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AUTHORITY

ONR ltr dtd 8 Jun 1971

588808

OFFICE OF NAVAL RESEARCH
LONDON

EUROPEAN SCIENTIFIC NOTES

ESN-21-2

28 February 1967



Distributed by the
Office of Naval Research Branch Office,
London

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**EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON**

Edited by

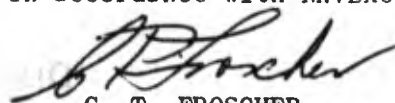
J.E. Rasmussen and Victoria S. Hewitson

28 February 1967

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European Scientific Notes is Group II Newsletter type Class B periodical prepared and distributed by the Office of Naval Research London in accordance with NAVEXOS P-35.



C. T. FROSCHER
Captain, U.S. Navy
Commanding Officer

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ONRL

Both ONR and its London Branch have recently celebrated their 20th anniversary. The editors of ESN considered this to be an appropriate occasion for a general article describing the history and present function of the London Branch. Dr. Peter King, who recently completed a period of service as Chief Scientist at ONRL, very kindly consented to undertake this task and has written the following paper.

ONR LONDON - THE NAVY'S INTERNATIONAL SCIENTIFIC EXCHANGE

The Office of Naval Research Branch Office, London, operates a unique service not only for the Navy but also for the broader American scientific community. The professional staff of ONR London, which includes Navy officers as well as civilian scientists, provides a direct link between European and US scientific research. Through regular visits to scientific and technical establishments in Great Britain and Europe and through attendance at international scientific meetings, ONR London personnel maintain communication pipelines which provide a steady two-way flow of information on scientific progress between this country and abroad.

ONR London, like its parent, ONR Washington, is a descendant of the World War II Office of Scientific Research and Development, which during the war forged a new partnership between the Federal Government and the American scientist. The success of OSRD stimulated the Navy to establish its own permanent organization which would continue this partnership and insure the technological evolution of the Navy beyond the end of the war. The Navy was considerably aided in this effort by the publication of Vannevar Bush's influential report, "Science, the Endless Frontier," in July 1945 in which he urged that government support and participation in science be continued beyond the end of the war. The Office of Research and Inventions, which had already been set up by the Navy in May 1945, was transformed by Act of Congress into the Office of Naval Research in August 1946 when it became the first Federal agency with the primary mission of supporting scientific research.

The need for international exchange of scientific information was also noted by Dr. Bush in his report. He stated that "increasing specialization of science will make it more important than ever that scientists in this country keep continually abreast of developments abroad." This was spelled out even more cogently by the Steelman Report, "Science and Public Policy," published in 1947. This report stated: "Even when conditions of free scientific publication exist, there is often a considerable time lag between completion of the research and publication. Moreover, it is important that research workers be aware of similar or overlapping interests at an early stage in the work in order to make plans for cooperation or for cross-checking results."

As it happened, OSRD had established a London Mission in 1940 for the exchange of war research information. It was logical to continue this function under ONR. In fact, the jurisdiction of OSRD London was transferred to the Navy in March 1946 before ORI had become ONR. The transition was made even smoother when Dr. Holbrook M. MacNeillie, who had headed the OSRD London Liaison Office, was appointed the scientific director for the new Navy London office. The first Commanding Officer following him was Commodore Robert E. Robinson, Jr. The Commanding Officers following him were Captains James P. Clay, Phillip D. Lohmann, Phillip S. Creasor, Bernard H. Meyer, Bradley F. Bennett, John K. Sloatman, Jr., William W. Schaefer, and the present incumbent, Captain C.T. Froscher.

The scientific directors who followed Dr. MacNeillie were Drs. Daniel B. Clapp, Charles E. Sunderlin, Maurice E. Bell, Samuel R. Aspinall, Gerard F.W. Mulders, David M. Gates, Howard E. Page, Immanuel Estermann, Peter King, and the present incumbent, Mr. Aubrey Pryce.

The initial objective of ONR London was to collect information on European research. Its mission, as originally stated, was to establish and maintain liaison with all scientific research agencies in free Europe and adjacent areas outside the Iron Curtain in order to keep the Navy Department, and especially the Chief of Naval Research, informed of all scientific endeavors in those areas.

Right from the start ONRL realized that it must develop an image of a truly scientific activity rather than an intelligence arm of the US government. Such an image was of crucial importance to the success of its mission.

A key element in achieving this success was the establishment of a policy of employing scientists highly respected in their fields. About 12 members of the professional staff are civilians from academic positions of the rank of full or senior associate professor or from government positions of corresponding professional standing. About 60 percent of this group are from universities and non-government research agencies. In most cases they have already established reputations in Europe, which gives them ready access to the academic community of Europe. Since they are not associated with military activities, they are in a good position to have a free exchange of scientific information with their colleagues. The remaining 40 percent of the civilian staff comes from ONR or other government activities. In addition, there is now an eleven-man military contingent. All of these officers have graduate training in various technical fields and two hold a PhD degree.

None of the civilian scientists remains for more than two years, with the usual stay from one year to 18 months. This rapid turnover is deliberate to permit the hiring of outstanding professors who can stay away from their universities for only one academic year plus two summers. The usual practice is to accept employment at ONRL during a sabbatical. Another reason for the short-term employment is that ONRL wants scientists who are actively engaged in research. If such scientists remained away from their work for an extensive period, they would be removed from the main stream of research in their fields and their effectiveness in the exchange of information would rapidly decrease.

The qualifications for a scientific officer on the staff of ONRL were probably best set forth by Dr. C.E. Sunderlin, one of the early scientific directors of ONRL. As Sunderlin describes him, the successful scientific liaison officer must, of course, be competent in his own special field. This means he must have intimate knowledge of all important research in his field in the US, for otherwise he cannot judge the importance and timeliness of research in Europe. He must possess sound judgment as to the relative importance of new developments. Sunderlin saw the scientific liaison officer as a man riding twin horses -- eager to do research himself but confining himself for the moment to the research of others.

In the early years of ONRL the work of the office centered on Great Britain. This was due not only to the fact that it took over the work of the OSRD London Mission but also because Great Britain, unlike most of the European countries, had not been occupied. Many of its research laboratories continued important fundamental research in spite of night bombing, V-1's and V-2's, and the rigors of war. Research work rapidly assumed a peacetime character in the UK, and university enrollment practically doubled during the first three postwar years.

Gradually, however, the other countries of Western Europe rebuilt their programs of fundamental research and began to restock their supplies of scientific and technical knowledge and personnel. National scientific organizations began to appear in these countries. In France it was the Centre National de la Recherche Scientifique (CNRS). Belgium, Holland, Italy and Spain established similar organizations.

German science was a special case. It had to be revitalized under military government and within the restrictions of inadequate laboratories, libraries and personnel. Nevertheless, ONRL discovered that in the early postwar years five to ten thousand scientists in Germany were engaged in some kind of research, and that the results of this research were largely unpublished. Such research would have gone unnoted for a long period without the scientific liaison work of ONRL.

European science made a remarkably rapid recovery and by the early 1950's was back on its feet. It was now ready and eager to absorb data on US research. This meant that ONR London not only had to collect material but also impart information on American progress to the European scientific community as well.

This made the ONRL scientific staff even more welcome when they visited European institutions and laboratories.

Several years ago when the Mutual Weapons Development Program was initiated, ONRL was given an additional assignment. This was to provide a contact between the laboratories of the British and other military establishments and the Navy's research and development programs. ONRL established a Naval Applications Section staffed by technically trained naval officers to carry out this function. They have become the major liaison between the Navy and European defense establishments. A certain amount of the time of these officers is spent on assisting with the administration of US overseas research and development programs. In addition, they often act as US observers or members on NATO committees or in other international negotiations.

The principal reason, however, for the existence of ONR London and the major focus of its attention is the scientific exchange program. ONRL has developed a technique which is as far removed as possible from the bureaucratic way of doing things. Everything is based on the personal touch.

The ONRL scientific liaison officer, as indicated earlier, obtains information by visiting laboratories and attending scientific meetings. In a year, approximately 300 laboratories in Europe are visited by the ONRL staff. The amount of time spent on visits to laboratories depends on the needs of the Navy and the energy of the scientist. Actually, he spends between 30 and 40 percent of his time in attendance at meetings and visiting laboratories outside the London area. While in London, in addition to his necessary routine correspondence, he prepares his reports for transmittal to scientists in the States, visits the local university and government laboratories and attends local scientific meetings and university seminars.

About 270 cities outside of London have been visited at least once. Eleven cities receive the bulk of the visits, with the greatest density in Great Britain. In addition to the major Western European countries, ONRL scientists visit the countries of southeast Europe and the Middle East as far as Israel. They also visit Poland, Czechoslovakia, Rumania, Yugoslavia, and Russia. They come to call on the individual European scientist, not to visit the institution where he happens to be employed. The ONRL visitor makes it plain that his activities are in no way covert and that the information he receives will be reported to the US Government and scientific community only and will not become part of the scientific literature. This conforms to the ethics of scientific reporting which follows the rule that the communication of scientific results for the purpose of publication can properly be done only by the research scientist himself.

When an ONRL scientist obtains information which he believes is of value to the scientific program in the Navy, he reports his findings in a variety of ways, depending upon the nature of the information. In some instances a letter will be sent to individual scientists, especially within ONR or to the Navy laboratories. When he wishes to send information of specific interest to a small group of specialists in the area, he may prepare a Technical Memorandum which goes to approximately ten addressees. This form may also be used to fulfill a specific request of one of the Navy technical groups or contractors. Usually about 40 or 50 of these memoranda are issued per year.

If the information is of much more general interest, such as to all those involved in the metallurgy program of the Navy, the more formal Technical Report is used, which might receive a distribution of two or three hundred copies. Examples of these reports are, "The UNESCO International Conference on Radioisotopes in Scientific Research" and "Zoology and Physiology at the University of Bergen." The number of these reports averages about 150 per year and has been quite constant since 1950.

Finally, material which is of general scientific interest is published in the inexpensively produced European Scientific Notes issued 10 to 12 times per year. This highly readable publication, which is as informal as two scientists chatting

over a cup of coffee, has steadily increased its circulation in recent years, a significant indication of the major service performed by ONR London for the American scientific community. In 1955, this publication went to about fourteen hundred addressees. Presently ESN goes to over 7,000 individuals in government agencies and research laboratories, ONR contractors and scientists in the US. The publication is not distributed to the press in order to prevent reprinting or dissemination of the material contained in it beyond the scientific community. Each issue carries a statement that the material is "not part of the scientific literature."

ESN, which contains a minimum of ten scientific articles in each issue, has been edited for some time by Victoria Hewitson and a scientist on the London staff who takes on the duty for six months at a time. There is no question that it contains valuable scientific data and shrewd analysis of European research capabilities available in no other publication. As a check to see whether ESN is consistently useful to its recipients, a survey was made a few years ago in which each recipient was required to state whether he wished to continue receiving it. More than 96 percent of the addressees replied in the affirmative.

One reason for the popularity of ESN is that ONR London is the only agency of the US Government engaged in foreign scientific liaison on such a broad basis. The State Department science attache office in any given country is not generally staffed with a large number of experts in various scientific fields, and in addition they are somewhat restricted by national boundaries, which limits their detailed scientific coverage. The overseas offices of the other military services do not engage in scientific liaison of the same nature and scope as that provided by ONR London. There has been no need since all of these agencies receive the reports from ONRL.

In addition to the reports prepared by the ONR London staff, the office transmits to the US copies of scientific documents published in Europe. About 2,500 titles per year are sent, although only a few copies of each report are distributed. About 75 percent of these documents originate in the UK, with other countries providing only a very small number. The reason for this is that the research report appears to be an Anglo-American invention and has not yet been adopted on a large scale by other countries.

Expediting the flow of technical information from the US to Europe is an equally important function of ONRL. Many of the European publications available to ONRL for distribution to the US are being received in exchange for US documents distributed by ONRL. Moreover, the American documents serve as an "admission ticket" to European laboratories and facilitate the acquisition of the scientific information which forms a basis for the compilation of ONRL's own technical reports.

About 7,000 research reports are received by ONRL each year from ONR contractors and a number of other government agencies. These are generally technical and annual reports which the scientist has prepared for the agency which sponsors his research, and other reports which the responsible agency considers appropriate for European distribution. Since an average of 15 copies of each report is sent, this means that ONRL receives more than 100,000 documents a year for distribution to European scientists. Only a small fraction of this number is sent to a routine distribution list. In the great majority of cases each report is scanned by an ONRL scientist who determines its distribution on the basis of his knowledge of the scientific interests of the recipient. Often these reports are sent to scientists who the ONRL liaison officer knows will have immediate use for the information because of its relationship to the research they are conducting. Such personal and timely distribution of information is greatly appreciated by European scientists and is a major factor in the large amount of good will built up by ONR London. ONRL also handles requests from European scientists for specific reports referenced in the publications they have received. In one year 300 requests for reports were received from European scientists and virtually all were filled.

ONR London also assists scientists working under the ONR program in their visits

to Europe and European laboratories. This aid takes various forms such as suggesting laboratories of interest and assisting in making appointments. Many other scientists find it of value to discuss with staff members their plans and to exchange information on research activities in Europe. These visits are welcomed by ONRL. Where possible, the same kind of assistance is given to European scientists planning to visit the US. In effect, ONRL has become a focal point for American scientists visiting Europe and vice versa.

ONR London also operates the Navy European Patents Program, administered by a Patent Counsel who can act for Navy systems commands and offices on patent matters arising in Great Britain and other European countries in connection with their foreign programs. He also advises on requirements and procedures in accordance with the laws of the various countries. This involves evaluating patent disclosures from contractors who have made inventions during the course of their work and liaison with officers of foreign governments regarding the security classification of patent applications filed in foreign countries. The Patent Counsel also receives and screens disclosures of inventions submitted by foreign inventors and assists interested agencies in negotiations with such inventors.

Although ONR London does not operate like any other ONR branch office and is separated from ONR Washington by 3000 miles of ocean, it does not work in a vacuum. ONR London has already responded to the increasing emphasis in ONR of supporting research which has direct naval relevance. Until a decade ago, ONRL was interested almost exclusively in basic science, since European scientific research is most important in basic and fundamental areas rather than in engineering and development. Now ONRL is giving increased attention to more immediate naval developmental programs. This actually began about 1955 when ONR London was assigned the responsibility for monitoring the MWDP weapons development programs under Navy cognizance and the Naval Applications Division was established. The officers who carry out this function also represent the Chief of Naval Operations and the material commands.

As ONR London became more involved with reporting on applied research and development in addition to basic research, its usefulness to Navy laboratories and the material commands became more apparent. It was also obvious that to fulfill this function ONR London must have on its staff officers and civilians with a broad range of technical and scientific specialties. This led to a new recruiting program established in 1965 by the Secretary of the Navy, in which scientific and technical personnel (GS-14 and above) throughout the entire US Government inhouse R&D community were encouraged to apply for short-term employment (one to two years) at ONR London. It is believed that this program will not only provide career development opportunities for laboratory scientists and engineers to enhance their scientific potential, but also will benefit their parent organizations and the Navy. (Employees remain on the rolls and payroll of their parent organizations and return there upon completion of their tour in London.) The background of personnel hired in this program ranges from basic research to systems engineering. ONRL now has on its staff scientists whose background will permit them to devote their time to such fields as power and fuels in all their applications, vehicles and missiles, underwater acoustics and its relation to undersea warfare, and electronics particularly as applied to weapons, weapon systems, infrared and radar. When Peter King was appointed chief scientist for ONR Washington last August after serving two years as scientific director for ONR London, his replacement was Aubrey Pryce who has served for the past several years in the Naval Applications Group in ONR Washington.

The interest of the US in European science has certainly not abated. In certain areas European laboratories have clearly demonstrated superiority, both in talent and facilities. Therefore, ONR London can be expected to maintain its value as a scientific listening post. Science magazine, recently describing the operation of ONR London, stated it this way:

"The very vitality of European science today puts ONR London's services at a premium, since in practical terms it is impossible to assess scientific developments from a vantage point 3000 miles away."

(Peter King)

MATERIAL SCIENCES

FUEL CELL DEVELOPMENT AT VARTA AGmbH

Varta, one of the world's largest battery manufacturers, produces all types of batteries, from the smallest sealed Ni-Cd to giant propulsion lead-acid systems for trains. (Over 300 German trains are powered at 120 km/hr with a 200-km range by Varta batteries.) Annual sales for Varta are about 300 million DM (1 DM = \$0.25). Their new central research laboratory at Kelkheim (30 minutes by rail from Frankfurt), headed by Prof. H. Bode, was opened formally in September 1966. The laboratory's 225 employees are doing research on Ni-Cd batteries, alkaline batteries, MnO₂ batteries, and fuel cell systems. The laboratory is ultramodern with an abundance of expensive, sophisticated equipment competitive with anything the US has to offer.

The fuel cell program is headed by Dipl. Ing. F. Wehrse (an engineer with aircraft industry experience). Fuel cell research began here in 1959 with a small group which explored fundamental electrode processes in conjunction with various academic efforts. In 1961, the group moved to some Varta facilities in Kelkheim and involved 25 persons covering virtually all fundamental aspects of fuel cells. In 1963 the research began to concentrate on low-temperature low-pressure 6N-KOH cells with nickel-nickel silver electrodes. Now, in 1967, the program has 90 people in three departments, Research, Development, and Production, at the new research laboratory and nearly 50 persons at the pilot production facility. The Research Department, headed by Dr. Hans Von Döhren, has about 25 people, as does the development section. The remainder are involved in electrode fabrication and systems engineering and assembly.

This fuel cell program is unique in many ways. First, Varta feels it must support fuel cell research as a defensive means to protect its position in the battery business. R&D funds for fuel cells come "off the top" as a corporate levy. Second, the technological base in advanced electrochemistry, materials fabrication, and packaging technique make the fuel cell studies a natural. Third, the heritage obtained by collaborating with Prof. E. Justi

and Dr. A. Winsel (Inst. for Technical Physics, Braunschweig) and with Prof. Dr. H. Gerischer (Physical Chemistry and Electrochemistry Inst., Technical High School, Munich), along with information exchange with Siemens, give Varta a technological base that is hard to exceed.

Varta's existing systems are based on the popular DSK electrode system developed by Justi and Winsel (Winsel is now with Varta). A detailed discussion of the company's electrode structures and chemistry was presented at Brighton in September 1966 (M. Jung & H.H. Von Döhren, "A contribution to the production of Raney nickel anodes for fuel cells," 5th International Power Source Symposium, Brighton, 20-22 Sep 1966, Pergamon Press). The electrodes are now rectangular and are either "one postcard size" (about 4 in x 7 in) or "two postcard size" (8 in x 7 in). The H₂ electrodes use Raney-nickel alloys which are activated and rendered non-pyrophoric by a proprietary treatment of the powders before pressing and sintering. (The three-layer nickel electrode consists of: a fine pure layer which is Mond nickel with low density 0.35g/cm³, the working layer with preactivated Raney powder mixed with Mond nickel and sodium carbonate filler and the Mond nickel-potassium chloride filler gas distribution layer.) The silver catalyzed oxygen electrode uses Raney nickel and 16-18% silver by weight. This is effectively 100-mg silver/cm² of electrode. The present modules incorporating these materials are price-competitive/unit area with sintered Ni-Cd electrodes. This represents a major improvement in electrode economics. The preactivated electrode system gives 200 mA/cm² at room temperature over the large areas discussed. Copper-promoted₂ electrodes have performed at 100 mA/cm² for more than 4000 hours. Varta's present electrode production capability is 1000 "postcard" electrodes per month. In addition to the work on fuel cell electrodes, advanced structures for hydrogen production by selective diffusion from reformer gases at temperatures below 400°C are being developed. Also, cells for the hydrolysis of H₂O are under life test.

Varta's present modules use ten cells of the "one postcard" electrodes in an alumina-filled epoxy supporting container. These modules weigh 33 kg/kW of power out. Table 1 shows the

progress in module energy/unit power and volume/power.

TABLE 1
"Typical Units"

Year	Characteristics	Electrode Shape
1957	0.5-W feasibility	circular
1962	500 kg/kW	circular
1963	142 kg/kW 121 liter/kW	circular
1965	87 kg/kW 31 liter/kW	circular
1965	68 kg/kW 19 liter/kW	3"x5" rectangular
1966-67	33 kg/kW; 14 liter/kW	about 4"x7" rectangular

Several systems were being built or tested, ranging from a 0.2-W buoy power-source to operate for two years unattended to 2-5 kW units for fork-lift trucks. Some systems are:

0.2-W buoy power pack: This H_2-O_2 system uses bottled fuel (two tanks, 6 in diameter x 24 in long), a $\frac{1}{2}$ ft³ KOH reservoir and a two-cell fuel cell operating at about 3 mA/cm² (therefore very efficient!). No other system can do the job, claims Wehrse. Several of these buoy systems are now on order from the German Navy;

Nominal 300-W H_2-O_2 system (will be - Air): Two were being tested when I visited. These are for silent power for the German Army. They appear well engineered and are neatly packaged in an 8-ft³ box weighing 85 kg. No attempt was made to pack the system tightly, and there is room for several modules to be added. Varta has perfected new pumps, valves, and other auxiliaries in their engineering program. One interesting feature is the slide-rack mounting of this system so that it can be pulled out of its case and repaired;

100-W Methanol- O_2 system (will be - Air): This system has a new proprietary electrode which utilizes the methanol directly. The package is about 2 ft³, complete with fuel;

Nominal 2-3 kW System (7-kW peak): This system fits the space for a battery in a heavy fork-lift truck and uses bottled H_2-O_2 . It has 32 ten-cell modules with "one postcard" electrodes. Approximate dimensions are 14 in x 24 in x 36 in.

The results of extensive research

on fuel sources for H_2 -Air systems were clearly demonstrated by several operating prototypes.

Ten 3-in diameter circular cells were generating 40 liters/hour of H_2 and had been operating for 3000 hours without degradation. No special explosion precautions were taken in system plumbing. The package was about 1 in x 4 in x 8 in. This cell was using the new preactivated electrodes described in the above reference. The hydrogen produced is ultra-pure and can therefore be used by the fuel cell systems directly.

A hydrazine-to-hydrogen converter using a porous copper, Raney nickel-copper electrode was working at 900 liters/hour with the module volume being 2 in x 4 in x 8 in. Water cooling was used in the laboratory model so that external dimensions with cooling fins would be greater.

One serendipitous result that excites Varta very much is the use of their electrodes in the Chlor-Alkali chemical process to tap off electrical power. Experiments indicate that more than 20% of the power required by this process can be reclaimed. Economic analyses have them and a customer convinced that this should be tried on a much larger scale. Perhaps all of their fuel cell research will be justified by the fruits of this one application.

The Varta fuel cell program is now maturing to the point where the next two to three years will see corporate decisions being made on mass production of fuel cell systems. The probability of success appears high. Potential applications are carefully screened by battery-wizened management, but all signs indicate a "go" situation.
(P.D. Maycock)

CARBON FIBERS FOR FUTURE REINFORCED PLASTICS

The Royal Aircraft Establishment (RAE) at Farnborough, England has taken a position of leadership in production of carbon fibers which, it is hoped, will ultimately find use as the reinforcing material in wound or fabric laminates. The RAE fibers consist of tiny crystallites of graphite bonded together so that each individual fiber has a diameter of about 6 μ (0.00025 in). Since graphite crystals have a very strong "a" axis, but are relatively weak in the "c" direction, the trick is to control fiber production so that

the crystallites have their "a" axes parallel to the fiber axes.

At present fibers can be made only in discrete lengths, produced by a batch process. The RAE is confident that the technology for production of continuous filaments, which they have under development, will be ready in a few months for pilot trials by manufacturers. The essential features of the fiber technology have been protected by patents. The latter are assigned to the National Research Development Corporation, Kingsgate House, 66 Victoria Street, London, SW 1, an agency of the British government charged with the mission of stimulating commercial applications for new developments. Manufacturers who can make carbon fibers by the batch process are:

Courtauld's Ltd.
Lockhurst Lane, Coventry;
and
Morganite Research & Development Ltd.
Battersea Church Road
London, S.W. 11

Mr. William Watt, Chemistry, Physics and Metallurgy Department, leads the carbon fiber research at RAE. Watt furnishes the following representative properties of individual fibers as compared with glass:

	Glass Fibers	RAE Carbon Fibers
Specific gravity	2.54	2.00
Tensile strength (psi)	250×10^3	300×10^3
Young's modulus (psi)	9×10^6	60×10^6

Recent work has shown that mechanical properties can be changed by varying heat treatment. A peak appears in the curve of tensile strength plotted against treatment temperature, at about 1500°C. Fibers treated at this temperature are giving a breaking stress of about 450×10^3 psi. Since Young's modulus increases with temperature in an approximately linear manner, fibers treated at 1500°C are less stiff with a modulus of 32×10^6 . An article on Watt's newest research will be published soon in *Nature*.

It is clearly apparent that carbon fibers have demonstrated superior strength in the laboratory. Considering the lower specific gravity, compared to glass, prospects of reinforced structures with superior strength-to-weight ratio may be envisioned. Yet

to be demonstrated, however, is the practical combination of continuous filaments in a suitable plastic matrix. A huge technological effort lies behind the present state of the art which has introduced glass fiber materials into everything that moves, from skis to space ships. The techniques devised by the glass industry may or may not be applicable to carbon-reinforced materials. (D.C. Hornig)

MATHEMATICAL SCIENCES

INTERNATIONAL COMPUTERS & TABULATORS (ICT)

ICT is Britain's largest computer manufacturer, commanding 40% of the British market. The company is undergoing dramatic transition as its punched card equipment is phased out and its new 1900 series of compatible computers (announced Sept. 1964) is brought in as a new major product. The 1900 range includes seven basic computers and a comprehensive collection of storage, input, and output equipment. The series has a 6-bit character bed with 24-bit binary words and has a standard interface. The machines are not compatible with IBM 360's. Typical systems range from a lower price of about £40,000 to an upper one of £750,000. One price-conscious version of the 1901 for smaller businesses can cost as little as £20,000. Over 650 of the 1900 series computers have been ordered with more than one-third slated for export. Last year's ICT sales (year ended 28 Sept 66) were £63.4 million, and profits were £2.22 million, before tax. This compares with a loss for the preceding year. Considerable Government encouragement has been given ICT. Over £250,000 have come from the Ministry of Technology under the advanced computer technology program. ICT also has a £5 million loan for R&D from the National Research and Development Council, and a £5 million credit guarantee from the Export Credits Guarantee Department appears certain. The latter funding will partially eliminate the financial stress caused by changing from direct sales to some rental in the 1900 series. This credit can only be used for export machines. It remains to be seen where sufficient capital will be obtained to allow mass rental of the

1900's in Great Britain. Success of ICT in the next two years depends significantly on generating enough reserve capital to allow this transition from direct sales to rentals.

ICT's recent rise as a major British computer manufacturer is mainly due to the know-how derived from its acquisition or control of EMI and a part of Ferranti. Ferranti's Computer Division had collaborated for years with Manchester University. The collaboration first generated the Mark I, the first stored-program digital computer ever built for sale by a manufacturer. Then followed the floating point Mercury, Pegasus, Sirius, Orion, Argus, and Hermes. The Ferranti Atlas, the culmination of 12 years of collaboration, was and is one of the most powerful computing tools in the world, because of the entirely original approach taken in its design and the technical innovations which made the approach possible. Most important is a supervisory system which automatically regulates the flow of work through the machine. The Atlas invoked advanced store technology and store allocation. Coupled with high-speed circuits, a million operations per sec were obtained. Some 200 jobs may be in the system at any one time, and a typical installation costs £2 million. An improved version of Atlas II was evolved at Cambridge.

At this point it seems pertinent to question why this Atlas technology, supposedly the most superior computer in the world, did not immediately place Ferranti in a position of world leadership in computing. Perhaps one clue lies in visits made by the authors to the Atlas computing centers and the new non-Atlas centers at various British universities. There seemed a strong tendency to denounce a competing Atlas or to denounce the Atlas program in general. Comments like "their tanks leak," "their compiler never ran," "their machine is always down," are indications of the attitudes which pervade the Atlas story. However, not to belabor this, we believe that Atlas suffered from several key problems:

1. It was oversold and ballyhooed with a blare of trumpets;
2. It suffered from inadequate Government funding to provide the peripherals required to make the centers truly useable;
3. Intense academic freedom lessened cooperation between software academics so that a British computer language did not develop.

In any case, ICT acquired much technological know-how from the Ferranti-Manchester team, and after several years of marketing RCA 1500's and Univac 1004's with ICT labels, it is now ahead of the British pack with the 1900 series. Of course the English Electric's highly successful KDF9 and its new Series 4 keeps the competition keen.

ICT research is centered around its two major groups: The Data Processing Equipment Group: Stevenage and the Computer Equipment Group at West Gorton, Manchester. The former is responsible for the production of the smaller, 1901, 02 and 03 computers as well as printers, card readers and peripherals. The latter group is responsible for the production and development of the 1904, 05, 06, 08 and 09 computers. Each has its own R&D laboratory. A visit was made to the Stevenage lab directed by Mr. P.G. Briggs, and some of the research will be covered in detail. As the West Gorton lab was not visited, second-hand information obtained from ICT professionals in the London headquarters and at Stevenage will be reported.

The advanced R&D laboratory headed by Briggs has 45 people in two sections, Physics and Engineering. Physics projects include high density recording (involving plated wire stores, enhanced disc devices, thin metal films), and support of the microwiring project. Engineering has four main projects: microwiring, multilevel storage, fluidics, and metal-oxide-semiconductor (MOS) technology. The most important is the microwiring project, which is ICT's answer to LSI (large scale integration). On a 2-in x 1-in alumina ceramic substrate, 50 silicon chips, with at least four gates each, are to be interconnected with up to four layers of conductors. The present system uses Emitter Coupled Logic (Motorola chips). The alumina substrate is first given a metal interconnection pattern, a layer of glass dielectric is applied, then a silk-screened metallized ground plane layer. The next dielectric is organic, and so on, until an interconnection matrix is built up. Between-layer connections are made by leaving holes in the dielectric and vapor depositing metallic bridges from one layer to another. After the interconnection matrix is complete, 50 tested chips will be ultrasonically bonded to the metallized pads. No working arrays

using the above technology have been produced yet, however, they expect success in a few months. This unusual mix of evaporation, silk screening, etching, glass and organic dielectrics may actually generate problems in this simple approach which are not yet appreciated.

Despite this present interest in next-generation devices, ICT computers now use outside components (US and British), and the improved 1900's with monolithic IC's will also be from outside vendors. The long-term order of preference for component suppliers is: (1) UK; (2) Europe; (3) US companies in Europe; (4) US companies. However, short-term purchases depend on availability and economics. The present research at Stevenage and, reportedly, West Gorton, is aimed at a generation five or more years hence.

Another project described in detail was Fluidics, which attempts to understand and make useful fluidic devices for ICT's interests. One device is an array of fluidic (gas) switches which are used as a contactless punched card or paper tape reader. Prototypes seem to be less expensive and more reliable than mechanical equivalents. The essence of this program is discussed in the following papers:

"Electropneumatic transducer using the acoustic switching of fluid logic elements," by G.A.R. Benson & D. Hawgood, *J. Science Instr.* 43, pp. 527-28, Aug. 1966; "Electrical transducers for fluidic systems in computer peripherals," by D. Hawgood, presented at the 2nd Cranfield Fluidics Conf., 3-5 Jan 1967, Cambridge, Paper No. F-3; and "Steady state and dynamic characteristic variations in digital wall attachment devices," by D.R. Steptoe, *ibid*, Paper No. B-3.

The West Gorton group, derived by the acquisition of a section of Ferranti, continues to have much interaction with the Ferranti labs at Bracknell. The R&D at West Gorton was reported as very advanced and aiming at a next-generation computer involving arrays of monolithic circuits, strip-line multi-layer boards (automatically produced with computer-generated interconnection paths), and a fundamental circuit element involving about 60 gates. This computer (called BASIC within the company) has been developed over four years and built in the last one and a half years. An experimental system is reportedly ready for testing, and involves a new way of indirect

addressing and a radical change in the address structure. Indications are that Electrical Engineering, Manchester, is again collaborating on this and that the 1970+ requirements of the National Computing Centre and the London Univ. Regional Centre might well be met by a giant British billion-bit machine using this technology. These are only inferences derived from statements, awful silences and gleams in eyes. It is a fact that a British giant machine has been proposed and is being worked on. All evidence indicates probability of economic success to be small but finite.

The ICT Planning Group, Putney House, London, headed by Mr. D. Eldridge, was visited. Some sections discussed were: (1) Market Planning, which is involved in the definition of future products to meet market requirements and the strategy of product launching, etc. (2) Software Planning - This section has grown to 800 persons in three years, of whom 700 are programmers. In the last 18 months more attention has been given to planning and standardization within the Department itself in such areas as COBOL programming, tape housekeeping and documentation. (3) System Development Operation - This group of 500 is developing a wide range of operating systems. Eight hundred programs are involved. Multiaccess system work is in evidence with 16 people working on multi-on-line programming. Simulation on the 1900 series is being used to obtain operating characteristics of software. This will be helpful in developing a MAC-type system with on-line users and background jobs involving interactive compilers with conversational modes. This simulation will be based on the 1906-7, of which 15 have been sold. However, the group emphasizes software for the 1900 series in general. This build-up in software at ICT has been very rapid, and reflects an increasing recognition of the importance of good software. The company does not favor sub-contracting in software.

Areas of future interest are the software for a random access system, the development of a realtime operating system, and an integrated management information system. Linear programming, PERT and Sketchpad work are also under way. Languages of interest to ICT are: COBOL, FORTRAN, ALGOL, NICOL (A small, simple commercial language which can easily be learned by experienced punchcard users),

Rapidwrite (for business), CSL and APT. (Notably absent is PL-1.)

In conclusion, ICT is certainly a modern, well-managed, high technology company, working successfully in a very competitive field. It seems to be covering all aspects of its business with endeavor adequate to continue to be competitive. (Paul D. Maycock, J.W. Hemann, and J. Cowie of the US Naval Postgraduate School, Monterey, Calif.)

MECHANICS

MECHANICS OF BONES IN SWITZERLAND

Early in 1958, fifteen Swiss general and orthopedic surgeons joined together to re-examine the common procedures then in use for the operative treatment of fractures. This group formed the Association for the Study of the Problems of Internal Fixation. Most of the initiative for this undertaking is due to M. Allgöwer, until recently chief surgeon at Cantonese Hospital at Chur. In July 1966 he was appointed to the chair of surgery at the University of Basel. Two other surgeons who took a prominent part in the development of the technique are M.E. Müller and H. Willenegger.

Quite early Allgöwer recognized that a purely clinical activity employing such a new technique was not sufficient to guarantee success and that it had to be backed up by rigorous basic research removed from a hospital. His attention was drawn to the Davos Research Institute. This Institute was founded around the turn of the century, at a time when Davos was one of the world's largest centers for treatment of tuberculosis, with the purpose of conducting research in this field. After WWII, however, with the advent of antibiotics, most of the sanatoria in Davos were converted into hotels, and the activities of the Institute receded to practically nil. Allgöwer conceived the idea of using the facilities of the Institute for the purposes of research on bones. He was successful in obtaining a number of research grants, both from the Swiss government and the US National Institutes of Health. By now, however, the Institute is practically self-supporting. The major part of its income derives from licensing and patent fees for the special sets of instruments which Allgöwer and his

collaborators developed and which are now produced commercially. This income, amounting to almost \$100,000 per year, could have been used privately by Allgöwer, but he chose to support the Institute instead. At the present time the Director of the Institute is M. Fleisch, who is a physiologist and who has lectured several times in the US.

One of the important sections of the Institute is the documentation center. For each case of internal fixation of a fracture in Switzerland and several other European countries, a code sheet is completed after the first discharge from the hospital and sent to Davos with X-rays taken before and after the operation. Based on this first code sheet, two cards are punched, and reduced prints of the X-rays are pasted on the back of the cards. One of these cards is returned to the surgeon and the second remains in Davos. After four months another code sheet and new X-rays are sent by the surgeon to Davos. Copies of X-rays are fixed to the punched card and one of the two cards with the original X-rays is returned to the surgeon. After the one-year follow-up, a final code sheet is completed on the assumption that the case can now be closed. If it cannot, the surgeon makes a note that an additional examination will be required after another six months.

The card file at Davos now contains over 8,000 entries and this documentation has proved very useful over the years in correcting mistakes. In the fall of 1966 a full-time statistician will be employed by the Institute to make full use of the available material.

Another project concerns artificial growing of bone tissue, and a study of the various effects which may influence growth rate.

Considerable attention is given to studies of strength of bones and implants. A large series of experiments on sheep have been carried out by S. Perren, which involve attachment of strain gages to the bones *in vivo* and also the attachment of strain gages to implants. A striking movie strip, which was shown to the general public recently as part of Swiss newscasts, shows a sheep whose fractured femur was fixed with an implant. Right from the operating table the sheep runs out into the meadow and starts grazing without any signs of discomfort.

In using implants for treatment

of fracture of bones, it was recognized that metallurgical problems associated with the implant material are of utmost importance for developing a successful technique. Of particular significance are the different types of corrosion of metals. Allgöwer, several years ago, established a joint research and manufacturing program with the Laboratory of Metallurgy of R. Straumann in Waldenburg (near Basel), Switzerland. This laboratory is located in the watchmaking part of Switzerland, and originally Straumann was a metal technician at one of the local firms. He was very successful in developing certain alloys for watch springs, became independent and founded his own laboratory, which is financed by the income from his own patents and licenses. The laboratory is located in a brand new spacious building and is extremely well equipped and staffed. In addition to metallurgical work, the laboratory pursues questions of bearing design for watches and fine instruments, manufactures specialized testing equipment and also does some work in ultrasonics.

S. Steinemann, a physicist, is primarily responsible for the metallurgical research on implant materials. The material for implants used so far is a type of austenitic stainless steel, but Steinemann is planning to consider titanium alloys in the future. He also plans to construct an instrumental model of a complete skeleton to study the stress distribution in various bones when the human body is subjected to various loading conditions. Some of his recent research dealt with metallosis. (F. Straumann, S. Steinemann, O. Pohler, H. Willenegger and R. Schenk, "Neuere experimentelle und klinische Ergebnisse über die Metallose," in Langebecks Archiv vereinigt mit Deutsche Zeitschrift für Chirurgie, 305, No. 1, 1963, pp. 21-8; 1. Tagung der Deutschen Gesellschaft für plastische und Wiederherstellungs-Chirurgie, April 20, 1963.)

The whole technique of internal fixation of fractures is described in detail in a recent book in English by M. E. Müller, M. Allgöwer and H. Willenegger. (M. E. Müller, M. Allgöwer and H. Willenegger, Technique of Internal Fixation of Fractures, Springer-Verlag, New York (1965).) (George Herrmann, The Technological Institute, Northwestern University, Evanston, Illinois)

ISRAEL AIRCRAFT INDUSTRY

Located at the Lod Airport outside Tel Aviv, the Israel Aircraft Industry is an outgrowth of an original overhaul facility, which is still an important function of the company. Currently employing about 4500, with about 180 engineers in R&D, the Industry has some capability in practically every aspect of airframe construction save in power plants. Some projects in the past have been to redesign the Boeing Skymaster to incorporate a swing tail and to equip it with new freight handling facilities suitable for aerial drop and to carry out some development and flight tests on a flexible wing airplane.

A current project is the complete design and production of a 12,000-lb turbo-prop civil airplane. The power plant will be purchased abroad. As there are no wind tunnel facilities at Lod, and the facilities at The Technion are limited, all model testing will be conducted in England at the British Aircraft Corporation.

M. Arens, formerly with Curtiss-Wright and educated at MIT and CalTech, is Vice-President in charge of engineering. Before coming to Lod, Arens was on the staff of the Aeronautical Engineering Department at The Technion.

Dr. A. Libai is head of the Structures Department. Formerly a student of Eringen at Purdue, Libai has continued his interest in the theory of thin shells to the extent that he teaches an evening course in Tel Aviv on the subject, which offers credit toward an advanced degree at The Technion. (In this way, the problem of the physical separation of Tel Aviv as the center of industry and hence of engineers and The Technion can be resolved without building a new engineering school.) He has recently extended the earlier work "On the non-linear elastokinetics of shells and beams," (Journal of Aerospace Sciences, Oct. 1962) in a soon-to-be-published paper which develops an invariant stress function for a shell of general shape that leads directly to the membrane contribution.

One of Libai's graduate students is studying the stability of a cylindrical shell acted upon by both a tangential and a dead surface load. The tangential load is assumed to remain tangent to the shell surface after deformation, while the dead load maintains its original direction.

Another graduate student is studying the vibration of a pressurized ellipsoidal shell of revolution. The deflections due to pressure are taken to be finite, while the vibration is considered to be a small perturbation on the initial state. In this way, the criterion of stability may be studied.

Dr. A. Adini, a former student of Clough at Berkeley, is Head of the Computing Department. Working with a Philco computer, the Department has accumulated a library of stiffness element matrices, including plane stress and axial force elements.

(H.E. Williams)

SOMETHING NEW AT THE UNIV. OF WARWICK

This is the second year for the Univ. of Warwick -- they have yet to graduate a class. Situated in the "Green Belt" three miles south of the center of Coventry, the campus shares the advantages of the industrial north and the rural life of Warwickshire. The address on Gibbet Hill Road and the reconstructed farmhouse which is used by the Grounds Department will certainly be a lasting reminder of country life.

One could elaborate at length about the many new features of educational life at Warwick -- the Mathematics Dept. of Prof. E.C. Zeeman that is all pure mathematics, the Molecular Sciences Dep. which encompasses chemistry and biology, and other facets -- but it is the purpose here to say something about engineering.

Head of the Department of Engineering Science is Prof. J.A. Shercliff. His book, A Textbook of Magneto-hydrodynamics (Pergamon Press, 1965), and his research (see Shercliff and M.D. Cowley, "The dynamics of electrically conducting gases in magnetic fields," Symposium on Dissociating and Ionizing Gases in Engineering, Cambridge, 1964) at Cambridge prior to his coming to Warwick are both well known. He started research at Warwick immediately upon arrival there and is currently studying the flow of liquid mercury in pipes in the neighborhood of discontinuities between conducting and non-conducting walls.

Shercliff recently completed a film on MHD for the series on fluid motion, being sponsored by the US National Science Foundation. The film is a sequel to "Vorticity," as it associates the effect of a magnetic

field on the flow of an incompressible fluid with the vorticity. It should soon be available for general distribution.

The department which Shercliff has organized has several novel features. First, Warwick offers a unified three-year engineering science course, designed to suit all kinds of engineers. No selection between different branches of engineering is required before admission; indeed, the course structure allows students to come undecided between engineering, physics or mathematics, and to decide after the first year. One should hasten to add that there is a special electrical science course within the department, into which students may enter after the first term of their second year. This exception is made "...because modern electrical and electronic engineering demands special treatment. The sophistication and breadth of the subject is now so great that students must be allowed to specialize rather more intensely if they are to compete effectively upon graduation..."

One of the more interesting faculty arrangements is the concept of the associate professor. Basically, the title of Associate Professor is conferred by the University on a distinguished professional person either in industry or a research establishment in order to promote graduate work in a particular field. Currently, a MSc course is being offered in the field of automatic control; the first associate professors to be appointed will be connected with this program. They are Mr. R.H. Macmillan (Director of the Motor Industries Research Association, whose station is at Lindley, only a few miles from the University) and Mr. J.G. Thomason (Head of Process Analysis at the Central Instrument Laboratories of International Chemical Industries, Ltd., Reading). The length of time that these men will spend at the University will depend both on the location and nature of their work. Macmillan will probably come often for short periods, while Thomason will come less frequently but probably for longer periods. It is obvious that such appointments constitute an important link with industry. The next graduate program to be established will be a MSc course in fatigue and vibration. Negotiations are now under way for an associate professor in this

area. It should be noted that these appointments are made for an indefinite length of time and are intended to augment the versatility of the permanent staff.

Another interesting feature of the curriculum is the design course given jointly by David L. Turner and John Wright. Turner came to Warwick this year from the Brush Electrical Engineering Co., where he was a consultant in the field of urban transportation (see "Never-Stop Transport and Other Neglected Ideas," New Scientist, 13 Jan 1966). He was previously in the Research Dept. of British Railways. Wright is a structural engineer and also came to Warwick this year.

After the separation of the electrical engineering students in the second year, all remaining engineers take the two-term design course. This is divided roughly into three equal parts. Turner lectures during his third on mechanics, components and the like, while Wright lectures for one third on structures, materials, and fatigue. During the last third, the students will be paired off to undertake an identical project. Roughly two weeks each are to be devoted to preparing drawings, construction, and testing. Both Wright and Turner will supervise, and the staff of the machine shop will be asked to cooperate.

The project for this year is the design of a motor operating on the peristaltic effect. A possible solution may take the form of a pair of wheels running on a flexible hose through which a fluid is pumped (see Fig. 1). It should be noted that these are simply plans for the future, as the first class is just about to begin the course.

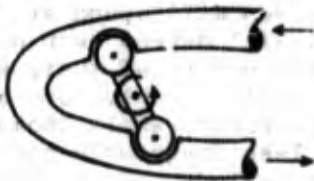


Fig. 1. Motor Operating on the Peristaltic Effect

As a final note, Wright is attempting to set up a design center at the University which would provide expertise to industry in the application of computers to the design of structural steel work. He envisions that such a center would consist of faculty, students, and full-time engineers. Not only would there be the capability to undertake fundamental research problems, but the latest in design techniques would also be available. By employing students, the center would have an economic advantage and the students could derive an educational as well as a financial benefit. Though Wright has met no opposition to his plan locally, there have been objections from universities outside Coventry and also from some consulting engineering firms. (H.E. Williams)

A NEW PROBLEM AREA FOR ENGINEERS

Moving along smoothly at 50 knots, a research vessel of a well-known shipbuilder in the UK suddenly and inexplicably rolled to port (say), and then veered to starboard. Fortunately, the only casualty was a broken rib, but it could have been a general disaster. This event and others less dramatic emphasized to R.E.D. Bishop, Professor of Mechanical Engineering, University College, London, that something must be done in order to predict the dynamic stability of ships.

With a notable background in the theory of vibration, chiefly applied to aircraft and heavy rotating machinery, Bishop notes with some surprise that very little is known about ship stability. More importantly, little or nothing is being done in the UK about implementing existing knowledge. It is clear that Bishop has both a personal interest in this problem and an interest in developing an expertise that would be significant to the national scene. The value of shipbuilding to the economy of the UK is obvious.

As the first step, which will attempt to define the problem areas and to promote interest in the problem, Bishop intends to give a short course on Ship Stability and Control from 26 September to 6 October 1967. In order that students may inspect actual test facilities and become acquainted with current research in this field, half of the course will

be given at the National Physical Laboratory, Feltham, and the other half at the Admiralty Experiment Works (AEW), Haslar, Portsmouth. Hopefully, about 24 students will attend, representing both industry and government laboratories.

Most lectures will be given by Bishop, with the assistance of A.G. Parkinson and Dr. B.S. Massey, who are also members of the Mechanical Engineering Department. Notes which will attempt to order relevant subject areas of mechanics are being prepared for distribution. It is expected that these notes will ultimately form the nucleus for a book on the subject.

If sufficient interest develops in the course, Bishop hopes to establish a permanent graduate course in ship stability at University College. In order to make this course as effective as possible, the continued cooperation of the AEW will be encouraged so that half the program would be given in London and half at Haslar.

If one may judge from Bishop's enthusiasm alone, this undertaking is sure to be an overwhelming success.

(H.E. Williams)

MISCELLANEOUS

SNOW AND ICE RESEARCH IN SWITZERLAND

The winter resort town of Davos is situated high in the jagged, snow-capped Alps in the eastern part of Switzerland not far from the border of Liechtenstein (which, together with Monaco, are reported to be the only European principalities to stand in awe of the armed might of Luxembourg). To reach this scenic town entails a four-hour train trip from Zurich, up over tracks which cling with goat-like tenacity to the steep rocky slopes and then plunge between 5- to 10-ft snow drifts on the relatively level areas in mountain valleys. Transferring to a modern tracked cable car at Davos-Dorf, the traveller is lifted in two steep stages another 1100 m above the valley floor to the Weissfluhjoch terminal. Here in a modern building at 2663 m above sea level is located the Swiss Federal Snow and Avalanche Research Institute.

This establishment traces its history back to 1935 when roots of the present program were established by Professor Naefeli. In 1942 the basic laboratory was constructed on its

current site; later additions have since been added in upward step-like progression at periodic intervals. Interestingly, the Institute is administered by the Swiss Federal Department of Forestry and operates within an annual budget of approximately one million Swiss francs (about \$240,000). Personnel now comprise eight scientists and 24 supporting staff under the leadership of Dr. M. de Quervain. Organizationally, the establishment is divided into five specialized sections.

Dr. Theodor Zingg, the Vice-Director, heads the first section which is primarily concerned with problems of avalanche prediction. Studies are centered around the meteorological and climatological aspects of snow, as well as the evaluation of snow cover during winter. States Zingg, "The current weather acts especially on the surface layer of a snow cover. The poor heat conductivity of snow is responsible for the thermal instability in a snow cover. This instability produces moisture transport in the upper levels and at the same time a metamorphism of the snow crystals into new shaped grains. This changes also the mechanical and physical properties of the snow cover. The phenomenon depends very much on the depth of the new fallen snow and of the whole snow cover. Especially the temperature gradient and the effective temperature of the snow determine the structure of snow and the grain shape. The avalanche activity depends on the stratigraphy and current weather. Important are: amount and kind of snowfall, wind action (separately or in connection with snowfall), temperature, radiation and rain (especially early in winter and in spring)." To obtain these data, observations are regularly submitted from approximately 50 stations distributed throughout the Swiss and Austrian Alps. These are correlated with local readings from a model field located about 2 km below Weissfluhjoch. Avalanche forecast bulletins are promulgated at least weekly for the benefit of highway departments and winter sports enthusiasts.

Section Two, under Dr. André Roch, studies the mechanical and rheological properties of natural snow, settling and creeping effects, plus avalanche flow and impact phenomena. A practical application of these studies has been the construction of various

types of experimental barriers with the objective of preventing, deflecting or otherwise controlling an avalanche.

Dr. H.R. In der Gand leads the third section which is mainly concerned with reforestation in avalanche zones and the interaction between snow cover and plants, with emphasis on the influence of creeping snow.

Dr. C. Jaccard, head of Section Four, is in process of phasing out of the Davos operation. (He is currently dividing his time between Davos and Neuchatel. He is expected to depart permanently about April 1967 for a full-time professorial position at the University of Nürnberg.) His Section is concerned with the physics of snow and ice, and studies are devoted to the electrical properties and surface effects of crystals. To assist in determination of structural parameters, a photocell microscope (Tomograf) which automatically records its read-out on tape for later computer analysis has recently been designed. Personnel stress, however, that it is yet too early to evaluate the usefulness of this instrument.

Section Five is devoted to the study of atmospheric physics with particular emphasis on the formation and growth of hailstones together with their high-frequency electric properties. Two large hail-tunnels, the most recent installed about two years ago, permit advanced studies under controlled conditions. Dr. Auf der Mauer heads this group.

Swiss studies are not isolated and share a commonality of interest with other groups both in Europe and the US. Some of these are:

a. University of Birmingham. Under the leadership of Dr. J.W. Glen, present projects are concerned with the plastic deformation of ice single crystals at low temperatures with a view to discovering the relationship of drop in plasticity to temperature decrease and in determining information on slip processes from low temperature tests.

b. Finland Institute of Marine Research at Helsinki. Primary mission of the ice department is to provide an information service for winter navigation; however, limited studies on the phenomena of ice cracking during reintensified cold weather and vibration of ice fields in strong wind conditions were completed during the winter of 1965-66.

c. The Laboratory of Concrete

Technology, State Institute for Technical Research, Helsinki. Dr. S.E. Pihlajavaara has a continuing program underway to study the compressive strength of ice. Mr. Veli Rahikainen, Lic.Sc., is conducting research to determine the practical feasibility of building ice bridges over the sea.

d. The U.S. Naval Civil Engineering Laboratory at Port Hueneme, California. A number of programs are oriented toward the investigation of the engineering properties of ice and snow. These are centered around the strength of sea ice and field studies in the Antarctic on the bearing capacity of processed snow.

e. The Navy Electronics Laboratory, San Diego. Scientists have been engaged in the analysis of data collected during eight nuclear submarine expeditions conducted between 1957-1962 in the Arctic Ocean. Emphasis has been on the preparation of detailed bathymetric and under-ice profiles along all tracks.

To return to the subject of Weissfluhjoch activities: Ski enthusiasts should be interested to learn that they have a choice of three excellent runs averaging 5 km each down to Davos and that all the staff regularly employ this mode of commuting home during the season. (One does not find a cloak room off the foyer of the establishment, only ski racks.) I asked Bruno Salm, assistant in the research activities of Section Two, how long this journey down the mountain took. "Oh," he stated contemplatively, "it takes me about 15 to 30 minutes dependent on the light and weather. My best time was 8 minutes, but since I broke my leg, I don't go so fast anymore!"

(J. Wm. Davis)

OCEAN SCIENCE & TECHNOLOGY

UK DIRECTORY OF MARINE SCIENCES

Within the next few months the Royal Society will publish a directory, Marine Science in the UK. It is being compiled on behalf of the Royal Society's British National Committee for Oceanic Research in cooperation with the Natural Environment Research Council, and follows the general pattern established by the 1964 French publication, La recherche oceanographique francaise - repertoire de

laboratories. The 700-800 scientists listed in the UK Directory, who are involved in some phase of research in the marine sciences, represent a considerable increase over the 275 referred to in An International Directory of Oceanographers published in 1964 by the US National Academy of Sciences and National Research Council.

Appropriately enough, the introduction to the volume is provided by Dr. G.E.R. Deacon, Director of the National Institute of Oceanography. This is followed by an organizational diagram of oceanography in the UK and a brief resume of British and international oceanographic programs, including the International Indian Ocean Expedition, SCOR working groups, and other comparable activities. Next is a map, giving the location of the principal centers of oceanography in the UK, and two tables which list in summary form the major and minor interests of government-funded and university laboratories. The various groups have been arranged in four general categories: (1) government-funded laboratories which are wholly marine in nature, of which there are 12; (2) university departments with continued interest in marine sciences as part of departmental policy, for which 57 are listed; (3) university departments in which some staff are involved in studies on any aspect of marine science, which includes 20 in the physical sciences and 21 in the biological sciences; and (4) government-funded institutions which are partially concerned with marine science, for which 13 are listed.

The information given for each of the laboratories should be extremely useful to American scientists. In addition to the name, address, and phone number of the present director, the major research interest, major geographic areas of research, and the scientific staff and their specific interests are included. This is followed by a list of research vessels for that particular laboratory, approved future plans, and facilities for training and research by university or other visiting personnel. A selected bibliography is included for each laboratory.

The Appendix also contains some very useful items. There is a general list of British research ships and facilities, a list of libraries offering facilities to workers outside the institution or department, and an

index of government-funded laboratories, university laboratories, and marine scientists in the UK. (J.D. Costlow, Jr.)

PHYSICAL SCIENCES

PULSE COMPRESSION IN THE UK

Mr. E.H. ("Ted") Boyenval heads the UK governmental activities on pulse compression technology (see E.H. Boyenval, "Pulse Compression Research in the United Kingdom," Radar Techniques for Detection, Tracking, and Navigation, p. 35 (Proc. of the 8th Symposium of the AGARD Avionics Panel, London, 21-25 Sep 1964)). According to him, recent experience with the Marconi-developed adjustable compensating network (see p. 45 of reference above) indicates that pulse sidelobes can be held down to 40 dB over a wide range of operating temperatures. As small and robust devices for pulse compression, dispersive gratings on crystal quartz (W.S. Mortley, The Marconi Review, 4th quarter, 1965) are useful for bandwidths of 15-20 MHz. Boyenval says that 100 MHz has been obtained with a quartz device and that Marconi, Ltd., (W.S. Mortley, "The Pulse Compression System for Radar," Industrial Electronics, 466, Oct. 1965) will ultimately obtain that bandwidth for systems with pulse lengths of $\frac{1}{2}$ to 5 μ sec.

Of possible interest is a publication, Proceedings of the Conference on Delay Devices for Pulse-Compression Radar (Institution of Electrical Engineers, London, 21 Feb 1966), which is available for approximately \$6 from the Secretary, Institution of Electrical Engineers, Savoy Place, London, W.C. 2. Mr. I.L. Davies, Royal Radar Establishment, closed this particular conference by saying that it had been spurred by the needs in radar for high equivalent peak-power and for more flexibility, and for the ability to choose between operating modes so that one can obtain either optimum velocity information or optimum range resolution. Sensible systems have been developed which provide equivalent system bandwidths as great as 20 MHz; but even for these relatively narrow bandwidths, the techniques require large systems that are difficult to set up and too complex for operational use. Acoustic techniques appear to provide promise of ultimately furnishing system band-

widths approaching 100 MHz, but they involve problems of inefficient coupling which have plagued ferrite devices. Although waveguides can be used as dispersive elements, the use of hundreds of meters of waveguide does not constitute a practical technique for many radar applications. There remains a strong need for engineering ideas which will permit the attainment of gigacycle bandwidths. (M.W. Long)

NAVIGATIONAL RADAR STUDIES AT ASWE

Dr. J. Cronney, Head of the Antenna Division of the Admiralty Surface Weapons Establishment (ASWE), Portsmouth, England, has been interested in the detection of targets in sea clutter since the beginning of radar during the late 1930's. Some of his early papers on clutter are: "A simple logarithmic receiver," Proc. Inst. Radio Engineers 39, 807, July 1951; "The reduction of sea and rain clutter," J. Inst. Navigation 7, 175, 190, April 1954; "Clutter on radar displays; Reduction by use of logarithmic receivers," Wireless Engr. 33, 83, April 1956.

During the last two or three years Cronney has again devoted time to clutter studies, and in 1966 he was awarded the PhD degree at Imperial College, London, for his investigations on the correlation of sea clutter pulses and integration time as pertains to a rapid scan radar. This research, and associated investigations on logarithmic amplifiers and a rapid, mechanically scanned antenna have been published. (J. Cronney, "Improved radar visibility of small targets in sea clutter," The Radio & Electronic Engr. 32, No. 3, 135, Sept. 1966; A. Woroncow and J. Cronney, "A true IF logarithmic amplifier using twin-gain stages," The Radio & Electronic Engr. 32, No. 3, 149, Sept. 1966; W.D. Delany and R.K. Kyle, "Antenna for rapid scan decorrelation radar," *ibid*, 156, Sept. 1966.) (A good review paper by A. Harrison, "Method of distinguishing sea targets from clutter on a civil marine radar," also appeared in The Radio and Electronic Engineer, 27, 261, April 1964.)

Cronney's investigations have been directed toward improving the detectability of navigational buoys in heavy seas. The radar operates at X-band, uses vertical polarization, and antenna speeds are adjustable with a maximum of 1400 rpm. The display system follows the antenna rotation, and prf

is such that only one or two pulses per beamwidth are displayed; pulses received from successive looks at the sea clutter are decorrelated. A conventional fluoride PPI tube and a storage PPI tube were used simultaneously. Cronney reports that the high scan-rate system, using a PPI and a human observer, gives signal-to-clutter visibility improvements of about 3 dB for 7 to 8-ft waves, and about 6 dB for 3 to 4-ft waves.

Cronney uses logarithmic amplifiers to minimize range dependence of displayed sea clutter. Good logarithmic response is obtained for a dynamic range of nearly 100 dB. The amplifier design does not use the successive detection principle with its associated video delay line; it features saturation without bottoming, rapid recovery, bandwidth that is independent of signal level, and does not require neutralization.

The papers immediately above include results for transmitting and receiving vertical polarization. Cronney has now obtained comparative results for horizontal and vertical polarizations with an antenna that scans at 600 rpm and for which polarization is alternately changed between horizontal and vertical. His observations indicate that the echo for transmitting and receiving vertical polarization is more effectively decorrelated than it is for transmitting and receiving horizontal polarization; also that echo for horizontal polarization is more bunched or clustered on the PPI. These results are consistent with polarization and statistical data given elsewhere (J.G. Boring, et al, "Sea return study," Georgia Inst. of Technology, Final Report on Contract NObsr-49063, Aug. 1957, DDC No. AD 246 180). (M.W. Long)

NEWS & NOTES

ESRO (the European Space Research Organization) has awarded an £8-million (\$22.4-million) contract to a European consortium for the manufacture of two European satellites. The consortium, known as MESH, includes the French Engins Matra, the West German group of Erno, Saab of Sweden and Hawker Siddeley Dynamics of the UK.

Great Britain is to have a national Non-destructive Testing Centre and a

Ceramics Research Centre, to be located at Hurwell, home of the Atomic Energy Research Establishment. The Ceramics Research Centre will take over from the Atomic Energy Authority and will serve the iron and steel, electronics, refractories, pottery, glass, and porcelain industries. The Non-destructive Testing Centre will spend about £200,000 a year when fully operational, but is expected to receive an income from payments for sponsored work, royalties, and commercial arrangements.

Manchester Univ. has been awarded a grant of £45,000 by the Science Research Council towards a design study for a new large steerable radio telescope. If the design follows the recommendations of the Science Research Council's 1965 report on Radio Astronomy (the "Fleck Report"), the new instrument may be one of high resolution, at least 400 ft in diameter, costing around £4 million. It will not necessarily be located at Jodrell Bank, but will be a logical extension of the three telescopes already in operation there.

S.P.S. Andrew is the first industrial-based professor to be appointed at Leeds Univ. He is Manager of the Agricultural Division's Catalytic Process Research Group at Imperial Chemical Industries, and has been appointed External Professor to the Dept. of Chemical Engineering at the University. He will guide the Dept's future research program and lecture both undergraduates and advanced groups.

Dr. Arthur F. Brown, Reader in Natural Philosophy at Edinburgh Univ., has been appointed second Professor of Physics at the City Univ., London, from 1 April 1967.

Dr. P.N. Butcher, Head of the Theoretical Physics Section at the Royal Radar Establishment, Malvern, has been appointed to a newly established Professorship of Theoretical Physics at the Univ. of Warwick.

Prof. D.W.J. Cruickshank, who occupies the Joseph Black Chair of Chemistry in Glasgow Univ., has been appointed to a newly created chair in the Dept. of Chemistry at Manchester Institute of Science and Technology.

Dr. A.S.G. Curtis, Lecturer in Zoology at University College, London has been

appointed to the new Chair of Cell Biology at Glasgow Univ.

A.J. Dale has been appointed Director of the Organisation and Methods Unit to be established by a consortium of Yorkshire and northeastern universities (Bradford, Durham, Hull, Leeds, Newcastle, Sheffield, and York).

Prof. B.H. Flowers, FRS, is to succeed Sir Harry Melville as Chairman of the Science Research Council in October. Flowers is presently Langworthy Professor of Physics at Manchester Univ., and Chairman of the Computer Board for Universities and Research Councils.

Dr. Samuel S. Gill, acting Head of the Manchester Institute of Science and Technology Dept. of Structural Engineering, has been appointed to the vacant Chair of Structural Engineering at the Institute.

Dr. Alick Isaacs, FRS, died in London on 26 January, aged 45. He was a leading virologist and the discoverer of Interferon. After graduating from Glasgow Univ., and winning a research scholarship to study in the Dept. of Bacteriology, he spent a year at Sheffield Univ. under Prof. C.H. Stuart-Harris, and then two years at the Walter and Eliza Hall Institute in Melbourne, Australia. On his return to England he went to the National Institute for Medical Research Virology Division. He succeeded Sir Christopher Andrewes as Head of the Division in 1961, and later became Head of the Laboratory for Research on Interferon. He was elected a Fellow of the Royal Society in 1966.

Vice-Admiral H.C. Lyddon is to be President, Royal Naval College, Greenwich, in May 1967, in succession to Rear-Admiral R.U. Bayly.

Prof. R.R. Porter, FRS, Pfizer Professor of Immunology, St. Mary's Hospital Medical School, London Univ., has been appointed to the Whitley Professorship of Biochemistry at Oxford Univ., from 1 Oct 1967.

Dr. F. Kingsley Sanders, Director of the Medical Research Council's Virus Research Laboratories at Carshalton, is leaving Britain in September to join Sloane-Kettering Research Institute, New York.

Technical Reports of ONRL

The following reports have recently been issued by ONRL. Copies may be obtained gratis by Defense Dept. and other US Government personnel, ONR contractors, and other American scientists who have a legitimate interest. However, because of the frequent content of proprietary and prepublication information, the reports cannot be sent to libraries or to citizens of foreign countries. Requests for ONRL reports should be addressed to: Commanding Officer, Office of Naval Research Branch Office, Box 39, Fleet Post Office, New York 09510.

- ONRL-1-67 Polarization Characteristics of Radar Echoes by M.W. Long
- ONRL-2-67 Flight Guidance in West Germany by Dr. Walter M. Hollister (ETH, Zurich)
- ONRL-3-67 Engineering Mechanics at the Technion - Israel Institute of Technology, by H.E. Williams
- ONRL-4-67 Mechanics and Engineering in Ireland, by H.E. Williams
- ONRL-5-67 Materials Research in Israel, by J.B. Cohen
- ONRL-6-67 Electronics Research at FOA, by M.W. Long
- ONRL-7-67 Marine Sciences in Roumania, by J.D. Costlow, Jr.
- ONRL-8-67 Marine Biological Station, University of Liverpool, Port Erin, Isle of Man, by J.D. Costlow, Jr.
- ONRL-9-67 Solid State Physics at Some Technical Universities in Northern Germany, by B.O. Seraphin
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UNCLASSIFIED

Security Classification

no unclassified status

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)		2a. REPORT SECURITY CLASSIFICATION	
OFFICE OF NAVAL RESEARCH BRANCH OFFICE LONDON, ENGLAND			
2b. GROUP			
3. REPORT TITLE			
EUROPEAN SCIENTIFIC NOTES 21-2			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)			
N.A.			
5. AUTHOR(S) (Last name, first name, initial)			
Rasmussen, J.E. and Hewitson, Victoria, Ed.			
6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS	
28 February 1967	25		
8a. CONTRACT OR GRANT NO.	8b. ORIGINATOR'S REPORT NUMBER(S)		
N.A.	ESN-21-2		
9. PROJECT NO.	9a. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)		
N.A.	N.A.		
10. AVAILABILITY/LIMITATION NOTICES This document is subject to special export controls & each transmittal to foreign governments or foreign nationals may be made only with prior approval of the Office of Naval Research Branch Office, Box 39, FPO, New York 09510			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY	
N.A.		N.A.	
13. ABSTRACT			
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DD FORM 1473 1 JAN 64

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