of higher vertebrates, the cerebellum of the turtle consists only of a single plate. This fact, as well as the existence of a basically similar but less complex cerebellar structure, makes the turtle an ideal model for general studies of the afferent cerebellar organization.

Electrophysiology Group

One of the electrophysiological groups, under the direction of R. Blanks, is studying the optokinetic system using cats and monkeys. They found that contrasting, moving point samples form the most effective optokinetic stimulus in the awake cat. If a point-sample is suddenly put into constant turning (step-stimulus), the speed of the slow nystagmus phase shows a jump-like increment which is followed by a

has played, and still plays, a major role in RF radiation research, it would be well if the other services were more prominent in future lecture series. This is not to speak lightly of this effort, which was first rate, by any standard.

For further information about this meeting, see ONR, London, conference report C-6-85, which you can order by using the self-addressed mailer inside the back cover of this issue.

5/14/85

THE BRAIN RESEARCH INSTITUTE, UNIVERSITY OF ZURICH

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 1986 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Switzerland's Brain Research Institute has a multidisciplinary program in neurobiological research. The approach, unusual in Europe, is producing major contributions to research.

Background

Professor Michel Cuénod is the director of the Brain Research Institute of the Faculty of Medicine, University of Zurich. (Cuénod is also the new president of the European Neuroscience Society.) The institute encompasses several disciplines in the field of neurobiological research: morphology, anatomy, neurochemistry, electrophysiology, and cell cultures. The advantage of having the various disciplines located in a single institute is that it fosters collaboration among the scientists so that a particular research project can be studied intensively at several levels. Cuénod considers that such a multidisciplinary program is the most effective and efficient way to study the nervous system. His approach is similar to that of many American universities which have set up brain research institutes with a multidisciplinary program. Cuénod's institute, however, is one of the few organizations in Europe using this format, as neurobiology in Europe is, for the most part, only a subdivision of existing departments such as anatomy or biochemistry--a situation which is not conducive to a multidisciplinary approach.

Cuénod and his colleagues have made major contributions to understanding how the integrative function of the nervous system operates. Their research has encompassed studies on the peripheral as well as the central nervous system. These researchers consider that in order to obtain a complete picture of the highly complex central nervous system (CNS) it is necessary not only to define the CNS pathways by their morphological characteristics and their functional significance but also to gather information about their chemical specificity in general and their neurotransmitters in particular. They believe that such a description of the brain is relevant both to functional questions presumably involving synaptic elements (for example, slow plastic changes related to learning and memory) as well as to pathophysiological problems raised by neurological and psychiatric disorders. Thus, modifications of synaptic properties which might reflect changes in synaptic efficacy, could only be measured if one had a detailed knowledge of pre- and post-synaptic organization in complex systems of the CNS. In order to obtain information about all aspects of neuronal function, these researchers have been carrying out experiments that encompass several disciplines within the area of neurobiology--i.e., morphology, electrophysiology, neurochemistry, and tissue culture. In this way, they are able to develop a complete description of the nervous system by integrating information about structure with function. A wide range of experimental sources--from fish to monkey--are being used in the research carried out at the Brain Research Institute. The reason is that certain kinds of information can be obtained more easily from one model than another.

Since there are so many research projects at the Brain Research Institute, only some of the programs are presented below.

Ultrastructure of Excitable Membranes

A research group headed by C. Sandri is engaged in studies of the morphology of synapses using the Mauthner axon collaterals in fish. This system has proven to be an excellent model for such investigations. The researchers have been studying the nodal membrane regions. This thornlike protrusion of the giant axon serves as a transfer point for commands to interneurons and to motorneurons. The investigators were

industrial hygienists. Neither the ACGIH TLVs nor the ANSI standard represents federal standards or guidelines backed by force of legislation. However, one or the other is generally adopted and used by those needing to apply them. The different branches of the Department of Defense use versions that are very close to the ANSI standard, with slight modifications. The National Institute of Occupational Safety and Health has been working on its own version of an RF radiation standard for several years now, but as of this writing it has not been published. To further confuse matters, several states and local jurisdictions have established their own standards, which are almost always more stringent than either the ANSI standard or the ACGIH TLVs.

The closest thing to an international standard is the one published as an interim guideline in 1983 by the International Radiation Protection Association (IRPA) and the one published by NATO as a Standardization Agreement (STANAG) 2345. The IRPA guidelines cover both occupational workers and the general public. It is five times lower than the other standards for the general public in the frequency range of 10 to 30 MHz. Mitchell showed Figure 1 to illustrate the differences in the principal guidelines and standards. The Canadian and UK standards are not shown on the figure. The differences between these and the ANSI standard are small.

The new human exposure guidelines have a number of safety features that are seldom considered. However, since the general public often perceives all forms of radiation as hazardous, regardless of level, Mitchell went on to highlight some of the inherent safety features associated with the new generation of standards.

Measurement Problems

As might be imagined, there are a number of practical operational problems involved with making measurements in the field and relating these to existing standards for personnel protection. Graham discussed at length a number of these problems and how the USAF Occupational and Environmental Health Laboratory has dealt with them. One of the problems discussed was that of making and comparing measurements using different types of instruments in and around a host of different antenna types. He discussed problems associated with airborne emitters, medical RF emitters and ground-based emitters. The key element, as pointed out by Graham, is adequate planning and preparation before going into any survey situation.

Conclusions

The lectures were very well prepared and expertly delivered. They covered all of the important areas necessary to allow the participants, representatives of several NATO military groups, to evaluate the general impact of new and proposed RF radiation standards on their operations. I am not convinced that the attending group actually took away with them all that was intended. This observation is based on the quantity and quality of questions and discussion generated by the participants. Perhaps there was a language problem. While it is true that the USAF

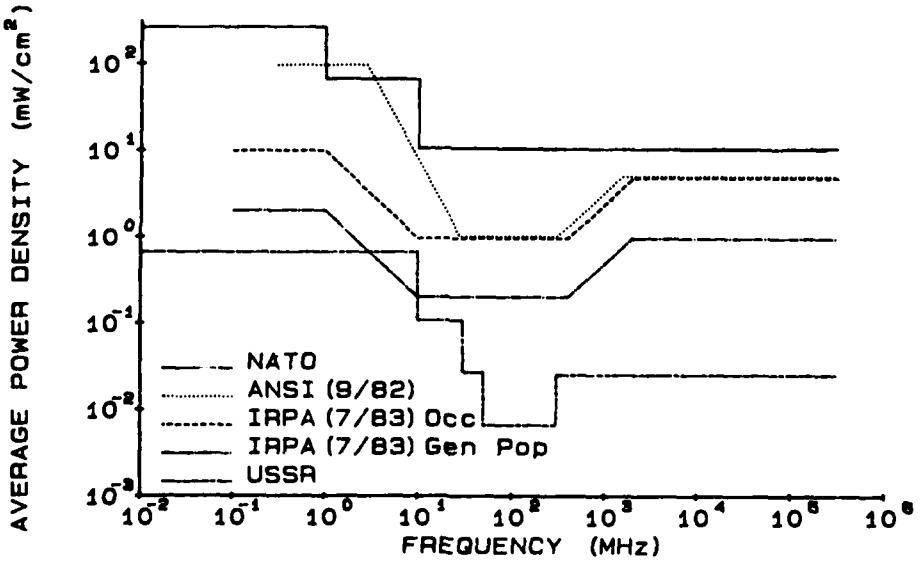

Figure 1. Comparison of RFR safety guidelines.

magnetic fields are of particular interest because they can penetrate deeply into the human body. However, biological effects, should they occur, are likely to be due primarily to induced electric fields within the body. Examples of some effects that have been reported are movement of hair on the body, generation of magnetophosphenes, and subjective complaints such as fatigue or headaches. In medicine, the effects of magnetic fields are being used both for diagnosis (nuclear magnetic resonance) and therapy (bone stimulation by induction and magnetotherapy).

There is much uncertainty in the determination of personnel health limits for frequencies below 100 kHz--largely because so far a good model has not been developed for the estimation of the risk in the frequency range involved here. Such a concept, however, is necessary as one cannot expect that the full frequency range can be studied by experiments with results similar to those obtained in the sphere of power engineering fields. Bernhardt's lecture described a simple concept that may serve as a basis in the discussion of the definition of personnel health limits. Parts of these ideas and considerations have already been adopted in the West German regulations (see *ESN* 38-10:530-532 [1984]) defining limits for frequencies above 10 kHz. The same considerations are employed in the "Safety Regulations for Working Places With Risks of Health Hazards by Electromagnetic Fields," issued by the trade association in West Germany; the regulations set limits for electric and magnetic field strengths above 1 kHz.

VLF to MF Hazards

Moving up somewhat in frequency, Guy discussed the biological hazards to humans exposed to the very low frequency (VLF) to medium frequency (MF) bands extending from 3 kHz to 3 MHz. He pointed out that these hazards may result from any one of several phenomena: (1) electric shock, (2) spark discharge, (3) elevation of tissue temperature, (4) burns, (5) pacemaker interference, or (6) the so-called neuroasthenic syndrome reported widely in the Soviet and East European literature.

As Guy pointed out, most of these have been well studied and documented. However, there is considerable controversy about the neuroasthenic syndrome, which produces a number of subjective responses, such as fatigue, loss of memory, decreased sex drive, and inattentiveness. The fact is that there have not been a large number of really good studies of the subtle and long-term biological effects due to electromagnetic energy in the VLF-MF range.

Guy has compiled a summary of the published literature reporting biological effects due to VLF-MF fields in both Western and Eastern-bloc countries. Most of the studies in the Western world have been carried out on animals, while more than half of the Soviet studies were done on human workers. While most of the effects reported were on the central nervous system and cardiovascular system, there seems to be an inconsistency between reported effects in animals and humans in terms of the same calculated SAR.

After some lengthy and detailed discussion on dosimetry and some of the problems attendant to the immersion of a human body in various field configurations, Guy gave some practical considerations for using dosimetry data in the application of standards. A number of cases were considered--for example, when the body is in contact with a good ground as opposed to the case when it is shielded from ground. Of course, there are differences depending upon which part of the body is in contact with the ground and the orientation with respect to ground: hands versus feet, standing versus sitting, etc. Guy concluded that only in very rare circumstances would individuals come close enough to VLF-MF sources to experience the levels of currents and SAR in their bodies that would exceed the safety criteria.

Exposure Standards

The impact of RF energy in the environment on the military and other industries is determined by the limits for human exposure dictated by human exposure standards. In recent years, there has been a proliferation of standards as research has provided more and more data on biological responses. Mitchell reviewed a number of the important standards and guidelines that are currently in use.

Mitchell showed how some of the standards and guidelines compared with the American National Standards Institute (ANSI) standard (revised in 1982). The first was the set of threshold limit values (TLVs) published by the American Conference of Governmental Industrial Hygienists (ACGIH). As with the ANSI standard, the ACGIH TLVs limit the absorption of energy in humans to 0.4 W/kg or less averaged over any 6-minute period. One difference is that the ACGIH TLVs extend down in frequency to 10 kHz on the low end and up to 300 GHz on the upper side. The TLVs are intended only for occupational exposure and are to be applied only by qualified

expressed as a harmful bioeffect. The few studies addressing this problem suffered, according to Krupp, one to several deficiencies in method, including relatively short duration of exposure, small numbers of subjects, inappropriate end-points, or incomplete dosimetry. Epidemiological appraisals also have not been adequately performed or cannot clearly relate findings to exposure history. A recently completed project, performed by personnel at the Bioelectromagnetics Laboratory, University of Washington School of Medicine, Seattle, Washington, and funded by the USAF School of Aerospace Medicine, was directed toward these concerns. Krupp reported that over a 4-year period of planning, pilot study, and definitive experiments, a lifetime exposure was given to a population of 100 test animals whose state of health, growth, and cause of death were closely monitored. An equal number of sham-exposed animals served as a comparison population. After 25 months of exposure, and at the point where 90 percent of both groups had died, the remaining subjects were sacrificed and assayed. The methods and results have been published as a series of nine technical reports. The overall conclusion was that no cumulative ill effects could be attributed to the lifelong exposure at absorption rates of 0.4 W/kg or less.

Krupp went on to point out that until solid human epidemiological data are available, some concern for long-term effects will remain. The difficulty in assessing implied that very subtle effects without a distinguishing lesion or disease entity will continue to encourage anecdotal epidemiological data. In the meantime, rational review of the existing data provides no reason to predict adverse consequences from lifespan exposure to currently allowable levels of RF radiation.

Accidental Exposure

There have been a number of real and imaginary accidental exposures to high levels of RF energy, both in military and industrial situations. This is inevitable given human fallibility. Graham reviewed several cases with which the USAF has been involved. He reviewed the procedures that have been developed to investigate accidents and to evaluate the health of the person who was overexposed. When the people exposed are USAF employees, according to Graham, they are kept under medical surveillance throughout their lives in order to detect any harmful effects that might develop.

Graham revealed that medical examinations conducted on persons who were overexposed to RF energy have shown few, if any, consistent clinical patterns. This is in contradiction to several reports in the popular media. In a few cases there was edema or erythema or both, or even minor imperfections in the lens of the eyes. However, these all either disappeared or caused no ill health. According to Graham, psychological and neurological examinations have also been uncharacteristic, except for anxiety in several cases where the individuals were so concerned about the possible consequences of the exposure that they exhibited such symptoms.

Epidemiological Studies

There have been several attempts to conduct epidemiological studies of human exposures to RF energy. To date, none has been fully accepted because of a number of complications attendant to such studies with RF energy. Roberts reviewed several such attempts and went on to discuss the requirements for good epidemiological investigations, how these general principles might be applied to RF energy studies, and why some of them can never be achieved. There are many pitfalls when one attempts to look back at a population that may have been exposed to RF energy, and Roberts cautioned the audience about these pitfalls. One of the most critical bits of information that is always lacking is the level to which the sample population was exposed. Since there is no such thing as an RF personnel dosimeter, people who work where they are likely to be exposed have no way to keep a record of that exposure. This then, as Roberts pointed out, is one of the most severe limitations to epidemiological studies in this field.

Power-Line Frequencies

Most of these lecturers dealt with the RF energy in the frequency range above 2 MHz. However, Bernhardt addressed the portion of the spectrum below 100 kHz, with particular emphasis on power-line frequencies of 50 to 60 Hz.

There is very little theoretical or experimental data available on the specific field strengths that humans can tolerate without ill effects in the frequency range between 0 and 100 kHz, with the exception of power-line frequencies. There are several industrial operations, other than in the power industry, in which people are likely to be exposed to substantial field intensities at frequencies below 100 kHz. Sources such as RF sealers and heating units are examples of these types of equipment. Here

times lower than those previously used, and that may have significant impact on future military operations.

The lectures in this series included presentations on: (1) the physical interactions of RF radiation fields with biological systems, (2) the biological effects of RF radiation exposures, (3) the procedures for measuring RF radiation fields in military operations, and (4) the development and operational impact of new RF radiation safety guidelines.

Besides Mitchell, the speakers and their affiliations were:

1. Dr. Carl H. Durney, Electrical Engineering Department, University of Utah, 3032 Merrill, Salt Lake City, Utah 84112.

2. COL Roger B. Graham, USAF, BSC, Vice Commander, USAF Occupational Environmental Health Lab., (USAFSAM OEHL/CV), Brooks Air Force Base, Texas 78235.

3. Dr. A.W. Guy, Department of Rehabilitation Medicine and Center for Bioengineering (RJ-30), University of Washington, Seattle, Washington 98195.

4. Dr. Jerome H. Krupp, Chief, Bioeffects Function, Radiation Sciences Division (USAFSAM/RZP), USAF School of Aerospace Medicine, Brooks Air Force Base, Texas 78235.

5. Dr. Norbert J. Roberts, M.D., Associate Professor of Medicine, University of Rochester Medical Center, 601, Elmwood Avenue, Rochester, NY 14642.

6. Dr. Jürgen H. Bernhardt, Institut für Strahlenhygiene des Budesgesundheitsamtes, Ingolstädter Landstrasse 1 D-8042, Neuherberg, Germany.

RF Interaction

The "kickoff" speaker was Professor Durney, who set the stage for understanding much of what was presented in later lectures by introducing the physical concepts of the interaction of RF energy with biological systems, particularly with humans. Durney presented a very good tutorial on dosimetry and its underlying concepts as well as the numerical and analytical techniques used for estimating the specific absorption rate (SAR) of RF energy that impinges on animals and phantom models for humans. He also outlined what needs to be done in terms of calculations and measurements of SAR in both the near and the far field of an antenna.

SAR and RF Energy

Guy presented a great quantity of data, most from his own very active laboratory, to illustrate the distribution of heating patterns and the consequences of localized SAR due to exposure to RF energy. He stressed the need to know the relationship between the absorbed energy, the tissue cooling mechanisms, and the temperature, if one is going to understand the thermally induced biological effects. He discussed the complexity that arises in the human body due to the different types of tissues, with differing water content, and the many interfaces encountered by the RF energy. Guy went on to discuss studies on RF-induced cataracts in the eyes of rabbits and how temperature and SAR are measured in such animal models. The cataractogenic threshold for primates as well as rabbits has been found, and the good agreement between the measured and the computed temperature fields found in these experimental animals suggests that it is possible to predict the ocular temperatures and hence the cataractogenic thresholds for man, if the blood flows and the SAR patterns are known. The SAR patterns can be obtained from model studies. However, there are insufficient data about the blood-flow rate to permit realistic estimates of thermal cataractogenic thresholds to be made.

Biological Effects Research Summary

Roberts presented a comprehensive summary of the research findings during the past 10 to 15 years related to the biological effects of RF energy. He reviewed the data available on such systems as single cells, cellular components, the immune and neuroendrocrine systems, integrative and regulatory systems, and metabolism. Roberts, a physician, specializes in immunological effects, and this interest was reflected in his first presentation. He pointed out that an accurate understanding of RF energy interactions with biological systems requires both a careful evaluation of past studies and well-designed and well-executed future investigations.

Long-Term Exposure

Krupp discussed the cumulative effects of long-term exposure to low levels of RF energy. He pointed out that of the more than 6000 articles in the literature today, the vast majority involve acute exposures at levels where significant thermal energy was deposited. The resulting effects, in most cases, could be explained on the basis of the specific energy absorption, expressed as watts per kilogram, with a generally accepted threshold for effects of 4 W/kg. The advocacy of nonthermal mechanisms by means of mathematical modeling, theoretical predictions, and *in vitro* studies has raised the possibility of subtle injury or alteration in function which, over time, would be

damage. In an earlier session, R.M. Glaeser (Berkeley) gave an interim report of the work being carried out in several laboratories to investigate the reduction in radiation sensitivity brought about by low temperatures. Cryoprotection for crystalline paraffin seems to work from 300K to 100K and then levels off, and there is a tenfold decrease in the sensitivity of purple membrane between 300K and 4K, although here too there was a leveling off at 150K. Does this mean we should put less emphasis on L HeII stages and work instead with LN_2 stages? Y. Talmon (Haifa) showed that the electron-beam-radiation damage to organic material is modified by ice, but that at the same time the damage to ice is affected by the organic material. It remains to be seen whether these dire results from model organic systems will also extend to more complex biological material. Using latex spheres embedded in ice, Talmon was able to show that the sensitivity to damage of the organic material was reduced if the ice was in a vitreous rather than a crystalline form. W. Chiu (Tucson) and R.M. Glaeser (Berkeley), while showing that embedding macromolecules in vitreous ice give high spatial resolution information, indicated that equally good results could be obtained from specimens embedded in glucose, although there was not a concomitant reduction in radiation sensitivity.

Equipment

The 4 days (and nights) of discussion were complemented by a comprehensive exhibition of equipment for low-temperature microscopy and analysis. In the short time these meetings have been running, it is encouraging to see a significant increase in the number of well-designed pieces of equipment--such as cold stages, transfer devices, and cryomicrotomes--available for purchase. Equally important, the majority of these devices work, enabling cryomicroscopy to move from the esoteric to the routine. Maybe the subject has now come of age and the need for these meetings has disappeared. The argument for adopting cryotechniques for all biological microscopy is secure and proven. While it is not surprising that so many people are now using one or more of these methods, it is astonishing that anyone should continue operating an electron beam instrument at ambient temperatures.

5/10/85

AGARD LECTURE SERIES ON THE IMPACT OF PROPOSED RADIO FREQUENCY RADIATION STANDARDS ON MILITARY OPERATIONS

by Thomas C. Rozzell. Dr. Rozzell was the Liaison Scientist for Biological Sciences in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is now with the Office of Naval Research, Arlington, Virginia, where he is Program Manager for Bioelectromagnetics.

During April the North Atlantic Treaty Organization's Advisory Group for Aerospace Research and Development (AGARD) held a lecture series dealing with the impact of proposed and existing radio frequency (RF) radiation standards on military operations. Three sets of lectures were held: in Rome, Lisbon, and Paris. Each series lasted 2 days, and the lectures were given by the same set of speakers at each. This article deals with the lectures given in Lisbon.

Background

AGARD Lecture Series No. 138, entitled "The Impact of Proposed Radiofrequency Radiation Standards on Military Operations," was opened by the series director, Mr. John C. Mitchell. Mitchell, who is Chief, Radiation Physics Branch, Radiation Sciences Division, US Air Force (USAF) School of Aerospace Medicine, Brooks Air Force Base, Texas, gave an overview of the use of RF energy by the military as well as by civilian industries. He reviewed not only the many types of RF emitters in general use, but also some of the possible levels to which personnel might potentially be exposed.

Mitchell pointed out that for more than 20 years most of the free world has used a single value to maintain personnel safety for radio-frequency radiation exposure. A power density of 10 mW/cm^2, time-averaged over any 6-minute period, has been applied as an acceptable exposure level, and it was generally thought to include a safety factor of 10. More recently, it has become clear that the inherent risks to health from RF radiation exposures are directly linked to the absorption and distribution of RF energy in the body, and the absorption and distribution are strongly dependent on the frequency of the incident radiation. Therefore, in 1982, when new RF radiation safety guidelines began to emerge, a frequency-dependent concept was incorporated. This resulted in permissible average power density levels for occupational environments that, depending on frequency, were two to 10

May 1986 from the Naval Postgraduate School, where he is Associate Professor of Materials Science.

The Soete Institute (SI) is the center for materials testing and welding development in Belgium. The research in weldability and fracture mechanics is particularly strong.

Background

In addition to its academic role as part of the University of Ghent, SI is the site for four research centers directed by Professor A.G. Vinckier (formerly of Westinghouse Research Laboratory): (1) the Center for Scientific and Technical Research of the Metal Working Industry, (2) Research Center of the Belgian Welding Institute, (3) Belgian Center for Technological Research on Pipes and Accessories, and (4) Service for Technology Advice. Most of the research is done by the first two centers, which employ about 70 people (30 of whom are scientists or engineers).

The work done by these two centers overlaps, and thus the two centers will be treated as one for the purpose of this article. The research is primarily focused on three topics: (1) welding metallurgy, (2) fracture mechanics, and (3) strain measurement techniques. This third area is a support function to the first two; however, excellent development work on nondestructive stress- and strain-measuring techniques is being done.

The research at SI is very progressive due to (in my opinion) the progressive nature of the offshore industry, the biggest sponsor of their work. The development of the Tyrol oilfield (by Shell International, Amsterdam) is placing new requirements on the materials used in offshore oil production as this field is in water over 350-m deep (the deepest field developed to date is about 300 m, to my knowledge). Thus, much thicker support structures for the platform will be required, which will increase the concern over brittle fracture and weldability of the steels.

SI is also involved in development work for other aspects of the petroleum industries--involving materials to be used from -165°C to 1250°C (liquid natural gas tankers and storage tanks and high-temperature pressure vessels).

This institute has excellent facilities for both laboratory mechanical testing and large-scale component testing. This is principally due to the efforts of one man, Professor W. Soete, the director of this institute until his retirement in 1982 after about 40 years of association with the organization.

Weldability

All types of welding except electron beam and laser welding can be performed, and a new computer-controlled weld thermal cycle simulator has recently been purchased. The work on weldability is led by Mr. A. Dhooge.

Weld Simulation. The software for the heat transfer model used to calculate the weld thermal cycle as a function of the welding parameters and weld geometry has been produced. Weld thermal cycles resulting from any type of weld at any position in the heat affected zone (HAZ) can be simulated in laboratory test specimens. The simulation is used to produce laboratory test specimens with simulated weld microstructures for mechanical property and fracture toughness testing. The weldability of hundreds of different materials has been evaluated using simulation techniques.

In one such study an offshore-construction steel with a carbon equivalent of 0.39 was subjected to a wide variety of simulated welding conditions and its resulting resistance to impact fracture assessed. It was found that the critical parameter in the weld cycle is the cooling time between 800°C and 500°C because this controls the microstructure of the HAZ. The simulator allowed the researchers to parametrically analyze the effect of many different variables--such as preheating, postheating, heat input, and weld geometry--whereas this would be prohibitively expensive to do with actual welds. However, one cannot rely completely on simulation welds because very complex interactions between the various parts (base metal, HAZ, and weld metal) of a real weld will occur that cannot be simulated. Thus, several real welds must be evaluated to validate the simulation results.

Reheat Cracking. The susceptibility of steel welds to cracking during postweld heating in the vicinity of 600°C has been thoroughly investigated by SI. During the post-weld heating, or reheating during multipass welding, many low alloy steels are susceptible to cracking. Often the durability of the steel at 600°C is so low that it cannot accommodate the small creep strains necessary to relax the residual stresses from welding. The general conception is that this creep strain is uniformly distributed throughout the weld region. However, Vinckier and Dhooge have performed many experiments that show that the overall strain may be small during stress relaxation but that all of this strain is localized to the regions

containing the highest residual stress. Thus, locally the plastic strain can be very large.

Figure 1 illustrates the specimen used for one of the experiments. The central hole is notched, and a fatigue crack is grown from it as shown. Two slits are cut axially dividing the central region of the test bar into three bars. The two outer bars are compressed plastically, causing a residual tensile stress in the cracked region balanced by compressive residual stresses in the two outer regions. The elastic strain in the specimen is determined from changes in 100-mm measuring grids laid out on each of the three sections, and moire patterns are used to measure the strain at the crack tip. The specimen is then heated to about 600°C, and the plastic strain accumulated at the crack tip during the stress relaxation is measured by changes in the moire fringes. The remaining residual stresses are removed by cutting the two outside bars. By measuring the number of moire fringes (all converging on the crack tip), the researchers have determined the amount of local plastic strain. For an initial residual stress of 22 kg/mm^2 and an initial plastic strain of 3.5 percent 0.5 mm from the crack tip, a total of 11.5 percent plastic strain accumulated at the 0.5-mm distance from the crack tip, while the stress relaxed to 4 kg/mm^2 at 600°C. They estimate that this is equivalent to about 15 percent plastic strain right at the crack tip.

After testing hundreds of materials and comparing the reheat cracking sensitivity with the ductility (reduction in area) from a slow-strain-rate tensile test at 600°C, they found that some useful rules exist for this correlation. One such rule is that if the tensile ductility is less than 5 percent, reheat cracking will almost always occur. If it is greater than 20 percent, cracking will not occur.

Many other different tests have been used at SI, all of which clearly show that large creep strains occur locally during stress-relieving heat treatments of steel welds. The amount of strain depends on the level of the residual stress *and* the size of the component (due to the stored energy in the form of elastic strains, which are converted into plastic strain during stress relaxation).

All of the weldability research is closely coordinated with other research centers in Europe, but the investigators seem unaware of similar work in the US (and vice versa). This seems often to be the situation in this subject.

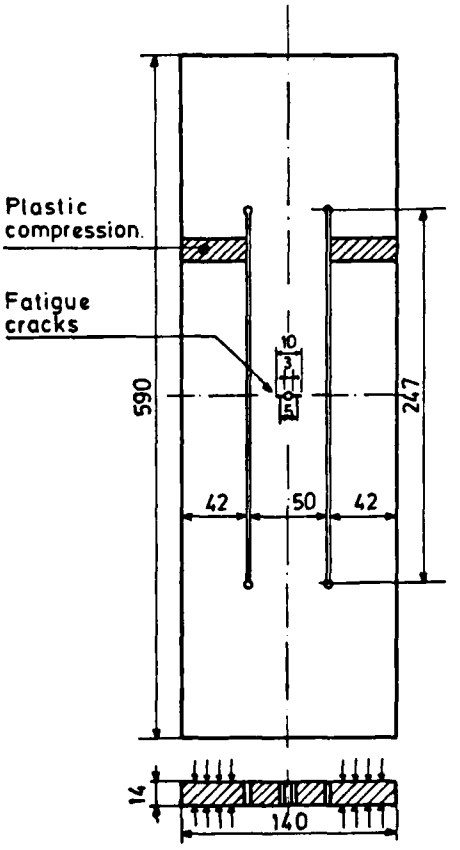

Figure 1. Reheat cracking specimen with tensile residual stresses.

Fracture Mechanics

The majority of the research at SI is concerned with understanding the fracture properties of steels, with emphasis on welded steel components. All types of laboratory tests (crack tip opening displacement [CTOD], drop weight tear, and J-integral tests) and large scale (some full-size components, but mostly wide-plate tests 1-m × 1-m × 200-mm thick) and Robertson crack arrest tests are carried out on wide plates and piping (in both steel and reinforced plastic pipes). The test pieces can be cooled to -196°C for testing and are fully instrumental for strain measurements (electrical strain gauge and moire fringe). The work on fracture mechanics is led by Dr. R. Denys.

After years of using both the CTOD method (developed by The Welding Institute, UK, and used by all oil companies as acceptance tests for offshore construction steels) and wide plate testing, Denys and Soete believe that the large plate test is the best criterion

to use to assess resistance to brittle fracture. If the plate undergoes gross section yielding before a defect propagates, then the materials should be safe for use. They feel that the CTOD results are often misleading; materials can fail the CTOD and still be suitable for use (Shell International, Amsterdam, also agrees with them).

The wide plate test using changes in the moire fringe patterns has been used to study the strain distribution around buried defects and the fracture properties of these plates. This same experimental method is being used to study the effect of weld metal strength (over- and under-matching the base metal's strength) on the fracture resistance of wide plate weldments. The results of these experiments will be presented at the offshore conference to be held in Canada in October. These results should be of interest to the US Navy's researchers at the David Taylor Naval Ship Research and Development Center, Annapolis.

In addition to these projects, the scientists perform some research on elevated temperature deformation under static (creep) and cyclic (fatigue) cracking for standard, small, laboratory test specimens and full-size piping components. The emphasis of this research is to understand the damage mechanisms in order to develop residual life prediction models for elevated temperature piping and pressure vessel materials.

Strain Measurement Techniques

In order to perform materials tests, SI has an excellent laboratory developing new strain measurement techniques. The work is led by Dr. P. Boone. Holography, moire frige and speckle correlations, acoustic emission, and electrical methods are continually under investigation. This group provides excellent support to the large structural tests performed at SI and has developed some very advanced techniques for strain measurements.

Summary

SI is performing materials research in several areas relevant to naval ship development. They have excellent large-scale testing and metallurgical analysis facilities used by a capable staff. Several of the staff are leaders in the materials evaluation and process development for the offshore oil industries in Europe.

5/14/85

Mathematics

MATHEMATICIANS WORKING WITH INDUSTRY--THE OXFORD EXAMPLE

by Charles J. Holland. Dr. Holland is the Liaison Scientist for Applied Mathematics/Computational Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until December 1985 from the Office of Naval Research, Arlington, Virginia, where he is the Deputy Division Director of the Mathematical Sciences Division.

In high-technology driven areas where industrial research staffs and budgets are large, infusion of new applied-mathematics developments occurs routinely. In less high-technology industries such is not the case, despite the apparent benefits to be gained. However, the last several years have seen increasing efforts in Europe and the US (Claremont, Duke, and most recently Rensselaer Polytechnic Institute) to expand this interaction of academic applied mathematicians with these industries. These recent interactions have taken several forms (see *ESN* 39-6:266-268 [1985] for an example in The Netherlands). Some build on the oldest and highly successful efforts of the Oxford Study Groups With Industry, which had its 18th annual meeting at Oxford University from 18 through 22 March.

In this article, I will concentrate on the Oxford Study Groups, outlining their objectives, format, and my impressions as to why they have been successful, as well as describing some of the problems discussed at the meeting.

Oxford Study Groups

The Oxford Study Groups With Industry concentrate on improved mathematical modeling and analysis techniques of physical processes. The goals of the Oxford Study Groups are to: (1) help industrial research workers solve problems in physical applied mathematics, (2) involve academic mathematicians in practical problems, and (3) provide suitable training for graduate students who wish to work in industry.

The goals are accomplished through annual week-long meetings which involve industrial participants (12 in 1985), who discuss their problems, and about 50 academic participants, including graduate students. Most of the academics are

from Oxford and other British universities, but a few foreign academics participate. The week is usually scheduled during spring recess and the week before the British Theoretical Mechanics Colloquium to encourage people from outside the UK to attend.

In the fall before the annual spring meeting, problems are solicited from industry by Professor John Ockendon, who heads the Oxford Study Groups. Along with postdoctoral students, he selects the problems which are suitable for investigation and produces suitable background material. Many of these problems come from industries that have participated in past years with success. British applied mathematics excels in continuum mechanics modeling and analysis. To match this expertise, Ockendon selects physical mathematics problems (welding, chemical reactions, etc.) which need improved modeling and analysis. He excludes problems in control, operations research, and statistics, for which less expertise is likely to be available.

The first day of the meeting, Monday, contained half-hour presentations from scientific representatives of each of the industries presenting a problem. Typically, the representative was an applied mathematician presenting an industrial problem that he had been working on over the last year. At the end of the first day, each academic participant joined a group that would attack one of the problems, although floating between groups was allowed. During the next 3 days, participants worked intensively on these problems, interrupted only by occasional "guest lectures" on topics thought to be useful for attacking the problems.

The last day, Friday, consisted of a presentation of the progress made on each of the problems. The goal on each of the problems was not to provide a definitive solution, but only to outline or provide a proposed attack for its solution to the industrial researcher. For some problems, these goals were achieved early in the week; for others the week saw relatively little progress.

Some examples of problems from this year's meeting are given below; work from prior years is explained in reports by Ockendon (1980, 1983).

What are the benefits of such a week to the industrial and academic participants? First, the industrial participant obtains considerable free expert assistance on how to tackle some difficult modeling and analysis problems. This assistance may range from advice on the correctness of mathematical models of the physical situation to numerical techniques for their implementation. For the academic participant, the reward is mainly the pleasure of doing practical applied mathematics in an intellectually stimulating group; no papers on the problems will necessarily be written, nor will scientific credit or consulting fees be obtained. Consequently, not every academic is likely to be happy in such an arena--but these restrictions produce a nice "natural selection." For graduate students, the meetings are an opportunity to get a view of typical industrial applied-mathematics problems. Moreover, they are able to see a group of applied mathematicians working together--often not seen in an academic environment, where research tends to be individually competitive.

Although the industrial problems may not lead directly to research papers, nevertheless the problems have suggested important general research directions that have been pursued by the study-group participants. According to Ockendon, over the past decade more than a quarter of the problems have concentrated on free and moving boundary value problems arising in traditional areas such as porous medium flow as well as new applications in crystal growth and metallurgy. This practical importance has led Ockendon and others to concentrate their research on these problems: A. Taylor at Oxford; C. Elliott at Imperial College; A. Crowley at the Royal Military College of Science, Shrivenham; and A. Lacey at Heriot-Watt. As a result, UK research is in the forefront in the area of free and moving boundary value problems.

Examples

Below, I will briefly describe two of the 12 problems treated at this year's study group to give an indication of the complexity of the problems that are typically considered.

A problem that was attacked successfully was brought by Unilever Research. It concerned the evolution of a simple reversible reaction within a small cell. In Unilever's system of interest, one species--say Y--is immobilized at one side wall and the other species, X, is dissolved in solution. The reversible reaction takes place only at the side wall. The interest lies in predicting both the X concentration profile and the concentrations of the complex XY as functions of time--especially in the diffusion-limited case.

The discussion centered around the mathematical analysis of a one-dimensional model given by a diffusion equation with a nonlinear boundary condition at the side wall containing the

immobilized species. With u representing the concentration of the species X in the interior of the cell and Z the number of occupied sites at the boundary, the mathematical system considered was:

$$u_t = u_{xx} \qquad 0<x<1$$

$$u_x\ (0,t) = 0$$

$$u_x\ (1,t) = -\ m\ \frac{dZ}{dt} = \frac{mE}{1+L}(LZ-u(1-Z)) \text{ at } x=1$$

and $u = 1$, $Z = 0$ at $t = 0$.

An asymptotic analysis was developed for the limited diffusion case (E very large), while an integrodifferential equation for Z was derived whose numerical solution appeared to pose no difficulty for E not too large.

An interesting problem with significant modeling challenges was brought to the group by the Central Electricity Generating Board (CEGB). It involved the analysis of welding with metal transfer occurring in arc welding. In this process, sources of heat and mass move over a metal substrate creating a solidifying liquid pool. The wire and substrate consist of the same material. At the suggestion of the CEGB, the members of the study group devoted themselves to analyzing: (1) the contact angle for the spreading film, (2) the effects of both surface tension and freezing in determining the limits to spreading, and (3) the time scales for spreading of the film and for heat transfer. At the end of the week, considerable analysis had been developed on simplified models, but it was clear that much more effort was necessary.

Conclusions

The Oxford Study Groups With Industry provide an excellent example of a successful way to increase interaction of academics with industry, to provide training for graduate students, and to suggest important research directions to focus. It is an environment worth duplicating to develop the next generation of mathematicians in the US who can model physical problems; unless we *again* plan to import that expertise from the UK.

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4/30/85

Mechanics

SURFACE-WAVE AND SHIP-RESISTANCE RESEARCH IN ISRAEL

by Patrick Leehey. Dr. Leehey is the Liaison Scientist for Naval Architecture and Applied Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1985 from the Massachusetts Institute of Technology, where he is Professor of Mechanical and Ocean Engineering.

An active program of research on surface waves and ship resistance is being carried out at Tel Aviv University and at the Technion in Israel. The new feature of this work is the concentration on nonlinear wave interaction using digital solutions of the Zakarov equation, a wavenumber description of the fluid dynamical processes involved.

Background

Professor Gideon Dagan of the Department of Mechanical Engineering of Tel Aviv University described for me the general background of the theoretical work in ship-wave resistance. His review, summarized below, helps to put the current Israeli research in perspective.

Until the 1960s the entire theory was linear and analytic. Linearization was applied both to the free surface boundary condition and to the body, making the usual thin body assumption. The names of Havelock, Mitchell, Kotchin, Weinblum, and Brard are associated with this period. Unfortunately, the results of this theory yield a very poor comparison with the experiment. The theory remained an academic curiosity and was not useful for practical calculations of ship hull forms. All ship hulls continued to be designed based upon series tests in towing basins. The reason for this poor comparison is not yet entirely clear. It is partially due to viscous interaction with the inviscid wave resistance. It is also, and perhaps more importantly, due to the fact that the wave resistance characteristics contain important nonlinear components.

In the past 20 years the advent of the computer has caused an upsurge in activity in theoretical wave resistance. Nonlinear surface boundary conditions have been incorporated into computer programs. The Japanese were extremely active in this field, perhaps too much

so, as they attempted almost too soon to apply their results to practical ship designs. A very good review of the recent progress in this field was made by Marshall Tulin (1978).

The linear theory fails mainly at low Froude numbers--that is, at Froude numbers below that corresponding to the peak of the wave resistance coefficient. Here we define Froude number as the ratio of gravity wave length to body length. Furthermore, most of the linear theories were two dimensional. As one proceeds to the zero Froude number limit, the surface boundary, to the first approximation, becomes a rigid wall. One can therefore reflect the ship hull form through this rigid boundary symmetrically and obtain a mean flow pattern about such a double hull form. Since the Froude number approaches zero, the waves that would appear in the next order would have very short wavelengths superimposed upon this uniform flow pattern. This general approach to the theory has been developed by J.B. Keller (1974). A rather important numerical calculation was done by Dawson of the David Taylor Naval Ship Research and Development Center in the US some years ago, using a numerical scheme for waves of short wavelength propagating on a spatially dependent mean velocity field. He obtained good comparison with experiment. (Unfortunately Dawson died rather young, a true loss to this field of research.) J.N. Newman (1976) wrote formal asymptotic expansions for these procedures.

Most recently, the theoretical effort has been concentrated on exploiting the Zakharov (1968) integral equation approach. The basic work subsequent to that of Zakharov was done by Yuen and Lake (1982) in a rather long paper. The Zakharov equation is in Fourier wavenumber space and deals with nonlinear interactions of long and short wavelengths.

Current Research in Israel

Over the past 2 to 3 years, Dagan and his colleague, Professor Touvia Miloh, have conducted a study of nonlinear wave resistance using a Zakharov-type integral equation. They presented one part of this work at the recent Symposium on Naval Hydrodynamics at Hamburg (Dagan and Miloh, forthcoming). Here they dealt with cases of a submerged cylinder and of a submerged sphere. More recently they have handled the case of a pressure distribution on the free surface. The distribution is symmetric and convects with a mean velocity. It contains a small parameter, called ε, which is essentially the ratio of the hydrostatic height of the pressure distribution to its characteristic radius. The other, and principal, expansion small parameter is the Froude number. They carried out expansions in Froude number for various order relations to the parameter ε. This work will appear in the *Journal of Fluid Mechanics*. They are presently working to extend it to the thin ship case. They feel, however, that this most recent work basically justifies their expansions in Froude number instead of the alternative parameter ε.

Dagan and I discussed the general question of two parameter expansions and related questions of uniform validity. At present such asymptotic theories do not appear to be sufficiently developed for use in applications. One very provocative, but fragmentary, development is that of Darrozes (1972), where, for a special problem, an asymptotic solution uniformly valid for two small parameters was obtained. Further development of such techniques could be of value in ship resistance theory, as well as in many other theories.

I met also with Michael Stiassnie, an associate professor in the Department of Civil Engineering at the Technion, Haifa. Stiassnie's specialty is the field of water waves. He was a research fellow at the Parsons Laboratory at the Massachussets Institute of Technology (MIT), from August 1982 through September 1983, working with Professor C.C. Mei. Stiassnie's publication list is quite impressive and includes cooperative work with Dagan and with D.H. Peregrine of the University of Bristol, UK. His recent paper with Lev Shemer (1984) is on the extension of the Zakharov equation for surface gravity waves to include higher order interactions for both finite- and infinite-depth waters. He reviewed for me the earlier theories of nonlinear water waves, including the Benjamin-Feir modulational instability of the third order Schroedinger equation for narrow band spectra, and finally the Zakharov equation for broadband spectra. All of these are weakly nonlinear as they do not include wave breaking. He is currently working on the solutions to the Zakharov equation, introducing broadband spectral initial data and determining the long time limit behavior of the system. He is also doing some floating breakwater research for a wave coming at a floating vertical lamina. The earlier Ursell solution has a square root singularity at the tip of the lamina. Stiassnie imposes a Kutta condition, which involves alternating vortex shedding from the lamina. In order to obtain finite energy, the vortices that

are shed must have finite cores. He has to introduce physical assumptions to determine the core sizes. He also assumes that there are no vortex interactions. His justification is that a vortex pair, once created, moves away downward from the lamina; hence the interactions can be ignored. This appears to be a reasonable conclusion for the calculation of forces on the lamina, but might not be appropriate, say, for determining the downstream flow evolution.

My final discussion was with Professor Lev Shemer at Tel Aviv University. We went into further detail about his studies with Stiassnie of nonlinear-surface-wave interactions using the Zakharov equation in wavenumber space. I asked him about the origin of the quintic wave interaction procedure that he is using. He told me that he is working with the fewest number of wave interactions which will produce significant nonlinear phenomena. One is not necessarily talking about that many different waves; it is quite possible to deal with a quintic interaction with only three separate waves involved. Such an instability is known as a Ferme-Pasta-Ulam instability, a term which originated in a totally different context. Shemer also pointed out that the work of Landahl on the boundary layer transition problem is based upon similar concepts.

Shemer's most recent paper with Stiassnie (1985) is on the long time evolution of Stokes waves from initial quintic sets of wavenumber patterns. A very interesting feature of these results is a periodicity wherein the initial data are returned to after an intermediate evolution of a relatively complex wave pattern. Shemer was cautious about calling the complex pattern chaos, but it was quite evident that he felt that such cyclic returns to initial data could evolve in systems that show intermediate chaos.

Conclusion

There is a lively and important cooperative research program between the Technion and Tel Aviv University on ship resistance and surface waves. This program involves modern analytical and computational techniques. It should contribute significantly to overcoming previous limitations on practical use of the theories.

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5/16/85

Physics

ELECTRO-OPTICS, QUANTUM ELECTRONICS, AND RELATED TOPICS PURSUED VIGOROUSLY AT THE HIRST RESEARCH CENTER

by P. 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.

Electro-optics (which, if some special application areas are to be emphasized, is also called optoelectronics) is surely not a new branch of physics. For example, the Faraday or Kerr effects have a respectable history. But both

electro-optical, and the simpler purely nonlinear optical phenomena, took on a prominent role with the advent of quantum optics, especially lasers, as well as with the advances in the fabrication of microelectronic solid state devices. For one thing, the extremely high energy levels of coherent laser light revealed novel nonlinear phenomena in electro-optical and optically active materials and made it possible to study and apply exciting unusual events such as frequency doubling, wave mixing, light amplification, phase conjugation, light modulation, real-time holography, and many other novel (or at least no longer exotic and hard-to-observe) marvels. On the other hand, these physical phenomena, when combined with other developments in modern optics and technology (such as low absorption and dispersion-free optical fibers, optical waveguides on all scales, optoacoustic effects, and radiation detectors and sensors) will lead to a remarkable revolution in communication, information processing, and data handling and processing. It should also be kept in mind that the modern techniques used for producing optoelectronic components and other, more general microelectronic devices are often closely related, as is their common theoretical background: solid state theory, electromagnetism, and quantum physics.

No wonder, then, that practically every self-respecting physics department or electric/electronic engineering department at universities and research institutes is deeply involved in fundamental electro-optical and microelectronics research. But this is not always the case with industrial research labs in the UK. It appears that, often, there is a tendency to concentrate only on research that is of immediate applicability for production of devices that already are, or very soon will have to be, available "off the shelf."

A notable exception is the leading firm, General Electric Company (GEC) of the UK, which employs 180,000 people organized in a horizontally structured range of fields of concentration, ranging from power generation through communications, avionics, and robotics to medical physics. It has brought into existence an independent system of basic-research laboratories with three, physically separated branches. I visited one of the largest, the Hirst Research Center, located in Wembley (a suburb of London). The Hirst Center employs about 1000 people, 700 of them possessing scientific or engineering degrees.

In this article I will report on a very few of the many research lines in optoelectronics and related fields I became aware of during my visit. I believe that, while one does not easily come across revolutionary breakthroughs on such a first trip, the topics I selected are of interest to a wide sector of the US research community. In addition to this article, see *ESN* 39-6:283-284 (1985) for information on Hirst's unique, long-range research department.

Diode Lasers and Multiquantum Wells

From my personal point of view, the most exciting research in this area is done in the Heterostructures Laboratory, headed by Dr. Süleyman Demokan. This lab has two sections: optical and digital. In the former, diode devices (light emitting diodes and lasers) as well as photodetectors are studied, and in the latter, high electron mobility transistors and heterostructure transistors.

Laser Diode Amplifiers. A primary project of the optical section is the development of high efficiency, high throughput, efficiently coupled laser diode amplifiers. The current practice of amplifying optical signals traveling in a fiber cable communication link is, of course, to first convert the optical signal by a photodetector into an electrical signal, amplify this electronically, and then reconvert by a diode laser into light. This power-consuming, expensive, and clumsy process also distorts the signal because the bandwidth of photodiodes is currently less than 100 GHz (corresponding to a pulse width of about 10 ps), and the bandwidth of electronic amplifiers is even less. There are several worldwide attempts under way to avoid these problems and achieve direct light amplification in optical communication systems. (I briefly described one type of current work in *ESN* 39-5:211-217 [1985], on the optics group of Imperial College, and another idea in *ESN* 39-7:335-341 [1985], on quantum optics in Madrid.)

One of the possibilities, which employs a laser diode in a Fabry-Perot resonant cavity-type mode of operation, has two major limitations. Firstly, to prevent the amplifier from oscillating, the injection current must be kept smaller than the threshold current, and this will limit the gain. Secondly, the critical nature of wavelength matching between the amplifier and the input signal creates problems with temperature stability and input spectral width limitation. For these reasons, Demokan uses a traveling-wave-type operation mode of the amplifier diode, which has no feedback. Such amplifiers do not saturate as readily as resonant amplifiers. The construction consists of

employing antireflection coating of both end facets of the laser. (Another method uses lasers with stripes forming a Brewster angle with the diode facets. This approach is also employed at Imperial College *(ESN* 39-5:211-217 [1985]). These arrangements ensure that the diode gives large amplification at high injection currents without starting to oscillate. In fact, a direct-current bias, several times larger than the threshold current of the noncoated laser diode, can be applied, and the gain bandwidth is virtually equal to the line width--i.e., about 1 THz. In addition, since semiconductor lasers are homogeneously broadened, harmful frequency hole-burning will not occur, and indeed the devices studied by Demokan's group achieve direct amplification within a very broad spectral range.

There are, of course, practical factors which limit the gain: (1) the coupling efficiency of the optical signal into the active region, (2) the residual reflectivity of the facets, and (3) the catastrophic-damage-intensity threshold of the output facet and the bulk. The Hirst scientists successfully coped with the first problem by using an optical fiber which has a micro-lens attached to its tip. The tip of the fiber is tapered to a radius which is compatible with the active region of the laser diode, and then the fiber tip is melted (or dipped in molten optical glass) to form a hemisphere which acts as a micro-lens. With this method, remarkable fiber-laser diode coupling efficiencies of over 60 percent have been achieved.

An interesting final remark is that Demokan believes that amplification methods can soon be perfected to a degree which will allow efficient free-space laser light communication between satellites.

Mode-Locked Diode Lasers. A second, related topic pursued by Demokan is the theoretical study of actively mode-locked diode lasers. Because of the small dimension of diode lasers, mode-locking must obviously be done by placing the laser diode in an external resonator. This can be either a conventional linear two-mirror configuration or a ring cavity. The end facets of the diode are antireflection coated so as to avoid the deleterious effects of the diode cavity modes. The first experimental mode-locking of a diode laser was accomplished only in 1978; various analytical approximations of the theoretical nonlinear models led to widely differing and often contradictory results.

Demokan recently constructed a theoretical model based on the case where the laser gain is modulated periodically. His model is not merely a steady-state account of the lasers dynamics, but it also includes transient effects. Unlike other models, it does not assume that the photon and electron densities are averaged (and hence uniform) over the diode's length. The model is quite sophisticated because now these densities are functions of position along the diode in the direction of light propagation as well as being functions of time (due to the time variation of the injected current).

Demokan made a computer simulation of this theoretical model. The results made it clear that the most important parameter that determines the duration of the generated pulse is the spontaneous emission factor (k). Better mode-locking (shorter pulses) require a small k-value. Since it has been theoretically shown that narrow stripe gain-guided diode lasers may have 100 times larger k than index-guided lasers with comparable active layer volume, it follows that index-guided diode lasers (such as buried-heterostructure or channeled-substrate-planar lasers) should be preferred for better mode-locking results. Since k is also inversely proportional to the volume of the active layer, lasers that are long and have a wide and thick active layer are preferred. Having thus established the structure of lasers for optimal mode-locking, Demokan proceeded to study the best choices of controllable parameter values. He found that to achieve the shortest pulse widths, the requirements are: (1) a large value of the radiative recombination coefficient, (2) a large optical confinement factor, (3) a large value of the gain coefficient, (4) a large value of electron transparency density, (5) large values of external mirror reflectivity and good coupling, and (6) small loss coefficients. Other operational parameters have been also analyzed. In addition to applying the results of this study for the building of an efficient experimental setup, Demokan is now planning to develop a similar computer model for passive mode-locking.

MQW Structures. Passive mode-locking of laser diodes ties up neatly with a completely new project, currently in advanced planning stages at Hirst. Nonlinear optical effects have been observed at room temperature in GaAs/GaAlAs multiquantum well (MQW) structures. The properties of these structures are potentially useful as saturable absorbers for passive mode-locking of GaAs laser diodes. In addition, and perhaps even more importantly, they could be used as high-frequency

ptical modulators for signal distribution in phased array radars operating at igh (10 to 100 GHz) frequencies.

The unusual nonlinear optical beavior of these MQW structures at room emperatures results from the two-dimenional nature of the quantum well. This mposes an exciton binding energy sever-l times greater than found in bulk aterial, while at the same time it does ot affect the value of the phonon oupling constant. The enhanced exciton inding energy manifests itself as two igh and narrow absorption peaks close o the band gap energy; these are not resent in bulk materials. Saturation of he excitonic absorption features occurs t relatively low optical intensities nd follows from electrostatic screening ffects caused by the optically created arriers.

Demokan proposed a program to grow, abricate, and test MQW GaAs/GaAlAs tructures. Growth will be attempted oth by metallo-organic chemical vapor leposition techniques and by molecular eam epitaxy. The MQW active layer will e about 1-μm thick and consist typical-y of 50 periods of 100-angstrom GaAs nd 100-angstrom $Al_{0.3}$ $Ga_{0.7}$ As depos-ts. The n^+ and p^+ layers should have arrier concentrations on the order of $.0^{18}$ cm^{-3}. Routine photolithographic and hemical etching techniques will then be sed in the fabrication process to solate and contact the MQW structures. igure 1 is a sketch of the MQW device tructure as envisaged now.

Soliton Lasers. There is at least ne more research line in the hetero-tructures laboratory that sounds excit-ng. Employing special optical fibers hich, in an appropriate wavelength omain, have negative dispersion, the roup will attempt to construct workable soliton lasers. However, for proprietary reasons, I could not obtain more detailed information on this topic.

A Compact Real-Time Optical Data Processing System

Work of great importance for military and industrial applications is done in the Optoelectronics Laboratory of Dr. L.C. Laycock. The experimental work is now near completion, and system construction is proceeding well. The background is as follows. The past decade has seen a steady increase in the application of optoelectronic techniques to data processing. The best-known approaches rely on Bragg cells, and they provide powerful signal processing operations such as correlation and spectrum analysis. As better wide-bandwidth optical fiber communication links are introduced within and between computing systems, the incentives to implement more efficient, faster, and more easily engineered systems using optical techniques will become steadily greater.

For example, progress in two-dimensional processing, by optical means potentially capable of handling immense amounts of data, has been hindered by the lack of high-performance input devices (spatial light modulators) and flexible real-time techniques that can process the data. Laycock and his colleagues believe that these demands on the choice and optimization of optoelectronic materials can be best met by the use of photorefractive media. The refractive index modulation that occurs in such crystals by the local electric fields created through the separation of charge sets can be regarded as a phase grating. If this phase grating was caused by directing a two-dimensional, intensity-modulated image into the

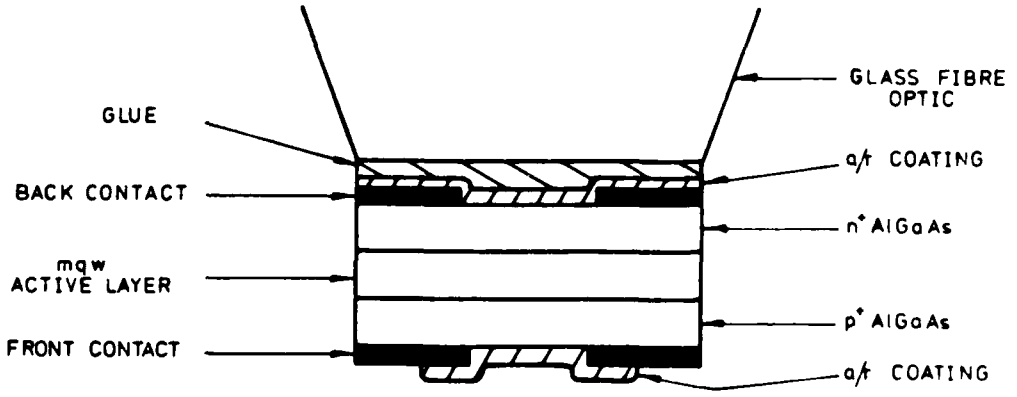

Figure 1. MQW device structure.

crystal, then the grating will contain data about the stored image and can be read out. A second ingredient in the Hirst optical data processing system is the use of degenerate four-wave mixing (DFWM). Two counter-propagating input beams interfere in the nonlinear material to generate the phase grating described above. A third input beam is diffracted by this grating to form an output beam. Under these conditions, the output wave has an amplitude which is proportional to one of the input waves, and it creates a phase-conjugate (time-reversed) replica of this input. This phase-conjugate mirror system can be used for compensating phase distortions that may occur in optical systems, and it has found several applications in the field of real-time adaptive optics. However, the Hirst researchers' interest in the DFWM system lies in the area of real-time optical processing, in particular for pattern recognition and correlation.

The simplest architecture for this application is a Fourier-plane correlator. The term stems from the fact that here the correlation of two input patterns (one to be analyzed in regard to the "sample" provided by the other) occurs at the coincident focal planes of two transforming lenses. The scheme of the device is sketched in Figure 2. Beams 1 and 2 are arranged to be counterpropagating (to within 1 minute of arc). The transforming lenses L_1 and L_3 are arranged so that their focal planes overlap in the nonlinear crystal. The two lenses produce, at their common focal plane, the Fourier transforms V_1 and V_3 of the field distributions u_1 and u_3 at the planes P_1 and P_3, respectively. In the photorefractive medium the fields V_1 and V_3 and the plane wave distribution u_2 induce the nonlinear polarization given by

$$P \sim \chi V_1 u_2 V_3^*,$$

(where * denotes complex conjugation), and this induced polarization results in an output field that propagates in a reversed direction to that of beam 3. The beamsplitter, BS, directs part of this beam onto the lens L_4 which performs a Fourier transformation of the intensity pattern V_4, which thus becomes the distribution u_4 in the output plane of this lens. It is well known that this u_4 is proportional to the correlation of u_1, and u_3, i.e.,

$$u_4 \sim \langle u_1 | u_3 \rangle.$$

Thus, reading out the distribution u_4 in the plane P_4 gives the desired pattern analysis of the image carried by beam 2, relative to the standard image carried by beam 1.

Of course, turning this idea into a practical device takes a lot of doing. Laycock and colleagues used a bismuth silicon oxide crystal and employed a low-power HeNe laser to produce the reference image (from a slide). The image to be analyzed was obtained through a liquid-crystal light valve illuminated by noncoherent light. A series of correlation experiments yielded excellent results, and Hirst may soon build a compact practical device.

Concluding Remarks

I have described the work (or rather, some of the work) done by only two of the research groups at Hirst. Time, and coherence of this article, did not permit a broader report--such as including a discussion of excellent

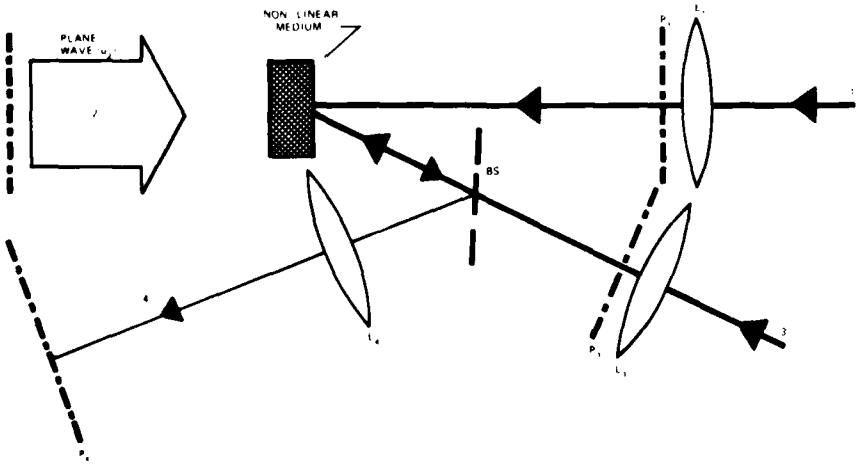

Figure 2. A Fourier plane image correlator based on DFWM.

ical-fiber research. Hirst has fine ılts both in the design of fibers ı arbitrarily varying refractive-ex profiles and the precise predic-ı of their properties, and in innova-e design of single-mode, distributed ical-fiber sensors. (Interested read- may contact me for reprints and pre-nts.) However, even with these and y other omissions it should be clear t GEC's Hirst Research Center is a adly based, high quality, fundamental earch facility for the development of oelectronics. Once again let me point that this is an unusual achievement the background of British industrial tory and practice.

/85

ER RESEARCH CENTER AT HULL UNIVERSI-UK

P. Roman.

It is hard to think of a physics or ctrical engineering department in the tern world which does not conduct e kind of research in the area of er research or applications. But re are only relatively few true *cen-s* of absolutely frontline work in s still rapidly developing area of at technological and military signifi-nce. Often such centers develop in ironments not hallowed by age-old dition, usually as the result of the orts of an outstanding, dynamic hority. A case in point is the laser up at the University of Hull. While ducting frontline research in high-er modern versions of CO_2 lasers, d-salt diode lasers, ultrasensitive rared detectors (which are highly ght articles, marketed directly by department), and unusual machining film etching laser applications microelectronics, the best known ievement of this group is their neering, historically established dership in x-ray laser research. il very recently the Hull group ieved the strongest x-ray gain in the ld, and their carbon-wire technique ms to hold promise for further ad-ces, even though at present they have n surpassed by researchers at Liver-e. It was not just this particular earch with obvious military signifi-ce, but also the other up-to-date and orously planned projects mentioned ve, that motivated me to travel to moors of Lancashire.

The University of Hull is a relatively young institution of higher learning. It originated in the 1920s and the modern, pleasing campus outside the city obtained its present form during a rapid expansion in the 1960s and 1970s. Next to chemistry, physics is the strongest field of science represented at Hull. In particular, the Department of Applied Physics has widely known research groups in materials science, low-temperature physics, and lasers. The head of the department is Professor S.A. Ramsden, an internationally acknowledged authority on lasers, and so it is not surprising that the strongest research facility is the laser group, which is actually one of the largest and highly acclaimed groups in the entire UK. It enjoys Science and Engineering Research Council, Ministry of Defence, and varied private industry support, and receives a significant number of Cooperative Awards in Science and Engineering. It will not be possible to do equal justice in this article to all the varied activities; I shall review here only work on x-ray lasers, high-power CO_2 lasers, diode lasers, laser applications in microelectronics, and related areas.

X-ray Laser Research

The development of coherent sources for radiation around and slightly below 150 angstroms (extreme ultraviolet [XUV] region)--and especially for wavelengths well below this, say down to 10 angstroms or less (proper x-ray region)--has presented a decade-long severe challenge to basic science and technology. There are a variety of scientific and practical (including military) reasons for this challenge.

The crux of the problem can be seen as follows. For lasers operating at or above the UV regime, the photon energies do not exceed 10 eV and are closely matched to the electronic or molecular energy levels of neutral or weakly ionized atoms. Thus, typical photon energies (a few electron volts) and transition lifetimes (on the order of nanoseconds) match well the characteristics of fast electric circuitry feeding a weakly ionized discharge, which may be used to pump either directly or indirectly a laser medium. However, for a hypothetical x-ray laser operating at about 10 angstroms, the photon energies are around 1 keV, and lifetimes may be less than a femtosecond. Consequently, the power required to pump the laser will increase rapidly as the wavelength decreases. A further difficulty is that the expected enormous power supplied by some external source must be somehow dissipated by the medium (pump power

nsities in excess of 10^{15} W/cm^2 may be quired). At present only three sources e known that can, in principle, de- ver the necessary pump power densi- es: a subsidiary ultra-high-power ser, an ultra-high-power particle am, or a nuclear explosion. The last- med is not suitable for most labora- ry experiments, and the particle beam thod has not received sufficient study far. It should be also noted that the oblem of building an operational x-ray ser is further complicated by the fact at, so far, no simple transmitting or flecting media at x-ray wavelengths ve been produced, so it is not yet ssible to let the laser signal build in a resonant cavity or by a distri- ted feedback system. Crystal reflec- rs at near-grazing incidence are the ly current possibilities, but would ad to extremely complex cavity con- ructions. The absence of a cavity im- ies that the laser must operate in a akly coherent traveling mode or ampli- ed spontaneous emission mode. Assuming rod-shaped medium, this form of opera- on requires an enormous gain-length oduct (about 20).

The extremely high pump-power need, nich is the principal problem for chieving x-ray laser action, is proba- y best achieved indirectly by pumping ne system to a relatively long-lived eservoir state, which may be slowly lled and then transferred into the oper laser state by some trigger. While nis approach relaxes the condition on ne external pump, it is limited to nort pulse action. Along these lines, a comising approach called the recombina- on laser has been developed. The in- ersion is achieved during a cascade nrough the excited states of highly harged ions following recombination nto a high lying state. In order to chieve significantly large gain within ne recombination cascade, it is neces- ary to first ionize the medium and then apidly cool it, so that the dominant ecombination is into high lying states ather than directly into the ground tate. This basic problem is probably est solved with adiabatic cooling by pansion (rather than by radiative heat oss). One particular realization of ne recombination laser mechanism, using -like ions (where it is not too diffi- ult to produce a high fractional popu- ation of the parent ion by stripping ne medium), was proposed as early as 10 ears ago by Professor G.J. Pert at ull.

Scientists at Hull were the first o develop the carbon fiber technique o be described below); the researchers nen conducted both a variety of experi- ments and computer simulations and, reporting significant gains, turned Hull into one of the few international centers for x-ray laser research. Pert worked in cooperation with Ramsden and Drs. D. Jacoby, R.J. Dewhurst, L.D. Sharrock, and G.J. Tallents; from time to time the Hull group cooperated also with the Rutherford Appleton Laboratory (RAL) permanent staff and with researchers at Queen's University, Belfast. It should be added that they kept up their work in the mid- and late 1970s (when other groups gave up) because they had a strong faith in the feasibility of their techniques.

Some readers will be glad to hear that one of the first demonstrations of gain in expansion cooled recombination systems was reported by Dr. J. Elton and coworkers at the US Naval Research Laboratory in 1982; they used slab targets irradiated with Nd/glass laser pulses and measured 2 cm^{-1} gain at 520 angstroms. However, in the same year the Hull group obtained gains as high as 25 cm^{-1} (over a 2-mm length) at the 182-angstrom line in hydrogen-like carbon VI, Hα. Until this summer, this was the largest plasma amplification in the X or XUV region ever observed. (Many readers will have heard of the recent results at Livermore which, in a selenium plasma, achieved amplification factors as high as 700 at 206 angstroms and output powers of several hundred watts. Amplification in yttrium plasma at 155 angstroms was also seen.)

The Hull group used carbon fibers, 1- to 4-μm thick and line-focused up to 10-J energy from a Nd/glass laser (with about 100-ps pulses) along a 2-mm-length section. The fully ionized material picks up one electron in the n=4 or 5 level, which causes the population inversion by cascading down, via radiation and collision processes, and leading to a bottleneck at the n=3 level, since the 2$\longrightarrow$1 radiative decay has the highest transition probability. Thus, the lasing occurs as a 3$\longrightarrow$2 transition of the hydrogen-like carbon ion C VI. It should be noted that at most 25 percent recombination takes place because some of the sample blows up. The experiment used an axial and transverse spectrograph to simultaneously measure the spontaneous and amplified stimulated emission. The researchers were surprised to find that the measured plasma parameters depended only very weakly on the fiber diameter and that 4 μm was as good as the calculated ideal 1.5 μm. Later they transferred their work to the VULCAN laser at RAL (*ESN* 39-5:209-211 [1985]), where they used a four-beam illumination of the visible (green)

μm wavelength (rather than at the ious 1.05-μm infrared).

Among other things, these experi- s at ultrahigh energies elucidated physics of their previous findings. example, it was inferred that the tive independence of the plasma on fiber width can be explained by nplete burn of the fiber. They also rtained that the partial heating of fiber has several merits. For exam- it allows tolerance against focal t variations and reduces refraction he beam out of the region of action. ently they are increasing the length he illuminated fiber section to 1 cm are having some difficulties with sing. Also, computer calculations est that the conditions of plasma tion have not been optimal so far. ddition, they feel that, in a sense, ran out of laser power. Thus, their is now somewhat in limbo. While ing for the updated VULCAN to become y operational, they are now perform- improved computer modeling. They furthermore, switching from carbon ments to thin aluminum foils. ing calculations for hydrogen-like tra indicate that with such foils 10-ps irradiation pulses, signifi- gain should be obtained at 39 ang- ms. In any case, they strongly be- e that the H-type recombination work more promise (because of more rable scaling laws) than the Ne-type tra relevant for the Livermore work selenium.

mer and Metal Vapor Lasers

Dr. H.J. Baker and associates are erned with improving and building kinds of visible and ultraviolet rs.

In the area of KrF, XeF, and XeCl r research, he investigates fast harge and electron beam pumping niques. Very short pulse magnetic ching has been experimented with essfully, especially with XeCl rs. These excimers can now be used, Raman shifting techniques, for the acement of the famed blue-green HgBr r. Regarding the latter, Baker also interesting progress: by extensive ies of recombination processes he eeded in miniaturizing HgBr lasers.

Additional work has been started to lop Cd and Se ion lasers with out- in the milliwatt region. This work ows closely similar efforts at the ow State University.

e Laser and Photodetector Diode lopment

Interestingly, this work in Dr. Thomas's study group grew from remote sensing research in the atmosphere. When high pressure, continuously tunable, infrared (IR) CO_2 lasers replaced the visible dye laser beam sources, the need for high efficiency tunable IR lasers as local oscillators in heterodyne detection systems, with efficiencies approaching the quantum limit, became a strong motivation for new developments. This led to the development of laser diodes based on the lead salts PbSSe, PbSnTe, and PbSnSe. Whereas pure PbS operates at 4 μm, the combinations listed above can be tuned between 4 and 30 μm. This is done primarily by composition tuning, but considerable fine tuning can be achieved either by pressure or by temperature control. The latter is effected either by a sophisticated heat source-heat sink arrangement or by adjustment of the Joule heat effect of a current. The problem is tricky because the lead-salt diodes operate only below 77°K (He cooling is needed), and therefore fine tuning demands controlling accuracy as sharp as 2 mK°. Apart from using these devices in the heterodyne receivers for which they were originally developed, Thomas aims also for applications in ultra-high-precision spectroscopy. For this work, extremely narrow band-width must be achieved.

In their support of the heterodyne receiver program, the research group also developed high-speed CdHgTe photovoltaic diodes. (The ion implantation procedures needed for this work were developed in cooperation with the Physics Department.) With these and other experimental detectors they can now cover the entire 2- to 20-μm range. They also experiment with small linear detector arrays. Future work is planned in the area of thermal imaging.

It speaks for the high quality of the work done in this group that they not only fabricate the laser diodes and diode detectors but also successfully market them for industrial clients.

High-Power CO_2 Laser Development

As in many other centers where industrial applications are of interest, development of different high-power gas laser systems is a serious concern at Hull. I only review two subareas.

Pulsed CO_2 Lasers. The laser group developed a variety of pulsed transverse electric atmospheric (TEA) lasers, operating at 10 μm, and varying from ultrasmall wave-guide systems to a large electron beam sustained facility which can generate 20-GW pulses with 1-kJ total energy. Discharge excitation techniques for both atmospheric and very high pressure (15 atm) operation are currently under investigation. The

latter would permit continuously tunable output in the 9- to 11-μm range. Temporal output control, using electro-optic switching, and injection mode locking are being successfully investigated. Applications vary from materials processing through photochemistry to interesting optoacoustic spectroscopy using continuously tunable devices.

One experiment in this area, currently nearing completion, deserves special mention. Dr. P.E. Dyer and his colleagues have used a short-pulse, low-energy, x-ray point source to axially pre-ionize high-pressure, transverse, electric CO_2 laser discharges. By using thin Al or Si plates (which act as x-ray transmissive windows) and IR reflective mirrors, this technique can be easily incorporated into *existing* discharge units. The use of axial, rather than the customary transverse, illumination simplifies the laser design because it eliminates the need for a slot x-ray window in the pressure vessel. Apart from improved uniformity, the absence of UV sparks within the laser enclosure has the further advantage over UV pre-ionization that CO_2 dissociation and the buildup of impurities limiting the lifetime of high-pressure devices is significantly reduced. For a 10-cm^3 device with pressures up to 10 atm and low voltage operation, laser outputs near 0.3 J have been obtained with this method.

CO_2 Wave-Guide Lasers and RF Excitation. Because of the very compact and simple nature of these systems which allow continuous tuning over a wide range at powers of several watts, these devices attract considerable interest. One of the important problems is to find simple constructions, ease of modulation, and efficient discharge excitation. Dr. D.R. Hall believes that these goals can be best achieved using radio frequency field discharge as opposed to DC gas discharge for excitation of such lasers. He points out that in Europe his group is the only one working along these lines. (It is known that work of this nature is done in the USSR.) In his experiments he showed that, in a sealed gas device, radio-frequency (RF) excitation leads to 18-percent direct electric energy conversion, which is twice as high as for DC discharge operation. The overall goal is to optimize performance characteristics of molecular gas lasers (primarily, but not exclusively, of CO_2 wave-guide lasers). Researchers are investigating high- and low-current discharge modes, each in a different range of frequency, pressure, and electrode separation. It also appears that variations in the RF discharge excitation procedures can affect the laser frequency. This is a side effect of which one may take good advantage.

One practical outcome of the optimization studies was the development of an extremely compact CO_2 wave-guide laser: it is only 20-cm long and has a 10-W power output. Numerous medical, space, and industrial applications suggest themselves.

Apart from applications to laser excitation, Hall and colleagues also do more basic RF discharge physics research. These can be quite difficult, especially if one deals with gas mixtures. One of the latest studies of Drs. Hall and P. Vidaud considers, for example, the effect of xenon on the electron temperatures of RF discharge CO_2 laser gas mixtures. They used a $CO_2/N_2/He$ mixture, added Xe, and found that this causes a considerable lowering of the electron temperature. They suggest several different and cooperating mechanisms of explanation.

Laser Machining and Direct Etching

One of the many laser applications at Hull involves laser machining and direct etching of films. Laser machining of thin metal films is of considerable interest in relation to microelectronics component fabrication and mask manufacture. The Hull laser group is versatile, as shown by the fact that the researchers are working in this field. Dyer and associates used a XeCl laser to demonstrate that thin metal films can be patterned in this manner on a single-shot basis with very low removal thresholds. They observed that the threshold falls well below the complete vaporization curve and that removal appears to correspond more closely with the melt phase. The researchers are sure that pattern generation with submicron resolution appears possible, using the laser in a projection lithography mode. They are now working on evaluating the ultimate attainable resolution.

A related work of the same group concerns the direct etching of polymeric materials using a XeCl laser at 308 nm. Similar experiments have been carried out previously, including work at the Rutherford Appleton Central Laser Facility, and led to a theoretical controversy: Is the phenomenon of removing molecular layers a photochemical or a thermal (melting-evaporating) effect? The Hull researchers, while keeping a low profile (no pun intended), feel that they have strong evidence that favors thermal degradation rather than direct bond braking as the mechanism responsible for significant material removal above a threshold fluence. For if bond braking

were dominant, then the interaction should be characterized in terms of the cumulative dose applied to the film, which was not the case. In addition, measurements of the temperature rise in 50-μm-thick films using a miniature thermocouple (12-μm wire diameter) directly contacted to the back of the film revealed that, within an experimental error of ±15 percent, all absorbed energy appeared as heat when the film was irradiated at below the threshold fluence; a decrease in thermal loading occured above threshold due to the ejection of energetic material.

Summary

In summary, the laser group at Hull, despite its apparent geographical isolation, is well and alive and continues striving for sustained international recognition.

1/3/85

Space Sciences

EUROPEAN SPACE AGENCY'S FIRST CORNERSTONE

by Norman F. Ness. Dr. Ness was until June the Liaison Scientist for Space Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is Chief, Laboratory for Extraterrestrial Physics, Goddard Space Flight Center, NASA.

The European Space Agency (ESA) has recently developed a long-term plan for scientific missions (see *ESN* 39-4:169-173 [1985]). In order to enable the interested scientific community to consider its response to the challenge offered by the survey committee's report, *Space Science--Horizon 2000*, an ESA workshop, Future Missions in Solar, Heliospheric, and Space Plasma Physics, was held at Garmisch-Partenkirchen, West Germany, from April 30 through May 3. Since this disciplinary area represents the initial cornerstone of future mission sequences for ESA, it is critically important for ESA and its member states to determine the manner in which these missions will be implemented. Of special relevance to the workshop were the CLUSTER and SOHO projects, which have been under study by ESA. It should be noted that in collaboration with the US National Aeronautics and Space Administration (NASA), ESA has proposed that both SOHO and CLUSTER form a portion of the International Solar Terrestrial Physics (ISTP) program.

Workshop Background

The workshop was very well attended by both European and US scientists and consisted of invited review papers in morning sessions followed by four separate working group discussions in the afternoons. Both the invited papers and the working group discussions were structured according to the following themes: (1) solar-planetary plasma interactions, (2) origin of the solar wind, (3) small-scale plasma structures, and (4) internal structure of the Sun. The invited speakers were asked to emphasize cross-fertilization between the several disciplines, as well as relevance of the *in situ* or remote sensing observations to other astrophysical systems. Cochairmen of the program committee were Dr. G. Harendel from the Max Planck Institute for Extraterrestrial Physics in Garching and Dr. M.C.E. Huber of the Institute for Astronomy, ETH-Zentrum, Zurich, Switzerland. Representing ESA was Dr. George P. Haskell and for the Max Planck Institute for Extraterrestrial Physics was Dr. W. Baumjohann. The four working groups were chaired by, respectively, A. Gabriel and R. Schwenn, B. Hultqvist and B. Paschmann, D. Southwood and J. Stenflo, and C. Frolich and D. Googh.

The invited papers of the four morning sessions included the following presentations: In session one, on origin of the solar wind, E. Leer presented "Coronal Hole Models and the Solar Wind"; E. Marsch, "Energy Input Into the Solar Wind"; D. Sime, "Corona and Interplanetary Medium During the Solar Cycle"; and J. Geiss, "Diagnostics of Corona by *in situ* Composition Measurements at 1 AU." In session two, on solar planetary interactions, Bengt Sonnerup presented "Solar Wind Interaction With Planetary Magnetic Fields"; W.H. Ip, "Solar Wind Interaction With Neutral Atmosphere"; V. Formisano, "Shock Waves in Space and in Astrophysics"; K. Schindler, "Plasmoids and Planetary Magnetic Fields in the Solar Corona"; and C.G. Falthammar, "Magnetosphere-Ionosphere Coupling." In session three, on small-scale plasma structure, E. Priest presented "Small Scale Reconnection"; A. Roux, "Generation of Field Aligned Current Structures"; C. Jordan, "High Resolution Observations of Magnetic Structures"; J. Heyvaerts, "Small

Scale Structures on the Sun"; and D. Montgomery, "MHD Turbulence." In the final session, on internal structure of the Sun, D. Gough presented "Theory of Solar Oscillations"; J. Harvey, "High Resolution Helioseismology"; E. Fossat, "Global Oscillations"; and, F. Praderie, "Solar Stellar Connections."

The research papers presented at this symposium will be collected into an ESA special publication and will be available from the ESA Publication Office, 18-20 rue Mario Nikis, Paris CEDEX 15, France.

CLUSTER

The CLUSTER spacecraft mission is a constellation of four spacecraft with suitable instrumentation to make comprehensive measurements of plasma particles in electromagnetic fields. Their orbits are designed to take them through the most interesting regions of the Earth's environments, such as the bow shock, dayside cusps, mid-latitude dayside cusp, and the magnetotail. The primary scientific objective of CLUSTER is to study small-scale structures ranging from a few to a few tens of ion gyroradii, which are believed to be fundamental in determining the behavior of key interaction processes of astrophysical plasmas.

The Earth's magnetosphere and the regions where it interacts with the solar wind form the closest and most accessible environment in which these processes can be studied *in situ*. The specific regions of the Earth's magnetosphere where the objectives will be studied are as follows: (1) the physics of boundary regions between two astrophysical plasmas, including plasma processes which transfer mass, momentum, and energy across a boundary (dayside magnetopause); (2) magnetic reconnection at such boundaries and in the plasma sheet imbedded in the Earth's magnetic tail, together with the associated plasma acceleration and large-scale reconfiguration of plasma and electric fields (dayside magnetopause and magnetotail); (3) magnetohydrodynamic turbulence, vortex formation, and eddy diffusion (cusp and entry layer); (4) structure of collisionless shock waves, particle acceleration, and wave generation (bow shock and interplanetary shocks); and (5) microstructure of plasmas and fields in the solar wind.

The instruments required to achieve these goals were presented as a "strawman" payload with respect to both instrument capabilities and resource requirements. Two payload versions are currently under consideration during the first phase of the study: (1) the baseline payload, which is part of a purely European mission using the Ariane launch vehicle; and (2) an expanded payload if CLUSTER is supported as a collaborative mission within NASA as part of the International Solar Terrestrial Physics program. For this, either the US space shuttle or ESA's Ariane is foreseen as the launch vehicle. The second payload version essentially contains the same but upgraded experiments as the first configuration as well as including a wide-band analogue data link experiment and one additional two-dimensional plasma analyzer.

The individual orbits have been selected so that they yield a three-dimensional configuration--i.e., a tetrahedron of the four spacecraft, throughout all regions of space to be studied, as mentioned earlier. The orbits are principally polar elliptical with apogee and perigee at 20 and 3 Earth radii, respectively. Since the associated separation distances vary over the orbit, as well as the mission, it is presently hoped that they will match the scale length of the regions to be investigated. The CLUSTER mission concept is being studied by two consortia. The prime contractors are Messerschmitt-Bölkow-Blohm, West Germany, and SAAB Scania, Sweden.

SOHO

The Solar and Heliospheric Observatory (SOHO) mission represents an amalgam of several earlier ESA mission concepts, and in particular its heritage is most directly from the DISCO project. SOHO would be placed near the Sun-Earth lagrangian point in heliocentric orbit. SOHO has as its primary role an investigation of helioseismology. This recently developing field for probing the solar interior has thus far depended on ground-based observations, including unique studies from observatories at the south pole in a joint French-US effort. But as is the case for studying periodic behavior or the spectra of all phenomena, a longer baseline is essential. In this case, that corresponds to more extended periods of observation and hence the need for observations from space. One unique aspect of the SOHO project is that it depends critically upon contributions of US scientists with specific instruments, such as a solar coronagraph, in order to study certain problem areas. ESA provides funds for only the spacecraft and launch vehicle but not the scientific instruments. Without expertise in any ESA member state, the implication is that there will be no funding for such instruments within ESA.

Future Action Items for ESA

At the end of 1985, ESA must decide which of these two missions it will go forward with--or both! The director general of ESA, Dr. Reimer Lust, attended the workshop; in his presentation he emphasized that in the current planning, are necessity NASA participation and significant contributions if ESA is to conduct both SOHO and CLUSTER as presently configured.

A third ESA mission possibility is the Kepler Mars Orbiter planetary science spacecraft. The ESA decision between SOHO-CLUSTER and Kepler depends heavily upon NASA's ability to commit its support to either or both SOHO and CLUSTER. Recalling that within the past few years NASA unilaterally canceled the US spacecraft in the dual-spacecraft International Solar Polar Mission, ESA is wary of the credibility of the US in these matters.

As reported in connection with the manned space flight program (*ESN* 39-1: 26-28[1985]), the European community is aiming at a more autonomous role in space research. Thus, it can be expected that ESA may simply decide to do a first-class job on one or two of these three missions, independent of US posturing regarding cooperation and participation. In his closing remarks, Dr. Roger Bonnet, the scientific director of ESA, warned the assembly that any approved program will have to be cost-controlled within a limit of 400 million accounting units (1 accounting unit = $0.90).

5/15/85

News and Notes

SYNTHETIC APERTURE RADAR STUDIES IN NORWAY

A very active effort to develop both the technology and software for processing data obtained by satellite synthetic aperture radar (SAR) systems for maritime studies is under way at the Norwegian Defence Research Establishment (NDRE), Kjeller, Norway. In addition to the development of special mathematical algorithms for digital processing of SAR data, the NDRE is in the process of designing and having fabricated by US sources the necessary very-large-scale-integration chips for vector oriented processing computer systems. This multiprocessor for image processing of SAR data will be used in the routine analysis of data obtained at the Tromsö ground station from the Canadian RADARSAT as well as the European Space Agency's Earth Resources Satellite 1. A special analytical technique called autofocusing has been developed (by Einar-Arne Herland) to treat the problems of ambiguity of SAR data without the requirement for extremely accurate information on the satellite orbit and orientation. This will enable Norwegian researchers to process data in near-real time without the delays presently accompanying the determination of definitive orbit and spacecraft attitude information. Further information on the SAR implementation can be obtained from Oddvar Sorasen at the Norwegian Defense Research Establishment, Division of Electronics, N-2007 Kjeller, Norway.

Norman F. Ness
5/22/85

ONE GROWTH AREA IN UK SCIENCE: THE BRITISH ANTARCTIC SURVEY

In spite of continued financial cuts for funding scientific activities by both the Science and Engineering Research Council and the National Environment Research Council (NERC), the NERC's British Antarctic Survey (BAS) has seen a substantial increase during the past several years. This is, in part, a direct result of the Falkland Islands crisis and the desire of the UK government to establish a more visible and operationally successful presence in the South Atlantic and Antarctic regions.

The BAS is responsible for British scientific research in the British Antarctic Territory and Falkland Island Dependencies. At the present time, over 100 permanent staff and 150 contract staff members are employed in the UK at the BAS facilities in Cambridge. The increase in financial support through the Department of Education and Science was made primarily to support an increase in Antarctic programs in the earth sciences and marine life sciences. These are two of the operating divisions of the BAS. The financial increase has gone mainly to staffing these two divisions with new appointments. The third division, atmospheric sciences, has not shared in the recent growth.

The BAS operates two research vessels with a total complement of more than 75 crew members, *RRS John Disco* and *RRS Bransfield*. In addition, the BAS has operated five permanently manned stations at Bird Island, South Georgia; Faraday, Argentine Islands; Halley, Coats Land; Rothera, Adelaide Island and Signy, South Orkney Islands. Satellite communications via INMARSAT now link four of these stations and the two ships with the Cambridge headquarters, enabling direct transmission of scientific data between computers at Halley and Cambridge.

The Division of Atmospheric Sciences is headed by Dr. Michael Rycroft and conducts research in the following general areas: solar terrestrial physics with emphasis upon whistler mode radio signal studies, magnetospheric pulsations, ionospheric physics, and geomagnetism. Research in the general area of the neutral atmosphere emphasizes the meteorology and climatology, chemistry, radiation, and dynamics of the atmosphere.

The Earth Sciences Division is headed by Dr. C.W.M. Swithinbank and conducts research in the areas of geology with emphasis upon magmatic arc studies, sedimentology, biostratigraphy, and the tectonic history of lesser Antarctica; the division also has as an active field geophysics program during the summers. In addition, marine geophysics, glaciology and glacier geophysics, and chemistry are active areas of investigation.

The Life Sciences Division is headed by Mr. W.M. Bonner and emphasizes in particular the offshore biological environment, such as a very special study on krill and fish, as well as more general physiological and biochemical topics. In addition, bird and seal studies were conducted on Bird Island, while in the area of terrestrial biology, invertebrates and plants are under study and freshwater medical research is done. BAS has been active in investigating not only the influence and special features of the environment on animal life but also the effects on humans under extreme environmental conditions.

Throughout the research conducted by BAS, a very active collaborative effort is made with university groups within the UK and worldwide. Scientific results of the survey's work are supplied to various world data centers and published in the *British Antarctic Survey Scientific Reports* and the *British Antarctic Survey Bulletins*. These are available from BAS at High Cross, Madingley Road, Cambridge CB3 0ET. In addition, scientists contribute professional papers to the corresponding specialist journals in their area of activity. The increased funding and the newly completed airport and facilities in the Falkland Islands will considerably enhance the productivity of the BAS in its activities.

Norman F. Ness
5/22/85

APPLIED IT IN WEST GERMANY

The Gesellschaft für Mathematik und Datenverarbeitung (GMD, or National Research Institute for Applied Information Technology) is in Schloss Birlinghoven near Bonn. It is owned and funded by West Germany and the State of North Rhine-Westphalia. Besides its headquarters location, there is a branch in Darmstadt, and there are two research groups in Berlin and Karlsruhe. The institute was founded in 1968 and now has a staff of about 700, of whom about 300 are scientists.

The three research institutes composing GMD are the Institute for Foundations of Information Technology, the Institute for Systems Technology, and the Institute for Applied Information Technology. In addition, there are two service institutes: the Institute for Computational Infrastructures and the Institute for Technology Transfer.

Institute for Foundations of Information Technology

The central function of this institute is the creation and development of the foundations of information technology by means of research in mathematics and computer science. The four research areas of this institute are distributed systems and procedures, processing mechanisms for symbolic data, multigrid concepts, numerical mathematics, and statistics for information technology.

Institute for Systems Technology

The subject of the Institute for Systems Technology is the methodology of the systems integration task--involving processor, storage, and transmission--and the objective is to provide developers of information systems with architectural models, construction tools, and proper basic system services for their construction work.

This institute has six divisions: Computer Architectures, Systems Engineering, Communications Technology, Program Structures (located at Karlsruhe),

Innovative Computer Systems and Technology (in Berlin), and Very Large Scale Integration (VLSI).

The newly created research groups at Karlsruhe and Berlin and the VLSI working group joined the institute at the end of 1983 and the beginning of 1984.

Several specific projects under development are the following: (1) system support for fault-tolerant application programming in distributed systems, (2) application-independent machine bases for manipulating and processing information in the office and administration sector, and (3) development system for vertically integrated VLSI components.

Institute for Applied Information Technology

This institute supports office and administrative work. Its primary research activities are directed toward office information systems, decision support systems, and expert systems. Problems in this field include knowledge basing of tools and systems, support of solutions for distributed problems, man-machine communication, and tapping new functions.

Institute for Computational Infrastructure

This institute deals with the integration of information technology components into an organization. The institute is divided into four research devisions: Integrated System Concepts, Universal Systems, Special and Laboratory Systems, and Technical Communications Infrastructure.

The Institute for Technology Transfer

This institute is engaged in developing, organizing, and promoting the exchange of information and products between GMD and its target groups. The four divisions of this institute are product transfer, knowledge transfer, market information transfer, and transfer of rules and standards.

J.F. Blackburn
5/19/85

COGNITION, MOTIVATION, AND INFORMATION PROCESSING

A new development in European psychology is aiming at an integration of research on motivation, emotion, cognition, and information processing. A network of researchers has sprung up from initial discussions held at the International Congress of Psychology, Acapulco, Mexico, in 1984. A follow-up session was included in the program of the Eastern Psychological Association meeting held in Boston from 21 through 24 March 1985. The aim is now to develop this network of active researchers into a more formal and permanent channel of communication for research and theory in this area. For information, write to Professor Vernon Hamilton, Department of Psychology, University of Reading, Building 3, Earley Gate, Whiteknights, Reading RG6 2AL, UK.

Richard E. Snow
5/8/85

IMPACT OF NEW TECHNOLOGY IN IRELAND

A previous article (*ESN* 39-5:179-183 [1985]) reported the results of surveys of the impact on education and industry of new information technology in France, Sweden, and West Germany. A new report on this topic as seen in the Republic of Ireland has now come to light. It is Healy, M., "The Impact of New Technology on Industry and Education," Occasional Paper Series No. 82/2, Economic and Social Division, National Board for Science and Technology, Shelbourne House, Shelbourne Road, Dublin 4, Ireland. The report covers recent surveys of the present situation in various levels of the Irish economy, with discussion of the challenges to education in the future.

Richard E. Snow
5/8/85

HVS IMAGE ANALYZERS IN PSYCHOLOGICAL RESEARCH

The HVS Image Analyzer is a computer system designed to fit video cameras and recorders of both European and US standards and to interface several kinds of microcomputers. It tracks video images at rates up to 50 measurements per second, and can give measures of target location, multiple target activity, horizontal and vertical distances, and area. Several different kinds of these units for different specialized applications are available. Applications

already pursued include the tracking of animals, fish, and insects in experimental and open-field environments, hand and limb movements, eye movement and pupil diameter monitoring, and helicopter, minisub, and other vehicle handling. For more information contact Richard Baker, HVS Image Analysing, 22 Cromwell Road, Kingston KT2 6RE, UK.

Richard E. Snow
5/8/85

SOCIETY FOR TEST ANXIETY RESEARCH

The Society for Test Anxiety Research is a network of US and European psychologists studying many aspects of anxiety and stress, though its main focus is test anxiety. It held its sixth international conference in Düsseldorf from 13 through 15 June. The organizer for this meeting was Professor Dr. Christine Schwarzer, Institut für Erziehungswissenschaft II, Universität Düsseldorf, D-4000 Düsseldorf, West Germany.

Substantial reviews of previous work by members of this group are available in English in a series titled "Advances in Test Anxiety Research" published by Swets and Zeitlinger B.V., Lisse, The Netherlands, and Lawrence Erlbaum Associates, Inc., Hillsdale, New Jersey. Volume 1 (1982) was edited by R. Schwarzer, H.M. van der Ploeg, and C.D. Spielberger. Volume 2 (1983) and volume 3 (1984) were edited by van der Ploeg, Schwarzer, and Spielberger.

Richard E. Snow
5/8/85

EUROPEAN ANNUAL CONFERENCE ON HUMAN DECISION MAKING AND MANUAL CONTROL

The Fifth European Annual Conference on Human Decision Making and Manual Control was held in Berlin from 3 through 5 June. Presentations were organized into five sessions; some notable topics within each are identified here. Session 1, Transport, included papers on peripheral visual signals and reaction time, eye movement and scanning strategy analysis in pursuit tracking, models of helmsmen during course-keeping, simulation studies of crew operation in container ships, and evaluations of workload in engine control, high-speed driving, and aircraft piloting. Session 2, Industrial Process Control, included papers on human and computer reliability, human-computer communication, and manual remote control of manipulations in space. Session 3, Man-Computer Interaction, featured papers on expert versus novice comprehension of complex computer programs, interactive graphic systems for interface design, and relations between structure and representation in interface use. Session 4, Problem Solving, focused on knowledge-based systems, interactive graphics, and management as factors in expert decision making. Session 5, Human Performance Modeling, included work on models of driver dynamics, control in complex systems, brain signals, tracking in weapon systems, stability in closed-loop control tasks, and control room operation. A final discussion session reviewed the results of the workshop.

For information regarding particular papers and proceedings, write to: Professor Dr. H-P Willumeit, Institut für Fahrzeugtechnik, Technische Universität Berlin, Strasse des 17 Juni 135, D-1000 Berlin 12, West Germany.

Richard E. Snow
5/8/85

NONCONVENTIONAL IMAGING DEVELOPED AT JERUSALEM

Various concepts and architectures are used for imaging systems and image manipulation. Various pros and cons are associated with the different solutions. For battlefield applications, one important need is manipulation in real time by processing the electrical signal. This requirement is connected with the ease with which Fourier-type algorithms can be applied to the image. One excellent approach toward this goal is offered by a method based on frequency multiplexing. Surprisingly, the idea was put forward as early as 1925 (in an obscure British patent), but for more than half a century there was no advanced theory and technology available to develop the concept and realize it technically. Recently Israeli scientists at the Applied Physics Division, Graduate School of Applied Science and Technology, The Hebrew University of Jerusalem, established the detailed theory and conducted an experimental demonstration of an incoherent imaging system based on frequency multiplexing.

Professor N. Ben-Yosef and Dr. G. Sirat showed how, by modulating each image pixel at a different temporal frequency, the entire image is converted into an electrical signal by using a single detector. In this way, the spatial information of the original image is mapped into the frequency domain of an electrical signal. They showed that a one-to-one relation exists between the spatial frequency domain and the time domain, and that there is also a one-to-one relationship between the spatial domain and the temporal frequency domains. This mapping then allows one to perform spatial frequency manipulations in real time, by processing the electrical signal.

The multiplexing was obtained by using a two-dimensional array of piezoelectric/elasto-optic light modulators. By using these two physical effects jointly, one uses the resonance characteristics of the piezoelectric oscillator, while at the same time one takes advantage of the excellent modulating properties of the elasto-optic effect. Indeed, the resonant electro-optic effect has a very high quality factor ($Q \sim 10^5$), thus allowing an excellent frequency definition ($\Delta\nu \sim 20$Hz) and unusually low operating voltages ($V \sim 1$ volt). The modulating matrix construction is based on well-known and precise technology--namely, accurate metal coating.

The scientists analyzed and demonstrated experimentally the way in which the matrix of piezoelectric/elasto-optic modulators performs as a space-to-frequency converter and maps the two-dimensional spatial Fourier transform into the temporal domain. They pointed out that the main advantage of the arrangement is the possibility to implement in the device two complementary functions: imaging and image manipulation.

Actually, two schemes of practical realization were presented and studied. The first consists of two one-dimensional arrays, each composed of discrete crystals. Here the two arrays are arranged as two crossed stacks of rectangular crystals. A more exciting, very compact approach to realization of the modulator that Ben-Yosef and Sirat proposed (and studied experimentally to some extent) is a monolithic system, where a one-dimensional array is formed as a piezoelectric wafer in which localized resonant domains are constructed. In this approach the number of tuned crystals needed is smaller, and the tuning of each is more effective.

This novel realization appears to me especially interesting for military imaging tasks; and therefore, to conclude this note, I attempt a brief description of the underlying physical phenomena.

A crystal plate has a thickness-shear mode whose resonant frequency is dependent on plate thickness. If the plate surface is coated by a thin film of material, the resonant frequency will be lowered (frequency shift due to loading of a harmonic oscillator). In the case where only a small area of the plate surface is coated, the wave equation for the thickness-shear mode will be different for the perturbed and unperturbed regions. For frequencies between the resonant frequencies of the loaded and unloaded plates the wave number is real in the perturbed region and complex in the unperturbed one--i.e., for these frequencies, the amplitude of mechanical vibration oscillates in the perturbed region and decays exponentially outside it. (This oscillation and the decay is, of course, in space rather than in time.) Oscillations at these frequencies are called trapped modes since they are spatially confined to the coated region. This phenomenon was described 20 years ago, but little use was made of it until recently.

Now, employing a crystal plate that is coated differently in different regions, one will have a plate which can sustain mechanical vibrations with different frequencies at different positions. Therefore, if the crystal has nonvanishing elasto-optic coefficients, one will obtain a transmitting plate that will modulate the light at different frequencies over this surface.

Preliminary results with modified grate plates showed favorable response and verified the accuracy of the analytic calculations.

Paul Roman
4/8/85

SIEMENS DEVELOPS POWERFUL FIBER-OPTICS COMMUNICATION SYSTEM

Siemens AG, one of the biggest and oldest European electrical/electronic engineering firms, has developed a data-transmission system in which both 565 Mb/s and two 140 Mb/s signals are simultaneously transmitted over a distance of 36 km, without the use of repeaters. Expressed in terms of audio channels, this corresponds to a capacity of 19,000 channels.

This feat was achieved by wavelength multiplexing, using four wavelengths in the range 1.3 to 1.5 μm. Crucial to this process was, of course, the use of the famous third glass-fiber window at 1.5 μm, employing a monomode transmission mode. In addition, Siemens has developed efficient high-power semiconductor lasers for these longer wavelengths (see *ESN* 39-4:162-165 [1985]), as well as other optoelectronic devices, including optical filters for the separation of several wavelengths.

The system was commissioned by the West German Bundespost and applied in a demonstration project called "Berlin IV." The success of the experiment shows that monomode fibers and up-to-date optical transmission techniques have reached maturity and allow for an economical application of this technology both for broadband and narrowband signal transmission, at all commercial stages, from large-scale distribution networks down to subscriber connections.

Paul Roman
5/1/85

A NEW INTERNATIONAL JOURNAL DEVOTED TO OPTICAL SENSORS

The proliferation of special-purpose scientific journals continues, despite the oppressive fiscal atmosphere that bedevils academia.

Enthusiastic scientists in Europe have started publishing the *International Journal of Optical Sensors*, which, because of its special orientation, may be of much interest to US Navy scientists and engineers.

As laser science celebrates its 25th birthday, and remarkable progress in optics and electronics leads to advanced optoelectronics, efficient optical communication has become a reality. But the enormous quantities of information that can be handled by optical communications systems have made new demands on the speed and accuracy with which the information can be collected and controlled, and this, in turn, has given rise to rapidly increasing interest in optical methods of measurement and interpretation--in optical sensors and optical signal processing. In addition to their speed of operation, optical sensors have many other advantages: immunity from electromagnetic interference, use of dielectric materials, no moving parts, intrinsic safety in hazardous environments, remote measurement, and ease of multiplexing.

The new bimonthly journal is dedicated to all aspects of the technology of optical sensors, including theoretical principles, signal processing, materials science, device fabrication, packaging, systems design, industrial and research applications, and operational economics. Both original publications and review articles will be accepted and rapid publication is being promised. Good news: no page charges will be levied.

Manuscripts should be sent to The Editors, c/o Department of Physics, King's College, London, WC2R 2LS, UK. Subscriptions can be filed with Newman-Hemisphere, 10 Bywater Street, London SW3. The cost of six issues is $100, which includes postage.

Currently, the chief editors are Professors A.J. Rogers (UK) and R.J. Weiss (US). The advisory board consists of 20 scientists, including two Americans.

Paul Roman
5/3/85

EIGHTH COLLOQUIUM ON MICROWAVE COMMUNICATION

The Union de Radio Scientifique Internationale (URSI) and the Hungarian Academy of Sciences are joining together to sponsor the Eighth Colloquium on Microwave Communication (8th MICROCOLL) in Budapest, Hungary, from 25 to 29 August 1986. This colloquium, which will be held concomitant with the 1986 URSI International Symposium on Electromagnetic Theory (see below), will deal with theoretical and practical aspects of systems and circuits with emphasis on microwave communication based on information theory, network theory, and computer-aided design. The program will include the following main topics:

- Trends in communication systems
- Informatics and signal processing
- Network theory and computer-aided design
- Microwave circuits and devices

Those wishing to present papers are requested to submit four copies of a 500-word synopsis (or the full proposed text) for evaluation by reviewing members of the international organizing committee before 15 October 1985. This and other requests for information should be sent to: Secretariat of the 8th MICROCOLL, H-1525 Budapest, 114, POB 15, Hungary. Telex: 22-4338.

Thomas C. Rozzell
5/21/85

URSI INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC THEORY

Budapest, Hungary, will be the site of the Union de Radio Scientifique Internationale (URSI) International Symposium on Electromagnetic Theory, to be held from 25 to 29 August 1986. The symposium will be devoted to all aspects of electromagnetic fields and waves, with papers to be given under the following topics:

- Field analysis and numerical methods
- Scattering and diffraction
- Antennas
- Guided waves (wave guides, open structures, etc.)
- Transient phenomena
- Random media
- Inverse scattering
- Fields in biological media (bioelectromagnetics)

The Technical Program Committee is soliciting original papers describing recent work in selected topics or any other topic related to electromagnetic fields and waves. Authors are requested to submit the title and a 50-line abstract in English before 15 October 1985; send the material to: Chairman, URSI International Symposium, Professor T. Berceli, Research Institute for Telecommunication, 1525 Budapest 114, POB 15, Hungary.

Thomas C. Rozzell
5/21/85

ONRL STAFF CHANGE

In June we welcomed a new liaison scientist, Dr. Tom Warfield; his specialty is underwater acoustics. He comes to us from ONR, Arlington, where he was Deputy Program Manager, Undersea Technology Project.

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.

Inaugural Meeting of the European Society for Cognitive Psychology, Nijmegen, The Netherlands, 9-12 September 1985.

New Technological Applications of Phospholipid Bilayers, Films, and Vesicles, Puerto de la Cruz (Tenerife), Canary Islands, 6-9 January 1986.

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EUROPEAN VISITORS TO THE US SPONSORED BY ONRL

Visitor	Areas of Interest	Organizations to be Visited	Want Information? Contact at ONRL
Dr. George M. Simnett Institut für Astronomie ETH-Zentrum CH-8092 Zurich Switzerland	Solar Physics	NRL (Aug-Sep 85)	Norman F. Ness
CDT Arnold Böhrer Rekruterings on Selectiecentrum Sectie Psychologisch Onderzoek Kazerne Klein Kasteeltje 9de Linielaan 1000 Brussels Belgium	Military Personnel Psychology	NAVPERSRANDCEN Univ. of Minn. ONRHQ (Aug-Oct 85)	Richard E. Snow
Professor Abraham Halperin Racah Institute of Physics The Hebrew University of Jerusalem Israel	Solid State Physics	NRL ONRHQ USA Night Vision Laboratory USA Harry Diamond Laboratory (Sep 85)	Paul Roman

EUROPEAN VISITORS TO THE US SPONSORED BY ONRL (CONT'D)

Visitor	Areas of Interest	Organizations to be Visited	Want Information? Contact at ONRL
. Peter Nenniger minar für Philosophie d Erziehungswissenschaft bert Ludwigs Universität 7800 Freiburg I BR st Germany	Cognitive Psychology of Text Analysis	NPRDC, San Diego (Aug or Sep 85) Univ. of Illinois Carnegie-Mellon Univ. IBM System Research Center (Sep 85) ONRHQ (Oct 85)	Richard E. Snow
olo Mele iversità degli Studi di Roma "La Sapienza" acolta di Ingegneria ipartimento di Idraulica Trasporti e Strade (n 37) ia Eudossiana, 3-00184 Rome taly	Fluid Dynamics	DTNSRDC NRL ONRHQ MIT (Sep 85)	Patrick Leehey

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SCIENCE NEWSBRIEFS FOR MAY AND JUNE

The following issues of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during May and June. *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
3-25	World's Lowest Operating Current Required for New British Semiconductor Laser, by Paul Roman.
3-26	SERC Reviews UK Free Electron Laser, by CAPT M.A. Howard, USN.
3-28	State-of-Charge Meter for Lithium Batteries: A Life and Money Saver, by David L. Venezky.
3-29	New National Research Laboratory Site in Portugal, by CAPT L. Laddie Coburn, USN.
3-30	Electrochemists: Heads-up for Meetings in UK, by David L. Venezky.

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MAY MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during May. 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
43-85	Multi-purpose Horizontal Fan Hovercraft
44-85	Seehecht--New Generation of German Torpedoes
45-85	British RPV for Real-Time Battlefield Surveillance
46-85	Environmental Data Conference
47-85	European Association of Remote Sensing Laboratories
48-85	Geophysical Data Near UK
49-85	German Wind Tunnel Developments/Capabilities at DFVLR Göttingen
50-85	EH-101 Helicopter Development Program
51-85	Royal Navy's Type 23 Frigate
52-85	European Ministers Reach Agreement on EFA Design

L REPORTS

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

1-85 *Space Research in the United Kingdom: An Assessment*, by Norman F. Ness. This report examines the history and funding of UK space research; discusses work in disciplines such as astronomy and astrophysics, solar system studies, and terrestrial studies; and considers prospects for the future.

2-85 *Biotechnology in Sweden*, by Claire Zomzely-Neurath. The enormous potential of biotechnology for wide-scale industrial application has been emphasized recently in Sweden by increased support by government and industry for basic and applied research. This report examines biotechnology research at the Royal Institute of Technology, Stockholm; the Lund Institute of Technology; and the Chalmers Institute of Technology, Göteborg.

3-85 *Electromagnetic Compatibility Conference Features Biological Interactions*, by Thomas C. Rozzell. The Sixth Symposium and Technical Exhibition on Electromagnetic Compatibility was held in Zurich, Switzerland, in March 1985. This report deals with a session on the interaction between electromagnetic (EM) waves and biological systems. The papers were on topics such as the hazards of EM fields, stationary magnetic fields, therapeutic techniques, microwave power dissipation, and measurement of specific absorption rate.

4-85 *The Second European Conference on Atomic and Molecular Physics*, by Paul Roman. The Second European Conference on Atomic and Molecular Physics was held in Amsterdam, The Netherlands, from 15 through 19 April 1985. This report focuses on presentations dealing with Rydberg systems, clusters, and coherent vacuum ultraviolet and x-ray ultraviolet generation. It also lists the topics of all other fields covered by the meeting.

5-85 *Recent Advances in Rare Earth Chemistry: IREC 85*, by David L. Venezky. IREC 85 was held from 4 through 8 March 1985 in Switzerland. A blend of solid state and solution chemistries was a first for the conference and provided an excellent stage for discussions on the use of rare earths in glasses, ceramics, alloys, and catalysts.

6-85 *AGARD Lecture Series on the Impact of Proposed Radio Frequency Radiation Standards on Military Operations*, by Thomas C. Rozzell. During April 1985, the North Atlantic Treaty Organization's Advisory Group for Aerospace Research and Development (AGARD) held a lecture series dealing with the impact of proposed and existing radio frequency (RF) radiation standards on military operations. This report discusses presentations on specific absorption rate and RF energy, biological effects of RF energy, long-term exposure, accidental exposure, epidemiological studies, power-line frequencies, very-low-frequency to medium-frequency hazards, exposure standards, and measurement problems. The appendix provides background on AGARD and its lecture series.

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