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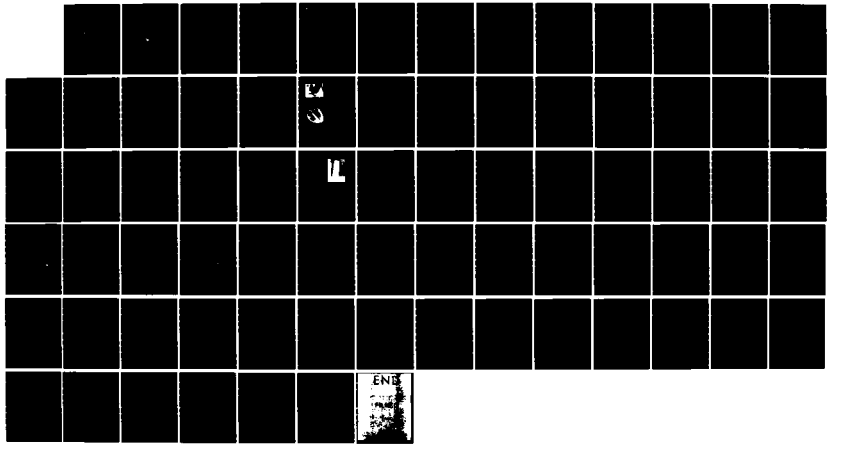

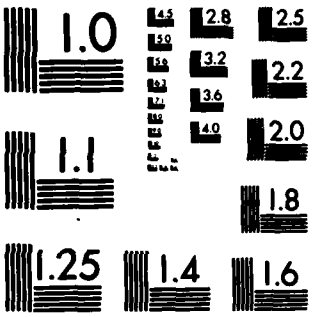

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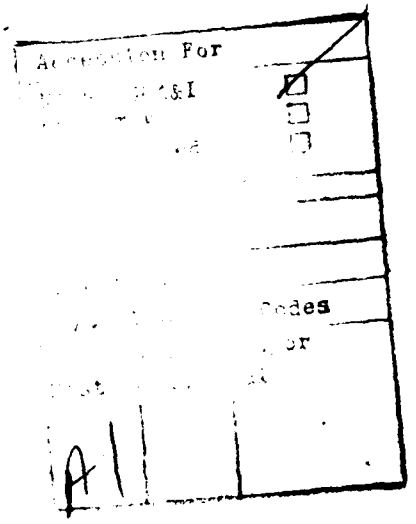

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Commanding Officer ..... CAPT M.A. Howard, USN
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BEHAVIORAL SCIENCES

BIOLOGICAL SCIENCES

COMPUTER SCIENCES

A conference sponsored by The Welding Institute dealt with the effects of residual, impurity, and microalloying elements on weldability and weld properties.

OCEAN SCIENCES

The Elat Mariculture Laboratory of the Israel Institute of Oceanography and Limnology Research is developing a fish-farming industry for Israel. The goal is to create an industry that will contribute to the Israeli economy locally and that will generate foreign currency through fish exports to European markets.

The UK's Permanent Service for Mean Sea Level collects, publishes, and distributes world sea-level data. The organization also analyzes and interprets selected data sets.

PHYSICS

Office of Naval Research, London, technical report R-6-84 reviews chaos concepts and recent experiments in a number of research areas as an introduction to a detailed description of European research investigating chaotic behavior with nonlinear, driven electrical circuits.

SCIENCE POLICY

The Federal Republic of Germany has announced a new research program in informatics--the catch is that there are no new funds for it. Current programs will have to give way.

The priorities of West Germany's Ministry of Research and Technology are discussed.

SPACE SCIENCE

The UK-Solar Maximum Mission Workshop focused on the current knowledge about solar flares and on important questions that need to be answered to improve the understanding of flare processes and mechanisms.

TECHNOLOGY

NEWS & NOTES

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BEHAVIORAL SCIENCES

COGNITION-MOTIVATION INTERACTIONS: EXAMPLES FROM BELGIUM

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 1985 from Stanford University, where he is Professor of Education and Psychology.

US research on achievement motivation has built up, over the past two decades or so, some fairly substantial theory to account for the role of motivation and related personality differences in influencing both cumulative achievement and performance on individual tasks (see, e.g., Atkinson, Lens, and O'Malley, 1976). It has delved also into the effects of personal cognitive attributions about success and failure on motivation and subsequent cognitive performance in particular jobs or tasks, including learning and problem-solving tasks (see, e.g., Weiner, 1974). From these sources also has come the argument that performance on many of the cognitive tasks studied by psychologists in hopes of building a theory of cognition is in reality as much a function of motivational variables as it is of purely cognitive variables; perhaps such performance often reflects motivational phenomena primarily. The argument applies both to paradigmatic laboratory tasks and to practical instruments such as intelligence tests. But it has been largely ignored by cognitive and differential psychologists.

The reasons for ignoring this argument seem clear (though not necessarily justified). Traditional tests and tasks are administered under conditions designed to produce constant motivation across experimental treatments and subjects, though the assumption that they in fact do so is rarely tested. Also, the past two decades have finally seen the emergence of analytic theories concerned primarily with the fine details of information processing in cognitive tasks and tests. In this context, it has been assumed that motivation can be left at an over-arching theoretical level; goals and motives are seen as providing a push to the cognitive system at the start, and perhaps some constant, sustaining level of activation, but not as interacting with the details of processing. Few cognitive psychologists have been willing to complicate their research problem, for the present at least, by introducing the possibility of cognitive-motivational interactions at the level of information processing (Norman, 1980, 1982). Fewer still would think of introducing personality variables that reflect motivational differences among their subjects at a more molar level. Yet it is clear, at least, that bringing cognitive theory to bear on the study of real-world performance will require that it encompass the intervening effects of motivational and personality differences.

There are now some signs of change in US psychology (Glaser and Lompscher, 1982; Snow and Farr, forthcoming). But it will be important as this new thrust builds for US researchers to attend to old and new lines of European research that have never assumed disjunction between the processes of cognition and motivation. One of these lines is pursued by several investigators at the University of Leuven in Belgium.

The father of Belgian research in this field was J.R. Nuttin, whose research on motivation and learning stretches back across many decades (see d'Ydewalle and Lens, 1980). The present brief article cannot review this whole stream. It instead presents a few current examples, mainly to whet US appetites for the full course. A later article will give some further examples, including parallel work in Germany.

One way to bring the broad issue of goals, motives, and values into connection with the study of cognitive functioning is to examine longer range attitudes and perspectives of different individuals in relation to immediate performance. Another way is to study personal expectations about the details of immediate performance requirements. The work of G. d'Ydewalle and W. Lens and their colleagues at the University of Leuven uses these tacks as well as several others.

A study by Van Calster, Lens, and Nuttin (1983), for example, derived from the possibility that some high school students might carry rather bleak attitudes about their own future given today's economic conditions; this could influence their motivation for cognitive achievement more immediately. The main hypothesis tested was that motivation to perform cognitively (e.g., to study in high school) is a function of interaction between the perceived instrumentality of such performance and attitudes about personal future. A related hypothesis predicted that future attitudes

influence academic performance through the mediation of achievement motivation. Data were collected on a large sample of Flemish Belgian high school seniors using questionnaire measures of study motivation (for example: I study on weekends; I work hard even in boring courses); perceived instrumentality of present academic performance for success in future life (for example: Doing well in my senior year is important for my future life; Doing well on exams contributes to my future success); and attitude toward the future (essentially a semantic differential instrument reflecting global affective attitudes plus expectations for control, structure, difficulty, and certainty in the future). Ability and achievement measures were also collected.

The results showed striking disordinal interaction; the correlation of future attitude with study motivation was strongly positive (r = +0.46) among those students scoring high in perceived instrumentality and negative (r = -0.10) among those scoring low in perceived instrumentality. Also, the correlation between future attitude and cognitive achievement was positive (r = +0.20) for students high in perceived instrumentality but negative (r = -0.14) for those low in perceived instrumentality. Both correlation differences were statistically significant and, as predicted, the second contrast was substantially reduced when study motivation was partialled out. The interactions were also demonstrated using contrasts between ability and achievement to reflect cognitive performance differences due to motivation differences. Regression analyses told the same story.

The interpretation is that the motivational effects of perceived instrumentality depend on attitude toward the future: high perceived instrumentality will have a positive effect when attitude is positive, but a negative effect when attitude is negative. The implication follows that inducing a future time perspective about present cognitive performance will increase motivation for persons with positive attitudes toward the future. But reference to the future consequences of present cognitive performance should be avoided for persons holding negative attitudes toward the future.

Lens's studies have also pursued implications of that part of the Atkinson Theory of Achievement Motivation that distinguishes between performance on particular immediate cognitive tasks and cumulative achievement over long time spans: cumulative achievement is expected to be a linear function of performance in particular tasks and strength of motivation, but the relation between strength of motivation and immediate performance itself is expected to be curvilinear (i.e., an inverted U). The curvilinearity results from inefficiency in performance caused by either under- or over-motivation; only optimal motivation for the task at hand will allow true ability to be expressed. Such a curvilinear hypothesis derives from the classical Yerkes-Dodson Law and has been demonstrated in relatively pure forms. Its demonstration in any particular complex situation, however, depends on the difficulty of the task in relation to the ability of the persons studied, and also on the degree to which ego-involving conditions accompany the task (Lens and De Volder, 1980).

Lens (1983) has now considered the academic examination system in Belgium in this context; his analysis suggests that the curvilinear relation should also be obtained here. This situation is complicated because academic performance over a semester or year is a cumulative achievement phenomenon, whereas the final examination requires an immediate cognitive performance; there are few or no intermediate performance tasks in this system. The theory posits that achievement motivation is the result of a combination of need for achievement and fear of failure (i.e., test anxiety in this instance); if either is too high or too low, the resultant achievement motivation will be nonoptimal. In this system, of course, need for achievement might display more cumulative properties, whereas test anxiety might be more connected to the immediate performance requirements of examinations.

The hypothesis was studied using standard measures of need for achievement and test anxiety in a group of Flemish Belgian first-year university students. The essential results are shown in Table 1. The curvilinear trend for both measures is clear. Though only the test-anxiety curve reached statistical significance, Lens's analysis lacked power; more powerful statistics would likely confirm what is apparent to the eye.

The implication is that optimal performance comes from intermediate motivation; too much or too little need for achievement or fear of failure apparently interferes with effective performance. The next step of course is to analyze the kinds of inefficiencies in cognitive processing produced by persons occupying the peripheral cells of Table 1; they need not be the same in each cell.

Table 1

Mean Examination Scores for First-Year College Students as a Function of Test Anxiety and Need for Achievement Scores

Test Anxiety	Need for Achievement: High	Medium	Low	Total
Low	53.5	55.2	50.1	53.1
Medium	58.1	60.3	53.4	57.1
High	50.1	52.6	49.7	50.1
Total	54.1	55.5	51.1	

The research of d'Ydewalle (forthcoming) examines motivation as an intervening variable in the details of cognitive information processing during simple learning tasks. The general hypothesis is that subjects in learning experiments construct, either explicitly or implicitly, a complex mental representation about the task and its requirements; this produces expectations that have motivational effects which in turn will condition methods of processing, uses of cognitive resources, and the learning and coping strategies of the subjects.

To show how expectations of the subjects interact with the presence-absence of details, the availability of a schema, and the nature of the experimental materials to influence performance, d'Ydewalle presents a series of simple experiments on free recall, recognition, text learning, and reproduction tasks In one experiment, for example, free-recall test versus recognition test expectations were induced by instructions for a word-list learning task. Then, half the subjects in each group received a free-recall test whereas half received a recognition test. A second list of words was then learned and followed again by either an expected or an unexpected test. Marked effects of these expectancy variations appeared in the order of the words learned and in primacy and recency effects, suggesting that subjects with different expectations encode lists differently and use working memory differently in the task.

In other experiments, meaningful texts were used instead of word lists, and text scrambling and study time were varied experimentally along with test expectations. It was shown that subjects expecting a reproduction test look more actively at the text structure, and their performance is particularly disrupted by scrambling of text sentences. But subjects expecting multiple-choice tests pay less attention to structure and are less influenced by scrambling. Unexpected reproduction tests cause the subject to try to reconstruct the text structure, but this is possible only with unscrambled texts. Interactions with ability appear--because subjects differ in their ability to detect and reconstruct the structure of the text under different conditions.

The work in Leuven is proceeding at a fast pace. Although it is too early for a precise summary or integration of what is being learned, and way too early for theory construction, one implication is clear. Cognitive theory cannot continue to leave motivational variables out of its information processing models. These variables have potent effects on the details of performance, and these are not just main effects; interactions abound!

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4/16/84

WHAT DO WE KNOW ABOUT QUESTION-ASKING?

by Richard E. Snow.

Questions pervade human behavior. They are essential to communication. They are ubiquitous in education. They are the fundaments of science. But what systematic understanding have we of the psychology of question-asking?

The answer is: Not much--we know rather little about question-asking as a cognitive or social phenomenon. We do know enough to ask this question, however, and that is a significant start. As Miyake and Norman (1979) have demonstrated, one must have at least some knowledge in a domain in order to ask sensible questions about it; it is possible to have too little information even to formulate a question, or so much that a question does not arise. But the Miyake and Norman paper and also a review by Flammer (1981) show that little previous research in US or UK psychology has addressed the issues beyond this; although there is some older relevant research in German- and French-language psychology and linguistics, and a long tradition of work in education on the special topic of teacher questions, a detailed cognitive analysis of the basics of question-asking has not been available.

Flammer's (1980, 1981; Flammer, Kaiser, and Müller-Bouquet, 1981) research at the Universities of Fribourg and of Bern, Switzerland, has sought to improve this situation. His particular focus is on what he regards as the prototypical question, i.e., the explicit information-seeking question; special cases such as rhetorical questions, or teacher questions designed to elicit from students what the teacher already knows, are left aside for the moment. The primary research questions are: What do people ask in what situation, and of whom? Why do they sometimes ask and sometimes not?

Flammer began with a conceptual framework consisting of the six postulates shown in Table 1, and then proceeded to investigate these in a string of empirical studies. Postulates 1, 2, and 3 together define the rather paradoxical phenomenon demonstrated by Miyake and Norman (1979). A questioner lacks information and so formulates a question designed to obtain the missing information. To formulate a "*good*" question--i.e., one that constrains the answer in the direction of what is needed--the questioner must already have some knowledge about the information needed. A good question, therefore, must be recognizable as such not only *a posteriori* (as effective in reaching a goal) but also *a priori* (as likely to have a particular effect). One central issue then is: What does the questioner have to know to ask a good question?

A further implication, particularly of Postulate 3, is that questions may vary in degree of generality--there are relatively general questions, such as "Hey, what's happenin', man?" and relatively specific questions, such as "What's that you're doing now, Charlie Brown?" The more specific the question the more the questioner must already know of the nature of the missing knowledge, and indicate this in the question. In some recent German work (Conrad, 1978), this characteristic of questions is called "structural answer determination."

Table 1

Six Postulates for a Theory of Question-Asking
(from Flammer, 1981)

1. Questions concern information (=potential knowledge) that the questioner lacks.

2. Questions presuppose some available knowledge.

3. Questions are formulated in such a way, or expressed in such a context, that the range of the acceptable answers is smaller than the range of all the statements the answerer is able to make.

4. Knowledge needed in order to ask a question is, at least in part, knowledge "about" the knowledge to be acquired, i.e., it is specifically related to the knowledge sought.

5. The need to clear up contradictory knowledge refers to a special case of missing knowledge.

6. The class of missing knowledge, about which questions are asked, also includes knowledge at a low level of confidence.

Postulate 4 carries the development further. If knowledge about knowledge is conceived of as organized in a hierarchy, then knowledge at higher levels may be thought of as identifying "holes" or empty cells at lower levels. Missing information may thus be identified as higher or lower in particular multilevel hierarchies. One such hierarchy used in Flammer's laboratory was developed by Schwarz (1980) to specify the structure of a certain class of texts. It contains six levels; the lowest level is the vocabulary, followed by the discrete sentences, the interrelations or sequences of sentences, the topic, the author's message and, at the highest level, the context of the author's message. Modern information-processing theories often use such hierarchies, characterizing the higher-order knowledge aspects of them as scripts, schema, or frames. With respect to questions formulated at a higher level to obtain information missing at a lower level, Flammer also notes the relevance of such constructs as "type knowledge" (used to ask for the actual tokens), "prototypes" (used to ask for the actual exemplars), and "class concepts" (used to ask for elements in the concept's extension).

Not mentioned by Flammer but important in a later connection is the apparent parallel between these distinctions and those made in some theories of intelligence. Spearman's (1924, 1927) theory, for example, posits three basic intellectual functions: eduction of relations (i.e., inferring the rule that connects two given examples); eduction of correlates (i.e., inferring another example given one example and a rule); and apprehension (i.e., knowing what one knows and what one does not know). In the abstract, at least, apprehension seems close to what one needs to know to ask a question. Eduction of relations would seem to be useful in filling holes higher in a hierarchy, given some pieces of knowledge at lower levels, whereas eduction of correlates should fill holes at lower levels, given some knowledge at higher levels. Both may provide alternatives to asking questions; a person may either infer missing information, or formulate a question to obtain it, or both. One might even say further that inferential reasoning is internal question-asking and -answering undertaken when apprehension is sufficiently precise to control it. Indeed, in some of Flammer's experiments it is found that subjects do not ask questions when missing information can be clearly inferred. This brings research on question-asking into the stream of other research on intelligence and reasoning in problem solving. One more issue for further work, then, is to determine the personal and situational determinants of decisions to infer rather than ask, or vice versa.

Postulates 5 and 6 acknowledge that contradictory knowledge and knowledge in which there is little confidence also often prompt question-asking. Questions arising from these sources, however, are

also considered information-seeking questions because it is the provision of further (i.e., missing) information that clears up contradictions or raises confidence.

To exemplify the sorts of research that support and elaborate this conceptualization, two of Flammer's experiments can be briefly summarized here. But much other work has been, or could be, done along various related lines. Some of these directions are noted in summary.

One experiment used the hierarchy of text-processing levels identified above and presented a suitable text to subjects using three conditions: an original form; a manipulated form, in which the order of the four paragraphs was changed so that the "problem" being discussed was identified in the last paragraph instead of in an early one; and a random form, in which the sentence order was entirely randomized. The findings were clear. The number of higher-order questions about the theme or topic increased as the text disturbance increased, whereas the number of lower-order, micro-questions about words and sentences decreased with increasing text disturbance. Macro-questions also tended to precede micro-questions. Thus, when the semantic theme or gist of the text is not apparent, subjects miss it and ask questions about it. Different levels of the knowledge hierarchy seem to determine the priority of filling different holes; micro-questions are reduced if higher-order information is also missing. Perhaps also subjects assume that obtaining more macro-information first will allow them then to infer missing micro-information.

In another experiment, subjects were told that they were to write the newspaper text of a police report appealing for witnesses to a hit-and-run auto accident. They were to obtain all the information they needed by asking questions of the experimenter, before writing the report. The experimenter answered each question in a predetermined manner. Subjects' questions and written reports could then be compared to a rewrite-rule text grammar established in advance by a survey of actual newspaper police reports and by logical considerations. The grammar had three levels of hierarchy. Of main interest was whether the set and sequence of questions could be predicted from the grammar and whether other distinguishable questioning strategies could be discerned for different subjects.

The results showed that the subjects' written stories corresponded closely to the text grammar, which also predicted what questions would be asked to some degree. But there were both additions (i.e., questions not predicted by the grammar) and omissions (i.e., questions predicted by the grammar but not asked). The additional questions were seen to be of three types: personal interest questions, not eventually needed for the writing but perhaps needed to produce a coherent personal image or reconstruction of the event by the questioner; questions associated with optional elements in the story; and assurance questions designed to increase the subject's confidence even though redundant with information already provided. Omissions identified information that was inferred rather than asked about, because information not gained through questioning nonetheless appeared in the written story.

It was also clear that the grammar did not predict the sequence of questions, even though it predicted the sequence of the stories produced. Some subjects followed the perfect linear strategy predicted by the grammar. But others showed a linear recursive strategy, running through the story linearly but with omissions which were then picked up in a second run of questions. Still others showed linear strategy with extensive focusing on the main theme at the beginning or end of questioning. The largest category of subjects displayed an event-centered strategy without evident linearity. And some subjects showed no discernable strategy at all. Thus it may be that subjects use idiosyncratic strategies guided by no general grammar to build up a personal conception of the story, and only then use a selection process during writing that is guided by the grammar.

A summary of progress to date, in the form of a crude schematic model of information-seeking processes, is shown in Figure 1. It is constructed partly from Flammer's work but also with an eye toward connections with current research on intelligence, and on relations between cognition and motivation (see preceding article). The main points depicted in Figure 1 are as follows:

1. There is a more or less continuous stream of cognized information that feeds the construction of knowledge hierarchies in defined domains. There is also a more or less continuous monitoring of this construction, the function of which is to apprehend "holes."

2. At least three personal motivations drive this function but also follow from it to decisions for action; there must be a felt need to obtain

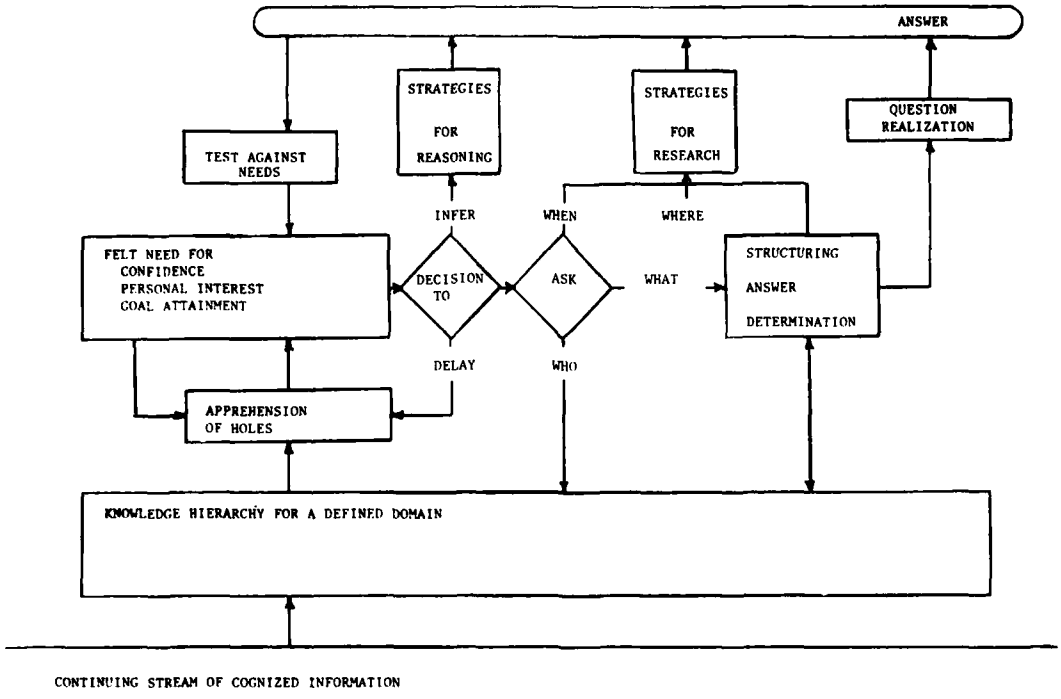

Figure 1. A schematic model of information-seeking processes leading to a question-asking.

missing information for either goal attainment, or personal interest, or increased confidence.

3. A decision to infer, ask, or delay then follows. To delay means to continue monitoring in hopes that apprehended holes will be filled by subsequent information from the stream. To infer means to invoke one or another strategy for information search through reasoning. It is likely that this decision also depends on certain personal motivations as well as on reasoning ability. There is a motivation to exercise abilities one possesses where possible and also a motivation to keep one's ignorance private; to ask a question is to make public a knowledge hole.

4. The decision to ask a question leads to further decisions about who, what, when, and where to ask. The when- and where-questions include the possibility of further internal answer-seeking by invoking one or another strategy for information search through research (e.g., library or empirical research). The who- and what-questions depend particularly on the knowledge hierarchy already available as the principal guide to choosing a "good" person to ask and structuring the answer-determination character of the question.

5. The information obtained, whether by inference, research, or question-asking, must be tested against the original motivations, i.e., for confidence, personal interest, or contribution toward goal attainment. The confidence test may be most critical for information obtained by inference.

6. The system is cyclical and driven by a macro-to-micro knowledge priority. But it is likely also to be highly idiosyncratic. People probably assemble personal knowledge structures and strategies for elaborating them that are both person-dependent and situation-dependent.

Research on the operations in knowledge structure required to formulate good, answer-determining questions seems to strike many other important topics for a general psychology of cognition. In particular, the identification of the personal and situational determinants of the apprehension of holes, the delay-infer-ask decisions, the who-what-when-where decisions, and the personal needs governing these processes, may also bring intelligence and motivation research into the picture in new and interesting ways.

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4/11/84

BIOLOGICAL SCIENCES

BIOMEDICAL RESEARCH IN SWEDEN

by Thomas C. Rozzell. Dr. Rozzell is the Liaison Scientist for Biological Sciences in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until August 1985 from the Office of Naval Research, Arlington, VA, where he is Program Manager for Cellular Biosystems.

The Swedish government feels very strongly about health care and is fairly ambitious in supporting biomedical research. It appears determined to obtain an edge for the country in biomedical engineering, biotechnology, and biomaterials and pharmaceuticals.

Government support for scientific research in Sweden is carried out primarily through several ministries, each of which has a number of sub-units and councils. Biomedical research is the responsibility of the National Board for Technical Development (STU), which is under the Ministry of Industry. The objectives of STU are:

1. To establish and maintain research and industrial technical competence in areas judged to be significant for the renewal of Swedish industry.

2. To coordinate the national research and development resources in order to advance social objectives and benefit society.

To accomplish these objectives, STU is granted the equivalent of approximately $125 million per year; the board uses these funds to support about 1500 new technical-development projects each year. The support provided by STU may include financial assistance to get a new idea off the ground, help with international patent applications or a commercial evaluation of the world market for the new product, assistance in setting up a full-scale testing program for the prototype, and even help in locating a manufacturer in Sweden or abroad.

STU seeks to achieve its goals through support of basic and applied research at universities, in cooperative research institutes, and in industrial firms. This targeted support complements routine research and development support and aims to orient the national research program quantitatively and qualitatively toward longer-term industrial needs.

The second main function of STU is to stimulate innovation and provide the framework for its commercialization. According to STU's Olof Jusinski, a lot of attention is given to individual inventors through funding in the early, high-risk, development stages of their projects. In addition to funds, assistance is provided in the form of project evaluation and advice. STU may also act as a broker to help commercial exploitation and to gain financial help from third parties such as venture-capital companies.

STU programs include a special emphasis on: (1) developing ideas from basic medical science and medical engineering, and (2) implanting these concepts in existing industrial companies or establishing new companies for their development. As regards companies that are relatively strong in terms of resources, STU sees its principal role as one of contributing to the development of new fields of activity.

Technology procurement is becoming increasingly common as a working method of developing new medical-engineering products. Apparently STU plans to continue this practice, which includes cooperation with the Swedish County Council's Fund for technology procurement and development.

Biomedical Research

The role of STU in research that borders on medicine and biochemistry is primarily to develop expertise in a few specific areas that are considered important for future applications. The provision of support in these areas is highly selective and generally based on comparison with technology already existing in Sweden.

Biomedical research that is especially oriented toward the physical sciences depends very much on STU for support. Currently there are 10 Swedish institutions being supported in such research. The role of the board in the development of expertise, international cooperation, and the promotion of new, commercially viable products is seen as being more significant in this area than in many of the others.

Following are some examples of recent projects that have been funded by STU.

Instant Blood Test. A method for making faster and far safer measurements of the hemoglobin content of blood has been developed by two hospital technicians, Jan Lilja and Sven Erik Nilsson. The inventors have sold the licensing rights for the system, called "HemoCaps," to Leo, a pharmaceuticals company in Helsingborg.

Lilja and Nilsson point out that in time the method will also have a large market in such contrasting fields as the food industry and in sewage and water treatment for analyzing silt in purification plants.

Normally a patient's blood has to be drawn up into a pipette, followed by time-consuming measurements requiring expertise and experience. The HemoCaps system eliminates the need for a pipette. Instead the test is carried out by means of a photometer with a control cuvette, reducing errors to essentially zero. Once inside the cuvette, the blood is mixed with and reacts to a dry reagent. The photometer compensates for any aging of the light source and the photoelectric cell. Reliability is thus, in practice, 100 percent.

The new method offers simplicity and speed, along with accuracy and a saving in time and personnel. One secret is the rigorous control in the manufacture of the cuvettes. The plastic material used must be exactly 0.13-mm thick, with a tolerance of not more than 2 percent.

Blood tests taken by conventional methods require up to 15 check items, whereas the HemoCaps method requires only four. The photometer supplies an answer in 1 minute. Anyone capable of carrying out a normal blood test can determine the hemoglobin content too.

The need for a safe and simple method of analysis is regarded as especially great in small hospitals and among private doctors. In the future there also may be a huge market in the underdeveloped countries.

To manufacture the HemoCaps, AB Leo Diagnostics has built a processing plant which has just gone into production. Within a few years there will be an estimated turnover of SKr50 million (about $6.5 million).

Lilja and Nilsson are busy seeking new fields and applications for the invention, which should have a wide market both in Sweden and abroad.

Supermagnet. Bertil Reenstierna (Lund University) and Otto Holen (Malmo General Hospital) have developed a new supermagnet that can be used to guide electrodes for pacemakers or nerve-blocking devices (in cases of severe pain) to the correct places in the body and keep them in place until tissue grows around the electrodes to hold them in place.

The electrode for pacemakers must be inserted through a vein to the tip of the ventricle inside the heart. There are many different types of electrodes currently on the market--electrodes with hooks, screws, and the like. It is difficult to put such an electrode in place, where it must be held securely while tissue grows around it to hold it.

During the approximately 10 days the process takes, the electrode is kept rigidly in place partly by one magnet located inside the tip of the electrode and partly by another magnet held in place outside the body (see Figure 1). In some cases the external magnet is also used to guide the electrode to the right place inside the heart.

At the tip the electrode is equipped with a so-called supermagnet made of cobalt and certain rare earth metals. Its tractive force remains at 37/1 relative to an ordinary magnet, bearing 74 times its own weight.

The outer cover of the electrode tip is made of platinum--iridium. The cover (catheter) is usually made of polyurethane. The supermagnet in the electrode tip weighs only 0.12 g, while the external magnet weighs 300 g. The external magnet is kept in place outside the body by a belt. After about 10 days enough fibrin has been formed to heal, and the external magnet and belt can then be removed. The device has been used in a large number of patients with excellent results. There is no spurious effect from the external magnetic field.

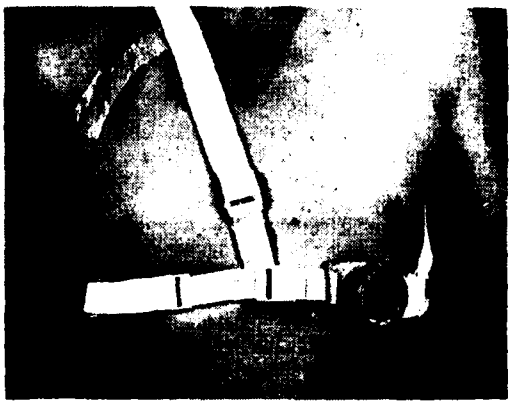

Figure 1. The supermagnet is placed outside the patient's body, where it is held in place for about 10 days.

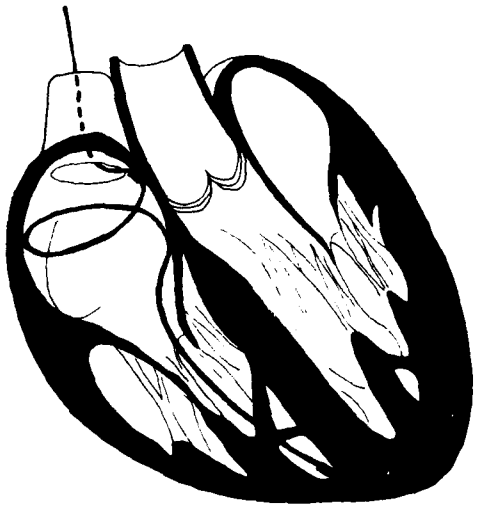

Figure 2. The coil is pressed against the walls of the auricle, where a contact can grow into place. At the tip it gives pulses to the ventricle, and further up in the coil it gives pulses to the auricle.

The technology mentioned above applies to pulses to the ventricles of the heart. Sometimes, however, signal communications are disturbed so that both auricles and ventricles must be controlled artificially. This requires two electrodes.

Reenstierna and Holen have made a common coaxial electrode instead of two separate ones. It consists of a coil with a protective cover of, for instance, polyurethane that can "remember" its spiral form. When inserted it is straight and controlled by an internal lead which is withdrawn when the electrode is in place. Thus the tip of the electrode is fitted inside the ventricle, and the coil opens out in the auricle.

The coil is pressed against the inside walls of the auricle, where an inserted contact grows into place, the whole device following the movement of the auricle. At the tip it gives pulses to the ventricle, and further up in the coil it gives pulses to the auricle (Figure 2).

Both the "memory" coil and the system of affixing electrodes by means of magnets are now patented techniques.

Diagnosis of Thrombosis. A simple noninvasive technique for the diagnosis of deep-seated veinal thrombosis has been developed by Drs. Staffan Zetterquist and Erline Nilson. This method of diagnosis replaces radiography in most cases, which is an extremely expensive method as well as being painful for the patient.

The apparatus they have developed is called the DeVeTherm and consists of an infrared-sensitive sensor placed on a movable arm and connected through a microprocessor to an XY-recorder. The sensor is moved along both legs without touching them, while its temperature and position are fed continually to the computer. The computer then traces out the temperature curve for each leg, as well as a curve for the mean temperature differential between the legs and a segmental mean temperature differential curve. Diagnosis can be made directly from these curves. In order to eliminate false positive results, the method can be combined with plethysmography, thus allowing diagnosis to be made with 99-percent certainty. The entire procedure takes only a few minutes to perform once the patient has adapted to the temperature of the examination room. The cost is about one-tenth that of a conventional thermography examination with an infrared camera; the procedure is also more specific and does not require specially trained staff.

DeVeTherm is being manufactured and marketed by Ekoscan AB, of Gothenburg.

Biotechnology

Biotechnology has been given high priority in the allocation of government R&D funds. It is assumed that biotechnology will be applied in the food, pharmaceutical, and organic chemicals industries, and in agriculture,

environmental conservation, and energy conservation.

There are relatively few companies active in biotechnology. However, several of these occupy leading positions in pharmaceutical, medical technology, testing, and equipment industries. According to STU's Lennart Pettersson, much of the current basic research in universities and research institutes is viewed as producing future input into existing companies, both in Sweden and in other countries.

The primary areas of research cover immunology, separation techniques, and immobilization techniques. Substantial contributions from individual firms and from STU have raised the standard of cellular and molecular biology to an internationally competitive level. The technique of using biocatalysts bound to solid substrates has reached an advanced level of development in Sweden. Thus far, however, only a few industrial applications of these techniques have been established.

STU is planning to provide increased resources for major projects concerned with the industrial applications of genetic technology and cellular biology. In this way, they hope to obtain the cooperation of a number of institutions, to increase Nordic collaboration, and to achieve even further involvement by industry.

It is considered extremely important to extend knowledge on immobilized biocatalysts--in order to fill existing gaps in information concerning the biological, technical, and economic factors that form obstacles to the development of industrial processes. Contributions are also planned for studies on computer control of biotechnical growth and process techniques. An important part of this work is the development of relevant measurement methods and of knowledge on the microbiological production factors involved. A new program in chemical technology is also planned, to cover organic synthesis.

A new technique to treat kidney problems is one recently successful STU-supported project. At the Lund University Institute for Applied Biochemistry a method has been developed to produce ketonic acids from equivalent amino acids. The technique is important for people with deficient kidneys, whereby nitrogen not dissolved in the kidneys builds up. A small test plant to serve the technology involved has been built at nearby Arlöv.

Patients with kidney deficiencies usually build up dangerous amounts of nitrogen that is not dissolved in the kidneys. The usual treatment is to attempt to counter this poisonous effect by strict dieting: plenty of carbohydrates are permitted, but few proteins.

Amino acids, essential to the body's functions, are then added where they are naturally lacking. But the amino acids bring with them additional nitrogen.

By using ketonic acids instead--they are analogous to the amino acids--it is possible to bring down the nitrogen content in the body. The process of transforming the ketonic acids to amino acids requires the consumption of nitrogen, thus giving a double positive effect.

The Lund University Institute for Applied Biochemistry has developed a method using immobilized enzyme/cell systems. The results of their research have been given to Sockerbolaget--the State Monopoly Sugar Company--for industrial purposes, resulting in the test plant at Arlöv.

Vital to the new technology is a yeast fungus, *Trigonopsis variabilis*, imported from Canada and now cultivated in Lund. *Trigonopsis variabilis* does its job without arousing all the thousands of other enzymes in the yeast fungus. The by-products they have had from the reaction have been positive and valuable.

There has been a problem in eliminating the peroxide that can damage both enzymes and ketonic acid. The solution was to use manganese dioxide, which decomposes the peroxides. This and the technology using immobilized enzyme/cell systems have patents pending.

The latter technology works by enclosing the enzymes in tiny polymer pearls packed in a column through which a solution is allowed to pass. The process is continuous and is easy to control. It is thus suitable for industrial usage.

To complete the productive cooperation uniting East and West there is a bacteria strain, *Providencia*, from Poland. *Providencia* has proved to be a useful bacterium. The researchers at Lund also use activated carbon against the peroxides. The bacteria are consumed during the process, but new mass is generated by means of nutrients added to the columns. The process is therefore quite easy to regulate.

STU has proposed a budget of SKr3.684 billion (about $483 million). The budget proposal includes sufficient funds for STU to properly exercise its function of stimulating the research and development activities of the country.

4/6/84

FREQUENCY OF MAGNETO-THERAPY INCREASING IN ITALY

by Thomas C. Rozzell.

Muscle sprains, contusions, psoriasis, migraine headaches, motor-function impairment, surgical complications, neuralgias, venous and arterial diseases (including artherosclerosis and Raynaud's disease), arthritis, rheumatism, ankylosing spondylitis, osteoporosis, pseudoarthrosis, and non-unions can all apparently be treated by the same therapeutic modality--low-frequency pulsing electromagnetic fields. At least this is the impression given during the First International Meeting of the Association for Biomedical Applications of Electromagnetism (A.B.A.EM.) held in Venice, Italy, in February. The meeting, entitled "Biological Effects and Therapeutic Applications of ELF Electromagnetic Fields," was a mixture of basic science (one-third) and clinical presentations (two-thirds); it was well attended by Europeans and Americans.

The impetus for the meeting was the increasing use, especially in Italy and to a much lesser extent in Germany and France, of magnetic or electromagnetic fields to treat a wide range of human diseases such as those listed above. There are two principal methods for producing the treatment fields. In the first an electric current is run through a solenoid to create a magnetic field of up to 350 Gauss at a frequency usually less than 100 Hz. There are at least eight companies in Italy and one in Germany producing equipment in this class. Characteristic of the equipment in this group are cylinders of approximately 45- to 50-cm diameter. In some cases the solenoid cylinder is placed around the patient, who sits during the treatment; in others the patient lies supine on a narrow bed and the cylinder slides continuously from the head to the foot during the treatment or, depending upon the area being treated, remains stationary. In either configuration, the patient is subjected to a pulsating magnetic field, the frequency and intensity of which is variable from 1 to 1000 Hz and zero to 350 Gauss (depending on the model). The field parameters in most of these devices are determined by punch cards for the ailment being treated. If there is an effect, it can be assumed that electric current of varying magnitude is thus induced in the body of the patient.

The second class of equipment producing electric and magnetic fields generally uses parallel plates, or as in the case of the sole US entry, Diapulse, an irradiating antenna. Five Italian and one French device compete with Diapulse in this class. No information is available on the maximum electric or magnetic field intensities in the bodies of patients, but frequencies range from 50 Hz up to 20 GHz. The frequency is usually fixed, however, in any given device.

It is recognized by at least some of the manufacturers of both classes of equipment that full acceptance and credibility will come only when reputable scientific and clinical evidence substantiates the therapeutic claims that to many seem speculative. It is to the credit of several of the companies that a number of laboratory studies have been initiated with the actual generators used clinically or with generators that simulate the field characteristics of the clinical devices.

Since the level of energy imparted to cells using low-frequency, low-intensity magnetic fields is insufficient to give rise to quantum phenomena or cause changes comparable to the level of the thermal energy (kT), some new models and hypotheses must be invoked to explain biochemical or biophysical mechanisms that may occur in and around exposed cells. Giovanna Morgavi and Sandro Ridella (Istituto per i Circuti Elettronici, Genova, Italy) reported at the Bioelectromagnetics meeting in Boulder, CO, last year a strong frequency-dependent behavior of sodium current through cell membranes, and Arthur Pilla (Mt. Sinai School of Medicine, New York) has suggested that modifications of intracellular ion concentrations may be controlling factors that trigger cell modifications. There are also those who feel that nonlinear molecular vibrations in the form of "soliton" waves may convey energy imparted by low-frequency electromagnetic fields. Whether such energy transport can trigger chemical reactions from one site to another is still clear only in the minds of some theoreticians.

We are seeing more and more examples of biological sensitivity to very weak electric and magnetic fields. Abe Liboff, working at the Naval Medical Research Institute, has shown that human fibroblasts exposed to low-frequency magnetic fields at amplitudes comparable to ambient geomagnetic levels consistently showed enhanced tritiated-thymidine uptakes. This may mean that such magnetic fields can increase DNA synthesis. Joe Delgado and coworkers (Madrid, Spain), on the other hand, have shown interference in the early organic

development of chick embryos (see *ESN* 38-6:297-301 [1984]).

Luiggi Zecca, G. Dal Conte, G. Furia and P. Ferrario (Milan, Italy) used a sinusoidal magnetic field at a frequency of 50 Hz and intensity varying between 0 and 58 Gauss to study survival time in mice subject to Erlich's tumor. This magnetic field was generated by a Ronefor therapy unit, one of the largest sellers. An 11-percent increase in survival time was found in the mice exposed to the magnetic field before and after injection of the tumor cells. This, they feel, indicates a possible enhancement of the immune response of the mice. They have also seen a decrease in the rate of acute inflammation in rats injected with the irritant carrageenin after 2 and 4 hours of exposure when compared with controls. Sergio Curri (Center for Molecular Biology, Milan, Italy) substantiated these observations by studying the morphological and histochemical changes that occur in the rat paw after injection of carrageenin. Does magnetotherapy thus have anti-inflammatory capability?

Another example of increased DNA synthesis, as evidenced by increased uptake of tritiated thymidine, has been demonstrated at the Laboratory of Molecular Endocrinology of the Catholic University-Rome. Researchers there used the Ronefor therapy unit to expose 3T3 cells, of fibroplastic origin, three times a day, at 2-hour intervals, for 30 minutes each. Cell growth rate (proliferation) was also higher in treated cultures than in the controls. In both cases, the significance of the effect increased with time.

Unlike laboratory studies, in which controls can be tightly managed and observations made in a double-blind fashion, the reported clinical investigations leave significant room for doubt. This is especially true for treatment of disorders that have a high degree of associated pain and where the dependent variable is alleviation of the pain. Many patients suffering from such diseases as rheumatoid arthritis or chronic back pains invariably report some degree of additional relief from any new treatment modality. There is a significant amount of psychological input in the pain process. On the other hand, treatment of a long-term pseudoarthrosis that has not responded to other types of treatment for 18 to 24 months provides fairly hard evidence in favor of electric or magnetic field therapy, or both. (Pseudoarthrosis is deossification of a weight-bearing long bone, followed by bending and pathological fracture, with inability to form normal callus leading to existence of a "false joint" that gives the condition its name.)

The same is true for bone fractures that fail to heal (non-unions). There are now records of more than 10,000 cases of non-unions worldwide that orthopedic surgeons could not mend by conventional methods that have responded to either induced or direct current stimulation. At the Institute for Experimental Surgery of the Technical University in Munich, Germany, Dr. Ascherl has treated more than 600 patients (over a period of 11 years) with artificial hip joints in which there was aseptic loosening of the implants. Normally such patients are candidates for surgery. The low-frequency pulsing magnetic fields gave a success rate of almost 67 percent in cases where there was a painful loosening at an early stage following the implantation. Septic loosening and other mechanically caused dislocation of the implants still requires surgery.

Another area that has received increased attention for this type of therapy, especially in Italy and Germany, is sports trauma. Problems such as acute lesions (muscle tears), sprains, contusions, and inflammations have all been treated with extremely low-frequency pulsating magnetic fields. Here it is very difficult to evaluate the results since the problems occur in young, healthy individuals who generally tend to heal rapidly. There are no controls with which to compare rates or efficacy of the treatment regime. Comparisons must depend on the clinician's general knowledge of the average course of healing of each disorder. There is the additional complication of tremendous individual variability. Thus, regardless of the claims made by clinicians, there is ever-present doubt as to the exact extent to which the therapeutic modality contributed to the healing of the ailment. What is needed are some good studies with double-blind controls and using, for example, standardized wounds or sprains in animals. If indeed the fields enhance wound healing there should be cellular changes that can be quantified.

While there is a tendency for clinicians and manufacturers, driven by economics, to make sweeping claims for new methods of treatment, there is an equal tendency for the scientific community to toss stones at new ideas. Somewhere in the middle there must be a common platform of understanding. The A.B.A.EM. meeting in Venice was a good

foundation on which to construct this platform.

4/10/84

COMPUTER SCIENCES

DISTRIBUTED SYSTEMS AT THE TECHNICAL UNIVERSITY OF BERLIN

by J.F. Blackburn. Dr. Blackburn is the Liaison Scientist for Computer Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the National Academy of Sciences, where he is Executive Director, Computer Science Board.

No central system supervisor keeps track of the use of data objects in a distributed multicomputer system. To obtain a safe operation of the system and support fault tolerance, in each node one needs a control which, in critical cases, allows access rights to be granted as restrictively as possible. Access-right control in each node can be most efficiently exercised by dedicated hardware. Once a system has complete control over the use of shared objects, the implementation of purely data-driven synchronization policies for interprocess cooperation becomes feasible.

Distributed multicomputer systems allow the following requirements to be fulfilled:

- High performance--through parallel operation of cost-effective hardware
- Modular system extensibility
- Fault tolerance
- System software simplification--through modularization and a high degree of hardware support.

W.K. Giloi and his colleagues at the Technical University of Berlin have shown how the introduction of object addressing at the hardware level greatly facilitates the programming of secure, distributed, multicomputer systems that combine fault tolerance with high performance obtained through parallel processing.

In such a system the user programmer should see only inter-process communication and not internode communication. The abstract view of interprocess communication should be achieved by architectural provisions, rather than by adding a large overhead by introducing communication supporting software levels.

The type-manager model and the object-exchange model are two types of interprocess communication models. The models differ in access mode, ownership of shared objects, and amount of data to be transferred in a single transaction. The type-manager model is based on the concept of abstract data types in which access to a shared data object is attained by use of functions of the type manager. This model is adequate for use in local area networks, in which object sharing is only a special case of resource sharing.

The most common manager model is the monitor, in which it is the only process that can directly access a shared object. This often causes a bottleneck in a system of cooperating processes.

The object-exchange model is better for distributed multicomputer systems, in which the required overall function of the system results from distribution of functions among the nodes of the system.

In the type-manager model the rule of mutual exclusion of data access can be enforced by an object model. For efficiency in a distributed processing environment, such an intermediary should not be involved in interprocess communications. A solution is to incorporate the mutual-exclusion policy into the interprocess cooperation protocol and support it by appropriate intrinsic mechanisms transparent to the user. Such a protocol should support both models of object sharing.

Object-Oriented Communication Systems

Although interprocess communication in distributed systems is based on the exchange of communication objects, the hardware in conventional systems only exchanges messages or physical memory locations between cooperating processes. The hardware has no knowledge of the existence of communication objects.

If communication objects are appropriately represented in the hardware, the exchange of objects can be handled, and their access can be efficiently controlled.

Protection in Distributed Systems

In principle there are two ways for implementing protection--through capability lists or through access-control lists. To support access control by dedicated hardware, the capability list is better because it allows the access-control mechanisms to be integrated into

the access path from the processor to the memory. This permits control of access right in parallel with address transformation.

For efficiency in capability addressing, the capability information must be represented in the hardware. An efficient capability addressing can be obtained through including access-control information such as read, write, and read/write in the segment descriptors as access-mode attributes for the segment. Segment descriptors can function as capabilities if the following conditions are met:

- There is a one-to-one correspondence between the segments and the objects of protection.
- Each subject is furnished individually with a segment descriptor when several subjects share an object with different access rights.
- Physical memory can be re-used only if the system has no segment descriptor for the physical segment.
- Access to segment descriptors is rigorously protected.

The access domains of the cooperating processes in a distributed multicomputer system must be rigorously isolated from each other. The access domain of a process is formed by its instruction object and its data objects, which are owned by exactly one process. The data objects are either local objects, locally used by their owner, or communication objects used for communication with other processes.

Communication objects allow the generation of object descriptors and other data structures needed for data access. A dedicated data access processor allows the introduction of capability addressing of objects in a manner that is transparent to the node computer. It controls the distribution of the capabilities within the nodes of the system. It also manages local memory.

Data-Driven Synchronization

In the system described by Giloi, process synchronization is a built-in mechanism of the high-level programming constructs used to establish interprocess cooperation. This synchronization must not unnecessarily restrict parallel execution.

The "remote process initiation" is the appropriate synchronization mechanism for a distributed multicomputer system when performance is an issue. The parallel execution of the cooperating processes is only limited by the data dependencies of the functions performed on the communication objects. However, the mutual exclusion of access to the objects of the cooperating processes must be insured by complete, rigorous access control.

Two parallel programming concepts provide the programmer an abstract view of interprocess cooperation at a sufficiently high level: the ADA Rendezvous and the Remote Procedure Call. Both concepts restrict or eliminate the potential for parallel processing in a multicomputer system. Both avoid nondeterministic situations by rendering the client process dormant while the server process is active. A more sophisticated solution is needed for a high-performance distributed computer system.

With the capability-based addressing mechanism, the system has control over the use of each data object, and a client can be prohibited from modifying the state of objects it has handed over to a server for processing. Object addressing makes feasible the "no wait" construct for interprocess cooperation, called remote process invocation (RPI).

Remote Process Initiation Policy

The rules of synchronization and interprocess communication (IPC) define the IPC policy of the system. This policy is implemented through a hierarchy of protocols. The top level, the IPC protocol, is reflected by appropriate high-level language constructs.

The synchronization rules of the remote-process initiation policy are designed to guarantee the highest possible degree of parallelism between the cooperating processes. The effect is as follows: (1) the execution of a client process is not held up by requesting a service from a server, and (2) the execution of a server process is not held up by signaling the completion of the requested service to the client.

In the RPI policy, interprocess communication can take place only at two synchronization points. Messages flow in one direction: client to server or server to client. The data objects exchanged are owned by the client. The following conditions must be fulfilled:

1. Autonomy condition: after a parameter exchange, the processes involved must be able to operate again totally independent of each other.
2. Restart condition: it must be possible to repeat a process initiation automatically--e.g., to initiate a surrogate process in another node if the first process initiation failed.

The following rules will fulfill these requirements:

1. A "write capability" for an object that is set up for communication by the client is in reality granted for a copy of the object. The copy is automatically generated by the system.
2. The client's access right for the objects used for communication is restricted to "read only," while the object (a copy of it) is used for communication with other processes.

These rules guarantee that the original of a communication object cannot be modified while the object is used as a vehicle of interprocess communication.

Language Implementation of the RPI Policy

Existing languages can be extended by adding the language constructs for the programming of interprocess cooperation based on the RPI policy. Additional statements are needed for:

- Declaration of processes
- Declaration of communication objects
- Initiation of server processes, including parameter passing
- Signaling of completion by the server
- Waiting for completion by the client, including timeout specification
- Exception handling.

The RPI policy supports the decomposition of complexity through modularization. It also facilitates information hiding and data encapsulation.

A process library is established in the system to perform the following tasks:

- Assigning to the processes unique identifiers that are used system-wide.
- Keeping the original of the global process table (of which each node supervisor has a copy).
- Ensuring consistency and completeness of process specifications; the library is the only authority in the system that may modify such specifications.

The Technical University of Berlin has built a distributed multicomputer system called UPPER (Universal Polyprocessor with Enhanced Reliability); it incorporates the previously described principles, policies, and mechanisms. The IPC protocol hierarchy, ranging from the logical link protocol over the bus access and transmission protocols up to the interprocess communication and cooperation protocols, is supported by dedicated hardware in the nodes of the system. The nodes are connected by a bit-serial coaxial cable bus that features the slotted ring protocol and operates at a bit rate of 280 million bits per second. Object addressing and the IPC policy based upon it have been implemented and are reflected in the parallel-processing PASCAL running on the system. The process library also has been implemented. Fault tolerance will be accomplished on the basis of the node as the smallest replaceable unit and the process as the repeatable atomic operation.

Reference

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3/29/84

EXPERT-SYSTEMS RESEARCH AT QUEEN MARY COLLEGE

by J.F. Blackburn.

The combination of quality theoretical work with real applications is a strong point in the expert-systems work at Queen Mary College, London.

A staff of eight professionals is carrying out a wide variety of research in expert systems and related topics. Research interests include: expert systems, rule-based control, philosophy of logic and reasoning, robotics, approximate reasoning, induction using fuzzy sets, information retrieval using non-Boolean methods, adaptive control of processes, and rule-based learning control of cement mills. Drs. E.H. Mamdani and H.J. Efstathiou described the scope of some specific projects.

A Formal Analysis of Design-Rule Checkers for Integrated Circuit Masks

The mask layouts for integrated circuits need to be checked for possible errors in complying with the design rules. Checkers for design rules often fail to find errors or may indicate spurious errors. The Queen Mary project does a formal analysis of the checking of design rules as a problem in knowledge transformation. The design of the circuit, representing the knowledge, is transformed from the logic diagram to the equivalent electronic circuit diagram and then from the circuit diagram to the integrated circuit mask

layout. The transformation may be stated as a set of production rules. This knowledge can then be used with an expert-system program to more formally express error checking.

Information Retrieval Using Fuzzy Logic

Researchers have investigated the theoretical aspects of using fuzzy logic in retrieval methods for documents, in similarity measures for Boolean search request formulation, and in assessments of the inclusiveness of information retrieval systems.

Enhancing Expert Systems Using Fuzzy Reasoning

A number of commercially available expert-system packages can combine knowledge of a particular field expressed in terms of rules with evidence about a particular case to produce a diagnosis and recommend an action. Often, however, the experts express their knowledge in imprecise terms not acceptable to existing expert systems. Fuzzy logic has been developed to take account of imprecision, and a project is under way to enhance a commercial package by incorporating some aspects of fuzzy reasoning. The terms in the rule may be fuzzy or imprecise--using "slightly" or "approximately" as modifiers, for example. Alternatively, the strength of the implication in the rule may not be absolute--e.g., "it is likely that."

Expert Systems in Maintenance and Manufacturing

Queen Mary College is studying the flexibility of using expert systems for maintaining production equipment. Experts from the company are working with the college staff in analyzing the procedures in diagnosis and repair of faults in production lines. Expert systems have been constructed from these findings, which have been used to develop techniques for knowledge engineering. The work is being supported by a large confectionary company.

Medical Applications of Expert Systems

Several kinds of medical data have been represented as flowcharts and tables and used as a basis for expert systems. The data are being used to compare and contrast the knowledge-engineering skills needed in medicine and in engineering. Resolution of the uncertainties in these fields should lead to a classification of problems which will help in choosing an expert system for a particular application and in developing appropriate rules.

Logic and Knowledge Representation

The ad-hoc reasoning methods used in most expert systems have limitations which are partially responsible for difficulties in further development of such systems. The fuzzy logic and fuzzy reasoning developed by L.A. Zadeh (University of California, Berkeley) have been suggested as a means of representing meaning, and they have many of the features required by expert systems. Logic and semantics are of great importance in representing meaning, but need to be examined from a pragmatic rather than a philosophical viewpoint. The researchers at Queen Mary College are complementing their industrial and practical work with an in-depth study of the role of logic, influence, and knowledge representation in expert systems.

Self-Organizing Controller for a Robot Arm

For several years Mamdani and his group have been investigating the properties of rule-based fuzzy controllers. The original algorithm was developed within the group and is being applied, after enhancement, to the control of a robot arm. The controller is self-organizing. Given some advice on how to arrive at a steady setpoint, it can devise its own strategy for doing so. The controller has been tested and can achieve satisfactory control after about three learning trials.

Self-Organizing Rule-Based Controllers for Cement Mills

The British company Blue Circle is supporting an investigation of the use of a self-organizing controller for their mills, which grind cement clinkers to powder. These mills are two-input, two-output processes and consume a very large amount of energy. Only 1 percent of this energy is used to break down the crystal structure of the clinker. Any small improvement in the control of these mills could produce a substantial benefit for the company.

4/18/84

NATO ESTABLISHES SPECIAL PROGRAM PANEL ON SENSORY SYSTEMS FOR ROBOTIC CONTROL

by J.F. Blackburn.

NATO has established the Special Program Panel on Sensory Systems for Robotic Control to monitor trends and

encourage international collaboration in sensory systems for use in the control of robots. Such cooperation will provide an integrated framework for the large range of research projects in many disciplines expected to play an important part in the widespread application of sensor-guided robots. These robots should be able to adapt to some variation in their surroundings and in particular should: (1) be able to compensate for deviations in the parts and processes they are handling; (2) be more reliable and simpler than present machines and thus be able to carry out tasks unattended for long periods; and (3) include image processing and control software operating in real time. These objectives apply to the next 5 to 10 years.

It is expected that the panel will bring together researchers from various engineering and scientific disciplines to exchange and develop technical information about sensing technology and machine intelligence as applied to robotics. The panel will consider not only short-range practical contributions, but also contributions whose applications are further in the future.

The first meeting of the panel was held in Brussels on 26 and 27 March. The meeting was attended by the eight panel members from NATO member countries and several NATO officials, including Dr. M. DiLullo, who was responsible for organizing the panel. I attended by invitation from NATO because of the survey of leading European centers active in robotics which ONR, London, has done (Scott Harmon, *A Survey of European Robotics Research*, Report R-4-84 [ONR, London, 27 January 1984]). Prof. Leon D. Harmon (Case Western Reserve University) was chosen as chairman of the panel. The active life of the panel is expected to be 6 years, with some rotation of membership during that time.

The panel decided to confine its attention to the following main topics:

1. Transduction, including peripheral preprocessing
   a. Robot sensors (internal, external, and environmental)
   b. Redundancy in sensing systems for improved performance
   c. Direct sensing
   d. Single modality systems (proximity, force, vision, acoustic, chemical, thermal)
   e. Multimodality systems
2. Pattern analysis and machine intelligence
   a. Relationships between sensing and estimation theory
   b. Combined-sense information processing
   c. Real-time object and environment measurement and classification
   d. Task description and robotic performance evaluation
   e. Knowledge representation and decision making
3. Control
   a. Hierarchical control theory and algorithms
   b. Multivariable control
   c. Optimizing control in redundant degrees of freedom
   d. Kinematic and dynamic issues.

The panel is operating under the NATO Scientific Affairs Division. The division's staff is responsible for implementing the programs of the NATO Science Committee. These programs are intended to enhance the scientific and technical capability of the NATO alliance by supporting cooperation and the exchange of information between scientists of member nations and by catalyzing remedial action to help close gaps in scientific knowledge and research capability.

The Scientific Affairs Division uses the following activities to advance science and technology:

1. Research fellowships: 700 per year at the postgraduate level in support of research and study outside the home country of the research fellow.
2. Advanced research workshops: 30 working meetings a year for intense exchanges among senior scientists to review progress in a given field and recommend future research.
3. Collaborative research grants: 300 awards each year in support of cooperation on specific projects carried out jointly by research teams in different countries.
4. Advanced study institutes: 60 tutorial meetings a year on advanced topics not in regular university courses. International faculty; 2 weeks' duration.
5. Double Jump: program to promote closer international cooperation between university and industrial research on projects of industrial interest. Fellowships and research grants are given.
6. Special programs: short-term, intense international cooperation in a few innovative fields at the frontier of disciplines.

The panel has not yet decided which of these to use.

The second meeting of the panel will be in London on 13 and 14 September; the third panel meeting will be held in Brussels on 3 and 4 December.

Professors Harmon and Pugh are undertaking a literature search to determine who is doing relevant research in robotics in the US and in Europe. They will of course use the information already available from many sources, including ONR, London, Reports R-4-84 and R-1-83 (J.F. Blackburn, *Robot Manipulator Control* [7 March 1983]), and *ESN* articles (see, for example, *ESN* 36-11, 36-12, 37-1, 37-3, 37-4, 37-5, 37-6, 37-7, 37-8, 37-9, 38-1, and 38-2). Results of Harmon and Pugh's survey will be edited and added to by all members of the panel and will be discussed during the September meeting; the meeting report will give the results of the survey. A comprehensive final report of the panel will only be made at the end of the panel's life.

4/4/84

PARALLEL PROCESSING AT THE UNIVERSITY OF AMSTERDAM

by J.F. Blackburn.

The research at the University of Amsterdam on parallel processing ranges over hardware design and construction, programming, and applications in high-energy physics. This work in high-energy physics heavily influences much of the hardware design and construction as well as the programming research. Prof. L.O. Hertzberger, who heads computer science in the department of mathematics and computer science, came from high-energy physics and retains a strong interest in that field.

The Fast Amsterdam Multi-Processing (FAMP) System

Researchers at Amsterdam have designed and built a fast multiprocessing system which can be used for second-state triggering and for on-line track filtering in high-energy-physics experiments. The system is based on the Motorola MC68000, a 16-bit word microprocessor with a cycle time of 125 ns. This provides an average instruction time of 500 ns. The instruction set supports operations on bytes (8 bits), words (16 bits), and long words (32 bits); and 8 million words of memory can be addressed.

The energies at which experiments in high-energy physics are performed have increased; this means that there are many more events to be recorded, which in turn implies a substantial increase in the total data stream. Therefore, the effective trigger rate is limited by the speed of data acquisition. Present experiments have detectors which can operate at a rate of one per 100 ns, while a fast trigger decision is taken in 1 μs. But the data-recording time is on the order of 0.01 s. Also, off-line processing of the data may take up to 1 s on a large computer for complicated topologies. This results in unacceptably large central-processing-unit demands for big experiments.

The FAMP system can be used for sophisticated trigger applications as well as in preprocessing techniques, both of which contribute to improvements in the processing. In most high-energy-physics experiments three different trigger stages can be distinguished:

1. Zero-stage trigger--nuclear instruments and methods logic is used to make correlations between a few detector signals. The precise timing of these signals is important. Decision time is between 10 and 100 ns.
2. Primary-stage trigger--the decision is derived from a large number of signals, using coincidence matrices and correlation tables. The timing is still important; decision time goes up to 1 μs.
3. Second-stage trigger--processors use hit/nohit information or drift times to perform complicated calculations. Signal timing is neglected. The decision time is on the order of 100 μs.

Large memories and programmable logic arrays are used in the first-stage trigger, whereas a number of microprogrammable special-purpose processors have been developed to serve as a second-stage trigger.

The FAMP was designed to be used for second-stage triggering and on-line track filtering, which uses the idea of parallel processing to compensate for the limited processing speed of microprocessors. The system performs real-time computations like track reconstruction, momentum determination, and invariant mass calculation.

The system is designed so that an almost unlimited degree of parallelism can be achieved. The approach used has the following advantages:

- Simple to adapt to future microelectronic developments.

- Possible to apply fast programming techniques by making use of large data tables.
- Simple to program by using an assembler or a high-level language like PASCAL.
- Possible to increase in a simple way the processing power by adding new system blocks.
- Simple to interface to the experiment.

For second-stage triggering, computing tasks can be split up into subprocesses which can run concurrently on a number of parallel processors.

System Software for FAMP

The operating system should offer the following features:

- Synchronization between tasks running concurrently on different processors.
- Periodic checks on the performance of the FAMP hardware.
- Management of interprocessor communication.
- User interface software.

A minimum operating system can be considered as a slave, and an extended operating system can run on the supervisor processor as master.

The extended operating system will control the minimum operating systems by using the priority interrupt levels of the MC68000. Consequently the user programs must be written as interrupt routines. Trigger programs will run at a higher priority level than the operating system routines.

The minimum operating system will, among other things, check the hardware performance. The internal synchronization, the experiment monitoring and the user interface routines will be provided by the extended operating system.

In multiprocessing systems the software has to control two data streams, that of the user programs and of the operating system. To avoid clashes, as both streams pass the dual port memory, the memory is divided into two blocks, each devoted to only one of the two tasks. To protect the message exchange, a pointer to a message block is protected by a semaphore which is tested by using the test and set instruction of the MC68000.

At present all software is written in MC68000 assembly language. However, the researchers want to write the system software wherever possible in a structured higher-level language like PASCAL. The new MC68000 development system of Motorola has a PASCAL compiler; a FORTRAN compiler is planned. Since the code generated by the Motorola compiler may not be efficient enough for many trigger applications, the University of Amsterdam is collaborating with the Free University of Amsterdam on the optimization of the MC68000 code generated by their PASCAL- and C-compilers.

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4/18/84

RESEARCH ON OPERATING SYSTEMS, COMPILERS, AND LANGUAGES AT THE FREE UNIVERSITY OF AMSTERDAM

by J.F. Blackburn.

Although the Free University of Amsterdam has had a program in computer science only since the late 1960s, the variety of research in computer science is considerable. There are four professors of computer science in the Department of Mathematics and Computer Science; they supervise research on operating systems, compilers, network protocols, programming languages, database sharing in distributed systems, and the mathematical theory of programming. This article discusses work in the first three areas.

Operating Systems

A.S. Tanenbaum has studied the operating system requirements for distributed database systems. Database systems have often been built on top of existing operating systems which were designed as a compromise between the requirements of commercial data processing, time sharing, scientific computing, and other applications.

The UNIX operating system, which is widely used, was studied as an example of a modern operating system that nevertheless presents problems for database systems built on top of it. UNIX maintains an in-core buffer cache of recently used disk blocks. When a disk block is needed and not found in the cache, it is read in and replaces the least recently used block. However, with large databases the likelihood of finding the required block in the cache is smaller. Also, UNIX attempts to prefetch blocks in advance when a file

appears to be read sequentially. Researchers at Amsterdam doubt that such accesses occur frequently enough to justify this procedure.

They also point out that there is lack of certainty that a WRITE operation actually forces the written block to the disk. After they have been "written," blocks are often kept in the cache to save a disk access if they are read again quickly. This complicates crash recovery because a block containing an intentions list or locking information is still in the cache. It is considered better to have the database system control this procedure.

Also, in UNIX a file is a linear sequence of bytes without structure. The operating system must maintain some kind of internal data structure, typically a tree. Given the block number in the file, this data structure produces a pointer to the block. If nonstructured files are the only ones available, the database system must maintain its own tree-mapping keys onto file positions, which are then mapped onto disk addresses in a second step. This is less efficient than mapping keys directly to disk blocks. Also, the user has no control over block placement.

The operating system for a database should provide its users a low-level interface with user control over issues such as buffering and interprocess communication. At the lowest level, the database system should be able to read and write isolated disk blocks with no system buffering and no implied relation between successive disk transfers. The system should be transaction oriented.

When the database system issues a READ or WRITE command, it should not be put to sleep awaiting completion of the action unless it explicitly so requests. Nonblocking I/O provides more flexibility.

A simple but adequate interprocess-communication facility is unbuffered packet transport. In a highly reliable local network, a simple stop-and-wait protocol with a timer for each packet is enough. Synchronization, locking, and acknowledgements can also be handled by sending packets. A "reliable transaction" protocol can be built on top of the packet protocol.

Generally among researchers two approaches have been used in the past for user authentication: access control lists and capabilities. Both presume a conceptual matrix in which each row corresponds to a user and each column corresponds to an object known to the system. The intersection of a row and a column tells what access, if any, the specified user has to the specified object. Since the matrix is sparse, it is never stored in its entirety. In one approach the system maintains a list indexed by object, telling which users may access the object and how. In a second approach the system has a list indexed by user, telling which objects the user may access and how.

In the system for database application devised at Amsterdam, called Amoeba, capabilities are used since they lend themselves better to controlled sharing of information in a distributed system. In Amoeba the basic elements are processes, ports, and packets. Processes communicate with each other by exchanging packets through their ports. Service is the term Tanenbaum uses for the function of carrying out the request from a process for work to be done; service is the model used for interprocess communication. It is defined by a set of commands and responses and is implemented by one or more *server* processes that listen to certain ports for requests.

When a process, P, has work for a service, S, P sends a message to one of S's ports. Knowledge of a port number means to the system that the sender has a right to use the port. All protection in Amoeba is based on port numbers.

To prevent users from constructing port numbers to which they have no legitimate access, the port numbers are chosen from a sparse address space. If port numbers contain N lists and if N is sufficiently large and only a tiny fraction of the 2^N possible ports are actually used, the chance of forgery is small.

The interface between the operating system and the database system is defined by a small set of primitive instructions, of which PUT and GET are the most important. However, higher level primitives like PUTREQUEST and GETREPLY are implemented by user-space library routines.

The generalized file system includes multiple-disk block servers, flat (nonstructured) file servers, relation servers, directory servers, and query servers.

The system arranges for nearly all of the file system to run as unprotected user code. Thus the database system's designers are free to provide their own file servers, relation servers, directory servers, and so on--giving them complete control over buffering, internal scheduling, acknowledgments, and locking. The researchers at Amsterdam believe this approach is better for a distributed system than connecting several computers with traditional operating systems.

Compilers

Tanenbaum, H. Van Staveren, E.G. Keizer, and J.W. Stevenson have developed the Amsterdam Compiler Kit, an integrated collection of programs designed to simplify the task of producing portable compilers and interpreters. For each language to be compiled, a program (called a front end) must be written to translate the source program into a common intermediate code. This intermediate code can be optimized and then either directly interpreted or translated to the assembly language of the desired target machine.

The tool kit helps one make a compiler for each of N languages on M different machines without having to write N×M programs. The approach is to write N front ends, each of which translates one source language to a common intermediate language, UNCOL (Universal Computer-Oriented Language), and M back ends, each of which translates programs in UNCOL to a specific machine language. Thus only M+N programs must be written.

The approach at Amsterdam is to include only algebraic languages and machines whose memory consists of 8-bit bytes, each with its own address.

The eight components of the tool kit are the processor, the front ends, the peephole optimizer, the global optmizer, the back end, the target machine optimizer, the universal assembler/linker, and the utility package.

A program to be compiled is introduced into the preprocessor, which provides macro and similar textual facilities. Its output is a program in one of the programming languages supported.

This output is used by the appropriate front end to produce intermediate code (UNCOL), which is machine code for a stock machine called EM (Encoding Machine). Typically a front end might build a parse tree from the input and then use the parse tree to generate EM code. To do this, the front end maintains tables of information such as declared variables and labels, and determines where to place the data structures in memory.

The peephole optimizer scans the EM code with a few instructions, replacing certain inefficient code sequences by better ones. EM contains instructions to handle efficiently numerous important special cases. By handling special cases in the peephole optimizer, the front ends become simpler, easier to write, and easier to maintain.

The global optimizer then examines the program as a whole and builds a data-flow graph to make possible a variety of global optimizations. The output of the global optimizer is still EM code.

The back end then produces a program in the assembly language of some particular machine. Each front end is a separate program, but the back end is a single program driven by a machine-dependent driving table. The driving table for a specific machine tells how the EM code is mapped onto the machine's assembly language. The back end does not actually read in the driving table at run-time. Rather, the tables are compiled along with the back end in advance, resulting in one binary program per machine.

The next step is to perform peephole optimization on the program. These optimizations are functions of the idiosyncracies of the target machine that cannot be performed in the EM language. The optimized target-machine assembly code then goes to the universal assembler/linker, which assembles the input to object format, extracting routines from libraries and including them as needed.

The utility package contains various test programs, interpreters for EM code, EM libraries, conversion programs, and other aids for the user.

Network Protocols

Tanenbaum has made a comparative study of network protocols using as a guide the Reference Model of Open Systems Interconnection developed by the International Organization for Standardization (ISO). He classifies networks as local, which are usually owned by a single organization, or long-haul, which normally involve the carrier and the user. A computer network is a collection of computers, called hosts, that communicate with one another.

In a long-haul network the communication facility is called the subnet, and often consists of a collection of minicomputers called interface message processors (IMPs), nodes or switches connected by high-bandwidth leased telephone lines or a satellite. When the IMPs are connected by telephone lines, they are normally located on the carrier's premises, with each IMP serving a number of hosts. Hosts and terminals are often funneled through remote concentrators. Local networks do not have IMPs. Each host has an interface card inserted into its back plane to control access to the network. The ISO reference model was designed primarily for long-haul networks; it can be used for local networks as well.

Networks are generally organized as a hierarchy of layers. In the ISO

reference model the seven layers are: the physical, the data link, the network, the transport, the session, the presentation, and the application layer. All layers are present in the hosts, but only the physical, the data link, and the network layers are in the IMPs.

The ISO model has seven protocols (rules governing the layer conversation). Data are passed vertically down the layers of the sending machine and up the layers of the receiving machine. Intermachine communication occurs only in the physical layer. The boundary between adjacent layers is called an interface. The layers, interfaces, and protocols in a network form the network architecture.

In the ISO reference model the physical layer protocol deals with the transmission of a raw bit stream. Its protocol designers decide how to represent zeroes and ones, how many microseconds a bit will last, whether transmission is full- or half-duplex, how the connection is established and disconnected, how many pins the network connector has, use of each pin, and other electrical, mechanical, and procedural details.

The data-link layer converts an unreliable transmission channel into a reliable one for use by the network layer. The raw bit stream is divided into frames, each with a check sum for detecting errors. The data-link protocol usually ensures that the sender of a data frame will repeatedly transmit the frame until it receives an acknowledgement frame from the receiver.

The network layer in a point-to-point network is primarily responsible for routing and handling congestion. In a broadcast network, routing is not an issue.

The task of the transport layer is to provide reliable host-to-host communication for use by the session layer. Details of the communication subnet must be hidden from the session layer or higher layers. The transport layer shields the user's portion of the network from the carrier's portion.

The session layer is responsible for setting up, managing, and discontinuing process-to-process connections, using the host-to-host service provided by the transport layer. It also handles some aspects of synchronization and recovery.

The presentation layer performs generally useful transformations on the data to be sent, such as text compression. It also performs the conversions required to allow an interactive program to converse with any one of a set of incompatible intelligent terminals.

The content of the application layer is up to the users. However, standard protocols for specific industries, such as airlines and banking, are likely to develop.

A possible implementation of layers might be to have the physical layer in hardware, the data-link layer in a special protocol chip, the network layer in a device driver, the transport and session layers in the operating system, the presentation layer in a set of library routines in the user's address space, and the application layer as a user's program.

Tanenbaum says the ISO reference model is not a protocol standard. It suggests places where protocol standards could be developed, but these standards themselves fall outside the domain of the model. Other organizations--such as the Consultative Committee for International Telephony and Telegraphy, the International Federation for Information Processing, and the American National Standards Institute--may develop specific protocol standards for the various layers.

Tanenbaum (1981) provides a detailed discussion of all the layers of the ISO reference model, but he points out that he is not discussing only the model itself. Emphasis is on the communication algorithms and protocols which are not discussed in the reference model.

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4/18/84

EARTH SCIENCE

LEANING BUILDINGS AND SINKING CITIES IN EUROPE

by Robert Dolan. Dr. Dolan is the Liaison Scientist for Geology and Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave

until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.

After spending 10 days in northern Italy looking into the question of sinking cities and leaning buildings, I learned that Venice is only the best example of a city with these problems. In fact, in northern Italy--and many other areas of the world--virtually every city that developed on a floodplain has problems with sinking and with leaning buildings.

The best example of leaning is, of course, the Leaning Tower of Pisa. Construction of the tower began in 1174, on the floodplain of the Arno River, and finished in 1350. However, even before the tower had been completed it had started to lean. By midway in the construction it was leaning so much that a correction was made to straighten it out. If you look closely at a photograph of the tower and measure the difference in the angles of the columns very carefully, you will find that the upper one-third leans less than the bottom two-thirds (Figure 1). I would like to add, parenthetically, that the photographs one sees of the Leaning Tower are not the result of special effects to exaggerate the angle. One's initial reaction is, "it's impossible, it can't be." The tower will, of course, fall someday; it is inevitable given that it leans a couple of millimeters more each year. But steps have been taken to slow the process. The most recent was the injection of concrete into the foundation area. My host said that this slowed the lean somewhat. After seeing it firsthand, I expect to read in the London *Times* any day now that the tower has finally toppled.

The problem in the case of the Leaning Tower (like thousands of other buildings in Europe) is land subsidence, the subject of the Third International Symposium on Land Subsidence held, appropriately, in Venice from 19 through 25 March. Land subsidence is not only responsible for the Leaning Tower, but also for the sinking and leaning of hundreds of other famous buildings in Italy alone. During the symposium field trip, for example, we visited a 13th century church on the floodplain of the Po River; the building had sunk so much that it had over 1 m of water in the burial vaults beneath the altar, and three distinct floor levels had been constructed to keep the main floor above the groundwater level.

The symposium was attended by about 125 participants from several nations.

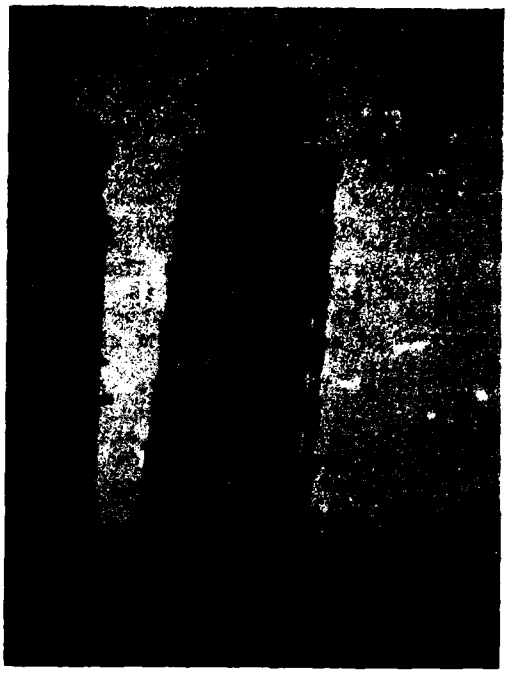


Figure 1. The top of the tower leans less than the bottom.

Included were people from most of the world's great sinking cities: Venice, London, Mexico City, New Orleans, Maracaibo, Bangkok, Houston, and Shanghai. In addition, papers were presented on subsidence in nonurban agricultural areas, such as the Central Valley of California.

But Venice typifies the problem underlying all these locations. These are cities and industrial areas that have developed on unconsolidated sedimentary materials associated with river floodplains (New Orleans), coastal marshlands (Venice), or soft lake beds (Mexico City). Therefore, in all cases there is a natural compaction or subsidence rate to cope with, in addition to compaction associated with the weight of the buildings and other developments. These two factors alone would spell trouble for a lot of historical buildings, but the major problem that has developed over the past 100 years, and particularly over the past 40 years, is the extraction of great volumes of groundwater from the aquifers beneath these great cities. This process has resulted in accelerated subsidence rates, up to 12 cm/yr in some urban areas. Between 1950 and 1970, the rate of sinking of Venice increased tenfold,

due primarily to groundwater extraction; however, for Venice, like most cities built in the coastal wetlands (New Orleans is another), subsidence is only one horn of the dilemma. A worldwide rise in sea level of about 1.5 mm/yr, (and in some places higher due to tectonics) results in progressively higher tides, storm-surge, and groundwater levels. In the case of Venice, 62 percent of the city is now flooded when the tide and storm surge reaches 1.3 m. This level occurred five times in the 50 years between 1916 and 1960, and 13 times in the 25 years since 1960. This suggests that storms and high tides are occurring more frequently, or that sea level is rising and thus lower high-water levels result in higher flooding. What has the city engineers and politicians most concerned is that if a high storm surge should occur at the same time as perigean spring tides, the height of the water could reach 2.5 m above sea level, which would flood over 90 percent of the city, with deep water occurring in some of the most important historical buildings.

Little can be done to change the rate of sea-level rise, other than construction of barriers around the cities. And if the meteorologists' predictions are correct that we face warmer temperatures and increased rates of glacial melting due to higher levels of CO_2 in the atmosphere, then even the substantial barriers now protecting some of the cities will be inadequate. One experiment reported at the meeting consisted of the injection of "grouting" into the substrate beneath a sinking island in the Venice Lagoon to check the rate of subsidence. In this case, the engineers even gained 10 cm of elevation; but the process is very expensive, and the discussion afterward suggested considerable pessimism in its general application.

In summary, the conclusion I reached after listening to 5 days of presentations and discussions is that the only solution available for most of the sinking cities and leaning buildings is to reduce the rate of groundwater pumping wherever possible, and like the Dutch 100 years ago, to build dikes around the most valuable developments. For a few of the historical treasures, such as the Leaning Tower, it may be possible to postpone the inevitable through site-by-site engineering, but given the tremendous number of such buildings in Europe alone, the cost will be extreme.

It seems ironic that most of the water being pumped from under the cities, resulting in their sinking and vulnerability to leaning and flooding, is used for domestic and industrial purposes by the people living there. For Venice, Bangkok, New Orleans, and some other cities, little can be done over the intermediate term of, say, 200 years or more. If one considers how long Venice has existed (over 600 years), and then considers a similar period in the future, it is highly unlikely that the city will exist as it does today. But the residents do have a good fleet of boats available for moving when the day of reckoning comes.

4/19/84

EDUCATION

PRC TEACHERS AND TECHNICAL INSTITUTIONS

by R.L. Carovillano. Dr. Carovillano, formerly at ONR, London, is Professor of Physics at Boston College.

This article describes the educational programs at lesser-known and special-purpose institutions in the People's Republic of China (PRC): Hebei Normal University in Shijiazhuang, Xi'an Jiaotong University, and Shanghai Jiaotong University. (A normal school is a teacher's college; jiaotong means transportation and communications, and a jiaotong university would correspond to an institute of technology in the US.) This article is based on information gathered during a trip that US physics teachers recently made to the PRC; for other articles about the trip, see *ESN* 38-5 and 38-6.

Hebei Normal University (HNU)

The school is in the large city of Shijiazhuang, which has a population of about 1.2 million, located in the province of Hebei and about 400 miles west (inland) of Beijing. There are two universities and 10 colleges in Hebei that train physics teachers. The students at HNU come from all over Hebei, including many from the rural areas. Students are chosen by the results of national college entrance examinations; each school picks students with the best scores, going down the list until its enrollment quota is met. Quotas at HNU and other institutions have been increasing because of the national need for "construction." Middle-school teachers may also be directed by their principal to attend HNU for further study.

About 80 percent of the HNU graduates go into middle-school teaching; the remainder go on to other universities or to the military. The latest statistics for the province largely determine the job assignments of the graduates; faculty recommendations also are taken into account. Graduates usually prefer being sent on to another university rather than a middle-school assignment because of the low salary and social status of a middle-school teacher. The monthly salary range for middle-school teachers is $80 to $190, with slightly higher levels paid to encourage teachers to go to rural areas.

HNU has a 4-year program, and students must finish in 6 years with continuous evidence of progress. Few students drop out of the program.

The faculty at HNU comes from universities all over the country. Faculty inbreeding was described as "not good," and attempts were made to avoid the problem. The faculty is now expected to do research. The average monthly salary ranges for the faculty at HNU are about $190 to $440 for professors and associate professors, and $125 to $190 for lecturers. The type of university is not a large factor in salary determination, but faculty salaries tend to be higher in the large cities.

The faculty-promotion process starts at the departmental level, passes to a university credentials committee, and requires approval of the university president. To become a professor, the candidate must also be approved by the Central Education Board. Promotion criteria are: the total amount of university work done; student opinion of teaching, including consideration of past students; and research. Research does not yet relate integrally to the promotion process beyond the direction of student dissertations. In the near future the PhD may be required for achieving the rank of professor.

The physics department has about 500 students and a faculty that includes eight professors, eight associate professors, 40 lecturers, and about 30 assistants. About 20 females are on the faculty, only one, an associate professor, holds a rank above lecturer. About one-third of the physics graduates from HNU are female. The freshman physics group (about 120 students) is taught in one large class. Students from different majors are not mixed since physics courses for them use different books.

The physics curriculum has five parts: general physics, theoretical physics, solid state physics, advanced laboratory, and applied sciences. Additional requirements include mathematics, psychology, foreign language, political science, and middle-school teaching methodology.

General physics continues for five semesters, each course having four or five lectures and three hours of laboratory per week, plus evening "coaching" sessions. Topics include mechanics, molecular physics, electricity and magnetism, optics, and atmospheric physics. The theory courses include theoretical mechanics, thermodynamics, statistical physics, eletrodynamics, and quantum mechanics. There is a strong emphasis on laboratory, except in the theory part of the curriculum. Experiments include spectrum analysis, x-rays, materials, and nuclear physics. Applied studies include electrical engineering and electronic circuits.

Class demonstrations are encouraged in general physics. At least one or two demonstrations are given in class each week. An assistant is assigned to facilitate setups, but the demonstration is performed by the lecturer.

Mathematics is studied through the level of advanced calculus and methods of mathematical physics. Most students study English, but some take Russian and a very few take Japanese.

Methodology used to be taught by middle-school teachers who were taken on as HNU faculty members. This practice is rare today. Nevertheless, methodology is taught only by faculty members with direct middle-school experience. A one-semester course is required that includes: experiments for middle-school physics laboratory, 6 weeks of practice teaching, and lectures on methodology. About 20 middle schools are used to provide the practice teaching for 120 physics students.

Xi'an Jiaotong University (XJU)

The city of Xi'an is most famous for its archeological importance and the terracotta-warrior finds that are currently under excavation. XJU is the largest of the 18 colleges and universities in Xi'an, and now the largest in northwest China as well. It was founded in 1896 in Shanghai and moved to Xi'an in 1956 to aid in the cultural and economic development of northwest China. The current university took form in 1959 and is directly under the Ministry of Education.

The student body at XJU consists of about 6300 undergraduates and 700 graduate students enrolled in MS or PhD programs. About 15 percent of the students are female. The institution has 14 departments, mostly in engineering, technology, and applied science: electrical engineering, electronics,

computer science and engineering, power machines, metallic materials engineering, power and energy, civil engineering, applied mathematics, applied chemistry, management, foreign languages, social science, and basic courses. The physics program is a large section of the basic courses department.

Research is done in departmental research laboratories and in four university research institutes. The institutes are in metallic materials and strength, mechanical and systems engineering, servosystems, and electrical engineering. Materials research is emphasized, particularly metals, insulators, polymers, and other complex materials. Other research programs are on population, library management, information, commerce, and conventional and new sources of energy. Recently established programs are in solar-energy research and biological engineering. XJU also runs four "factories" for machines, electronic devices, equipment for science teaching and research, and publishing. About 80 percent of the ongoing research is by government plan or need. As of January 1984, XJU had awarded a total of about 150 MS degrees and no doctorates.

The university library has 1.2 million volumes and 3000 periodicals, of which 1300 are foreign. The library holdings are mainly in engineering and science. Many volumes are in foreign languages, particularly English, French, Japanese, Russian, and German. Extensive holdings, reference books, and encyclopedias are available in English. The claim was made that XJU has all of the important periodicals in the world for the library to be an important center for materials research. Library management at XJU was described as "backwards," involving no computer usage and much manual work.

The faculty numbers 1600, including 400 professors and associate professors. The total university staff is about 4000, with some 1400 assistants. About 10 percent of the faculty is female. Professors and associate professors teach 8 hours per week and direct graduate-student research. Lecturers teach 10 hours per week.

XJU is a large community of about 20,000 people. All students and families of married students are housed in facilities on campus. Daily needs of the community require a large staff. The university provides schooling for the children from kindergarten through middle school. Some graduates have used the XJU school system from kindergarten through college. Adult education is also provided.

The student body comes from all over China. Of the students who select XJU as a university they wish to attend, XJU gets first choice. All applicants take the national entrance examination. About 30 to 40 percent of the students come from the local province. Enrollment provision is made for special classes to meet special needs of the province. Other special classes are also set up to promote the development of other areas of China. Minorities constitute about 10 percent of the student body.

The curriculum is essentially the same for all students during the first 3 years. Specialization takes place in the fourth and final year. All students take two semesters of physics, three and one-half semesters of mathematics, one semester of chemistry, and three semesters of mechanics.

The university physics course has a total of 220 contact hours; 160 hours of lecture and 60 hours for laboratory. About 110 hours of lecture time are devoted to classical physics, and 50 hours to modern physics. There are 4 to 6 lecture hours per week. Assigned problems are worked independently by students. Assistants spend some time explaining the homework after the fact. Laboratory has one 3-hour meeting every other week and is completed in 1 year. The labs have good scientific equipment, some made in China and some in England, Japan, and the US. Only the workbenches and chairs were of low quality in the labs.

Mathematics includes differential and integral calculus. Engineering mathematics begins in the third semester and includes topics such as matrices, special functions, and probability.

Graduates of XJU do well. About 15 percent go on for the MS degree, and about 50 students are in PhD programs. The others go into industry. None goes into middle-school teaching. Students going into industry are given industrial experience before graduating. About 60 to 70 percent of the students are given job assignments that meet their expressed job preferences. About 10 percent do not get their choices. There are very few dropouts or failures in the student body.

XJU is a "key" institution of the Ministry of Education and receives additional support from the Ministry of Industry and from the province. Key institutions receive preferential treatment in terms of faculty assignments, financial support, and student quality. Support from the Ministry of Education promotes the quality of the student body and the graduates from XJU.

Support from the Ministry of Industry promotes the technical aspects of the program and helps place XJU graduates in research institutes and factories. XJU graduates are expected to have solid foundations in science and the capability to work in science. Middle schools are also designated as key within a province (not through the Ministry of Education), and graduates of key middle schools have a better chance to enroll in a key university.

XJU is actively engaged in foreign exchanges and programs. About 200 faculty members and many graduate and undergraduate students have spent time studying abroad, and many foreign faculty members have visited XJU. Since 1978, the greatest effort has been to develop relations with US institutions. More than 1000 graduates of XJU are now working or studying in the US. Formal agreements exist with universities such as Georgia Tech., Cornell, Pittsburg, Syracuse, and MIT. Other agreements are with Canada, the UK, Holland, France, Switzerland, West Germany, and Japan. The cooperation with universities generally consists of an interchange of scholars and visits by foreign faculty members to XJU. Visiting faculty lecture, assist in the development of laboratories and programs, or collaborate in research.

Some exchanges also take place with the USSR and Eastern European countries. Several Soviets attended a conference at XJU last year.

XJU has held international meetings and plans to be active in sponsoring international conferences and cooperative projects. Support from international organizations is required for these activities. Current support of $7 million was provided by the World Bank for the establishment of a computer and measurement center.

Looking ahead, the plan is for XJU to undergo a significant expansion. By 1990, the faculty will be increased by about 50 percent, and the enrollment will be about 11,000 undergraduates and 3000 graduate students. The plan is for the graduate student body to increase approximately tenfold in 6 years--an enormous growth rate.

Shanghai Jaiotong University (SJU)

Founded in 1896 and originally named the South Ocean University, SJU is one of the oldest polytechnical universities in China. The institution has 12 departments, a school of business management, and five research institutes. Programs emphasize applied science, engineering, technology, and communications. There are applied chemistry, applied physics, and applied mathematics departments; engineering departments in electricity, naval architecture, power machinery, electronics, materials, mechanics, and industrial management; and departments of foreign languages. SJU has a few students majoring in English.

The student body consists of about 6000 undergraduates and 800 graduate students. MS and PhD degree programs began about 3 years ago. About 50 students are in the doctoral programs. The faculty numbers about 1800, which includes 550 professors and associate professors. In a catch-up maneuver, about 200 faculty members were promoted this year. A significant number of faculty appointments, about 300, were made since the cultural revolution. About 10 percent of the faculty and 25 percent of the student body are female.

SJU will expand its student body and faculty significantly by the year 1990. At that time, 8000 undergraduates, 3000 graduate students, and 2400 faculty members are planned. A separate college of engineering may be formed. Because the university is located in downtown Shanghai, adequate space for expansion will be a problem. Construction of a new library began in 1982.

Entrance requirements are high at SJU. Mathematics is emphasized in the core program. Students are encouraged to undertake independent study; they have ready access to open labs. Students attend university colloquia regularly; there are many of these meetings since more than 6000 scholars and educators visited SJU in the last few years (in addition to President Jimmy Carter).

All undergraduate programs require 4 years, except for the department of precision instruments, which takes five. Two semesters of basic physics are required of all students, and four semesters for students in applied physics,

The MS program in physics requires 30 units (or about 10 courses) plus at least a year of research, and takes at least 2 years to complete.

The quality of the faculty is improving steadily. New faculty appointees must have "top" degrees. Senior faculty members spend one-third time at research. Research is expected of junior faculty members too--but for them teaching loads are very high, requiring more that 40 work hours per week. Publications and professional society recognition are acknowledged signatures of research accomplishment. More than 60 faculty members traveled abroad last year to present papers at

meetings or to further research collaborations.

The retirement age for lecturers is 60 for women and 65 for men. The retirement age has not yet been set for professors or associate professors. There is a shortage of professors at SJU, so faculty of that rank are allowed to teach into old age.

More than 100 SJU students and several professors were at US institutions studying or doing research this past year. SJU has institutional agreements with many universities, including Columbia, the University of Pennsylvania, and the Wharton Business School.

4/10/84

ENGINEERING

UNDERWATER ACOUSTICS IN SOUTH AFRICA

by R.J. Bobber. Dr. Bobber, now a private consultant, was Superintendent of the Underwater Sound Reference Division, Naval Research Laboratory, until his retirement in 1980. Recently he spent several months in South Africa.

This article provides an overview of South African research in underwater acoustics. Work at the following institutions is highlighted: (1) the Central Acoustics Laboratory (CAL) at the University of Cape Town (UCT); (2) the National Underwater Acoustics Centre (NUAC), which is located with the Institute for Maritime Technology (IMT) in Simons Town, about 25 miles south of Cape Town; and (3) the National Institute of Materials Research (NIMR) of the Council of Scientific and Industrial Research (CSIR) in Pretoria.

CAL/UCT

The CAL is part of the Electrical Engineering Faculty and was founded by Prof. Semmelink some years ago to provide local expertise in architectural acoustics. With Semmelink's retirement and with the scarcity of sponsors for research in architectural acoustics, the emphasis has changed to underwater acoustics. Dr. Ron New (formerly of Catholic University and the US National Oceanographic and Atmospheric Administration and now with Capitol Institute of Technology) was head of the CAL for 1 year. He was succeeded by Prof. P.N. Denbigh from the University of Birmingham, UK. Denbigh, with a strong background in sonar, has developed a substantial research program in sonar systems and techniques. Most of the experimentation is at high frequencies (100 to 3000 kHz). These frequencies are used in real systems such as side-scan sonar and in models, where they permit smaller tank facilities. The CAL has a tank that is about 1×1×2 m. Except for Adrian Jongen, who is on the teaching staff, and Denbigh himself, all the research personnel are graduate students.

The various research projects are as follows:

1. Increasing parametric transduction efficiency by using low-velocity fluids in a nonlinear medium such as freon. (Jongens is doing this work.)
2. Measuring the density of schools of fish by statistical treatment of the acoustic scattering from the schools.
3. Using a two-sensor phase difference technique for measuring the direction of reflections in side-scan sonar.
4. Controlling side-scan sonar pulses with a microprocessor to achieve automatic and continual focusing of pulses at all ranges.
5. Using artificial stereoscopic visualization in bottom-profiling sonar.
6. Measuring a ship's speed by correlation of two signals separated in space or time.
7. Developing a three-dimensional sonar.
8. Detecting target angle with one square piston sensor and using cross-correlation between two patterns and two frequencies. (Denbigh would like to know whether anyone else has tried this.)

NUAC

NUAC is a new organization. It receives administrative and other support services from the IMT, of which it is an outgrowth. However, in function and funding NUAC is independent. Several years ago a decision was made that underwater acoustics was a science and technology needed by, but absent in, the Republic of South Africa. So a substantial sum of money was provided for a building and tanks; NUAC moved into its new facilities in September 1983.

NUAC comprises two test and calibration tanks, about a dozen offices and laboratories, and a dozen full-time and part-time engineers and technicians. One tank is very large at 11×11×20 m. A secondary tank connected to the large tank is equally long but smaller in

width and depth at 3.5×4×20 m. The smaller tank is intended as a holding tank for marine animals, with the expectation that marine-animal acoustics will be part of the program. Both tanks can be filled with either fresh or salt water. Both are acoustically isolated from the earth and the building.

NUAC is a corporate rather than a government organization. Although it receives much support from and is closely associated with the South African navy, its mission is quite general; fishing interests, for example, contributed funds for the facility and expect to use it. Notwithstanding NUAC's corporate status and small size, its mission includes the function of the US Naval Research Laboratory's (NRL's) Underwater Sound Reference Division, as well as some parts of Naval Underwater Systems Command and Naval Ocean Systems Command. Current activity centers on instrumenting the tank with the usual electroacoustic, electronic, and mechanical equipment, and developing in-house capability in transducer technology.

Current key personnel are Mr. Gary Zets, Dr. David Naude, and Mr. Leon Krige. NUAC staff members are relatively inexperienced in acoustics and electroacoustics. They have various amounts of formal education in the subject, but are working hard to catch up with their counterparts in the US and Western Europe. NUAC uses contractors, such as CAL and NIMR, to augment its small staff, and of course draws heavily on the unclassified literature from the US and Western Europe.

NIMR/CSIR

The CSIR is a large organization comparable in size to NRL or the US National Bureau of Standards. Its scope is national in nature and is very broad, ranging from basic subjects such as astronomy and nuclear physics to applied subjects such as foods and transportation. Its main site is in suburban Pretoria. NIMR is one part of CSIR and is headed by Dr. B. Clark. Within NIMR is a division dealing with ceramics, headed by Dr. S. Hart and with Dr. Angus Kingon as principal investigator. A few years back this group was asked to develop a local capability for producing piezoelectric ceramics such as PZT and to build a reservoir of expertise in this subject. It has already done this. Both Clark and Kingon have spent time at the Materials Research Laboratory at Pennsylvania State University.

Now the group is moving on to basic research in acoustic materials and applied research in sonar transducers. The processing of PZT materials is being improved to obtain more uniform and predictable electromechanical parameters. A better database on the characteristics of both active and passive acoustic materials is being established. Research on new piezoelectric materials such as PVF_2, ceramic-polymer composites, and lead titanate is planned.

The lead titanate is especially interesting. The Japanese have found that it has zero d_{31} and g_{31} constants. This feature would simplify transducer designs that depend only on the d_{33} or g_{33} parameters, and would give the ceramic a useful hydrostatic mode. A current flaw and peculiar characteristic is an order of magnitude increase in the dielectric loss at frequencies below 1 kHz.

The transducer work is currently limited to the study of modeling techniques--both conventional equivalent circuits and finite element models. The researchers have a way to go to catch up with other aspects of transducer technology already well established in the US and Western Europe.

Research Priorities

None of the three organizations is doing research in underwater acoustics as the term is used to mean, for example, propagation, noise, reverberation, and scattering. NUAC/IMT does have long-range plans for this, but acoustic instrumentation, research ships, and other equipment must come first. In this respect South Africa is no different from the US and Western Europe 40 years ago. The Acoustical Society of America honors individuals in underwater acoustics with its Pioneers Medal, named in honor of Messrs. Fessenden, Langevin, Pierce, Fay, and Hayes. Four of these pioneers made their mark in transducers, and the exception, Harvey Hayes, was at least associated with transducers in his role as Superintendent of the original NRL Sound Division. So the discipline in South Africa is following a traditional pattern.

4/3/84

MATERIAL SCIENCES

COMPOSITE MATERIALS RESEARCH IN FRANCE

by Tsu-Wei Chou. Dr. Chou is Professor of Mechanical Engineering at the University of Delaware.

This is the second article in a series on European research in composite materials. Research by France's Mechanics and Technology Laboratory and the Université de Bordeaux, I, is featured this month.

Last month, *ESN* examined work in the Federal Republic of Germany; in August, research in The Netherlands and Denmark will be highlighted. For detailed information about composites research in the UK, see *ESN* 37-4 through 37-12. In addition, US Office of Naval Research, London, Report R-5-84 provides an overview of European research on polymers and composites.

Laboratoire de Mecanique et Technologie

The Mechanics and Technology Laboratory at Cachan, France, was founded in 1975 to unify the research of the Mechanics, Civil Engineering, and Manufacturing Engineering departments of the College of Technical Instruction (ENSET). In 1978 ENSET and the Pierre and Marie Curie University (Paris IV) agreed to make this a common laboratory of the two institutions. The Mechanics and Technology Laboratory also has been associated with the National Center for Scientific Research (CNRS) since 1977 in the area of physical sciences for engineers. Thus the research teams at the laboratory are composed of members from ENSET, Paris IV, and CNRS. The objective of the laboratory is to promote interdisciplinary research on theoretical and experimental as well as basic and applied aspects of the mechanics of brittle and ductile solids. The director of the laboratory is Prof. P. Ladeveze. Current research areas include anisotropic plasticity, viscoplaticity, damage and fracture, experimental techniques, and computational methods.

In composite materials, a major effort has been made to study in collaboration with Société Nationale Industrielle Aérospatiale and Aérospatiale the damage and fracture of three-dimensional carbon-carbon composites. Researchers have performed experimental studies of shear and of tension and compression. In the tension and compression experiments, the loading axis was parallel to or at an angle with the carbon-yarn directions. Because of the presence of local inhomogeneities and problems of load introduction, researchers experienced some difficulty in achieving tests with pure tension, compression, or shear load. However, this difficulty has been resolved. The damage phenomenon has been characterized as the progressive deterioration of the composite due to initiation and growth of microvoids and microcracks. Damages in tension and compression occur in the linear elastic range, whereas shear loading induces anisotropic elastic-plastic deformation.

To describe the damage phenomenon, researchers have developed a mathematical model based on the idea originally proposed by Rabotnov and Kachanov.

Université de Bordeaux, I

The Laboratorie de Chemie du Solide du CNRS at Université de Bordeaux, I, has conducted interesting research in high-temperature composites. This laboratory is unique in its ability to fabricate metal- and ceramics-matrix composites, in its particular expertise in surface studies by metallurgical means, and in its close interactions with Société Européenne de Propulsion-Bordeaux and other nearby aerospace-research establishments. My host at the laboratory was Prof. R. Naslain.

In the area of metal-matrix composites, Naslain and coworkers have been most concerned about the wetting of fibers by liquid metals, the need of fiber treatment before composite processing, and fiber/matrix interfacial reactions. In collaboration with several industrial partners, the laboratory has done research with the liquid infiltration technique. Titanium matrix composites reinforced with boron and silicon-carbide fibers are being studied to investigate fiber/matrix interactions and their influence on macroscopic composite properties. A minimum amount of chemical reaction between fiber and matrix is desirable to develop the necessary adhesion for load transfer. On the other hand, too much reaction results in the growth of a brittle layer around the fiber and reduces strength.

The researchers are studying composites obtained by hot-pressing continuous filaments--uncoated boron $B(B_4C)$ and SiC--within a titanium-base matrix--unalloyed titanium or Ti-6Al-4V. Microanalyses of the fiber-matrix reaction zone and kinetics studies show that chemical compatibility can be increased by diffusion barriers applied on the filaments and by alloying elements added to the matrix. Filaments of $B(B_4C)$ and SiC have comparable chemical compatibilities versus titanium. From bending tests, it appears that the composite strength is very sensitive to fiber-matrix reaction. The strength loss is less for $B(B_4C)$ than for uncoated boron filaments.

In the area of carbon/carbon composites, innovative work is being done. The poor oxidation resistance of carbon/carbon composites limits their application in nonoxidizing atmospheres.

Researchers at Bordeaux have tried to overcome this by replacing part of the carbon matrix with a refractory material that has good chemical compatibility with carbon and high oxidation resistance. SiC and TiC have been used.

The residual open porosity of carbon/carbon preforms is filled with one of these carbides according to a chemical-vapor infiltration process. The infiltration parameters are optimized according to a thermodynamic and experimental approach. To obtain an in-depth deposition within the pores rather than a surface overcoating, temperature, total pressure, and gas flow rate must be kept as low as possible. Pure SiC or TiC is deposited only for well-defined initial gas compositions. Composites with a two-dimensional microstructure and a carbide volume fraction up to 0.40 are characterized from a mechanical, thermal, and chemical point of view. Replacing part of the carbon matrix by SiC or TiC increases compression strength and rigidity, tends to reduce thermal expansion anisotropy, and increases significantly the oxidation resistance (up to 1500°C in air for SiC-infiltrated materials). More recently, the work has been expanded by using nitrides for infiltration.

Another interesting area of composite research is the controlled-floating-zone melting of *in-situ* composites. A piece of equipment for directional solidification based on a controlled-floating-zone technique has been designed in order to confine the height of the melted zone to a given small value. In addition, a relative rotation of the two solid parts of the ingots is activated to provide a laminar flow within the liquid. The researchers have identified advantages of these conditions with regard to the homogeneity of the ingot composition and the thermal and morphological stability of the growth interface. The effect of a convective flow on the directional solidification of eutectic alloys also has been studied. Assuming a laminar stationary flow parallel to the growth interface within the liquid boundary layer where the solidification takes place, the researchers have proposed a simple model and compared it with numerical solutions of diffusion equations. The good agreement between theoretical and numerical treatments makes it possible to predict the influence of such a convective flow on eutectic growth morphology.

3/29/84

TRACE ELEMENTS AFFECT WELD PROPERITES

by B.A. MacDonald and R.W. Armstrong. Dr. MacDonald is Group Leader, Materials Division, ONR, Arlington, VA. Prof. Armstrong, formerly at ONR, London, is currently on sabbatical leave from the University of Maryland, College Park, at the University of Cambridge, UK.

Minor alloying or trace elements can be important in controlling the weldability and weld-fracture properties of metal alloys. New appreciation for these elements prompted The Welding Institute to arrange the first international conference on the effects of residual, impurity, and microalloying elements on weldability and weld properties.

Held in London from 15 through 17 November 1983, the conference had 300 registrants from 17 countries. There were 45 papers in six main sessions: "Weld-Metal Properties," "Cracking in Welds," "Problems From Impurity Segregation," "Cast-to-Cast Variations," "Weldability--Influence of Steel," and "Weldability--Influence of Consumables." About two-thirds of the conference papers were preprinted in a bound volume by The Welding Institute (TWI), Abington Hall, Abington, Cambridge CB1 6AL, UK; most of the remaining papers are now available from TWI as well.

A number of common concerns emerged from the combined presentations and discussions. Acicular ferrite (AF), composed of small ferrite grains containing finely dispersed carbides, is mainly responsible for producing improved toughness of weldments in high-strength, low-alloy (HSLA) steels--and titania inclusions are beneficial to intragranular AF nucleation. Research and development work continues on attempting to predict the mechanical properties of weldments from formulas based on chemical composition--despite the knowledge that trace-element compositions are difficult to control, and quite variable microstructures are often involved. Delicate control must be exercised in balancing the effects of small concentrations of elements such as sulfur; while they can promote weldability, they can also contribute to deleterious weld properties. Progress has been made with modeling, such as describing the gradient of surface tension as the driving force for weld-pool dynamics and developing time-temperature curves for solute segregation at grain boundaries and cavities in weldments. But much more work along this line needs to be done. Further details are given

in the following description of the conference sessions.

Weld-Metal Properties

Submerged-arc welding was the main method covered in the studies of weld-metal properties, although the other techniques of manual metal-arc, flux-cored arc, and metal-inert gas arc welding were also included among the papers on this topic. The studies were concerned with increasing the percentage of AF in weldments--especially relating to the nucleating influence of inclusions which also are associated with obtaining a fine austenitic grain size. L. Devillers, D. Kaplan, B. Marandet, A. Ribes, and P.V. Riboud (Institut de Recherches de la Sidérurgie Francaise) emphasized thermal expansion and lattice registry considerations for explaining the beneficial AF nucleation effects of globular inclusions of aluminum-manganese silicate containing titanium. The results were supported by M.E. Saggese, A.R. Bhatti, D.N. Hawkins, and J.A. Whiteman (Sheffield University, UK), who measured a dramatic increase in the percentage of AF with increase in the titanium content of ternary MnO-SiO_2-Al_2O_3 inclusions in bead-on-plate welds, as shown in Figure 1.

H. Terashima and P.H.M. Hart (TWI) favored the transfer of titanium through a titania-containing weld flux rather than through the filler wire during the welding process. They emphasized the consideration of balancing the chemical composition of elements, including oxygen, to achieve the desired types and sizes of inclusions for promoting AF formation. Figure 2 is a schematic diagram showing the combined effects of aluminum, titanium, silicon, manganese, and oxygen on AF formation. A certain oxygen level is needed during solidification to provide the requisite inclusions, and this level is increasingly difficult to achieve for increasing alloying element compositions.

Other papers were concerned with the effects of elements such as boron, sulfur, phosphorus, arsenic, antimony, lead, and tin on weldability and weld properties. C.F. Düren (Mannesmann-röhren-Werke AG, Mülheim, West Germany [FRG]) noted a positive effect of TiB additions on the toughness of weldments and attributed the improved toughness to Ti-B-nitrogen interactions. Boron inhibits the formation of grain boundary ferrite. Positive results on toughness occur in the range of 0.001 to 0.010 weight percent, but the optimum level of boron has not been determined. G. Almqvist, B. Gretoft, L.-E. Svensson, and L. Wittung (ESAB AB, Gothenburg,

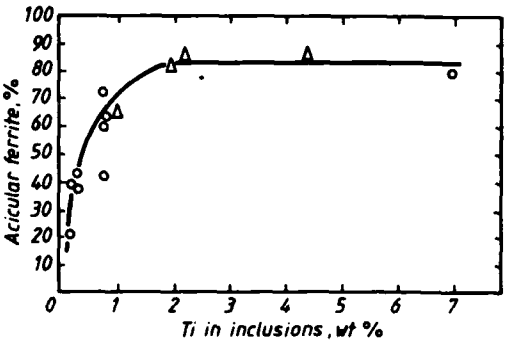


Figure 1. Percentage AF versus titanium content of MnO-SiO_2-Al_2O_3 weld-bead inclusions.

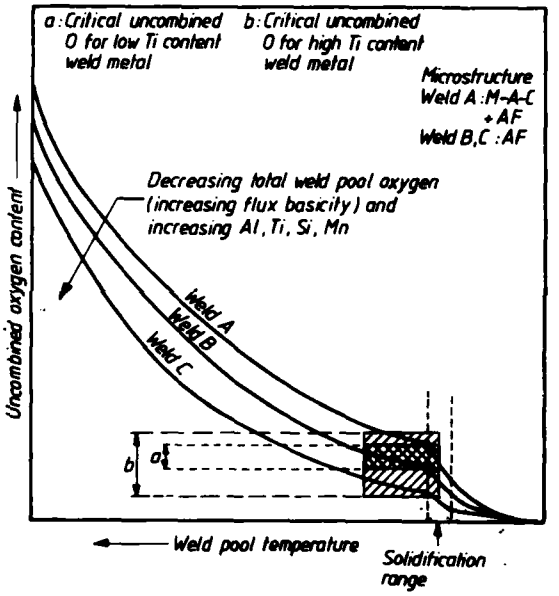
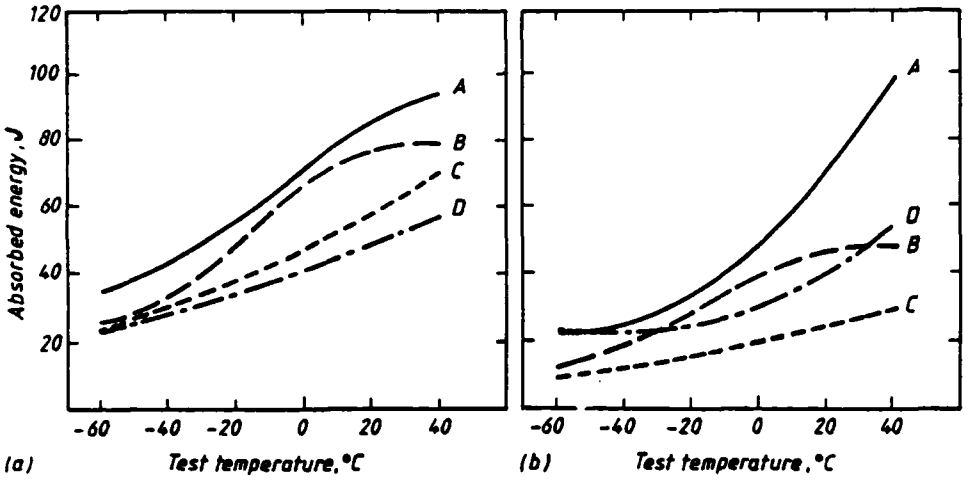


Figure 2. Effect of uncombined weld pool oxygen content during welding on the formation of AF or ferrite with aligned martensite-austenite-carbide (M-A-C).

Sweden) presented results on temper embrittlement of carbon-manganese ferritic weld metals; the trace elements tin, arsenic, phosphorus, antimony, and sulfur migrated to prior austenitic grain boundaries and promoted intergranular fracture. Remarkably enhanced concentrations of the elements were found on the grain-boundary-fracture surfaces. Figure 3 shows specific results obtained on the impact energy absorbed in fracturing the ferritic weld



Test no.	Sn, %	As, %	Sb, %
A	0.001	0.006	0.011
B	0.010	0.022	0.001
C	0.003	0.042	0.056
D	0.065	0.007	0.046

Figure 3. Impact toughness of ferritic weld metal for various combinations of impurity elements: (a) as welded, (b) stress relieved for 2 hours at 575°C.

metal in an as-welded and stress-relieved condition. Considerable discussion centered on this paper. Phosphorus appears to be the most important embrittling agent among the five elements studied whose total content was recommended to be kept below 0.02 weight percent if weld metal embrittlement was to be avoided. An even lower concentration was recommended for increased alloying content or for welding procedures involving large heat inputs.

Several research areas seemed worthy of further attention. The mechanisms by which inclusions promote AF nucleation should be determined, along with an optimum composition, size, and distribution of inclusions. Much of the research has been done on single- or double-pass welds; an important question was raised: Would multipass welding create heat affected zones that adversely affect AF formation and properties?

Cracking in Welds

R. Killing, H. Thier (SLV Duisberg, FRG), and F. Burat (Eisenbau Krämer, Hilchenbach-Dahlbruch, FRG) investigated the effect of residuals and free oxygen during solidification of welds on sulphide precipitation behavior and hot-cracking susceptibility. A globular oxysulphide precipitate, favored by high oxygen levels, was associated with hot-cracking resistance. Nevertheless, low oxygen and a minimum of residuals in the basic filler materials are necessary for requisite high-temperature toughness.

R.G. Baker (Jayman Ltd., UK) discussed the establishment of welding procedures to avoid hydrogen-induced heat-affected-zone cracking while achieving maximum heat-affected-zone hardness criteria for microalloyed steels in pipeline and offshore structures. The comparative hardenabilities of microalloyed steels and the traditional carbon-manganese steels were indicated schematically to depend on austenite grain size, as shown in Figure 4. The worry was that at a cooling rate R an appreciably reduced portion of the heat affected zone would be hardened and a steep hardness gradient would be produced.

A. Brownrigg, C.-J. Chong, G. Glover (BHP Melbourne Research Laboratories, Australia), and E.E. Banks (Woodside Offshore Petroleum Pty. Ltd. Perth, Australia) followed up with an assessment of very large differences in heat-affected-zone hardenability measured in bead-on-plate tests for five

normalized carbon-manganese-silicon-aluminum-niobium plate steels. The results were attributed to the hardenability effect of boron on weld properties at compositions near to the limit of measurement; consequently, boron levels were suggested to be restricted to 5 parts per million, especially in low oxygen, nitrogen, and sulfur steels. The effect of boron on hardenability is of less concern in low-carbon or carbon-equivalent steels.

Problems From Impurity Segregation

Studies of diffusion bonding, weld stress relief, and temper embrittlement were reported. In a definitive study of the interface structure of several diffusion-bonded steel materials, C.E. Thornton and E.R. Wallach (University of Cambridge, UK) determined with Auger electron spectroscopy (AES) that residual antimony and tin segregated to interfacial voids, prevented their closure, and thus contributed to low impact properties. Further fundamental results on impurity segregation and cavitation behavior were presented by C. Lea and M.P. Seah (National Physical Laboratory, UK). Copper and sulfur segregation (as well as antimony and tin) to cavity walls was shown to occur by AES. Temperature-time curves were determined for isoconcentration profiles of segregating elements. The temperature ranges over which particular elements segregated to the surface were determined by AES for two steels (Figure 5). The results show, for example, that tin is a major problem for hot cracking of plain carbon steel stress-relieved at 700°C, while antimony and sulfur contribute to poor diffusion bonding at 850 to 900°C.

Y. Ohno, Y. Okamura, S. Yano, T. Fujii, and K. Yamamoto (Nippon Steel Corporation, Japan) showed, with AES results, that calcium added to molten nickel-free HT80 steel reduced the amount of free sulfur and its consequent deleterious effect on stress-relief cracking at grain boundaries. A.A. Tavassoli, A. Bougault, and A. Bisson (Centre d'Études Nucléaires de Saclay, France) reported on the phosphorus-induced temper embrittlement of A508, C1.3 pressurized water reactor steel material, employing AES as well.

Cast-to-Cast Variations

Many examples were provided of practical welding problems created by poor weld-pool penetration into the base plate material. Nine of 10 papers presented were concerned with varying penetration in stainless steels, of which the 304 austenitic stainless steel

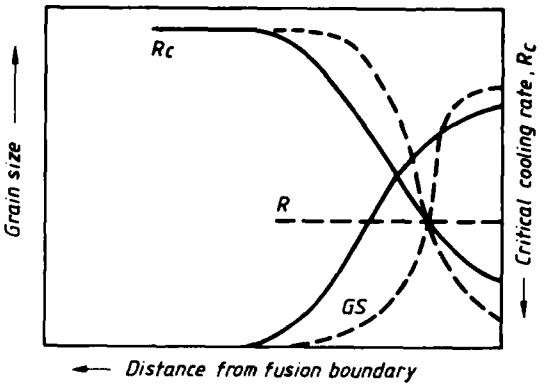


Figure 4. Schematic variation of austenite grain size (GS) and critical cooling rate (R_c) as a function of distance from fusion boundary for microalloyed steel (dashed profiles) in comparison with traditional carbon-manganese steel (solid curves).

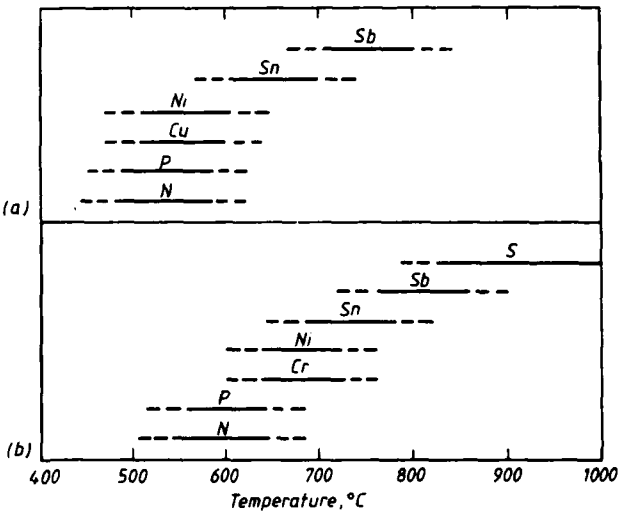


Figure 5. Temperature regimes for dominant impurity segregation in two steels: (a) 5 NiCrMoV steel, (b) .12C steel.

used in the nuclear and petrochemical industries is a prime example. It was demonstrated repeatedly that different welding behaviors were obtained from materials having otherwise the same composition specifications--thus indicating the importance of trace alloying elements in determining weldability.

J.L. Robinson, S. de Rosa, and G.A. Hutt (TWI) summarized the current situation for welding austenitic stainless steels. The weld-bead depth (D) to

top width (W) ratio, D/W, was chosen to characterize weld penetration. D/W was found to vary in the range of 0.3 to 0.5. Variable penetration was obtained for laser and electron-beam welding and for arc welding. Surface oxidation was not a problem. C.R. Heiple, P. Burgardt, J.R. Roper, and J.L. Long (Rockwell International, Golden, CO) presented the Heiple-Roper model of surface tension (γ) gradient as the fluid driving force which is affected by trace elements in determining the weld-pool shape. Additions of sulfur, selenium, tellurium, and oxygen increase weld penetration because such surface-active elements dominate weld-pool fluid motion through the Marangoni effect; that is, fluid flow occurs along a surface from a region of low surface tension to one of higher surface tension. The Marangoni effect normally is associated with a positive gradient of γ with temperature, and this promotes improved weld penetration (Figure 6). The model appears to offer the best explanation of variable weld penetration--due to the sensitive influence of elements on the gradient of γ. Other discussion focused on factors such as viscosity, γ alone, the state of iron ionization, and arc variables as additional considerations involved in weld-pool dynamics.

Measurements of γ as a function of temperature are of interest. B.J. Keene, K.C. Mills (National Physical Laboratory, UK), J.L. Robinson, and M.H. Rodwell (TWI) described a technique for measuring γ for liquid metals to a temperature of 2000°C based on careful observations of the oscillation frequencies exhibited by levitating droplets: $\gamma = 3\pi mw^2/8$, where m is droplet mass and w is the natural vibrational frequency of an oscillating droplet. The measured variation of γ with temperature fitted the variable welding penetrations encountered in tungsten inert gas (TIG) welding of types 304 and 316 austenitic stainless steel sheets. Sulfur and oxygen played a major role in reducing the surface tension, although they interact strongly with other alloying elements as well. It was concluded that more measurements are needed of such surface-tension effects.

M.J. Tinkler, I. Grant, C. Gluck (Ontario Hydro, Canada), and G. Mizuno (Atomic Energy of Canada Ltd.) related to the Maragoni effect the problem of weld-pool shift--that is, deviation of the weld to one side of the joint line. The deviations encountered in the TIG welding of 304L stainless steel tubing were attributed to variations in sulfur content in different heats of the stainless steel. The skewed convective-flow

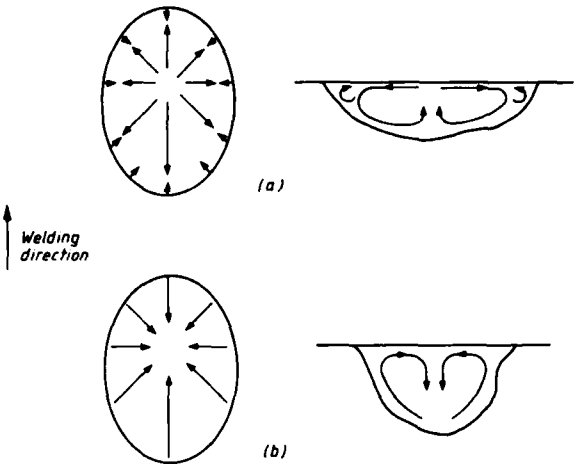


Figure 6. Heiple-Roper model of surface and subsurface fluid flow in weld pool according to negative (a) or positive (b) temperature coefficient of surface tension.

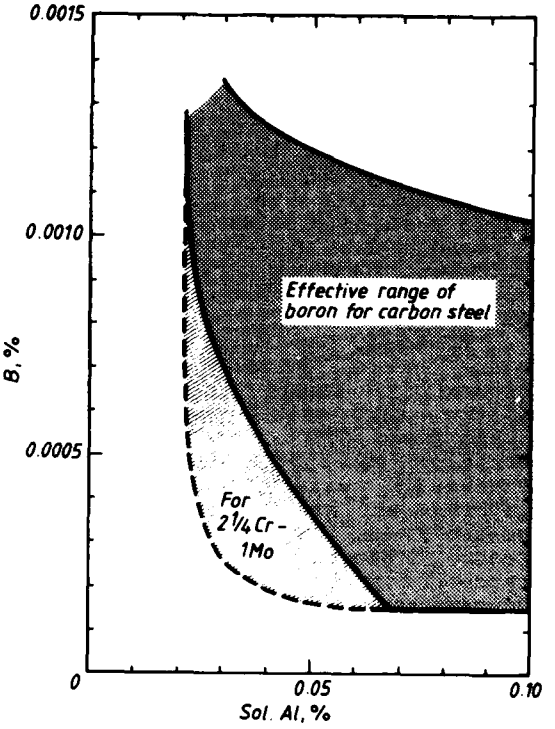


Figure 7. Effective range of boron and soluble aluminum for increased hardenability influence during normalizing treatment.

patterns were overcome by use of copper-alloy heat sinks into the standard welding head so as to allow higher heat input to the weld pool. Sulfur contents between 100 and 200 parts per million were recommended for relatively uniform weldability.

Weldability--Influence of Steel

The influence of specific alloying elements on the weldability of low-carbon steels was the main subject of this session. M. Nakanishi, S. Watanabe, and J. Furusawa (Sumitomo Metal Industries Ltd., Japan) described weldability and toughness advantages of adding aluminum and boron to thick pressure-vessel-plate materials to achieve increased hardenability during normalizing heat treatments. The effective range of additions to A515 and A516, Gr.70 plate and to a chromium-molybdenum steel are shown in Figure 7.

Other papers explored electric steel making and ladle refining for control of hydrogen and nitrogen contents with consequent reduction of impurities for improved weldability; copper alloying effects in steels and weldments; the weldability of low-sulfur and rephosphorized carbon-phosphorus steels; electroslag welding; weldability of line pipe and HSLA steels treated with calcium, rare earth metals, or tellurium for sulfide shape control; and weldability of automotive high-strength-steel sheets. R.M. Rivett, S.A. Westgate, and M.G. Murch (TWI) gave a comprehensive review of welding conditions, weld properties, and quality control involved in the automotive industry.

Weldability--Influence of Consumables

Metallurgically controlled welding filler wire, submerged-arc welding consumables, and weld-metal coatings were the topics of the closing series of papers. Trace-element control coupled with improved manufacturing of welding wire to prevent surface contamination was recommended as an important aspect of obtaining improved weld properties for a broad range of engineering materials, including welded aerospace applications. Inductive heating and bending of line pipe with welded seams for Arctic applications have produced stringent conditions for the properties of the weldments. Promising results were obtained by N.H. Croft and R.L. Hipley (Associated Piping and Engineering Corporation, CT) with 3-percent nickel wires deposited with basic fluxes. In this case, improvements in toughness were associated with a microstructure of fully tempered martensite. A.W. Marshall and J.C.M. Farrar (Metrode Products Ltd., UK) presented an analysis of weld-filler requirements for welding the newer, highly alloyed, low-carbon austenitic stainless steels. Close control of carbon, silicon, and niobium are needed to gain corrosion resistance and to avoid weld cracking. New weld fluxes were formulated to keep the weld composition within the desired range to give corrosion resistance and adequate mechanical properties.

4/9/84

OCEAN SCIENCES

FISH FARMING IN THE NEGEV DESERT

by Robert Dolan. Dr. Dolan is the Liaison Scientist for Geology and Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.

The Israel Institute of Oceanography and Limnology Research (IOLR) consists of several divisions or laboratories. The National Oceanographic Institute, in Haifa, includes the office of IOLR's Director, Dr. Colette Serruya, and the departments of physical oceanography, hyperbaric physiology, marine geology, chemical oceanography, and marine biology. The Kinneret Limnological Laboratory has a special-focus program on Lake Kinneret (the Sea of Galilee) and the Jordan River and its tributaries. The southern-most research station of IOLR is the Elat Mariculture Laboratory.

While on a field trip to the Dead Sea, Elat, and the Gulf of Acaba with members of IOLR, I was able to spend a few hours with Mr. H. Gordin, the Director of the Mariculture Laboratory, which is about 100 m from the Israeli/Jordanian border. Although my interest in fish is for the most part limited to *Salmo gairdneri*, I must admit that 3 hours with Gordin were among the most interesting I've spent while with ONR, London.

Gordin's lab has a staff of 40, including 12 full-time scientists. Their mandate is direct: develop a mariculture (fish-farming) industry in Israel that will contribute to the Israeli economy locally, but also will

help generate foreign currency through fish exports to European markets.

The Israelis are optimistic about this new industry. Israel has all of the environmental attributes for mariculture--lots of clear sea water and an abundance of solar radiation. Development of a major freshwater fish-farming industry has limited possibilities because virtually every drop of fresh water (and now even brackish water) is used in Israel. So the desert areas of southern Israel look promising. They are close to unlimited sea water, the sun shines there 90 percent of the year, and the temperatures are relatively high. The higher overall temperatures of the water and air mean more intensive photosynthesis rates so the production of algae, oysters, shrimp, and fish is faster per unit time per unit area.

The Elat laboratory began research in 1970 on the possibility of raising on a commercial basis an edible native oyster, *Saccostrea cuculata*, and a local fish called rabbitfish, *Siganus vivulatus*. Three years of work on these species resulted in little success: the oyster was a slow grower and susceptible to diseases and predators; the rabbitfish was not highly desired in Europe, and it did not grow well in captivity. When I asked why they didn't use results from the many years of mariculture practiced by the Japanese, Gordin pointed out that most efforts in fish farming are species-specific, so the successes in Japan, Europe, or the US would not be suitable for Israel.

Following these early setbacks, Gordin and his colleagues decided in 1973 to concentrate all of their energy and resources on one fish, the gilthead sea bream (*Sparus aurata* L.). This fish was chosen for three reasons. First, it is highly prized in southern Europe, selling for $5 to $7 per kilo. Second, in 1973--before the Egyptian/Israeli peace treaty--large numbers of the sea-bream fry could be collected in the Bardawil Lagoon in North Sinai, thus avoiding the costly and time-consuming hatchery step in the development of the industry. Third, the sea bream is a lagunar species, so it is tolerant of a wide range of environmental conditions such as temperature and salinity.

Early on in this research it became evident that a steady, reliable, year-round source for sea-bream fry might not be possible at the best natural site (Bardawil Lagoon was in occupied Egyptian territory). Thus, the investigations had to include all aspects of establishing the sea bream as a "farmed animal." An interdisciplinary team was assembled to investigate nutrition, reproduction, disease, larval rearing, and farming techniques. The idea was that concentrating on one species would allow the scientists to make the most rapid progress toward a commercial venture, which is the primary motivation for the entire Elat operation.

The major problem in the program, even after 10 years of intense effort, is the low survival rate of the fish larvae. The price of an individual sea-bream fingerling from a commercial fish hatchery is about $0.30, much too high for a mass-production system. And since the natural source (Bardawil Lagoon) is no longer available for obtaining fry, the program included an all-out effort to produce large numbers of fingerlings at very modest prices. In nature the survival rate for the fingerling sea bream is less than 1 percent. So far the Elat lab has achieved 8 percent, but the goal is 10 to 15 percent.

Gordin's team has had considerable success in getting the fish to spawn in a more desirable cycle than their natural one. The water is treated with sex hormones, and the tank environments are modified. As a result, the spawning season is extended, so there is a supply of fry throughout the year.

Since the declared goal of the Elat lab is to farm the sea bream at the earliest possible date, the scientists initiated a program of research on farming techniques even before many of the reproductive and other biological problems had been solved. After 10 years of work they have developed two environments for commercially raising sea bream: floating sea cages and saltwater ponds.

The floating cages have a screen mesh small enough to keep the sea bream in and predators out. The idea is to use the natural circulation of the sea to provide ideal environmental conditions for rapid growth. Growth is accelerated because the fish in the cages are fed at rates approaching their metabolic limits. Sea bream in cages installed in the Gulf of Aqaba grew to market size (300 g) in 16 months from hatching, using food at a 1:2.5 conversion coefficient, at a density of 220 fish per cubic meter of cage space. The survival rate for the fish is very high--over 90 percent.

Although the Elat team still has a number of problems to work out (for example, how to hold the cages in place during storms), the method is so simple, and biologically and economically so sound, that Gordin feels that in relatively protected waters it should be the main farming technique for sea bream

and, perhaps later, for a highly desirable species of sea bass. The sea does most of the work. It maintains a constant environment (temperature and salinity), changes the water at rates which maintain a high oxygen level, and removes excretory products--all at minimal cost to the farmers. The team's present and future work will concentrate on adaptation of the technique in protected bays and in the open sea.

In their intensive seawater ponds the results have been mixed. With eight ponds of 250 m^2 each, the yields were about 1 ton of sea bream per year per 1000 m^2; however, after the first good results the yields have decreased every year. The main problem is that primary production in the ponds--due to fertilization of the water through fish feeding (the fish only use about 10 percent of the food supplied) and intensive solar radiation--reaches 20 tons of organic carbon per year. Most of this material sinks to the bottom of the pond and decays, mostly anaerobically, releasing into the water toxic compounds such as H_2S, CH_4, NH_4, and others. As the pond gets older, the amount of organic decay increases, and more of these toxic compounds are released. As a result, the water quality deteriorates, growth rates decrease, and in extreme situations the fish die. To correct this, Gordin's team flushes the ponds continuously with fresh sea water, and--among the most interesting developments of recent years--they have experimented with passing the runoff water, which is rich in nutrients, through racks of edible oysters. In one case, 1000 oyster spats grown in the outflow troughs reached market size (65 g) in just 9 months--a rate of growth faster than any reported in the literature. In later experiments, they were able to produce 1.3 tons of oysters per 1000-m^2 pond areas, and they soon expect to reach 2 tons. In addition to the work with oysters, the researchers have experimented with shrimp as another secondary product of the fish pond. So far, Gordin has reached 125 kg of shrimp per 1000 m^2. For reasons that are still unclear, the team has not been able to bring the shrimp to the "market-fattened" state required. But ideally, the system Gordin has in mind is for every 1000-m^2 pond (1.5-m deep) to produce 1.5 tons of sea bream per year; to use the runoff water to feed oysters, which will yield 2 tons per year; and finally to circulate the runoff from the oysters into ponds or tanks with shrimp, with a yield of about 250 kg per year.

In summarizing his 15 years of work at Elat, Gordin said that the project had been very exciting and satisfying for a research biologist in that it had from the beginning included a mix of basic research, highly applied research, some engineering, and now economics. The national goal is to produce 3000 tons of exportable fish per year, which would result in an income of about $50 million. He also said that much of what they had learned bordered on "art" in that the state-of-health of a large fish tank or pond can, at times, be seen by eye or taste to have a problem, with no chemical test to confirm it. His staff of young people are highly dedicated and willing to work within the interdisciplinary framework. At this time, he said, one of his greatest problems (other than local poaching) is keeping his core staff in the lab and at work. They are getting invitations to visit other countries weekly, and the flow of visitors consumes a lot of their time. So, hearing that final comment, I thanked him for spending Saturday morning with me and returned to the geology group.

4/16/84

MEAN SEA LEVEL

by Robert Dolan.

Sea level is not level. Waves, tides, and storm surges can cause sea-level fluctuation on the order of 10 m, and the sea surface may, at times, slope more than 1 m/100 km. In addition to these short-term variations, many of the world's coastal areas are either sinking or rising relative to the ocean's levels due to tectonic movements of the continents and ocean basins.

In 1983 the UK's Permanent Service for Mean Sea Level (PSMSL) observed its 50th anniversary. PSMSL is headquartered at the Institute of Oceanographic Sciences (IOS) at the Bidston Observatory near Liverpool (*ESN* 38-4:199-202 [1984]). Since 1933, PSMSL has collected, published, and distributed world sea-level data and has analyzed and interpreted selected data sets.

Monthly and annual mean values of sea level are sent to PSMSL from sites throughout the world. When received, the data are checked for consistency and, if possible, reduced to a local reference or bench mark. The PSMSL data bank now holds tidal data from over 1000 stations. About 400 of these have series

of at least 20 years, and 112 stations have data before 1900. There is, of course, an uneven global distribution, with most of the stations located in the northern hemisphere.

PSMSL is a service organization; its staff members can help answer questions concerning sea-level data for anyplace in the world. In addition, they have published three reference volumes on the subject, they have a catalogue of all data held, and they provide advice on data reduction and analytical filtering methods.

Now to the obvious question. Is sea level really rising? The answer is yes, definitely. The longest tidal gauge series held by PSMSL is from Brest, France, which begins in 1807. When these data are analyzed, with the short-term fluctuations filtered out, they show a coherent rise in sea level of about 10 cm per century. When similar analyses are made of the San Francisco tidal data (over 100-year record), the rise is 11.5 cm per century. While visiting Bidston recently I was shown the results of a detailed analysis of 10 stations from worldwide locations. The results show a rise of 22 cm per century, ±1.4 cm. Most of this rise is presumed to be due to melting of glacial ice or a warming trend of the oceans.

Over the next few years two new developments are expected to improve the coverage and relevance of the PSMSL sea-level data.

1. The Intergovernmental Oceanographic Commission is supporting a series of courses at Bidston on sea-level measurement and data reduction. Up to four students at a time from developing countries will be invited to participate in intensive, practical, 3-week courses. The first course, held in 1983, was attended by people from the nations around the Indian Ocean, and another will be held this summer.

2. Staffing changes within the Institute of Oceanographic Sciences have allowed PSMSL to appoint a full-time physical scientist to undertake research into the global and regional trends of the sea levels. Separation of local and global trends will contribute to a better understanding both of vertical land movements and of changes in ocean circulation patterns.

PSMSL receives financial support from the Federation of Astronomical and Geophysical Services, the Intergovernmental Oceanographic Commission, and the UK's Natural Environment Research Council. The budget last year was $70,000, with about one-third coming from non-UK sources.

To request or send data, write to:

Permanent Service for Mean Sea Level
Bidston Observatory
Birkenhead
Merseyside L43 7RA
UNITED KINGDOM
Tel. No. 051-653 8633

4/19/84

PHYSICS

NEW REPORT EXAMINES CHAOS CONCEPTS

by David Mosher. Dr. Mosher, formerly at ONR, London, is Supervisory Research Physicist at the Naval Research Laboratory, Washington, DC.

The Office of Naval Research, London, has just published technical report R-6-84, *Europe Approaches Chaos With Electrical Circuits*. The report reviews chaos concepts and recent experiments in a number of research areas as an introduction to a detailed description of European research investigating chaotic behavior with nonlinear, driven electrical circuits.

In some nonlinear dynamical systems, the behavior changes from simple and predictable to chaotic as some external control parameter is varied. An example of this behavior is hydrodynamic flow around an obstruction in a fluid stream. When the fluid speed is low, the flow is laminar, and a downstream probe measures a constant velocity. As the speed is increased, eddies with a regular structure are formed behind the obstruction and are convected downstream to produce a periodic variation in velocity. At still higher speeds, the flow becomes fully turbulent, and the downstream velocity varies erratically and unpredictably.

During the last few years, analogous transitions from simple to chaotic behavior have been observed in a variety of hydrodynamic, biological, electronic, chemical, and optical systems. Although these systems are physically very different, extremely simple, deterministic mathematical models can reproduce the approach to chaos for all of them. The recent understanding of this universal behavior has provided important and

fundamental insights about turbulence and noise.

The application to noise is of particular interest to the Office of Naval Research in Arlington, VA. The Nonlinear Dynamics Program within the Physics Division includes basic research to study the evolution of chaotic nonlinear systems using analytic theories, computer simulation, and experiments with electrical circuits. The objectives of the research are to understand chaos-induced noise in sensors, transmission lines, computer memories, and communications systems. Because of the universal nature of chaos the research will also provide understanding of turbulent behavior in other physical systems of interest to the US Navy.

The electrical circuits--really nonlinear analog computers which solve the differential equations describing idealized physical systems--represent a bridge between the simple and highly abstract deterministic models and the experiments where complicating and competing effects can obscure the universal behavior. Recent results from the UK, Portugal, West Germany, and Italy with applications to microwave electronics, nonlinear optics, Josephson junctions, and general noise control are discussed.

Further details are available in technical report R-6-84, which you can order by using the mailer inside the back cover of this issue.

4/25/84

SCIENCE POLICY

BONN'S NEW INFORMATICS PLAN--WHO'LL PAY?

by James W. Daniel, Scientific Director for Europe and the Middle East for the Office of Naval Research's London Branch Office. Dr. Daniel is on leave until August 1985 from the University of Texas, where he is Professor of Mathematics, of Computer Sciences, and of Education.

In March, the Federal Republic of Germany's Research and Technology Minister, Heinz Reisenhuber, announced a 5-year package of measures to close Germany's gap with the US and Japan in the broad area of informatics (microelectronics, communication, data processing, office automation, and industrial automation). The total 5-year government expenditure will be about $1125 million (DM3 billion, assuming DM1.00 = $0.375). At $225 million per year, this is nearly 9 percent of the annual expenditure of the Ministry of Research and Technology (BMFT), which must provide the money (see next article). And there's the catch. This impressive new program will not bring any new funds to the BMFT; old programs have to give way.

The Informatics Program

The informatics funds will be spent in 1984 through 1988 to encourage research and development in this general area, especially research involving small- or medium-sized firms or involving industry/university cooperation. The major areas of research emphasis were described to me by Dr. J.-B. Mennicken of the BMFT's research-policy group (funding amounts are for 5 years of research): sub-micron technology ($225 million); industrial automation ($135 million); micro-peripherals ($120 million); chip technology ($75 million); expert systems ($75 million); computer-aided-design for software ($60 million); computer architecture ($60 million); computer-aided design for integrated circuits ($34 million); integrated optics ($34 million); and the development of key components in microelectronics ($34 million).

Funding the Program

I asked Mennicken whether the BMFT will receive any additional funds especially for the new informatics program. He replied that he expects the BMFT budget--about $2663 million in 1984--to grow only by 2 percent or so per year to account for inflation, and that money for the new program will have to come from that planned total. In short: the informatics program will replace existing programs.

Whose ox will be gored? Mennicken says that decision will be made during the next several months, and the 1985 BMFT budget should reveal the answers in detail. For the moment, he would only state that reductions were already being planned in BMFT's support of research and development on non-nuclear energy (where the government feels further progress is up to industry), on water and other natural resources, on transportation, and--starting in 1987--on nuclear energy. Since the mentioned areas for cutting involve in 1984 only about the total amount needed for the informatics program in 1985, it is clear that either they will be cut very deeply indeed or that other areas will suffer also.

ESN will follow this program and report on its development when information is available.

3/29/84

GERMAN RESEARCH-MINISTRY FUNDING

by James W. Daniel.

The 1984 budget of the Ministry of Research and Technology (BMFT) is the first for which the present Christian Democratic government of the Federal Republic of Germany (FRG or West Germany) is wholly responsible. The budget thus reveals the R&D policy to be expected from this important actor on the international R&D stage. In line with the government's philosophy, the budget reflects efforts to curb federal spending, to stimulate R&D capacity but leave detailed decisions to the private sector, and to emphasize key areas of modern technology.

Background

The FRG is a major international R&D force. Its per capita R&D expenditure--taking purchasing power into account--is about 80 percent of that in the US, leading Japan's roughly 70 percent and France's roughly 60 percent, for example. This amounts to some 2.5 percent of the FRG gross national product, about the same percentage as in the US. Total R&D expenditures from all FRG sources in 1983 were about $17.6 billion (equating DM1.00 to $0.375), of which $4.5 billion came from the federal government. Well over half the federal expenditures on R&D were made by the BMFT, including most of the federal research funds; thus the BMFT budget serves as a major indicator of federal research policy.

Budget Goals for 1984

The 1983 BMFT budget totaled about $2588 million. For 1984, this figure is up nearly 3 percent to $2663 million; this increase is nearly twice the 1.6 percent valid for the federal budget as a whole, reflecting the government's philosophy of curbing spending yet stimulating development. Inflation amounted to about 2.8 percent in 1983. According to Dr. J.-B. Mennicken, head of the BMFT's research-policy group, the primary goals in creating the 1984 budget were to increase the emphasis on "indirect" programs that develop research capacity rather than support specific projects and to rearrange the emphasis among areas that receive "direct" support.

In recent years, about 10 percent of the BMFT budget has gone to support FRG participation in international programs such as the European Space Agency, and roughly 30 percent is used to support national research establishments such as the Max Planck Institutes, the Fraunhofer Institutes, and the "Big Science" centers; the remaining 60 percent has been available for the mixture of indirect programs and direct programs. In 1982, this 60 percent was split roughly 12 to 48 between indirect and direct, respectively; in 1983, the split was about 15 to 45; for 1984, it is about 20 to 40. With a total of about $2.6 billion in the BMFT budget, this change in emphasis has shifted some $200 million from direct programs into indirect programs since 1982.

The 1984 budget, according to Mennicken, emphasizes five major areas for direct support: biotechnology, materials science, basic environmental science, health science, and informatics. This last topic, which includes microelectronics, communication, data processing, office automation, and industrial automation, was identified by the government in March as a target for still greater emphasis in the 1985 and later budgets (see the preceding article). Those research areas experiencing reduced emphasis include non-nuclear energy, water and other natural resources, and transport.

1983 and 1984 Detailed Budgets

The BMFT breaks its budget into five main sections: General Research Support; Scientific and Technological R&D; Information Technologies; Energy Research and Technology; and Space and Oceanographic Research, and Transportation Systems. The further breakdown and the data used to generate the figures below were provided from the BMFT budget by Robert Morris, Science Counselor in the US Embassy, Bonn.

General Research Support amounts to about $246.5 million in 1984, up 12 percent from about $219.6 million in 1983, both excluding administrative costs. Funds in this category are usually matched one-for-one by the individual states in the FRG and are used to finance the following: the basic and applied sciences via the Max Planck Institutes and Fraunhofer Institutes, humanities research, international research cooperation, and the application of R&D results in small- and medium-sized industries. Table 1 shows the 1983 and 1984 budgets in this area.

Note the striking increases in funds to promote research in small- and medium-sized industries (189 percent) and to promote the availability of risk capital (84 percent). Most of the increase for the Max Planck Society is for the new institute on polymer chemistry.

Scientific and Technological R&D totals about $561.1 million in 1984, down 1 percent from about $566.2 million in 1983, both excluding administrative costs. Funds in this category are primarily used to finance the following: programs in environmental protection, resource conservation, and socioeconomic efficiency; efforts to improve living standards through health science; and the basic support of selected national and international research centers. Note in Table 2 the increases for nonmetallic materials (14 percent), ecological and environmental R&D (12 percent), biotechnology (11 percent), climatology (65 percent), and the DESY electron synchrotron (29 percent).

Information Technologies accounts for about $232.6 million in 1984, up 8 percent from about $214.3 million in 1983, both excluding administrative costs. These funds finance R&D on electronics components, communication technology, information processing, database systems, production technologies, and technological communication.

Table 1

BMFT Budgets for General Research Support (In Millions of Dollars)

Program	1983	1984
International scientist exchange	2.8	3.8
Research promotion, small and medium industries	5.2	15.0
Promotion of scientist transfer to industry	0.0	1.1
Risk-capital promotion	5.0	9.2
Research-planning promotion	0.8	0.8
Technology-transfer promotion	3.5	3.7
German Society for Peace and Conflict Research	1.1	1.2
Social science promotion	1.1	1.2
Academy of Sciences	4.4	4.4
Humanities promotion	4.5	4.7
Eur. Org. for Astronomical Res. in S. Hemisphere	4.7	4.5
Cooperative R&D	3.4	3.8
Max Planck Society	139.2	145.5
Fraunhofer Society	39.1	41.1
Berlin Science Center	4.8	6.5
TOTAL	219.6	246.5

Table 2

BMFT Budgets for Scientific and Technological R&D (In Millions of Dollars)

Programs	1983	1984
R&D on improving work conditions	37.5	37.5
R&D on technological risks, disasters, and safety	3.1	3.2
CERN	74.1	78.0
Eur. Lab. Molec. Biol. and Eur. Conf. Molec. Biol.	4.8	5.1
Promotion of international cooperation of labs	3.4	3.8
Institute Max-von-Laue-Paul Langevin	10.8	11.4
Promoting research on raw materials:		
Prospecting, exploring, mining minerals	6.8	7.1
Preparing, refining metal minerals	43.5	39.4
Nonmetal raw and basic materials, processing	7.9	9.0
Special iron and steel R&D program	48.8	13.1
Nonmetal materials investments	4.3	4.4
Ecological/environmental R&D and planning	50.0	56.0
Ecological/environmental capital costs	15.4	16.3
Biotechnology R&D	23.6	26.3
Medicine/health R&D	28.9	30.9
Climatology	2.3	3.8
Promoting water research	11.6	11.4
Promoting R&D in nuclear science, lasers, heavy ions	32.1	33.2
German Cancer Research Center	31.1	31.3
German electron synchrotron (DESY)	49.8	64.2
Society for Heavy-Ion Research	26.2	25.4
Hahn-Meitner Institute for Nuclear Research	31.4	33.6
Society for Radiation and Environmental Research	37.7	38.5
Society for Biotechnological Research	13.2	12.3
TOTAL	566.2	561.1

Table 3 shows the 1983 and 1984 budgets. Note the 83-percent increase for R&D in production technologies--this mainly means robotics and computer-aided design and manufacturing.

Energy Research and Technology amounts to about $1045.7 million for 1984, down 2 percent from about $1065.8 million for 1983, both excluding administrative costs. This part of the budget deals with the following: development and building of advanced nuclear reactors; reactor safety; uranium supply, processing, and reprocessing; coal gasification and liquefaction; and advanced technologies for the transmission, storage, and conversion of energy. Note in Table 4 the decreases in reactor-safety work, in the Nuclear Research Center (Karlsruhe), and in new energy sources, as well as the increases in developing coal-refinement installations (10 percent) and fast-breeder reactors (18 percent).

Space and Oceanography Research, and Transportation Systems totals about $515.9 million in 1984, up 1.4 percent from about $508.9 million in 1983, both excluding administrative costs. Funds in this area support space and aviation R&D, oceanographic R&D, polar research, and R&D for urban and long-distance transportation systems and technologies. Table 5 shows the 1983 and 1984 budgets. Note the decreases for the operation of test and ground installations for extraterrestrial science, for communication satellites, for marine mining, and for construction R&D, as well as the increases in capital costs for extraterrestrial science (64 percent), polar research (11 percent), and Antarctic research (112 percent).

Table 3

BMFT Budgets for Information Technologies (In Millions of Dollars)

Program	1983	1984
Promoting technology in measuring, steering, optics, materials	10.9	11.3
Promoting R&D in production technologies (CAD/CAM, robotics)	14.4	26.4
Promoting information processing	17.6	18.8
R&D in electronics	40.5	42.0
Microelectronics special program	56.3	56.3
R&D on communication technologies	32.1	33.9
Society for Mathematics and Data Processing	21.2	22.1
R&D on industry/science/administration communication	7.5	7.9
Supra-regional information centers	13.8	13.9
TOTAL	214.3	232.6

Table 4

BMFT Budgets for Energy Research and Technology (In Millions of Dollars)

Program	1983	1984
International Energy Agency	13.1	9.9
Eur. Soc. for Chemical Preparation of Spent Nucl. Fuels	5.0	4.6
Research promotion in nuclear safety	45.8	44.6
Research promotion for non-nuclear energy:		
new energy sources and saving energy	89.8	70.5
coal and fossil energy, geothermal energy, power stations	82.8	86.3
development of coal-refinement installations	57.5	63.2
Promoting development of research reactor for low enriched fuels	2.6	2.6
Promoting development of fast breeder reactors	143.4	168.8
Development of high temperature reactors	143.4	113.1
Uranium enrichment	37.2	38.2
Development of fuel elements and nuclear waste management	80.9	89.5
Nuclear Research Center, Karlsruhe	172.4	160.8
Nuclear Research Center, Jülich	130.2	134.3
Max-Planck Institute for Plasma Physics	28.4	29.2
GKSS Research Center	29.3	30.1
TOTAL	1065.8	1045.7

Table 5

BMFT Budgets for Space and Oceanographic Research and Transportation Systems (In Millions of Dollars)

Program	1983	1984
Preparatory studies for space research	6.8	6.8
SPACELAB use for applications and industry ...	14.3	15.0
Promotion of development and use of satellite data for research	4.4	4.7
Promotion of basic extraterrestrial science research	15.4	15.4
Capital costs for extraterrestrial science research	22.9	37.6
Operation of test and ground installations ...	10.2	9.3
European Space Agency	140.7	143.6
Development/construction/ tests of communication satellites	43.1	25.5
Promotion of aviation research and technology ..	29.3	29.8
DFVLR aerospace research center	79.3	81.8
Marine mining R&D and capital costs	24.4	21.8
Marine R&D on pollution, food, fishing, temperatures	18.0	19.0
Ground transport R&D and capital costs	90.7	92.3
Promoting R&D on construction	5.7	4.5
Polar R&D	10.8	12.0
Antarctic research station and "Polar Star" ship ..	4.1	8.7
TOTAL	508.9	515.9

3/30/84

SPACE SCIENCE

SOLAR FLARES, THE SOLAR MAXIMUM MISSION, AND WORKSHOPS

by R.L. Carovillano. Dr. Carovillano, formerly at ONR, London, is Professor of Physics at Boston College.

This article reports on topics relating to the UK-Solar Maximum Mission Workshop that consisted of three meetings held at Oxford, UK. The Oxford meetings (11 to 13 April 1983, 7 to 9 September 1983, and 26 to 28 March 1984) were coordinated with similar workshops on the Solar Maximum Mission (SMM) held at the Goddard Space Flight Center (GSFC) of the National Aeronautics and Space Administration (NASA). The three workshops focused on our current knowledge of solar flares and on important questions to answer for understanding flare processes and mechanisms. The UK-SMM Workshop was sponsored by the British Science and Engineering Council and the US Office of Naval Research, London. About 50 scientists, mostly Europeans and a few Americans, attended the meetings. A few persons attended both the UK and GSFC meetings to provide greater communication and avoid excessive duplication of effort between the workshops.

Solar Flares

Solar flares are violent eruptions that occur in the vicinity of sunspots. Energetic particles and an increased intensity of electromagnetic radiation at essentially all wavelengths are ejected during flares. The particle radiation reaches the earth in a matter of minutes, persists for a day or more, and produces important magnetospheric and ionospheric disturbances. The onset of a flare is very abrupt, requiring no more than a few seconds, and the duration varies up to 4 hours with an average of 20 minutes, as seen from ground-based observations. Major questions on flares relate to trigger mechanisms, the source of the energy, acceleration processes, the role of magnetic fields, and the plasma processes involved.

Satellite observations are crucial in the observation of flares since almost none of the high-energy radiation emitted penetrates through the earth's atmosphere. Early x-ray observations of flares from space were made by the Naval Research Laboratory and American Science and Engineering (Cambridge, MA). The solar plasma associated with flares is now known to exist in a large range of physical conditions that vary during the lifetime of the flare. Satellite observations have emphasized the great differences between flares, but a few characteristics have emerged. Three rough categories may be defined from space observations: impulsive flares, which are most common; thermal bursts; and gradient bursts. Impulsive flares have an abrupt onset of hard x-ray brightening at the footprints, as though caused by electron beams. The radiation fluctuates at first during the impulsive x-ray and evolves into a smoother thermal phase. These occur in the lower corona, have a systematic delay of soft x-rays,

and are characterized by asymmetries in brightness. Thermal bursts have high electron densities and temperatures of about 30 million degrees Kelvin or more. Spectroscopy indicates that FeXXV and FeXXVI are present and behave differently, as though emitted from different components of the plasma. Gradient bursts start in the high corona and appear to involve thermal electrons magnetically confined. The emitting region is about 20 million degrees Kelvin and has an electron density of about 3×10^{10} cm^{-3}.

A problem in interpreting flare observations is that unique structures cannot be deduced unless the radiation originated from a single emitting level and not several distinct ones. Differential emission measurements are more useful to infer the structure of emission regions. Another problem is that several flares are usually present at the same time. Thus, observations can rarely be associated with only one flare, and performing "clean" case studies or modeling the observations has limited validity.

The Solar Maximum Mission

The Solar Maximum Mission (SMM) satellite was launched by NASA on 14 February 1980 into a low, nearly circular orbit with an altitude of about 560 km and a period of about 96 minutes. The primary mission objectives related to the dynamics of solar flares and measurement of the total irradiance from the solar disk. After about 10 months of operation, the SMM attitude-control system, which was crucial for the proper functioning of most instruments, failed. The primary purpose of the April 1984 flight of the space shuttle (STS 41-C), under the command of Navy Captain Robert L. Crippen, was to repair or retrieve the SMM satellite. The workshops at Oxford and the GSFC were designed to prepare European and US solar physicists for the reactivated mission.

When plotted against time, the number of sunspots present on the surface of the sun varies rather regularly with an 11-year cycle. The name of the Solar Maximum Mission refers to the maximum of the sunspot cycle that last occurred in 1980. The launch date of SMM was appropriate because solar activity, which includes the occurrence of solar flares, is observed to be essentially proportional to the sun-spot number. As chance would have it, however, the sun was not very active during the shortened lifetime of the SMM mission. Nevertheless, some striking discoveries were made.

SMM included six spectroscopic instruments designed to observe the solar chromosphere and corona, and a broad-band radiometer to measure the total solar irradiance (the so-called solar constant). The energy range covered by the spectrometers extended from visible light (about 0.1 eV) to high-energy gamma rays (about 160 MeV), with a gap only in the extreme ultraviolet (UV) range (about 1 eV or 1000 angstroms).

In its short lifetime, SMM observations have produced surprises and important discoveries. The solar constant was shown to undergo continuous fluctuations of about 0.05 percent, with larger variations at times of high solar activity. Total sunspot area correlates with solar constant variations. This result can be understood physically since sunspots are cooler than the photosphere and radiate less electromagnetic energy. Solar-flare energies were found to be larger than expected, at times by a factor of 100 or more, and involve nuclear processes to a surprising degree. Much information relates to the coordinated observations of individual flares from SMM instruments and ground-based observations. These include the spatial location of flare signatures, the time evolution of the flare, and the special role of hard x-rays. Flares are associated with flare loops or prominences whose shape is governed by magnetic fields anchored to the sun at sunspot regimes of opposite magnetic polarity. SMM observations show that hot plasma fills the loop, which then explodes into a flare. Hard x-rays are emitted from the footprints of the loop, at the solar surface. Microwave radiation, which is characteristic of the plasma temperature, comes from the top of the loop where the magnetic field is most inflated.

The Shuttle Repair Mission

The April flight of the shuttle concerned two principal objectives: to repair or retrieve SMM, and to launch the long duration exposure facility (LDEF). The SMM rescue effort was the key objective and received the most public attention, but the LDEF program was also of major importance. LDEF is a large structure (about 30×14 feet) with a modular design that accommodated 57 experiments involving 190 investigators from the US, Canada, and seven Western European countries. LDEF will be retrieved from space in about 9 months during a shuttle mission.

The SMM rescue effort was important for several reasons. The replacement cost for the SMM mission would have been about $250 million, whereas the rescue mission's cost was about $48 million.

The reactivated mission has an expected lifetime of 3 years. Extensive astronaut training was required for the rescue mission; the training has been documented in an impressive film that is now available from NASA (the film premiered in Europe at the March 1984 workshop meeting at Oxford). Experience from the rescue effort will affect future satellite design and fabrication requirements, particularly for space repair. The US Department of Defense and industrial and commercial organizations scrutinized the rescue effort as a test of the shuttle as a work platform and as a demonstration of the feasibility of manufacturing in space. The SMM modules returned by the shuttle will provide valuable information on the time-integrated effects of radiation on instruments in space. This information will be used in the continuing effort against instrumental obsolescence and breakdown. Finally, the rescue was the pioneering mission of a shuttle rendezvous with a spacecraft or space platform. NASA plans for possible future space rescue or repair missions include the $60-million General Electric Landsat 4 earth resources satellite and the Indonesian Palapa satellite.

Although SMM was launched long before the first shuttle flight, it was built and designed at the GSFC for possible repair and servicing in space by the shuttle. Thus, when the planned 2-year mission developed serious problems after only 10 months, the rescue mission soon became a reality. The SMM attitude-control system, which lost pointing accuracy when fuses failed, was designed for modular replacement. A more difficult task requiring special tools and much rehearsal was the repair of the electronics box of the coronagraph instrument, which was not designed for replacement in space.

Now that the satellite has been successfully reactivated, the SMM objectives will continue to emphasize flares (which should be less frequent than in 1980 since solar activity is approaching a minimum, but perhaps more large flares will occur). Another objective will be to spend more time observing active regions in general, including solar prominences, mass ejections, and sunspot regions. The repaired coronagraph will be able to provide images of Halley's comet near the sun, which could be most interesting.

The UK-SMM Workshop

The coverage of flares at the UK-SMM Workshop was divided into three parts: nonthermal processes, particle acceleration, plasma physics; thermalization phenomena, hydrodynamics, transient effects; and thermal plasma and overall flare energetics. The format of each workshop was similar, beginning and ending with a plenary session; otherwise participants worked in one of the three major groups or a subgroup thereof. The principal convener of the workshop was Dr. R.W.P. McWhirter (Rutherford Appleton Laboratory [RAL], UK), and area leaders were: Dr. J.C. Brown (University of Glasgow, UK); Dr. R. Pallavicini (Arcetric Astrophysical Observatory, Italy); and Dr. G. Emslie (University of Alabama, Huntsville) and Dr. G.M. Simnett (University of Birmingham, UK). An ample exchange of information took place during and after each meeting. Each participant wrote a brief report, which was submitted prior to departure, that identified topics studied, collaborators, and plans for publication.

The principal satellite data used or discussed at the conference were from SMM; the Japanese satellite HINOTORI; the US Air Force satellite P-78, which included flare monitoring instrumentation from the Naval Research Laboratory; and the Russian satellite Intercosmos 7. Ground-based radio and visible-light observations and other data were also used. The observational range of the HINOTORI satellite extended from 1 keV to 7 MeV, emphasizing x-rays and gamma rays.

Participants worked on and discussed a number of projects and carefully selected flares for intensive study because of good data coverage. The selected flares occurred on 9 November 1979, and on 30 March, 29 June, and 5, 8, and 12 November 1980. The purposes of the studies undertaken included:

- Seeking correlated time variations in different flare data--for example, microwaves and x-ray observations.
- Establishing a relationship between hard x-ray emissions and magnetic fields.
- Finding the spatial relationship of simultaneous Hα, UV, soft x-ray, and hard x-ray data.
- Using FeXIX data as a density diagnostic.
- Determining the kinetic energy of the mass flow.
- Deducing the electron distribution compatible with the hard x-ray data.
- Understanding the rate of separation of Hα ribbons.
- Interpreting the Kα emission.
- Examining mass motions required by the blue shifts in the FeXXl and CaXIX spectra.

- Assessing the role of non-Maxwellian electrons in the SiIII spectrum.
- Making numerical models of solar flares.
- Analyzing emission measurements.

Theoretical discussions included the adequacy of certain spectroscopic calculations and interpretations, the role of magnetic field merging and reconnection rates in two-ribbon flares, plasma dynamics and instabilities, the adequacy of current flare models, the role of collisional heating versus reverse-current heating, and whether reversed-current generation was by a sustained electric field or by electromagnetic induction.

Several scientists used models or simulations to compare with observational results. Flare models are essentially one dimensional, hydrodynamical, and stationary or time-dependent, depending on the purpose of the model. The geometry is constrained to simulate magnetic effects of confinement (but no dynamics). Calculations tend to be long and computer-intensive because of steep gradients in space, the need for small time steps, the overall need for many grid points, and the total runout time required. At the workshop, workers on models were from Palermo, Arcetri, Mullard, Utrecht, and other sites.

Pallavicini and S. Serio (University of Palermo, Italy) performed numerical simultations of the 12 November 1980 flare using the so-called Palermo code. Properties of the Palermo code are as follows: (1) it is a one-dimensional, time-dependent hydrodynamics model; (2) it uses energy, momentum, and mass conservation; and (3) it uses a half torus of constant cross section for the flare geometry. With given input parameters and heating, emitted spectra are calculated in time and compared to flare observations. Considerations included the effects of plasma motion on spectral lines, the dynamical response of the plasma to heating, energy input requirements, the spatial and temporal requirements on the heating function, and the effects of nonthermal electron contributions on the thermal phase of the flare.

Parameters are chosen to match observed flare conditions. In a completed simulation, the flare was represented as a single loop with a footprint area of 2.5×10^{17} cm^2, a half-length of 2×10^9 cm, and heating at the top of the loop. The next simulations will heat the flare from the footprints. Agreement with observations is mixed, and trends are duplicated better than absolute values.

R. Mewe (Space Research Laboratory, Utrecht, The Netherlands), J. Jamimiec (Astronomical Institute, Wroclaw, Poland), and J. Sylwester (Space Research Center, Wroclaw, Poland) searched for nonequilibrium effects in the impulsive phase of flares using spectra from the bent crystal spectrometer (BCS). Time-dependent model calculations of dynamical loops have been performed by Pallavicini and Doscheck (Naval Research Laboratory). These were used in ambitious multimodel effort with the objective of improving atomic parameters and the overall model of flaring loops. The procedure was to use the Palermo model to describe the plasma, feed this into the Utrecht code for the time-dependent ion balance, feed this to the MSSL spectral model, and obtain the synthesized loop spectrum to be compared to the BCS observations. Preliminary results indicate that transient effects are important for the first 0.5 to 2 minutes of the impulsive phase. The line-to-continuum ratio and the enhancement of inner-shell atomic-excitation lines are indicators of transient effects. Unfortunately, a hundredfold increase in sensitivity of the BCS would be required to observe these calculated effects.

Many other studies were undertaken, and results were reported at the workshop. A few of these are mentioned below.

E. Antonucci (Institute of Physics, Torino, Italy) described her work to locate the source of heating in the flare; the research combined spectral observations and model predictions. Description of the profile of the spectrum is model-dependent. For the same radiation signature, heating the flare at the bottom of a flare loop requires more energy by a factor of 3 to 20 than heating the top of the loop. In the spectral analysis of calcium and iron lines using the Palermo model, her main conclusion is that changes in line profile can be reproduced by adjusting the location of the energy deposition in the flare.

J. Lemen (Mullard Space Science Laboratory, UK) discussed the study of the calcium abundance in flares. The method uses the property that the Ca line to continuum intensity ratio is only weakly dependent on temperature in the range 10 to 25 million degrees Kelvin. The ratio is measured during the decay phase of the flare as a function of the declining temperature and compared for different flares. An offset is found for different flares that is interpreted as an abundance difference. For 15 case studies, the extreme abundance variations found are from about

1.5 to 2.5. The rate of decrease of temperature in the decay phase of the flare is found to be essentially independent of the calcium abundance, and this may prove to be a useful diagnostic for the He-like ion ratio present at the surface. Theoretical fits to the observations are quite poor unless arbitrary assumptions are imposed, such as multiplying recombination rate coefficients by a factor of four.

P. Mac Neice (University of Cambridge, UK) reported on a significant workshop effort, involving many investigators, to study a single flare using all available observations and an associated modeling description. The flare chosen (12 November 1980) does not fit the conventional two-ribbon or single-loop description and is somewhat of an intermediate case. FeXXI in addition to OV lines were seen in the hard x-ray brightening of the footprints during the impulsive phase of the flare. High preflare coronal density indicated enhanced heating prior to the impulsive phase. Antonucci pointed out the apparent contradiction of the data that FeXXV emissions were most intense at the top of the flare loop, whereas the soft x-rays were more intense at the footprints. A unique interpretation of the data had not been achieved and important questions, such as the stages and sites of energy release or the nature of the hard x-ray emission, were not adequately resolved. A manuscript on this work is undergoing its third revision, and a publication is planned.

S. Volonté (University de Mons, Belgium) described his work to improve diagnostics from the atomic model for Fe by including cascade contributions within n=2 levels (S and P states) and n>2 levels. Ions studied include MgXII, CaXX, and FeXXVI. Data from Intercosmos 7 were used in this work.

A.G. Emslie (University of Alabama, Huntsville) and A. Mackinnon (The University, Glasgow, UK) reported on the role of non-Maxwellian particle distributions in the diagnostics of spectral lines. Because cross sections normally peak where particle distributions are Maxwellian, there is normally no strong diagnostic role for non-Maxwellian distributions. An exception is provided by SiIII for certain line ratios. There is some evidence from Naval Research Laboratory observations of the quiet sun that non-Maxwellian tail distributions are needed to explain their measurements.

Emslie and J.D. Lawson (RAL) contrasted the role of electro-thermal instabilities to heat the electrons to very high temperatures in tokamak versus solar-flare plasma. The main effect comes from the Joule heating term, H, given by

$$H = \sigma E^2 = j^2/\sigma.$$

Here E is the electric field, j the current density, and σ the electrical conductivity. In tokamak plasmas, because the electric field is essentially constant, a temperature enhancement increases the electrical conductivity, which increases the Joule heating of the plasma, which will increase the temperature further and a runaway instability takes places. In the flare plasma, however, j is essentially constant, and an increase in temperature produces a decrease in Joule heating, which is stabilizing.

Emslie suggested an observational test of whether the corona is heated by collisional effects or return-current effects. The key point is that ohmic heating is temperature-dependent, whereas collisional heating is not. If there is a stationary state energy balance between beam heating and conduction, then typical scale lengths (or inverse temperature gradients) are determined. For collisions, the scale length varies with the temperature T as $T^{7/4}$, as in the standard coronal loop model where the scale length at the top of the loop in the corona is much larger than near the bottom in the transition region. Thus, the ratio of a line intensity in the transition (tr) region to that in the coronal (c) region will scale with temperature as $(T_{tr}/T_c)^{7/4} = 10^{-3.5}$ if $T_{tr} = 10^5$ degrees Kelvin and $T_c = 10^7$ degrees Kelvin. For ohmic heating the scaling length has a steeper dependence and goes as $T^{5/2}$, and the line intensity ratio, $(T_{tr}/T_c)^{5/2} = 10^{-5}$, is a factor of about 30 less than the collisional result. Thus, the ratio of transition region lines relative to coronal lines should be more intense with a collisional heating scenario than with a return-current scenario. A calculation is being done to predict expected intensities for CaXIX and OV lines.

R. Harrison (University of Birmingham, UK) discussed the x-ray signature of solar coronal mass ejections. In averaging the x-ray intensity plotted in time, one can extrapolate to infer the onset of the flare and the existence of a precursor signature. For different cases, the precursor peak intensity was 2 to 38 minutes prior to flare onset.

4/20/84

THE ITALIAN INTERPLANETARY SPACE PHYSICS INSTITUTE

by R.L. Carovillano.

The Istituto Fisica Spazio Interplanetario (IFSI, the Institute of Interplanetary Space Physics) is one of the research laboratories of the Consiglio Nazionale delle Richerche (CNR, the National Research Council). The institute, located in Frascati, Italy, just outside of Rome, has four research groups dealing with interplanetary physics, cosmic rays, gravitational waves, and infrared (IR) astronomy. Dr. M. Dobrowolny has been the director of IFSI since 1982. The research staff totals about 45 persons; about 30 have doctorates. IFSI has participated in several European and US space missions, contributing experiments, co-investigators, and data analysts.

Interplanetary Physics

The interplanetary-physics group is the largest at IFSI (about 18 members) and emphasizes the earliest work of the institute, space plasmas and magnetic fields. The group's research includes data analysis, theory, and the development of experiments and proposals for future space missions.

Data-analysis efforts relate to space experiments, developed collaboratively between IFSI researchers and US or European colleagues, and the study of data available from the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA). Staff members have analyzed data from a large number of important missions, including GEOS 1 and 2, HELIOS 1 and 2, the ISEE series, IMP 8, Voyager, and other satellites. Data analysis studies have been conducted on the solar wind, the earth's magnetosphere, and the interactions between the magnetosphere and the solar wind. Some results from these studies are mentioned below.

A statistical study has been made of discontinuities in the interplanetary magnetic field, including effects of heliocentric distance and heliographic latitude. The Alfvénic turbulence in the solar wind has been studied and the power spectral density obtained as a function of frequency and heliocentric distance between 0.29 and 0.87 AU. (An astronomical unit [AU] is the distance from the sun to the earth, about 900,000 miles.) The total power in the magnetic field components and in the magnitude of the field decreases systematically with increasing frequency and with radial distance, suggesting the presence of a dissipative mechanism in the solar wind. Other studies on the magnetic field cover the effects of large solar flares, the large-scale structure of the field between 1 and 6 AU, the spiral structure of the magnetic field with adjacent sectors of opposite polarity, the structure of the field across sector boundaries, and comparisons of the large-scale structure of the solar equatorial magnetic field inferred from spacecraft observations and from ground-based coronagraphs. The magnetic field is found to rotate through large angles (essentially 180 degrees) across sector boundaries with respect to the ecliptic plane. Most field changes at the sector boundary may be described as tangential discontinuities.

Magnetospheric studies have proceeded on several topics, depending on the available database. IFSI has emphasized research that draws upon more than one database and has participated in NASA's coordinated data-analysis workshops. Studies have included ion beams in the tail of the magnetosphere; the locus of the high-latitude plasma sheet boundary in the tail; substorms; comparison of the observed and modeled magnetic field at geostationary orbit; coordinated observations of magnetic pulsations in space, in the ionosphere, or on the ground; and heavy ions in the tail.

Because the solar wind is a supersonic flow, a bow shock wave forms in front of the earth. After crossing the bow shock, the solar wind plasma becomes subsonic and is deflected away from the earth by the geomagnetic field; the locus of the plasma-field boundary surface is called the magnetopause. Along the earth-sun line, the distance to the bow shock is about 14 earth radii, and the distance to the magnetopause is about 11 earth radii. The regime between the bow shock and magnetopause is called the magnetosheath. Magnetospheric boundary studies at IFSI go back about 15 years to the early important work of V. Formisano on the motion of the magnetopause. Current studies on the interaction of the solar wind and the magnetosphere investigate plasma and magnetic field properties near the bow shock or the magnetopause.

Magnetic fluctuations and backstreaming particles in the foreshock region are studied to determine the role or nature of turbulence at the bow shock. Other studies relate to correlations of large electrostatic waves (10 mV) and ion beams at the bow shock, a determination of the electric field across the bow shock, and magnetic reconnection signatures in plasma and field parameters at the magnetopause.

Theoretical research at IFSI proceeds along lines complementary to the data-analysis efforts described above or relates to planned space missions. Much theoretical work is done in collaboration with scientists from other institutions and countries. A few of the theoretical efforts are described below.

The Kelvin-Helmholz instability has been investigated as a means of exciting surface waves at the magnetopause. Such waves could be observed at the magnetopause or could possibly generate internal magnetospheric oscillations. Other studies relate to incompressible turbulence, instabilities in magnetic neutral sheets in the presence of flow, and mechanisms for the "critical ionization velocity" with possible applications to solar wind-comet interactions.

A major theoretical effort in collaboration with the Smithsonian Astrophysical Observatory (SAO) of Harvard University supports the tethered satellite system (TSS). TSS is a joint program of NASA and Italy. Two tether satellites are planned, one for electrodynamics experiments and one for atmospheric studies. The satellite will be tethered directly to the shuttle. The tether will be electrically conducting oraninsulator, according to mission objectives, and may be as long as 100 km. The TSS program will provide new and exciting opportunities to probe the ionosphere and perform *in-situ* measurements of the upper atmosphere at previously inaccessible altitudes. TSS will be launched in 1985 or 1986. The IFSI efforts have been to model the electrical characteristics of the tether system, and to investigate the radiation from the conductive tether moving through the geomagnetic field and the effects on the ionosphere.

IFSI is involved collaboratively in several experiments for future space missions. These include two experiments on GIOTTO, ESA's mission to study Halley's Comet. The principal investigator (PI) of the magnetic field experiment is F. Neubauer (Braunschweig University, Federal Republic of Germany [FRG]) with institutional collaboration from NASA's Goddard Space Flight Center (GSFC) and IFSI. The PI of the plasma experiment is A. Johnstone (Mullard Space Science Laboratory, UK) with institutional collaboration from the Max Planck Institute for Aeronomy (Lindau, FRG), the Kiruna Geophysical Institute (Sweden), and IFSI. In a related effort, Formisano is co-investigator for the plasma-wave experiment, which is being built at ESA's European Space and Technology Center, on the Soviet Venera-Halley spacecraft. Other collaborative efforts are a plasma experiment with several European laboratories, and a magnetic-field experiment on one of the satellites in the planned International Solar Terrestrial Program that involves several nations and satellites.

Cosmic Rays

The cosmic ray research at IFSI is done in collaboration with the GIFCO Research Branch of CNR located at the Marconi Institute of Physics of the University of Rome. Most of the cosmic ray group and the main cosmic-ray instrument, the ISFI neutron monitor, are also located at the university. The research done is to seek correlations in cosmic-ray data obtained from the worldwide ground-based network of monitors with appropriate satellite data of the solar wind and low-energy cosmic rays in space. Efforts are made to seek physical conditions in space that would account for observed variations in the ground-based cosmic ray intensity. In another line of research, the anisotropy of the cosmic-ray intensity in space is studied for its dependence on solar-wind structure, such as high-speed streams associated with coronal holes.

Gravitational Waves

The Italians have always been strong in developing concepts and principles at the frontiers of physics. Special and general relativity and the structure of particles are such areas of strength today. General relativity has been particularly difficult to pin down experimentally because effects are small and extremely difficult to observe except in special circumstances. Observable effects generally require the presence of a large mass that gives rise to a special observable effect (such as the bending of a light ray). Of special interest for more than a decade has been the possibility of establishing the existence of gravitational waves. The gravity research at IFSI is in this area.

The activity at IFSI is focused on developing detection techniques based on the use of Weber-type antennas to measure impulsive effects of catastrophic cosmic events. The work is done in collaboration with Prof. G. Pizzello and his group at the Physics Institute in the University of Rome. A 390-kg cryogenic antenna is being used at IFSI to develop a scheme to measure a quantum of gravity. The IFSI antenna is rated as one of the most sensitive in the world for gravitational research. In the past it operated at 77°K to study the terrestrial noise background, and

significant effort is directed toward obtaining the much lower temperatures required for the intended deep-space observations. In another effort in collaboration with SAO, the feasibility of a gravimeter using the TSS is under study.

Infrared Astronomy

The IR astronomy group is the smallest at IFSI. Its research programs involve making ground-based observations from available telescopes and developing new sensors. The 1.5-m Gornergrat telescope and the 1.8-m Asiago telescopes have been used to study selected IR sources with IFSI spectrophotometers. Instrumentation efforts have included the development of sensors to extend the observable wavelength regime in both directions (from IR through ultraviolet), and the development of a TV system to improve the pointing accuracy of telescopes, needed for the study of faint objects, and image-processing capability.

The range of research at IFSI is quite large and diverse for its modest size. Yet programs are productive and recognized. The professional staff has a good publication record (particularly Dobrowolny and Formisano, but also B. Bavassano, C. Bonifazi, M. Candidi, S. Orsini, M. Storini, and G. Velloresi) and is active (though limited by budgetary constraints) at major international meetings. A key to their success is the sustained effort given to establishing collaborative programs with outside groups and scientists. In addition to strong ties with the large groups at the University of Rome and other Italian universities, IFSI has established formal ties with many European and US institutions. Recent publications by IFSI staff members have been coauthored with many distinguished foreign scientists, including L.F. Burlaga (GSFC, NASA); A.J. Handhausen (National Center for Atmospheric Research, Boulder, CO); N.F. Ness (GSFC, NASA); A. Pedersen (ESA, Noordwijk); A. Galeev and R.G. Sagdeev (Space Research Institute, USSR Academy of Sciences); J. Weber (University of Maryland); A. Korth (Max Planck Institute for Aeronomy, FRG); A.J. Lazarus (MIT); C.T. Russell (UCLA); and R.A. Greenwald (Johns Hopkins University, Applied Physics Laboratory).

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4/25/84

TECHNOLOGY

MINE WARFARE RESEARCH AND DEVELOPMENT IN FRANCE

by Chester McKinney. Dr. McKinney is the Liaison Scientist for Underwater Acoustics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Texas at Austin, where he is Senior Research Scientist at Applied Research Laboratories.

The naval mine or seamine was invented by David Bushnell, a Yale student, for use against the British fleet during the American War of Independence. Descendants of these mines have been used with impressive effectiveness in virtually every maritime or riverine war since the US War Between the States. The mine continues to be a highly respected weapon--largely because it is effective and because the costs of clearing minefields, measured in time, money, and lives, generally are significantly greater than those associated with the planting of the fields.

In principle the mine has changed little in more than a hundred years--in general, it is an inexpensive but deadly weapon which lies in wait for its victim and uses its own built-in intelligence to decide if and when to explode. In detail, the modern mine is very different from the stereotypical device, a submerged but buoyant mine with which a ship or submarine had to make physical contact to cause actuation. A common type of mine is cylindrical (2-m long by 0.5-m diameter) and contains about 600 kg of modern conventional explosive. It rests on the ocean floor in water depths of 100 m or less. Within the mine are a variety of sensors, signal-processing circuits, clocks, arming devices, and other components. The most common sensors are those which detect changes in the ambient noise--magnetic, acoustic, and pressure--caused by a passing surface ship or submarine. The primary tasks of the sensor package are to

detect, locate, and classify targets; detonate the explosive at the proper time; and counter a host of countermeasures.

The most effective mine countermeasure (MCM) is to destroy the mine factory, mine storage depot, or minelaying vehicles. Once in place, a modern minefield is not easy to counter. (The major cost in planting an offensive minefield generally lies in the delivery phase, not in the mines. For unopposed planting of defensive fields this is not the case.) Techniques and tactics for clearing minefields are usually categorized as minesweeping or minehunting. Classical sweeping methods include: (1) towing wires, armed with a number of explosive cutters, through the water to sever the mooring lines of tethered (buoyant) mines, and (2) generating magnetic and acoustic signals (which are designed to simulate the disturbances or "signatures" of ships and submarines) in the water to "fool" the mines and cause them to actuate. It is difficult to simulate the hydrodynamic pressure signature of a large ship, short of using another ship of comparable displacement (known as a Guinea Pig ship). Minehunting is the general technique of using sensor systems such as sonar, magnetometers, and even optical devices (underwater TV) to search an ocean area for individual mines and neutralize each one by removing it, explosively destroying it, rendering it safe, or avoiding it. MCM is a high-risk occupation.

This sketch of mine warfare, for reasons of brevity and security, omits much more than it includes, but perhaps it will serve as an introduction to the subject for the general reader. Today there are many types of mines, bottom resting and tethered, some static and others mobile, some entirely autonomous (after planting) and others remotely controlled. No single mine can meet all requirements. MCM, now as in the past, is a "bag-of-tricks," usually including a mixture of sweeping and hunting as well as other techniques and tactics. Mine warfare (MWF) is a prime example of the game of measure-countermeasure-counter counter, ad infinitum.

In most European navies MWF occupies a position of greater relative importance than it does in the US Navy; however, even in Europe the MWF segment is small compared with those such as submarine and anti-submarine, surface, and air warfare. Small though the field may be, the technologies involved are diverse and often complex. Subjects of importance include underwater acoustics, magnetics, optics, electronics, computers, signal processing, robotics, hydrodynamics, marine architecture, precise navigation, materials, and explosives. It is obvious that the small MWF community does not have the resources to conduct all of the needed research and development and must (logically) borrow technology from many other areas and use its limited assets to do only work which is specific to MWF and which otherwise would not be done. Examples of such specific work are: high-frequency, very-high-resolution sonar; high-frequency, shallow-water acoustics; very-low-frequency, very-shallow-water acoustics; magnetics; and pressure fields of ships. The artificial intelligence incorporated into some mines and sonars is not trivial.

France, like several other Western European countries, has a good MWF capability and a vigorous research and development program to support the fleet (see next article). France is especially strong in the area of minehunting systems, but it does not neglect minesweeping and mine development. The Groupe d'Études Sous Marines de l'Atlantique (GESMA), a small French government research and development activity at Saint Nicolas (about 10 km from the major naval port of Brest), plays a key role in the total French MWF activity. It is in charge of all technical problems connected with seamine warfare, including applied research, exploratory development, advanced and engineering development, production, and fleet support. It is truly a cradle-to-the-grave organization in regard to the technical aspects of MWF, which covers mines, mine laying, and MCM.

GESMA, with about 135 employees (25 scientists and engineers) is spread thin to cover all of its responsibilities. The director of the establishment is ICA Hubert Pasteau. (French Ministry of Defense [MOD] activities dealing with research and development, as contrasted with naval operations, are generally headed and partially staffed by members of a corps of Armament Officers. For example, ICA literally means Chief Engineer, Armament; IA is Armament Engineer. These officers frequently move to other posts. Most of the professional engineers and scientists work under a different type of long-term contract and are classified as Civil Engineers or ISC.)

GESMA is organized into a Research Section (headed by ISC Pretet), a Development Section (headed by ISC Forget), and several support groups. In-house, the division of funds is 20 percent for research, 60 percent for development, and 20 percent for fleet support and other activities. The

research section covers magnetics, acoustics, hydrodynamics, and operations research. The development section covers sonar, sweeping, mine disposal, and ship protection. The research section has a staff of 30, including six engineers and 13 technicians. There are also about 30 people in development. By discipline there are 60 in acoustics, 25 in magnetics, and 10 in mine work. Mr. Pierre Maguer is head of the acoustics research. He has been a member of the staff since GESMA was established in the late fifties.

The special facilities for MWF research and development are excellent. The Saint Nicolas complex includes a well-instrumented underwater sound tank (20×7×3 m), a much longer towing tank, and a good magnetics lab, as well as the usual computer center, library, and fabrication shops. A much larger (115×13.4×11 m) underwater sound tank is in the navy yard in Brest. A field station, located at Lanveoc, on Brest Roads a few kilometers from Saint Nicolas, includes shore-based acoustic, magnetic, and pressure ranges with permanent in-water sensor arrays, as well as mobile ranges (in vans). GESMA has the sole use of a small ship and two larger vessels (400 and 600 tons) as needed. They also make extensive use of vessels in the MCM fleet. A new special-purpose trials ship for GESMA is in the French Navy Shipbuilding program. In brief the facilities for applied research and development in MWF are adequate and are as good as I have seen in Europe. This year GESMA will move into a new building designed for their sole use in the Brest navy complex. The design is for a staff of 150 and includes at least one large underwater sound tank.

The GESMA staff conducts analytical studies, systems analyses (trade-off comparisons), and experiments in the lab and at sea; develops equipment specifications; monitors development and production contracts; and provides fleet support as problems arise. Its in-house acoustics work is concentrated on high-resolution sonar, underwater sound generators (low frequency) for minesweeping, and sensors systems for acoustic mines. Frequencies of interest run from subaudible to the low megahertz. Magnetics research is done in support of development of magnetic mine sensors, magnetic sweep devices, and magnetometers to detect mines. Current topics include the development of permanent magnets for which the polarity can be quickly reversed or neutralized and the development of highly sensitive magnetometers. By measuring three components and five gradients of a magnetic field one can (coarsely) measure direction and range to a source, and hence magnetic moment, but this requires high sensitivity if useful ranges are to be achieved. Economy in cost, power consumption, and size are essential for use in mines and also for minehunting. The classical induction coil sensors clearly are not suitable, and flux-gate types lack the desired sensitivity. Cyrogenic squids have high sensitivity but are not suitable for use in long-life unattended mines, and nuclear-magnetic-resonance devices use too much power. Work on solid-state electron resonance magnetometers looks promising.

Clearly GESMA, with its small staff, cannot do all of the necessary research and development. To complement and supplement its in-house work, GESMA spends about 50 percent of its budget on outside contracts with industry and universities. It supports small projects (mostly unclassified) with about nine French universities. Subjects include nonlinear acoustics, acoustic-echo-structure studies, and signal processing, among others. However, the bulk of the contract work is with industry. These contracts include the fabrication of experimental hardware and the design and fabrication of equipment prototypes. GESMA does very little in-house equipment detail design and fabrication. Industrial contracts also include analytical studies, laboratory research, and trials at sea. I find it difficult to determine precisely what work is being done in-house and what is done under contract; but it is very clear that a close working relationship exists between GESMA and industry. Virtually all contracts are let on a sole-source, preferred contractor basis. This arrangement has the strong advantage of allowing a contractor to specialize in a given area and to build up and keep an experienced staff. When one talks about the excellent French minehunting sonar program it should be recognized that the program is the integrated work of GESMA and Thomson-CSF; the program in mine-disposal systems is the joint effort of GESMA and Société ECA, and so forth.

The success of the French MOD in developing a good MWF capability can be attributed to several factors. I believe that they make good use of all of their resources and that good integration, cooperation, and feedback exist. Space does not allow me to even mention the many other components of the system, including several layers of MOD offices and the fleet. Having all of the technical problems assigned to a

single laboratory is efficient, provided that lab performs its functions well (and this GESMA seems to do). The use of sole-source preferred contractors allows efficient use of time, and probably money, and ensures good technical expertise (again assuming that the preferred contractors perform well). The feedback from the fleet operators to the research and development lab is extremely important, and this is done superbly in France. Another important point is that the French MOD seems to have struck a good balance between doing paper studies and building hardware. Studies are very important, but do not themselves sink ships or find mines. Hardware, if designed on a sound basis and built properly, is useful only if it is used, and used, and used, with the results being fed back to the researchers, developers, and planners. France seems to do this well. They have had a MWF research and development program for at least 25 years. They have made good use of technology generated in other countries, and they have made their own important contributions, most notably in minehunting sonar and mine disposal. Some of their current projects are rather bold and pioneering; we should follow their progress closely and with keen interest.

4/12/84

SONAR RESEARCH AND DEVELOPMENT AT THOMSON-CSF, BREST, FRANCE

by Chester McKinney.

Although underwater acoustics certainly has important applications in the civilian sector (e.g., oceanographic research, navigation, exploitation of mineral resources, and fisheries), the major users are the various navies of maritime countries. These navies are the largest sponsor of relevant research as well as of development of devices such as sonars. While considerable basic research and some development is conducted in universities, the bulk of such work is done in government laboratories and by industry. Therefore if one desires to learn the state of underwater-acoustics research and development in a given country, those are the activities which need to be visited.

Traditionally, industry does some advanced development, all engineering development, and production. The share of applied research and exploratory development done by industry varies from country to country. In the UK there is a strong trend toward industry doing more of all research and development, much the same as has happened in the US. In France, West Germany, and Italy, industry has long done the bulk of such work. In France the policy has been to have preferred contractors for specific areas of military R&D and to issue sole-source contracts (i.e., no real competition) for development, with the same company doing the production. Thomson-CSF (T-CSF) has long been the major contractor for the French navy's underwater-acoustics equipment with divisions of CIT-Alcatel doing some major projects and being the only significant competitor. Recently it has been announced that CIT-Alcatel will merge with Thomson-CSF, which now will have a virtual monopoly on military underwater-acoustics equipment in France. Evidently this merger and others have the strong support of government. Export sales of military equipment is highly desirable (since this helps defray the high cost of development), and France as well as other European countries are emphasizing export. Having a single, large "national" representative probably improves the international competitive position of the company. At present nearly 50 percent of T-CSF sales are in other countries.

T-CSF, with its various subsidiaries, is quite large, having about 83,000 employees. About 20 percent of sales are spent on R&D, with over 15,000 employees in that sector. These figures include both contract and company-funded work. There is a corporate Central Research Laboratory, near Paris, but most of the R&D is done within the various divisions. About 50 percent of the total T-CSF work is in the areas of electronics and detection devices (e.g., radar and sonar). The underwater-acoustics work is done in the Division Activities Sous Marine (DASM) by the main plant in Cagne-sur-Mer (near Nice) and by smaller groups in Brest and Gradigan. DASM was established in 1963 (at Cagne) primarily to cater to the French navy's needs for underwater-acoustics equipment. A subsidiary was started at Brest around 1970, primarily to work in the area of mine warfare and oceanographic instrumentation. DASM in total has about 1500 employees and estimated 1984 sales of FF520 million. (The CIT-Alcatel merger will add another 1000 employees to DASM.) The Cagne complex handles transducer development for all of DASM, most of the system

production work, and research and development on surface-ship and submarine sonar, torpedo homing units, and several other lines, including surface acoustic waves (SAW) devices and ultrasonic imaging systems for medical use. Mr. Noel Clavelloux is Managing Director of DASM, and Mr. Bruno Lallement is head of the Brest operation.

In this article I will describe only the acoustics and sonar work done at the Brest plant. The effort of this plant is heavily oriented toward research, exploratory development, and engineering, rather than quantity production; total employment is about 350. Unless noted otherwise, all of the work discussed is done in close cooperation with the Ministry of Defense (MOD) laboratory GESMA located nearby (see preceding article). During the past two decades T-CSF and GESMA have developed and produced a family of very-high-resolution sonars, primarily for minehunting, which are considered by many (myself included) to be the best available in the free world for minehunting in shallow water (depths less than 60 m).

A popular design concept for minehunting sonars is to use a medium-frequency (∿100 kHz) echo-location sonar to search ahead of a surface ship to detect mines or minelike objects. Resolution cells about 1.0 degree in azimuth by 1.0 m in range have been found to be acceptable for resolving mine-size targets against a background of reverberation from a typical sand bottom. Detection ranges are usually less than 500 m for platform speeds of 5 to 6 knots. Usually a fan of sonar receiver beams is employed to cover a forward-looking sector of 20 to 90 degrees (depending on the particular sonar). But detection alone is not adequate. The bottoms of most ship channels are cluttered with objects, man-made and natural, which acoustically are similar in size to mines. A popular solution is to incorporate in the sonar a higher resolution mode (at a higher frequency, ∿300 to 400 kHz) to examine a small area around a suspect target in fine detail. Typical resolution cells are 0.35 degree in azimuth by 10 cm in range. The higher frequency is used to achieve the improved angular resolution with an acceptable size of transducer, but this in turn results in shorter ranges--generally less than 200 m. Classification of a target as a mine (or mine-like) is based on using the higher resolution to paint a very coarse acoustic image of the target and of the acoustic shadow cast by the target. From the image the approximate size and shape of the target can be estimated. With the sonar parameters given above, the range resolution of 10 cm is quite good (being small compared to the target size), but the angular resolution is marginal (about 1.0 m at 150 m range), being comparable to the target size. This has the effect of reducing and diluting the shadow image and enlarging the target image. Thus classification must rely heavily on range resolution. In brief, accuracy of classification is limited by the angular or cross-range resolution. If it is feasible for the minehunting vessel to circle the target, thus enabling the target to be seen from different aspects, the classification task is made much easier. Imaging improves with decreasing range, but usually one does not like to approach a suspected mine closer than 100 to 150 m.

Sonars of the type just described were pioneered by the UK in the late fifties (type 193) and by the US a few years later (AN/SQQ-14). GESMA and T-CSF started development of the same generic type almost a decade later than the UK and US, but by about 1971 they were in production with their DUBM-20's, which were installed on the five new CIRCE class minehunters--the first such craft designed specifically for minehunting. (The UK and US had used converted minesweepers.) The French made good use of the US and UK experience and technology. The DUBM-20 incorporated nothing dramatically new but did make a number of evolutionary improvements which resulted in a very fine sonar for shallow water. Perhaps the most important improvement was to use a somewhat higher frequency (∿480 kHz) and a larger transducer array for classification, which provided an azimuthal beamwidth of 0.17 degree and suppressed the receiver beam patterns minor lobes to -24 dB. The combination of these two straightforward designs resulted in a significant improvement in imaging, especially of the acoustic shadow. By operating with as high a source level as the water nonlinearity would allow and by using good signal processing and circuit design, the French were able to achieve good classification (imaging) at ranges of 180 m.

These sonars proved to be quite good, and the French navy has used them effectively for more than a decade in cleaning up the mass of World War II ordnance (e.g., mines and torpedoes) which litters the coastal waters and channels of France. The sonars also were used to clean up the Suez Canal before its opening. But technical and operational success does not guarantee financial success. A production run of five sonars (all that France needed at

the time) is very small, and there were no foreign sales. The latter probably is due to at least three factors. There was not much of an international minehunting market at the time, the T-CSF sonars were not well known outside France, and the DUBM-20 was expensive. T-CSF equipment is well designed and very sturdy, but not cheap.

In part to reduce the price (for both domestic and export sales) the DUBM-21A was developed. It incorporated a number of improvements (in circuit design and signal processing), but a major change was to employ a much smaller electronically scanned field of view in the detection mode. This significantly reduced the size, weight, and cost of the hull-mounted transducer assembly. In my view, it was a step in the wrong direction, but there are legitimate arguments for both sides. This sonar enjoyed more financial success in that eventually 10 sets were bought by the French for use on MSO minesweepers (obtained from the US in the fifties) which were converted to minehunters, and another five were sold to a European NATO country. But the French hit the jackpot with the advent of the French-Netherlands-Belgium Tripartite minehunter program. In this program the three countries developed a common ship design (with glass-reinforced-plastic hulls); all the ships will use the same suite of mine countermeasures equipment. A total of 40 ships are being built; each country is building its own ships, and equipment purchases (e.g., engines, electronics) are being divided among the three. T-CSF is to supply the minehunting sonar and certain other items. The DUBM-21B (an improved DUBM-21A) was developed for this program.

A distinctly different generic type of sonar is the side-scan or side-looking variety. The most popular configuration is to have a ship or helicopter tow a submerged body through the water. This body usually is in the shape of a long, thin cylinder. In the walls of the cylinder are mounted long-line transducer arrays, which project and receive sound at right angles to the arrays. This is now a very common type of sonar used for mapping the ocean floor. The US Navy pioneered with the invention and development of very-high-resolution, high-frequency, side-scan sonar in the late fifties. The US fleet sonar was the CMK1 Shadowgraph, which was developed by the Naval Coastal Systems Center and Westinghouse, and was in production in the early and mid-sixties. This sonar operates at about 1.3 MHz and has a resolution cell of about 8×8 cm, but the range of each sonar is only about 27 m. A system consists of two towed bodies (each with two sonars) to cover a path about 100-m wide, with a speed of advance of 5 to 6 knots. The CMK1 is still in use and to my knowledge, it has the highest resolution of any operational navy sonar. GESMA and T-CSF followed a few years later with an almost identical copy of the CMK1, but with one important change. The French sonar, DUBM-41, operates at approximately half the frequency, and thus double the range, but with a resolution cell of about 15×15 cm. The design of this sonar was able to take advantage of dramatic advances in electronic technology which occurred during the sixties. (The electronics are solid state rather than the vacuum tubes of the CMK-1.) A much superior paper recorder was another evolutionary improvement.

The DUBM-41 is an excellent bottom-mapping, very-high-resolution sonar, and it is used routinely by the French navy for such work. The French bought about six systems, and I am not aware of any export sales. Most customers for side-scan sonar do not require the very high resolution (as well as other features) of the CMK1 or the DUBM-41. Commercial side-scan sonars are produced in quantity by perhaps two dozen companies (worldwide) for a cost as low as $50,000. Naval minehunting sonars are likely to cost at least an order of magnitude more. It should by noted that the elementary side-scan sonar is simple in principle but can become much more complex (and costly) in practice if one requires high speeds of advance, longer ranges, *and* very high resolution. These requirements lead to multiple beams, longer transducers, and dynamic (time-varied) focusing, among other things. GESMA and T-CSF continue to be involved in the development of more advanced side-scan sonars, but it is not feasible to discuss such work in this article.

The newest minehunting sonar to be developed by T-CSF is the TSM-2022. It is a T-CSF private-venture project, but GESMA certainly funded exploratory development relevant to the sonar during the 6 years or more that the sonar has been evolving. The TSM-2022 is a multi-mode sonar designed to do many things and yet be less expensive and smaller than the DUBM-20/21 series. It can be installed on craft smaller than the conventional coastal minehunters and should be well suited for converting a variety of craft (including minesweepers) into minehunters. The desire to be successful in the export market certainly had

an influence on the system concept and design.

The TSM-2022 basically is a single-frequency (200 kHz), hull-mounted sonar which can be operated by one person. The transducer array is a line 1.5 m in length, with which 40 receive beams are formed. The unique feature of the sonar is that the array can be mechanically oriented to operate in four different modes. For one mode, the line array is horizontal with the beams directed forward. This mode would be used for conventional minehunting and mine/obstacle avoidance. If the array is rotated 90 degrees in the vertical planes (beams still forward), the sonar provides high resolution in the vertical plane, which can be used to advantage in determining the vertical position of targets in the water column. If the array is returned to the horizontal but rotated 90 degrees about the length axis so that the beams point downward, one has a multibeam bathymetric survey sonar. Finally, if the array is rotated so that the beams look to the side, one has a multibeam side-scan sonar. A sonar for all applications (but with a few reservations)! When not in use (or for maintenance) the array is rotated to the vertical, in which position it can be retracted inside the hull. The diameter of the trunk is only 75 cm, a distinct advantage for small craft installation and for craft conversion.

It is obvious that a number of compromises have been made in the design of the TSM-2022. The choice of frequency is a compromise between what might be best for detection (at longer range) and best for target classification. However, in compensation a longer than usual aperture is used. (This is feasible because of the method used for deployment and retraction.) More important is the transmit beamforming technique. The projectors are located at the extreme ends of the array. The projected beams form an interference pattern in which (as is well known) the width of each lobe is half of what it would be if the full array were used as a projector. To fill the gaps between lobes, two frequencies are used, selected so that the lobes of one coincide with the nulls of the other for the sector of interest. The inherent convolution of the transmit and receive beams yields an angular beamwidth which is half that of the full array. The problem is that the array must be stable (within about one quarter of the beamwidth) throughout the ping cycle (not just the ping duration)--so there are very strict requirements on the stabilization of the mechanical rig for the array. (For this sonar, as well as most hull-mounted minehunting sonars, transducers are mechanically stabilized in roll and pitch and electronically in yaw. There is no heave stabilization.) If the scheme works, then the TSM-2022 should have about the same classification capability as the DUBM-20/21. The vertical-scan and down-looking modes should work as well as any other hull-mounted sonar with comparable characteristics. The side-scan mode is not likely to work as well as specially designed towed side-scan sonars, especially in waters deeper than about 25 m.

T-CSF is breaking some new ground with its TSM-2022, and we will follow its use with great interest. Certainly it incorporates some very interesting and appealing features. If successful, it likely will be a popular sonar. It is interesting that 12 sonars had been sold on the export market to three different countries before the first system had been completed. The first of the TSM-2022 has now been delivered to Sweden for use on its new LANDSORT class of minehunters. The French MOD has yet to make a commitment to purchase any, but first wants to see how well the sonar performs.

During the past 20 years GESMA and T-CSF have conducted considerable exploratory development and have developed a number of good high-resolution sonars (several in addition to those I have discussed). In my view, for some time they borrowed heavily from other countries in terms of concepts and added their own good engineering and evolutionary improvements. However, this situation is changing, and they are now developing systems which have more of their own imprint. For example, some of the planned improvements to the rather aged DUBM-20 systems may be stretching the available technology to the limit. It is noteworthy that T-CSF is subcontractor to Raytheon Co. (US) for the classifier portion of the AMSS (AN/SQQ-32) sonar, which will go on the US Navy's new MCM-1 and MSH classes of mine countermeasures ships, of which a total of 31 are planned for construction. One news account has stated that this might mean as much as $25 million for T-CSF.

High-resolution sonars are not the only products of T-CSF, Brest. They also produce a family of seamines, both combat and training types. These are aimed primarily at the export market but were developed in cooperation with GESMA and other MOD groups. T-CSF also produces oceanographic instruments, with the Doppler acoustic log (speed-over-the-bottom) being best known. An adaption of this device is marketed as

an instrument to remotely measure the current-speed profile in a water column. In the field of magnetics they produce degaussing equipment and degaussing ranges as well as magnetic mechanisms for mines.

4/17/84

NEWS & NOTES

ESN INVITES LETTERS TO THE EDITOR

ESN is beginning a column of letters to the editor in order to encourage dialogue about scientific developments and science policy in Europe and the Middle East.

For information about submitting letters, see the announcement at the end of this issue's table of contents.

Larry E. Shaffer
4/30/84

COD-LIVER OIL *IS* GOOD FOR YOU

If your mother ever insisted on giving you vile-tasting cod-liver oil to protect you from colds, flu, and every other disease known to mankind, she may have been on to something. Epidemiologists say that Eskimos--who have a diet that is rich in oily food, such as whale and seal meat--are mostly immune to cardiovascular disease. Their diet contains a lot of a fatty acid called eicosapentaenoic acid (EPA). EPA has been shown to prevent the production of a powerful hormone, thromboxane A_2. This substance causes the smooth muscle lining the walls of blood vessels to contract, thereby causing hypertension. Recently, B.E. Woodcock and coworkers at the Royal Hallamshire Hospital in Sheffield, England, have shown that EPA also decreases the viscosity of the blood and so may be of use in treating and protecting against peripheral arterial disease (*British Medical Journal*, 288 [1984], 592).

The research team randomly assigned 19 people with established peripheral arterial disease to receive supplements either of fish oil rich in EPA or a mixture of corn and olive oils. After 7 weeks they found that those receiving fish oil had substantially lower blood viscosity than the group receiving corn and olive oil. The fish oil group also showed a drop in the total amount of fats in their blood.

It is not known exactly how EPA changes blood viscosity, but it has been shown to inhibit the clumping together of blood platelets; and clumping of platelets is yet another factor in the development of arterial disease. One mechanism that has been suggested is that EPA substitutes for normal phospholipids in the red-cell membrane and thereby changes its flexibility. This could account for the decrease in viscosity.

An important result of the study, though, is that supplementing the diet with EPA has tangible benefits for people already suffering from peripherial artery disease. Three of the 10 people taking fish oil, for example, found that they walk longer distances without pain.

So take your cod-liver oil.

Thomas C. Rozzell
4/10/84

SWEDEN BUILDS SATURATION DIVING SYSTEM

After approximately 4 years of development, the first wholly Swedish saturation-diving system, made by Gothenburg Diving Technique (GDA), is now in operation. The system was developed in collaboration with the Swedish National Board for Technical Development, the STU (see article elsewhere in this issue), and is capable of operating at depths down to 300 m. There are two chambers in the system, one providing accommodation for six people and the other serving as an entry lock for docking of the diving bell. While the chambers are specifically designed to work with the GDA "Deep Diver" diving support ship, they can also be installed in almost any other vessel or structure, or fitted into a compact mobile unit.

A number of prototype units of special equipment have been developed and built in connection with the saturation system, including equipment for monitoring divers' electrocardiogram, heartrate, respiration, and body temperature along with a Doppler bubble-detection device. The system also features a communications system for divers; it includes a new type of microphone and earphone set, a helium voice unscrambler, and an automatic decompression system.

A spinoff of the GDA-STU project has been the development of a special habitat for hyperbaric repair of submarine power cables at a depth of some 50 m.

Other GDA projects include rebuilding and modernizing pressure chambers for the Swedish navy, constructing an experimental chamber for the University of Gothenburg, constructing and manufacturing a wide range of equipment for the Swedish offshore fleet, as well as constructing and manufacturing treatment and surface-decompression chambers.

Thomas C. Rozzell
4/9/84

ROBOT CENSUS: TOO MANY MANUFACTURERS

The British Robot Association (BRA) predicts that many small manufacturers of robots will be out of business by 1990. The companies that are left probably will be selling new ideas to large manufacturers, according to *New Scientist* (23 February 1984).

These predictions are part of the BRA's robot census for 1983. According to the survey, Europe last year had 12,500 robots, the US 8000, and Japan 16,500. The census listed the following specific figures: West Germany, 4800; France, 2600; Sweden, 1900; Italy, 1800; Britain, 1753; Belgium, 500; Spain, 400; Australia, 300; and Finland, 120.

According to the BRA, in the past the US exaggerated the number of robots it needed, so overseas manufacturers flooded the marketplace with their equipment. "More realistic figures are to be produced [by the US] now to discourage competition," said Tom Brock, the BRA's executive secretary.

In short, there are too many manufacturers, and they are going after just a few buyers. The situation is similar in West Germany and France. According to Michel Parent, president of the French Robot Association, "There are some firms around that have yet to sell a robot. It's certain that the manufacture of robots in the 1990s will be by large corporations. They will need the innovative process that is often best carried out by small companies."

For an overview of robotics research in Europe as of 1981, see *A Survey of European Robotics Research*, ONR, London, Report R-4-84.

Larry E. Shaffer
4/12/84

STAGE SET FOR EUROPEAN STANDARDS FOR BIOMATERIALS

The first colloquy on the corrosion and degradation of biomaterials was held at the Council of Europe in Strasbourg from 5 through 7 March 1984. Because of the increasing use of biomaterials and the possible clinical effects of introducing foreign substances into the human body, the attendees taking part in the colloquy drew up a set of conclusions and recommendations. These may eventually lead to biomaterial standards and regulations that are analogous to those governing medicines. It was felt that there is a need to facilitate the establishment of national institutions to study problems of biomaterials and that the organizations should be linked at the European level. To highlight problems caused specifically by the living environment, such institutions would study the biochemistry and electrochemistry of materials to be implanted in the human body.

One of the problems examined at the meeting was that of records. It was agreed that a descriptive record should be instituted that would become a part of the medical file of implant patients. Such a record would be designed to provide details of the biomaterials used for the implants. The group also discussed ways to help researchers--for example, by publishing a specialized dictionary and by adopting standards for factors such as implant design, alloy construction, and machining quality. It was concluded that a database on explants (implants no longer in use) should be created as a means of improving implants through statistical survey and research.

The conclusions of the colloquy will be submitted to the European Joint Committee for Scientific Cooperation at its meeting on 29 November 1984. A full report of the colloquy will be published later.

Thomas C. Rozzell
4/9/84

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The British Association for the Advancement of Science (BAAS) will hold its 146th Annual Meeting from 10 through 14 September 1984 at the University of East Anglia. The program for the 17 scientific sections of the association

will include lectures, symposia, and other discussions. These will relate not only to the particular interest of individual sections, but will in many cases be interdisciplinary, with a number of sections coming together for joint sessions on matters of complementary interest.

Two seminars are being planned by other societies during the week of the BAAS meeting. These specialist seminars will be organized by the Operational Research Society and the Institute of Physics.

Further information on the meeting may be obtained by writing to:

Dr. David Morley
BAAS
23 Savile Row
London W1X 1AB
UNITED KINGDOM

Thomas C. Rozzell
4/9/84

COMPUTATIONAL PHYSICS CONFERENCE

The Europhysics conference on "Software Engineering, Methods and Tools in Computational Physics" will be held from 21 through 24 August 1984 in Brussels, Belgium. The purpose of the conference is to bring together physicists and other professionals, such as software engineers and computer scientists, interested in some aspect of computational physics. Topics will include computer systems and developments, program writing and maintenance, software capabilities, documentation systems, text manipulation systems, computer-language libraries and packages, algorithm and method banks, and specific tools in computational physics, such as networking, databases, and graphics.

Invited speakers and the titles of their papers are as follows: I.G. Lima and P. Trealeaven (University of Newcastle upon Tyne, UK), "Programming Languages for the Fifth Generation Computers"; R. Martz (University of Zürich, Switzerland), "Object Oriented Programming"; C. Mazza (European Space Operations Centre, Darmstadt, Federal Republic of Germany), "Control of Software Development"; S. Kamiya (Fujitsu Ltd., Japan), "Languages and Software Development Tools for Supercomputers"; I. Pyle (University of York, UK), "PASCAL, MODULA, and ADA"; M. Metcalf (European Organization for Nuclear Research [CERN], Geneva), "Has FORTRAN a Future?"; and A.I. Wasserman (University of California, San Francisco), "Modern Software Development Methodologies and their Environment."

The conference will be held at the University of Brussels, Campus Oefenplein. Inquiries should be made to:

EPS/CPG Brussels Conference 84
Attn: Dr. Paul Van Binst
University of Brussels IIHE
CP 230 Bd. du Triomphe
B-1050 Brussels, BELGIUM
Telex: 61051 vubco

Invited papers and selected contributed papers will be published in a special issue of the North-Holland journal *Computer Physics Communications*. The conference is organized by the Computational Physics Group of the European Physical Society and sponsored by the European Physical Society and the University of Brussels.

R.L. Carovillano
4/19/84

CONFERENCE ON STABILITY IN ORBITAL MECHANICS

The conference "Stability of the Solar System and its Minor Natural and Artificial Bodies" will be held from 6 through 17 August 1984 in Cortina D'Ampezzo, Italy. This is a NATO Advanced Study Institute and the fifth under the direction of Prof. V. Szebehely (The University of Texas at Austin) and Prof. G. Colombo (University of Padua, Italy).

The institute will emphasize recently developed dynamics and stability methods applied to the solar system. Satellites, asteroids, meteors, planetary rings, artificial satellites, and space probes are included. The principal subjects of the program are:

- Quantitative and qualitative methods of stability analysis.
- Hill's, Poincaré's, and Liapunov's approaches to stability.
- Surfaces of sections, mappings, fixed points, bifurcation.
- Modifications and new generalizations of the general and restricted problems of three bodies.
- Stochasticity, ergodicity, and statistical mechanics interacting with stability, long-time predictions, and integrability in celestial mechanics.

- Modern artificial-satellite theories with and without drag.
- The stability of hierarchical dynamical systems.
- Resonance and stability in the asteroid belt and the Trojan satellites.
- New observational and theoretical results of planetary rings.

Lectures, seminars, and special addresses will be made at the institute. Seminars will be open and quite informal, providing opportunities for audience participation, including the presentation of short research papers of a tutorial nature. Presentations will be in English. Program speakers include two Nobel laureates, Ilya Prigogine and Steven Weinberg, and four Browner Prize recipients, George Contopoulos, Boris Garfinkel, Walter Fricke, and the conference director, Victor Szebehely. Other distinguished scientists will serve as principal speakers, seminar leaders, and panel members.

For further information, write to:

Prof. V. Szebehely
Department of Aerospace Engineering
The University of Texas at Austin
Austin, TX 78712

or

Prof. Ennio Rossiznoli, Manager
Instituto Antonelli, Cortina
Zuel di Sotto, 101
ITALY
Telephone: 0436/2278

R.L. Carovillano
4/19/84

INTERNATIONAL CONFERENCE ON DIGITAL SIGNAL PROCESSING

The triennial International Conference on Digital Signal Processing will be held in Florence, Italy, from 4 through 8 September 1984. The conference conveners are V. Cappellini (University of Florence) and A.G. Constantinides (Imperial College of Science and Technology, London). The conference features theory, applications, and techniques of digital signal processing and digital filtering. Topics will include design methods and techniques, quantization effects, accuracy and stability, multidimensional filtering methods, digital image processing, fast parallel processing, hardware implementations, array processors, and applications to speech, radar, sonar, biomedical techniques, remote sensing, moving object recognition, and robotics. The keynote address will be given by Bruce Wald (Director of the Space and Communications Technology Directorate, Naval Research Laboratory, Washington, DC), who will speak on sources of improved signal-processing performance.

More than 300 papers were submitted for consideration, and about 150 were chosen for presentation. In addition to European and US contributions, about a dozen papers are from Japan, some from industry. There is a strong US interest in the conference. On the basis of accepted contributions, popular areas will be speech identification, speech processing, image processing, and digital-signal-processing chips.

Special sessions by invitation will be held at the conference on speech processing, radar-signal processing, remote sensing, microprocessors, array processors, biomedical signal and image processing, and robotics; a program on architecture for digital signal processing is being organized by Y.S. Wu (Naval Research Laboratory). Wu's session will focus on new-generation, high-throughput digital signal processors. Prof. H.T. Kung (Carnegie Mellon University), father of the systolic array, will be the featured speaker in the architecture session. Wu has also arranged a panel discussion, "Analog-Digital Structures," to examine pipeline architectures and various implementations.

Sponsoring organizations of the conference are the US Office of Naval Research, London; Imperial College; the University of Florence; the European Association for Signal Processing; the International Centre for Signal and Image Processing; and the IEEE-Middle and South Italy Section.

Inquiries about the program may be made of:

Prof. V. Cappelini
Istituto di Elettronica
Facoltà di Ingegeria
Via di S. Marta, 3
50139 Florence, ITALY
Tel: (55) 470046 or 431090
Telex: 570231 IROE

Conference proceedings will be published by North-Holland.

R.L. Carovillano
4/12/84

PUBLICATION ON SOLAR RADIO STORMS

The publication *Noise Storm Coordinated Observations, May 16-24, 1981*, has been released in Report No. 57 by the Institute of Theoretical Astrophysics (Oslo). The report is a supplement to the Proceedings of the 4th CESRA Workshop on Solar Noise Storms, Duino Castle (Trieste, Italy), 9 through 13 August 1982. The Committee of European Solar Radio Astronomers (CESRA) sponsored the workshop in connection with the international program on the Solar Maximum Year (1980).

At the workshop, a decision was made to carry out analyses of coordinated ground-based and satellite solar-noise observations for the period 16 to 24 May 1981. The chosen time interval included two sustained noise storms with good observational coverage. Contributions were collected and edited by Ø. Elgarøy (University of Oslo, Norway), C. Mercier (Meudon Observatory, France), A. Tlamicha (Astronomical Observatory, Czechoslovakia), and P. Zlobac (Trieste Astronomical Observatory, Italy). The editors also authored a summary paper with interpretations in the published report. Report No. 57 includes 18 papers and would be of value to scientists interested in solar disturbances as reflected in solar radar observations.

Inquiries may be directed to:

Institute of Theoretical Astrophysics
University of Oslo
P.O. Box 1029
Blindern, Oslo 3
NORWAY

R.L. Carovillano
4/12/84

NEW PUBLICATIONS FROM SWITZERLAND IN EDUCATIONAL RESEARCH

Two new series of publications in Switzerland deserve the attention of US educational researchers. Neither is at present published in English.

One series is a collection of books issued by the Swiss Society for Research in Education under the general editorship of Anne-Nelly Perret-Clermont and André Giordan of the Department of Psychology, University of Neuchâtel. The series is dedicated to the study of education from all disciplinary viewpoints. The publisher is Editions Peter Lang SA, Jupiterstrasse 15, CH-3015 Bern, Switzerland. Most books currently in the list are in French, though the series covers French, German, and Italian work; has plans for German-language publication; and hopes also for eventual translations into English. Some representative titles (with loose translations based on title and abstract) are: J.-M. De Ketele, *Observer Pour Eduquer* (Observing the Educational Process); E. Esperet, *Language et Origine Sociale des Eleves* (Language and the Social Origins of the Student); A.-N. Perret-Clermont, *La Construction de l'Intelligence dans l'Interaction Sociale* (Intellectual Development in Social Interaction); G. Vergnaud, *L'Enfant, la Mathematique et la Realite* (The Child, Mathematics, and Reality); F. Carugati, F. Emiliani, and A. Palmonari, *Tenter le Possible* (To Tempt the Possible--One Experience of Adolescent Socialization in a Community); L. Allal, J. Cardinet, and P. Perrenoud, eds., *L'Evaluation Formative dans un Enseignement Differencie* (A Collection of Papers on Formative Evaluation of Teaching Adapted to Individual Differences); J. Weiss, *A la Recherche d'Une Pedagogie de la Lecture* (Research on the Pedagogy of the Lecture). Expected in 1984 are: G. Mugny, ed., *Psychologie Sociale du Developpement Cognitif* (Social Psychology of Cognitive Development); and E.H. Saada, *Les Langues et l'Ecole* (Languages and the School).

A new journal, carrying articles in both French and German, has the dual title *Bildungsforschung und Bildungspraxis-Education Et Recherche* (Educational Research and Educational Practice--Education and Research). It is published by Klett + Balmer & Co. Verlag, Chamerstrasse 12a, CH-6301 Zug, Switzerland. Recent articles include (again loosely translated with help from abstracts): *Kontrovers: Schuljahresbeginn* (Controversy over School Beginning); *Kognitive Komplexität* (Cognitive Complexity); *Moralisches Verhalten* (Moral Restraint); *Chercheurs et Practiciens de l'Education* (Researchers and Practitioners in Education); *Test Comparatif en Mathematique* (Comparative Tests in Mathematics); and *Le Projet "Living Languages" du Conseil de l'Europe* (The Project "Living Languages" of the Council of Europe). The journal is now beginning its sixth year.

Richard E. Snow
4/11/84

INTERDISCIPLINARY SCIENCE REVIEWS DEVOTES ISSUE TO PERCEPTION

The journal *Interdisciplinary Science Reviews*, published in England, performs a unique and much-needed service in the scientific literature: it carries cross-disciplinary basic research. Issue No. 1 of 1984 (Vol 9) is dedicated to such research in perception. Psychologists working in this field should take particular note, because the editorial, overview commentary, and five articles make clear, detailed, and quite valuable contributions from perspectives other than psychology alone: the authors include two physicists, a physiologist, and a computer scientist, in addition to psychologists.

N.H. Fletcher begins with an article on "The Physical Bases of Perception" in which he reviews the initial person-environment interactions that produce the raw materials for perception. Auditory and visual information is covered in detail, but the chemical senses and mechanoreceptors are also included. The information theory of physical and neural channel capacity is also reviewed. Fletcher thus helps build the road from physics through anatomy and neurophysiology to brain and behavior, and hopes to meet psychology and psychophysics coming from the opposite direction.

D.I. McCloskey follows with his studies of sensation and movement, based originally on Sherrington's initial work on muscular senses. One aim is to identify the intramuscular receptors responsible for conscious proprioception. This ties in with studies of effort, tension, and perceived timing in movement.

C.A. Taylor then combines his expertise in physics and in music to provide an entertaining as well as useful review of complex auditory perception. One learns about: the waveform differences between the sound of an audience chattering, an orchestra tuning up, a pop group, and Mendelssohn's Violin Concerto, and something of their composition; the nature of perceived quality and the formant characteristics of musical instruments; the effects of multiple tones, harmonics, and consonance and dissonance; and the effects of memory and of the physical surroundings on perception. It is clear that the ear-brain system does not simply do frequency analyses; it responds to time variations and is both sensitive and insensitive to aspects of complexity in ways that make for fascinating questions for further research.

M.A. Arbib and coauthors address the possibilities for designing perceptual systems for humans as well as robots. Following a review of simple perception by robots, the problems of visual-flow fields, navigation, and depth perception are discussed. Various visual computational algorithms are then brought together to examine the problem of how multiple processes are orchestrated in complex perception. The problem becomes one of designing algorithms that both analyze the explicit features of scenes and also aggregate regions that together characterize distinctive portions of scenes, i.e., that use interaction between low-level processes and high-level knowledge effectively.

R.H. Day reviews the present state of understanding of illusions. Six classes of optical illusions are focused upon: perceptual simulations, intersecting-line illusions, object-field illusions, component-object illusions, induced contrast, and illusory contours. But the point is general--illusions should be interpreted as the result of perceptual processes that under normal circumstances would give rise to veridical perceptions. The best way to attack unexplained illusions, therefore, is to ask: "What is the natural stimulus that sets these perceptual processes going, and what roles do these processes normally play in veridical perception?" This should lead to understanding of the contrived or special natural conditions that in this instance produce an illusory effect.

In sum, the collection makes for excellent reading on the frontiers of an interdisciplinary science of perception, for expert and novice alike.

Richard E. Snow
4/11/84

HUMAN FACTORS AND INFORMATION TECHNOLOGY

The UK government designated 1982 "Information Technology Year." As part of a program to interest and educate the public in this important and fast-moving area, the National Electronics Council established a working party, chaired by Dr. I.D. Brown of the Medical Research Council-Applied Psychology Unit, Cambridge. A principal charge to the working party was to examine the question of

usability and the design problems associated with promoting it. One product of this effort was published in December 1983 and is being widely distributed in the UK. Titled "Human Factors and Information Technology," the report offers a broad survey of design problems and the potentials of the applied science of ergonomics (or human factors engineering) in meeting them. The 70-page brochure itself is an excellent example of effective design for public communication and education. It deserves review by everyone concerned about these issues or facing the need to understand and communicate about them to others.

Sections of the report include a look at the next 10 years of likely developments in information technology, the challenges that must be met to realize their full potential, and the traditional attitudes that produce "inhuman factors" in design. A variety of excellent examples of well-meaning but extremely poor technology design are given. The report then details the uses of ergonomics in incorporating human factors into improved design. A review of principles and methods, and several revealing case studies, provide clear and concrete illustrations useful for government officials, business managers, manufacturers, technology designers, educators, and general users. There are detailed recommendations for all these groups as well as for practicing ergonomists. A list of resources for further information and study is also provided.

The report is available from the National Electronics Council, Abell House, John Islip Street, London, SW1.

Richard E. Snow
4/10/84

DAVID CARTWRIGHT ELECTED FELLOW OF THE ROYAL SOCIETY

Understanding the tides is fundamental to understanding the ocean's dynamics. Before 1965 we knew very little about deep-water or offshore tidal characteristics. In 1968 Mr. David Cartwright of the UK Institute of Oceanographic Sciences began an investigation into this subject that resulted in a distinguished path of discovery recognized on 15 March 1984 by his election as a Fellow of the Royal Society. The citation read: "For distinction in his contributions to physical oceanography, especially to the understanding of tides in the open ocean."

Robert Dolan
4/19/84

ONRL STAFF CHANGE

In June we welcomed a new liaison scientist, Dr. Charles Holland; he is on reassignment from ONR, Arlington, VA. His specialty is applied mathematics.

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.

Tenth General Assembly of the European Geophysical Society, Louvain-la-Neuve, Belgium, 30 July - 4 August 1984.

Fifth International Symposium on Gasflow & Chemical Lasers, Oxford, UK, 20-24 August 1984.

Fatigue '84, Birmingham, UK, 3-7 September 1984.

International Conference on Digital Signal Processing, Florence, Italy, 4-8 September 1984.

Surface Modification of Metals by Ion Beams, University of Heidelberg, Federal Republic of Germany, 17-21 September 1984.

Ninth European Specialist Workshop on Active Microwave Semiconductor Devices, Veldhoven, The Netherlands, 10-12 October 1984.

MARCH AND APRIL MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during March and April. 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
24-84	European Aerospace Updates
25-84	A Thermo-Chemical Heat-Storage Gel (HSG) With Applications to Survival Equipment, Field Medicine, Military Vehicles and Cold Weather Operations
26-84	Delivery of Twin-Keel Multipurpose Survey Vessel to Norway

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SCIENCE NEWSBRIEF FOR MAY

The following issue of *Science Newsbrief* was published by the ONR, London, Scientific Liaison Division during May. *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
2-3-84	UK Oceanography: Changes in the Wind, by Robert Dolan.

ONRL REPORT

To request the report, check the box on the self-addressed mailer and return it to ONR, London.

R-6-84: *Europe Approaches Chaos With Electrical Circuits*, by David Mosher. In this report, the underlying concepts for the period-doubling route to chaos are presented, and the scope of recent research in a variety of physical systems is briefly noted. Then European research investigating chaotic behavior in nonlinear, driven electrical circuits is discussed in detail. These circuits--really nonlinear analog computers which solve the differential equations describing idealized physical systems--represent a bridge between the simple and highly abstract deterministic models and the experiments where complicating and competing effects can obscure the universal behavior.

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