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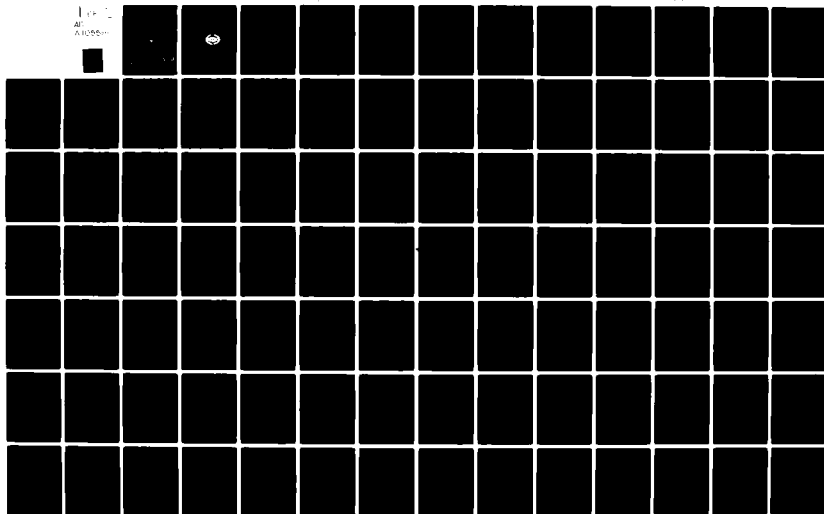   SELECTIONS FROM EUROPEAN SCIENTIFIC NOTES 1946 - 1976.(U)
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OFFICE OF NAVAL RESEARCH
LONDON

SELECTIONS FROM

EUROPEAN SCIENTIFIC NOTES

1946 - 1976

DEPARTMENT OF THE NAVY
O. N. R. LONDON BRANCH

Issued on the Occasion

of the

30th ANNIVERSARY

of the

OFFICE OF NAVAL RESEARCH

and of its

LONDON BRANCH OFFICE

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FOREWORD

On 1 August 1946, the Congress of the United States
of America established the Office of Naval Research
to "...plan, foster and encourage scientific research...",
an action which was in many ways a benchmark in
the Federal Government's role for the broad support
of science in the national interest. As a descendant
of the wartime Office of Scientific Research and
Development, ONR further developed the unique part-
nership between the Federal Government and the
American scientist which OSRD had built. In 1940
OSRD had established a London Mission for the ex-
change of research information, and it was logical
to continue this function under ONR.

The Office of Naval Research Branch Office, London,
provides a unique service for the Navy and for
the broader American scientific community as well.
The professional staff of ONR London supplies 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 help
to furnish a steady two-way flow of information
on scientific progress and problems. Its success
has prompted the establishment of a similar Branch
Office in Tokyo, Japan.

EUROPEAN SCIENTIFIC NOTES, a monthly publication,
is one of the principal means by which ONR London
has kept the US scientific community informed
of European scientific developments. This volume
of selections from *ESN* is published to mark the
30th anniversary of ONR London. The choice of
representative articles from among the approximately
seven thousand published during the thirty years
of *ESN* has obviously presented a very difficult
problem. The articles selected, therefore, should
be viewed as a cross section of *ESN* in time only.
The wealth of material available and the desire
to produce an anniversary volume of tractable size
precluded a more ambitious anthology that would
reflect in greater detail *ESN*'s thirty-year cover-
age in terms of subject, researcher and country
of origin, and potential or actual application.

We hope that this Special 30th Anniversary volume
of *ESN* will serve a dual purpose, by providing
a retrospective view for our colleagues in the
US and by acquainting the European scientific
community with the range of ONR's interests and
the nature of our reporting.

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β-RAY SPECTROGRAPH

January 1947

Dr. O. Klemperer, Royal College of Science, London University, is designing a β-ray spectrograph of the magnetic-focusing type. This spectrograph, to be used in the study of β-decay, is designed for 10,000,000-volt β-rays and is similar in principle to the M.I.T. instrument used by Deutsch, Peacock, and Roberts. The windings alone will require a ton of copper.

SCIENCE IN HIGHER EDUCATION

January 1947

The Society for Visiting Scientists at 5, Old Burlington Street, London, was formed in 1944 as an informal meeting place for British and foreign scientists. Luncheons and teas are served and lodging is provided for visiting scientists, this latter provision being particularly important at present when the London hotels are very crowded.

From time to time the Society for Visiting Scientists holds discussion meetings at which leading scientists discuss timely topics in an extremely informal manner. On Wednesday, 18 December, such a meeting was held to discuss "The New Place in Higher Education." Sir Ernest Simon was in the chair; the speakers were Professor Sir John E. Lennard-Jones, Professor R. V. Southwell, and J. T. Saunders, Secretary General of the Faculties, Cambridge.

The thought that science might have a new place in higher education was brought into focus by the Barlow Report, which indicated a need in Britain for approximately twice as many scientists as had been found necessary before the war. Clearly some change or increase in the educational facilities for scientists would be necessary if the recommendations of the Barlow Report were to be carried out, and it seemed an appropriate time to discuss the objectives of scientific education. The discussion was mainly motivated from a vocational standpoint and considered what types of positions were available for scientifically trained people and the types of training most likely to provide satisfactory candidates for these positions. It was pointed out that the university programs in science are terribly crowded and it would probably be desirable to simplify the curriculum somewhat. The question was raised as to whether it would be preferable to have a broad scientific training, which would necessarily be somewhat superficial or restrict the training to a narrower field which could be penetrated more deeply. The feeling of the meeting was that the need for a broad training was based on the assumption that a person would never learn anything after he left the university, and therefore must learn everything he would ever need to know while at the university. It was thought that this assumption caused a great deal of confused thinking on the organization of scientific curricula and that this difficulty could be overcome in part by adequate provision for adult scientific training. It had been found during the war, when most scientists had to investigate problems in unfamiliar fields, that it was possible to learn the tricks of a new trade in a relatively short period of time. This would seem to indicate that university training in science should aim at covering a good sample of basic scientific material so that the student would learn how to attack and solve problems of a scientific nature. In planning scientific curricula, it should be

assumed that a student would learn in later life the tricks of the particular trade in which he engaged, and that he would also increase his general knowledge and extend his competence over a broader range.

THE EFFECTS OF RETARDATION ON LONDON'S THEORY OF VAN DER WAALS FORCES

February 1948

Professor H.B.G. Casimir, of the Philips Research Laboratory at Eindhoven, Holland, spoke at the Eidgenössische Technische Hochschule at Zurich, on 21 January 1948, on his recent work, in collaboration with Dr. D. Polder, relating to an anomalous behavior of London-van der Waals forces at large distances. This work is of special interest because of the quantum-electrodynamical considerations that are involved, and because of its connection with the notion of zero-point energy of an electromagnetic field.

Professor Casimir commenced his discussion with a brief summary of the various possible types of intermolecular forces. Among the first type are: electrostatic forces between ions, electric dipole forces, and forces between higher electric multipoles. The second type are homopolar forces. The third type are the so-called London-van der Waals forces.

The last type is a mutual attraction, resulting from the mutual polarizability of the constituent atoms or molecules. On the usual picture, the intermolecular energy associated with this type of force falls off at large distances as $1/R^6$, where R is the separation of the particles. However in certain coagulation processes in colloid chemistry, where the London-van der Waals type of force is expected to play a part, indications have recently been found at the Philips Laboratory that the "intermolecular energy" falls off more rapidly than $1/R^6$ at large distances.

Professor Casimir has found an explanation for this anomaly in the following terms. From the quantum-electrodynamical point of view, the usual expression for the intermolecular energy may be written in the form

$$\sum_{n,m} |q_1|^2_{on} |q_2|^2_{om} / R^6 (E_n + E_m)$$

where $|q_1|_{on}$ is the magnitude of the induced electric dipole moment of the first atom or molecule when excited from the ground state to the state of energy E_n, and where $|q_2|_{om}$ and E_m are similarly defined. But it turns out that, when $R \sim hc/2\pi E_n$, the induced oscillating dipole of the second atom is out of phase with the inducing oscillating dipole of the first atom. At sufficiently large distances between atoms, therefore, a retardation effect enters, which may be expressed in terms of a phase difference ϕ between the two oscillating dipoles, where ϕ depends upon the mutual distance R.

An analogous situation arises if one considers a single atom or molecule enclosed within a metal cavity containing standard electromagnetic waves. If the atom is located at a distance R from the cavity wall, and has a dipole moment q, then its interaction energy with the wall may be regarded as arising from the presence of another atom with equal moment q, located at a distance R from the wall. This interaction energy will be proportional to q^2/R^3, or, on a quantum-electrodynamical picture, to $|q|^2_{oo}/R^3$, where

$$|q|^2_{oo} = \sum_n |q|^2_{on}$$

Now, in this case, the effect of retardation is to modify the interaction energy in such a manner that it may be written as proportional to $|q|^2 f(R)/R^3$, where $f(R)$ is a function of R which accounts for the retardation.

On the more detailed quantum-electrodynamical picture, the effect of retardation is to change the form of the interaction energy to (within a proportionality factor)

$$\sum_n |q|^2_{on} f_n(Rk_n)/R^3$$

where $k_n = E_n/2\pi hc$. The function of $f_n(Rk_n)$ plotted against Rk_n, is unity when $Rk_n = 0$, and begins to fall off perceptibly when $Rk_n \sim 1$. At large values of Rk_n, the function $f_n(Rk_n)$ behaves asymptotically as $1/R$, and the interaction energy assumes an asymptotic form which is (within a proportionality factor) $hc\alpha/R^4$, where α is the classical polarizability of the atom.

At large distances, therefore, the intermolecular energy falls off proportionally to $hc\alpha_1\alpha_2/R^7$, where α_1, α_2 are classical polarizabilities of the two atoms or molecules. The effect of retardation, at large distances, is then essentially equivalent to multiplying the classical formula $\alpha_1\alpha_2/R^6$ by the approximate factor $250\ e^2/R$, where e is the electronic charge.

This retardation effect on the intermolecular energy is in qualitative agreement with the experiments on colloids at the Philips Laboratory, and the experimental work is being continued with the aim of establishing a quantitative check. It is to be noted that the effect of retardation is ordinarily not perceptible in other applications of van der Waals forces, because it is not observable at distances less than about 200 Ångström units. With the exception of colloid phenomena, and possibly also of liquid helium, there do not appear to be any other experimental situations where one may measure the van der Waals forces at such great distances.

An equivalent physical interpretation of this retardation effect can be found from the point of view of the zero-point energy of an electromagnetic field; and also, from this point of view, there arises the possibility of performing interesting experiments with the aid of centimeter wave techniques.

Thus, a metal cavity containing standing electromagnetic waves is known on quantum theoretical grounds to possess a certain zero-point energy. If one introduces into this cavity a small polarizable particle, with a polarizability α, located at a distance R from the cavity wall, there will result a relative frequency shift $-\Delta\nu/\nu$ which is proportional to the interaction energy of the particle with the cavity wall, i.e., to $hc\alpha/R^4$. If we write $(\Delta E)_R = h(\Delta\nu)_R$, then $(\Delta E)_R$ is proportional to $-(h\nu)C\alpha/R^4$, and $(\Delta E)_\infty = 0$. Hence $(\Delta E)_\infty - (\Delta E)_R$ is proportional to $hc\alpha/R^4$. But the difference $(\Delta E)_\infty - (\Delta E)_R$ may be simply interpreted as the change in the zero-point energy of the cavity, due to the presence of the polarizable particle. This, then, gives another physical interpretation of the retarded interpretation energy between the particle and the cavity wall.

LOW TEMPERATURE RESEARCH AT THE KAMERLINGH ONNES LABORATORY, LEIDEN

February 1949

The Kamerlingh Onnes Laboratory at Leiden is under the direction of Professor C. J. Gorter. For a previous report see ESN-2, 203 (1948), in which the staff and organization of this laboratory are described. This report gives further details on research in progress.

Properties of Helium II - An extensive program of research on properties of liquid He is underway.

Professor Gorter has been considering the thermodynamics and equations of motion appropriate to the two-fluid model of He II, analyzing the results of various assumptions as to the dependence of the free energy on temperature and the relative concentration of the two fluids. He concludes that a particular choice of the free energy function is necessary to draw the current quantitative conclusions from

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the two-fluid model in regard to the fountain effect, velocity of second sound, viscosity, and relative concentration. Professor Gorter and Dr. J. H. Mellink have applied this model, in the form proposed by Tisza, to analyze heat flows in slits and capillaries. The calculated values of viscosity of the normal fluid agree with those obtained from oscillating disc experiments. Equations of motion which allow for mutual friction of the two fluids (proportional to the cube of the relative velocity) are given which lead to formulas for heat flow, flow of matter, mechano-caloric effect and absorption of second sound waves. Some difficulties with heat flow in very narrow capillaries ($<1\mu$) and the mutual friction in wide capillaries at high velocities are mentioned.

Dr. Mellink has recently completed a thesis on transport phenomena in liquid He II, the essentials of which have appeared in Physica 13, 180, (1947), continuing measurements of W. Keesom and G. Duyckaerts. Measurements were made on the heat conductivity, the fountain effect, and the flow of He II through slits. The first two quantities have been measured over a range of slits from below 1μ to greater than 100μ at various temperatures and temperature gradients; the resulting complicated behavior varies considerably with the width of the slit. At present attention is concentrated on the flow velocity under various conditions.

Dr. G. J. van den Berg and Mr. Van Vollenhoven are measuring rates of flow of films of He II. A beaker supported by a spring is filled with He II, and empties by film flow over the edge, the rate being followed by observing the spring.

Mr. Smith (of England, now working at Leiden) is preparing to make measurements of the viscosity of the normal component of He II by rotating a set of closely spaced discs. It is planned to rotate discs at large relative velocities to determine the mutual friction between the components of the He II, which is thought to vary as the cube of the relative velocity of the components.

Properties of Helium Films - The work of Dr. J. Kistemaker on adsorbed films of He on glass, which determined film thicknesses by measuring the relative pressure between two helium-filled vessels of the same volume but different surface area, is being continued by Mr. H. Tjerkstra. Instead of taking X-ray shadowgraphs of mercury menisci, the change in capacitance produced by motion of a diaphragm between the two vessels is measured, which makes the method very much more sensitive.

Dr. M.H.P.R. Frederikse has been making measurements of heat capacity of thin films of He adsorbed on finely divided material (jeweler's rouge). These show that the λ-point in the specific heat is much weaker for thin films and shifted to lower temperatures, but that it approaches the normal behavior for thick films.

Concentration of Helium[3] - Dr. K. W. Taconis has been concentrating He[3] from atmospheric helium by thermal flow methods (through jeweler's rouge) and by superfluid film transfer. The former method has the disadvantage that too much He[3] is adsorbed on the filter, so the latter is used in the final concentration. Small amounts of material with a percent or more of He[3] can be obtained, but the bulk of the concentrated material has about five in 1000 parts of He[3].

Electromagnetic Behavior of Salts at Low Temperatures - Paramagnetic relaxation measurements at liquid He temperatures are being made by Mr. D. Bijl. The real and imaginary parts of the magnetic susceptibility of the salt are measured as a function of frequency at various temperatures by means of a bridge. The a.c. field which is superposed on a large static field along the same direction varies in frequency up to about 500 cycles per second at these temperatures to cover the dispersive region.

Dr. R. P. Penrose (visiting from Oxford) with the collaboration of Bijl is making microwave absorption measurements at 3 cm wavelength on very dilute copper salts (less than one part in twenty) at liquid He temperatures. The transmission of microwave field through a cavity containing the salt, in a perpendicular magnetic field, is measured. The microwave resonance shows a fine structure (four lines) which arise from the orientations of the nuclear moments in the very strong field produced by the electron moments at the nucleus, corresponding in this case to some 100,000 oersteds (splitting is $0.01-0.02$ cm^{-1}). Although there are two copper isotopes, this does not complicate the fine structure since they have the same spin and only slightly differing moments. This

observation confirms a suggestion of Gorter (see letter in Physica, Dec. 1948) for aligning atomic nuclei by using this very strong field. This suggestion is to demagnetize a mixture of paramagnetic ions, some with nuclear moments and some without, for example to .01°K and a residual field of a few hundred oersteds. The ions, and therefore the nuclei, will be aligned in this field, and the directional anisotropy of nuclear reactions specific for those nuclei may now be studied. The fine structure due to nuclear moments also influences the specific heat of the spin system,

$$C_H = \frac{b}{T^2},$$

where b is determined by paramagnetic relaxation measurements. The value of b can be accounted for partly but not completely by the magnetic interaction of the ions. Similar experiments are being undertaken by Mr. Ubbink using a tunable resonant cavity and waveguide inputs.

A new relaxation effect in chrome alum has been discovered by F. W. de Vrijer at liquid H_2 temperatures with a relaxation time of 10^{-7} secs. in a small field of 300 oersteds. Apparently this is a relaxation in the system of spins, energy being transferred in this system. The relaxation is independent of temperature but depends on orientation of the field with the crystal axis. Since the spin-lattice relaxation time is 10^{-4} seconds at these temperatures and the spin-spin relaxation time about 10^{-9} seconds, the relaxation phenomena are easily separated. A report on this by Gorter and de Vrijer is now in press in Physica.

Nuclear Relaxation Experiments - Dr. N. Bloembergen has completed his measurements on nuclear resonance absorption in solids and the influence of impurities on the relaxation times and line widths. The influence of impurities has been shown to account for the measurements (at least as to order of magnitude) and will be discussed in a paper to be published shortly. A remarkable effect discovered in $CuSO_4 \cdot 5H_2O$ is the broadening of the spacing of the set of some 10 proton resonance lines as the temperature drops from liquid hydrogen to liquid helium temperature. This is explained by exchange effects between copper ions.

Measurements have also been made on copper powder and the paramagnetic relaxation time has been found to be independent of T in agreement with the theory of Heitler and Teller. Bloembergen is leaving Leiden to return to Harvard University in the near future. His research is being continued at Leiden by Mr. Poulis.

Scale of Temperature Below 1°K - Adiabatic demagnetization and the establishment of the scale of temperature below 1°K is being carried out by Dr. D. de Klerk, M. J. Steenland, and van der Marel [see Nature 161, 678 (1948)]. After an adiabatic demagnetization, the real and imaginary parts of the susceptibility (χ' and χ'') are quickly measured on a bridge with a measuring current of something like 100 milliamperes at 50-500 cycles. This current serves both for measuring and for heating. Heat is in this way uniformly distributed over the material. The values of χ'' and the strength of the alternating field (calibrated separately) give the amount of heat added in a given time. The entropy S can be found as a function of χ'' by extrapolating the latter back to zero time (instant of demagnetization) when the entropy is known. Using both ΔS and ΔQ (heat added) as functions of χ'', the absolute temperature can be found. Above the Curie point, the alternating field still produces some heating, presumably due to a relaxation effect of some kind since it varies roughly as the square of the frequency. Below the Curie point, heating is probably due to a combination of hysteresis losses (remanence occurs) and relaxation effects. The lowest temperature measured is 0.003° obtained with chrome alum. An article is in press in Physica.

Isotherm Measurements - The isotherms and densities of saturated liquid and vapor up to the critical point of xenon are being studied by Mr. Dekking. This is the last and heaviest of the rare gases to be measured (except for radon, which is not practicable). Elaborate purification has to be undertaken because considerable amounts of other rare gases are mixed in the sample. It is interesting that glass tubing about 1.5 cm diameter (walls 3 mm thick) will stand 60 atmospheres and some of the glass capillaries used in the manometers will stand up to 200 atmospheres pressure.

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Mr. Smit is constructing a super-conducting galvanometer which will be used in making thermoelectric measurements in superconducting metals. Although there are no thermoelectric effects between metals when superconducting, in the neighborhood of the critical magnetic field and critical temperature these effects appear in an interesting way. These phenomena were discussed by Gorter at the Amsterdam Conference on the Physics of Metals last

summer, proceedings of which will appear in a few months in a special volume.

Dr. H. van Dijk, who has made many careful measurements on the thermodynamic temperature scale, is planning precise comparisons of the temperature scale based on the susceptibility of chrome alum and iron ammonium alum in the liquid helium range with that established by the vapor pressure measurements on helium.

MICROWAVE RESEARCH AT THE COMPAGNIE GENERALE DE TELEGRAPHIE SANS FILS, PARIS

May 1949

The Compagnie Générale de Télégraphie sans Fils (C.S.F.) is the controlling member of a group of ten affiliated companies located principally in France and engaged in the manufacture of radio tubes, radio transmitting and receiving equipment, and in commercial broadcasting. C.S.F. is primarily engaged in carrying on research and in the administration of affairs of the affilitated companies.

The Research Center of C.S.F. is headed by Dr. M. Ponte and is divided into three research departments: Electronic Research, the Technical Director of which is Dr. Robert Warnecke; General Research, Technical Director, M. Henri Gutton; and the Physico-Chemical and Electron Optics Research Department which is headed by Dr. Violet. A general description of the research being carried on by this organization was given in ESN 2, 100 (1948). A more complete description of the research program and recent results has been published in the Annales de Radioelectricite, Volume 3, No. 14, October, 1948, under the titles "Sur le Rendement des Tubes a Modulation de Vitesse," by P. Guenard, R. Warnecke and Colette Fauve, and "Sur l'Aide que Peuvent apporter en Television quelques recents Conceptions Concernant les Tubes Electroniques pour Ultra-Hautes Frequences," by R. Warnecke and P. Guenard. Some more recent results have become available and will be given here.

Magnetron-Type Traveling Wave Tubes - A form of traveling wave tube is under development at the Electronic Research

Department in which the helix is bent around in the form of a doughnut with an electron source in the shape of an emitting ring inside the doughnut. The entire tube is maintained in a magnetic field perpendicular to the plane of the helix. The objective of this design is to derive power from the beam of electrons over a large area as the beam is being accelerated through the helix to a circular collecting ring outside. If the development is successful, it is planned to use this tube as. a power amplifier in the final stage of a television transmitter. Theoretical calculations have been carried out and a model of this tube has been constructed. This model has produced a power output of 250 watts at 45 percent efficiency at a wavelength of 20 cm. The tube operates with a magnetic field of 500 to 1000 gauss and with 2000 volts anode voltage. A bandwidth of the order of 200 mc was obtained with a gain of the order of ten decibels.

Use of a Magnetron as a Modulator - Research work is continuing in the General Research Department on the use of a magnetron tube for modulation of microwave energy. The applications envisaged for a magnetron modulator include the modulation of the master oscillator stage in a television transmitter and the use of this system for switching power from one branch of a waveguide to another. The magnetron is connected by means of a T to the waveguide in which the microwave energy is to be modulated. The

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modulation is accomplished by varying the standing wave ratio at the T. Although it was originally expected that it would be possible to modulate powers up to one kilowatt by this method, recent work has indicated that approximately 200 watts is the maximum which can be modulated with the present design. Ten to twenty volts d.c. in the form of microphone output applied between the cathode and anode of the magnetron is sufficient to modulate from 100 to 200 watts of power.

Optical Polish Sealing Technique for Small UHF Vacuum Tubes - A production development of interest at one of the manufacturing affiliates of C.S.F., the Société Independante de T.S.F., is a technique of sealing vacuum tubes which require short leads and high dimensional stability of the tube elements. Disk type presses are fabricated from powdered glass using tungsten or molybdenum lead wire. These are then ground along the edge to a spherical shape of radius approximately ten cm and given an optical polish by polishing with four successively finer grades of abrasive. The bulbs are ground to produce surfaces which fit the presses and are polished in the same way. The tube elements are mounted and adjusted on the disk press after grinding. The bulb is sealed on to the vacuum system open end up. The mating surfaces are cleaned with alcohol and the press and elements are placed within the bulb. The system is evacuated, the fit of the ground surface being sufficiently good to hold a vacuum. A graphite ring is placed around the region to be sealed, an induction heating coil is placed over the ring, and an electric oven is lowered over the whole assembly. The oven is brought to 500°C and held for a period ranging from five to ten minutes. At the end of this time the carbon ring is heated by high frequency for 15 to 20 seconds, during which time sealing takes place without distortion of the press or the bulb, or oxidation of the elements. It is claimed that this method results in a strain-free seal and enables the tube to be designed with shorter leads than is possible with the ordinary sealing process. Patents have been issued on this process, and C.S.F. has stated its willingness to make them available to prospective users in the United States.
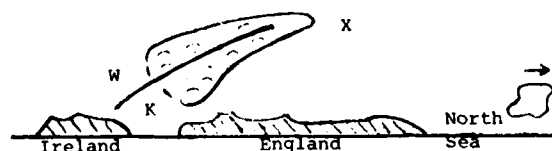

CLEAR AIR TURBULENCE ON A JET SYSTEM

January 1950

On a recent test flight extremely severe turbulence was encountered by the De Havilland "Comet" aircraft at about 35,000 ft in a region of clear sky and strong wind. In some bumps the plane's accelerometer indicated absolute accelerations of +3g to -1.6g (increments of +2g to -2.6g) corresponding to equivalent vertical gust velocities of +48 and -62 ft/sec.

The analysis of the synoptic situation at the time of the test flight (1045-1630 GMT, 14 November 1949) showed a warm front moving eastward, with the surface front passing through eastern Ireland and oriented in a general NW-SE direction. The winds at 34,000 feet (approximately 250 mb) were NW-NNW, 140-190 kts. There were thus good reasons for believing that the plane was in a strong "jet stream." A vertical cross section perpendicular to the flight path of the aircraft is shown below and the relative position of the "Comet" is marked by an X.

Just prior to meeting the turbulence, the aircraft was carried up some 500 feet as though by a wave. The plane remained in the turbulent zone for eighteen minutes during which time it was subjected to accelerations approaching the acceptable design limit and culminating in the extremely severe bump described above, which forced the pilot to change course in the direction of a long line of distant cloud in search of smoother air. Turbulent zones of the same general magnitude were encountered on other stages of the test flight.

The experience of the British European Airways Clear Air Gust Project confirms the data of the "Comet" flight. In the opinion of Dr. G. S. Hislop of the De Havilland Aircraft Company Limited, clear air turbulence may also result from other causes but that associated with jet streams is probably the most severe.

READING CONFERENCE ON SEMICONDUCTORS

October 1950

A conference on semiconducting materials organized by Professors N. F. Mott and R. Ditchburn and Dr. H. K. Henisch was held at Reading University 10-15 July 1950. Professor N. F. Mott opened the conference by outlining the present state of the theory of semiconductors and barrier layers. Two important theoretical problems emphasized were that of the origin of surface states and that of the drop in activation energy of germanium with increasing impurity concentration at impurity concentrations much lower than theoretically expected. Evidence was presented for believing that surface states both in p- and n-type semiconductors were due to adsorbed oxygen. Adsorbed oxygen could exist on the surface in several possible states depending in part on its location with respect to crystal growth steps.

A detailed account of papers and discussions will appear in a forthcoming technical report, which may be requested from the Technical Information Division, Code 250, Office of Naval Research, Washington 25, D.C. A short account is given below of some of the European contributions, with emphasis on new types and applications of semiconductors.

Controlled Valence Oxidic Semiconductors - Numerous oxidic semiconductors are of value because they are thermally stable and may be used in the form of ceramics. In magnetite, Fe_3O_4, interchange of valence between metallic ions of different valence on similar crystallographic sites amounts to electron transfer and therefore electronic conductivity. Experiments have been carried out under E.J.W. Verwey, Philips, Eindhoven, to create artificially the conditions necessary for this mechanism in a variety of other oxidic systems and produce almost any desired conductivity and temperature dependence of conductivity. For instance, by the addition of a certain percentage of lithium oxide to NiO, an equivalent percentage of the divalent nickel ions in the mixed crystal lattice is forced to become trivalent, in order to compensate for the invariant univalence of the Li. A solid solution in which 10 percent of the metallic atoms are lithium, $(Li_{0.1}Ni^{II}_{0.8}Ni^{III}_{0.1})O$, has resistivity of one ohm-cm, as compared with 10^8 ohm-cm for pure stoichiometric NiO. This change is not due to the presence of lattice defects. As the concentration of lithium atoms drops from 2.5 to 0.01 percent, the slope of the straight line plot of log-conductivity versus 1/T rises from 0.7 to 0.9 electron-volt. Among the other systems studied are mixed strontium and lanthanum titanates, having the perovskite structure, and mixed zinc and titanium ferrites, having the spinel structure.

Semiconducting Properties of Grey Tin - Pure grey tin powder has been prepared by G. Busch, Eidgenössische Technische Hochschule, Zürich, by sealing carefully washed, heavily

cold-worked bars of Johnson-Matthey 99.9963 percent pure white tin into vacuum envelopes and cooling to -25°C (c.f. ESN 4, 174). The cold working is accomplished by rolling the bars at -50°C into thin strips. Addition of aluminum up to 0.1 percent speeds up the transformation greatly, but for higher concentrations the transition is more and more suppressed. The conductivity is measured as a function of temperature by the change in Q of a tuned coil into which a pellet of the powder, formed with a lacquer, is inserted. The reference conductivity is that obtained after transformation back to white tin, produced by raising the temperature above 13°C. For various impurity concentrations, all curves of conductivity versus temperature have a common intrinsic portion with an activation energy of 0.1 electron-volt. For the impure specimens the complete curves have a sharp minimum where the conductivity departs from the intrinsic portion. Pure grey tin shows a negative Hall coefficient increasing in magnitude with falling temperature. Grey tin with relatively high aluminum content has a positive Hall coefficient independent of temperature down to liquid air temperatures. Intermediate concentrations of aluminum produce, as the temperature drops, electron conductivity down to a certain temperature and hold conductivity below this temperature.

Transistor Action in Lead Sulphide - Crystals of lead sulphide, selected for photovoltaic effects and good rectification characteristics, have been found by H. C. Banbury, H. A. Gebbie and C. A. Hogarth, University of Reading, to exhibit transistor action. Voltage gains as high as 150 and power gains up to 15 have been observed. While the performance is not as good as for germanium transistors, it is of great theoretical interest to be able to study transistor action in a rather different type of crystal lattice. For the samples used, the directions of rectification and transistor action indicate deficit semiconduction. Measurement of Hall effect and conductivity indicate a mobility of about 350 cm^2/volt sec, considerably lower than for germanium. An interesting feature of the work is that current gain greater than unity has not yet been observed, in spite of many variations in electrode forming treatments. The

usual current gain is about one-third, although values as high as 0.9 have been reached, but in poor transistors.

The Crystallization of Semi-Metals - Selenium and other substances exhibiting semi-metallic properties, such as Te, P, As, Sb, and C, exist in at least two modifications with very different structures and electrical properties. An investigation has been made by H. Krebs, Bonn, of the influence of heat treatment, impurities and certain catalysts on the transitions between modifications. In the metallic modifications the lattice is disturbed in a special way, and the control of the transformation may be useful in controlling the electrical properties. The hexagonal form of selenium, just after transformation from the amorphous form (one-third eight-membered rings and two-thirds hundred-membered), may be regarded as a high polymeric substance and x-rays show the hexagonal lattice initially highly distorted. As the small ordered regions or micelles grow, x-rays show strong mechanical stresses and the conductivity rises. Impurities such as sodium, iodine or quarternary alkylammonium iodide (R_4NI) influence the speed of hexagonal crystallization and the conductivity. In contrast to Se, amorphous Te crystallizes at room temperature. The black metallic phosphorus of Bridgman has been produced by a catalytic method that is very simple, the transformation taking about two days for completion and not requiring pressure. It is conducting and shows rectifier properties.

Hall Coefficient in Lead Telluride Single Crystals - Hall coefficient measurements have been made by R. P. Chasmar and F. H. Putley, Telecommunications Research Establishment, on plates cut from single crystals of PbTe of dimensions 1½ x 1½ x ½ cm, at temperatures from that of liquid N_2 to 1100-1200 K, and fields of 1000 to 10,000 gauss. Both positive and negative values of Hall coefficient have been found, ranging from carrier densities of 3 x 10^{19} for positive holes to 1.2 x 10^{19} for electrons. Cooling the crystal increases the mobility, and values 1000 times as great as in polycrystalline materials are found. Specimens with positive

carriers at low temperatures exhibit a reversal of Hall coefficient sign a little above room temperature. Plots of log Hall coefficient versus 1/T for different samples have common straight line portions at high temperature. This portion is believed to be the region of intrinsic conductivity and the slope of the curve gives an energy gap of 0.62 electron-volts.
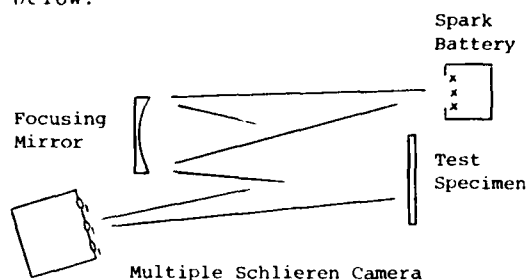

AN EXPERIMENTAL TECHNIQUE FOR RECORDING ELASTIC WAVES IN SOLIDS

August 1951

Prof. Hubert Schardin (Freiburg -i.-B.) has been making high-speed motion picture studies on the breaking of glass by means of a technique which has a large range of possible other application. The principal experimental tool in his investigation is a multiple spark schlieren arrangement, used by the author in numerous other contexts to obtain sequences of pictorial records from phenomena proceeding at very high speeds. The apparatus differs from a common schlieren system by possessing, instead of a single light source, a compact battery of 24 sparks and a corresponding number of knife edges and camera lenses, each being placed at one of the source images projected by the common schlieren optics. The sparks are fired in sequence, a known delay occurring between successive discharges. In this particular instance, a time delay of from 10-2 micro-seconds between successive pictures proved satisfactory. The installation, however, permits a reduction of the interval between successive frames to a fraction of a micro-second.

This apparatus makes it possible to record not only the propagation of cracks, but also the progress of the elastic waves initiating and accompanying the breaking. For this purpose three different experimental arrangements are used. The first is the generally employed procedure of stress optical analysis, exploiting stress-induced birefringence and its effect on polarized transmitted light. The second arrangement also operates with transmitted light, using the schlieren edges to render visible the deflection of the light caused by regions of the glass plate where the two surfaces are deformed in opposite directions (the deviation caused by parallel deformation,

i.e., bending, is too small to be detected). The third set-up is sketched below:

Multiple Schlieren Camera

The light of the spark sources is reflected from the silvered surface of the test specimen and refocused by a concave mirror on to the schlieren edges. Very small deformations of this surface will now cause corresponding brightening or darkening in the image obtained by the camera. The merit of this arrangement lies in its ready adaptability for similar investigations using opaque materials, provided it is possible to smooth the surface adequately. Complete flawlessness of the surface is not necessary because deformations are recorded as changes from initially prevailing conditions, and ordinary window glass has been found satisfactory.

The photographs illustrate and distinguish the numerous phenomena accompanying the propagation of elastic waves in glass, as well as their interaction and their reflection from free boundaries. Longitudinal and transverse waves are readily distinguished by their different speeds of propagation. Bending waves can be distinguished from shear and pressure waves by the fact that they show

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dispersion, their velocity depending on the ratio of wave length to plate thickness. Interaction phenomena between these waves and with the forming surface of an incipient crack are strikingly illustrated, giving unambiguous guidance in simple theory. Schardin is able to get close agreement between observations and theory even in cases of considerable complexity, such as, for instance, the origin and configuration of Wallner lines on the breaking surfaces of a rod which has failed in tension. The majority of this work will be found described in *Glastechnische Berichte* 23, 1, 67, and 325 (1950).

PHOTOCHEMISTRY OF LIGHT SENSITIVE EXPLOSIONS

December 1951

The photochemical and photographic behavior of various systems has been under study in the Photographic Institute at the Federal Institute of Technology in Zürich. The work is under the direction of Professor Eggert and some of their recent researches were presented at the Paris Conference on Sensitive Emulsions [ESN 2; 246 (1951)].

The photographic behaviors of a layer of silver azide in gelatine and of a layer of silver chloride in gelatine were found to be quite similar. The silver produced in the two cases was determined by electrometric titration. In experiments where the photosensitive layers were pre-treated with potassium nitrite solutions, the two substances exhibited markedly different behavior: for identical irradiation the azide yields the same amount of silver as before but the chloride has a 4-5 fold increase. Silver azide emulsions can be developed using developers of extremely low basicity (pH 7-8).

The quantum yield in the irradiation of nitrogen iodide was studied using a refined microbalance. The irradiation intensity was 10^{17} quanta per square cm per second, at an average wave length of 5000 Å. Under a pressure of 15 mm of mercury the quantum yield depends on the intensity and time of irradiation. With increasing intensity or time a limiting value, roughly corresponding to a quantum yield of unity, is approached.

The intensity of irradiation has to be increased by a factor of 10,000 to produce ignition. The detailed mechanism of the ignition of the substance was studied in collaboration with Col. Cassagnou and Professor Schardin in St. Louis (France). It should be added that the chemical definition of the nitrogen iodide presents a notoriously difficult problem. The stoichiometrically pure substance, NI_3, has probably never been prepared.

The ignition and combustion were studied in detail using a spark motion picture camera taking 5×10^5 pictures per second. The following conclusions are of interest: the detonation is initiated by the irradiation and not by the compression wave of the illuminating spark. The detonation wave of one sample is capable of exploding a neighboring second sample. The detonation of the sample occurs no later than at the time when the light source used reaches its maximum radiative intensity; this time can be as short as 4×10^{-6} seconds. The absolute energy required for the ignition thus depends on the intensity characteristics of the spark.

An explosive mixture of silver amide ($AgNH_2$) and silver imid (Ag_2NH) was also investigated. This material is considerably more sensitive than nitrogen iodide, and retains its sensitivity in the moist condition. While its explosive characteristics are similar to nitrogen iodide, it is more resistant to photolysis.

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EFFECT OF THERMAL STRESS ON THE HUMAN ADRENAL GLAND

February 1952

Abundant experimental evidence exists that heat and cold stimulate the adrenal-pituitary system in animals. A. Pekkarinen and O. Kinnunen, Department of Medical Chemistry, University of Helsinki, have searched for evidence that the stress of an ordinary Finnish bath is adequate to evoke over-action of the adrenal gland in humans. A Finnish steam bath produces marked sweating and slight loss of body weight in 15 to 30 minutes. This appears to be evidence of a slight "stress" according to the concept of Selye. The quantity of 17-ketosteroids excreted and the number of circulating eosinophils was determined in 13 experiments on 6 healthy non-pregnant women 20-30 years of age. Urine was collected at 30 hours prior to the bath and for three days thereafter at intervals of 4 hours. The eosinophil counts were made daily at 2 p.m. two days prior to the bath, 4 hours after, and for the succeeding few days.

The 17-ketosteroids were excreted at the rate of 0.42 milligrams per hour during the control period. This rate rose to 0.65 milligrams per hour 4 hours after the bath and decreased slowly to 0.55 milligrams per hour in 24 hours, returning to normal in 48 hours. The number of circulating eosinophils decreased 18 percent 4 hours after bathing. There was, however, a slight leucocytosis induced by the bath and when this is taken into consideration the eosinophil count decreased 27 percent relative to the other leucocytes. A normal number of eosinophils was found 24 hours after the bath.

These data lead the authors to conclude that the stress occasioned by a Finnish steam bath is sufficient to stimulate mildly the adrenal-pituitary system in humans. It must be noted, however, that the subjects used in these experiments were accustomed, or perhaps, adapted, to the stress of these baths.

EUROPEAN NUCLEAR PHYSICS LABORATORY

April 1952

At a meeting in Geneva 12-15 February 1952, the proposed European Nuclear Physics Laboratory under UNESCO sponsorship was discussed by delegates from 12 European countries. As a result of this meeting the countries represented will commit themselves formally to the establishment of a European center for nuclear physics and to certain financial contributions.

The countries represented at the present time are the United Kingdom, Norway, Sweden, Denmark, Holland, Belgium, France, Western Germany, Switzerland, Italy, Yugoslavia, and Greece. At a previous meeting held at UNESCO headquarters in Paris in December 1951 it was decided to establish as a first step some preliminary cooperation in European nuclear physics research. To this end the facilities of the Institute of Theoretical Physics

in Copenhagen were chosen to furnish some theoretical guidance for experimental work in high energy nuclear physics. The British delegation offered to make available the Liverpool 400 MeV proton synchrocyclotron, which is expected to be in operation by next year.

At the same time study groups were set up to plan a European Nuclear Physics Laboratory which will probably be located at Geneva. Its main piece of equipment will in all likelihood be an accelerator to produce protons of several Bev (bevatron) and possibly a 500 MeV machine.

As soon as the necessary number of countries ratify the draft agreement passed in the Geneva Conference, a Council of Representatives will be set up as the governing body.

A MAGNETOPHOTOVOLTAIC EFFECT IN GERMANIUM

April 1953

Dr. Pierre Aigrain and M. Hubert Bulliard of L'Ecole Normale Superieure, Paris, have recently observed a magneto-photovoltaic effect in single crystals of germanium at room temperature, and have developed a mathematical theory which seems to be in agreement with the observations. They have suggested that the effect be called the "Kikoin" effect after the Russian who first observed it in 1934 in CuO at liquid air temperatures [Kikoin and Noskov, *Phys. Z. Sowjet.* **5**, 586 (1934)].

The Kikoin effect is observed when a semiconductor in a magnetic field is exposed to a beam of light at right angles to the field. The effect is observed as an e.m.f. along a direction at right angles to both the illumination and the magnetic field. According to Aigrain, it may be understood intuitively by picturing the trajectories of holes and free electrons created by the light beam as being bent by the magnetic field in opposite directions and thus producing a potential gradient.

Frenkel [*ibid*, **8**, 185 (1935)] attempted to explain the effect, but his analysis depended upon postulation of a difference in the mobility of the holes and electrons. Subsequent experiments have demonstrated that the effect can be found in specimens where the electron and hole mobilities are substantially the same, and it was this consideration which led Aigrain and Bulliard to re-examine the problem.

In the last few months, they have derived new formulas to describe the effect and have made measurements, the results of which support these formulas. It is their conclusion that the Kikoin voltage can be described by

$$V_k = \frac{AL}{B + L}$$

where

$$A = \frac{hH}{C\left[1 + \left(\frac{\mu H}{C}\right)^2\right]} \cdot \frac{D^2 \alpha \beta}{\sigma + D(\alpha + \beta)}$$

and

$$B = \frac{N\ell}{2} \cdot \frac{\beta D}{\sigma + D} \frac{(\sigma + \beta D)}{} \frac{(\alpha + \beta)}{(\alpha + \beta)}$$

where
V_k = Kikoin voltage
L = light intensity in photons/cm^2/sec
H = magnetic field
h = length of specimen
D = diffusion coefficient
α = adsorption coefficient for the wave length used
β is defined by the equation $D\beta^2 = 1$
τ = carrier lifetime
C = velocity of light
σ = surface combination rate
N = density of free carriers in the unilluminated specimen
ℓ = thickness of specimen
μ = electron mobility = hole mobility

The above formulas indicate that for high light values a "saturation" voltage is obtained equal to A.

These results fit both the published results of Kikoin and Noskov and also the recent measurments on germanium. Under certain limiting conditions, the different terms in the above formulas may be evaluated separately. By a combination of such experiments, it is possible to deduce all of the parameters characterizing the specimen under observation: the average carrier mobility, the diffusion coefficient, the lifetime of the carriers, and the surface recombination rate. Aigrain has suggested that this method may prove more convenient than conventional methods using the Hall effect and microelectrodes.

Notes describing these preliminary results will appear soon in *Comptes Rendu*, and further information will also be found in report ONRL-21-52 available from the Office of Naval Research, Technical Publications Office, Code 740, Washington 25, D.C.

The two main processes by which dense bodies can be formed from metal powders are sintering and hot pressing. The relationship between these techniques is of interest since they both involve movement of material at elevated temperatures but differ with regard to driving forces. Several mechanisms have been suggested to explain this mass flow, but only volume diffusion and plastic flow are now generally recognized as responsible for the major density changes. In the case of sintering it has not been conclusively demonstrated which of these two mechanisms is primarily operative. Since the pressure-produced material flow by a vacancy diffusion mechanism is not sufficient to account for the large amount of densification produced in hot compacting, plastic flow would appear to be the basic mechanism in this process.

On the basis of the above reasoning, J. Williams and K. H. Westmacott (A.E.R.E., Harwell) have made a study of the rheological behavior of a powder mass during hot compacting to establish the mechanism of mass flow and to explore possible consequences of this process. As a result of dilatometric measurements on the hot compacting behavior of Cu, Fe, Al, Th, Zn, Ag, Mg, and Be, it has been found that the results are most readily interpreted as a two-stage process of densification.

First-Stage of Densification. During the early "transient" stage, the rheological model of a Bingham solid is not applicable, a more suitable model being a solid possessing a yield point and having non-Newtonian viscosity, with an approximate second power relationship existing between rate of strain and stress. The idea of a strain-dependent yield point is more in accord with the theoretical explanations of transient creep than the constant yield point of the Bingham solid, and is far more successful in explaining the experimental results. A phenomenological explanation for the existence of the second power relationship can be given in terms of a spectrum of yield points arising from the anisotropy of flow in individual particles, with a powder

mass as a whole behaving isotropically. This rheological behavior coupled with rate considerations indicates that dislocation movement is primarily responsible for the early stages of density increase, and consequently several factors relating to the scale upon which slip can occur, become of importance. From an examination of the geometry which can occur during compacting it appears that restrictions exist at least as rigid as those obtaining during deformation of a polycrystalline material. Such crystallographic restrictions can explain the observed differences in compacting behavior of magnesium and beryllium compared with the cubic metals. Further complication of the nature of the yield point term to be used in the rheological model occurs if multiple glide is a feature of the compacting process.

Second-Stage of Densification. It is during the steady stage of densification that diffusion is most likely to play a major role through viscous grain boundary slip, although the nature of this requires elucidation. Relative movement of the particles by this slip process may be rate determining during this stage, and hence grain growth could also have an effect.

In hot compacting the junctions between the particles may be expected to differ from those in cast metal, being imperfect and requiring time to adjust their structure. Boundary sensitive properties such as mechanical properties, diffusion, and nucleation might therefore vary with time of hot compacting for constant density. If plastic flow is the operative mechanism during sintering, the conclusions reached for hot compacting will also apply, and similar effects are to be anticipated.

Practical Consequences of Results. Several points of technological importance emerge from the investigation. Maximum densities are obtained using powder of the highest packing density and smallest particle size, other conditions being constant. The effect of a prolonged time of compacting has

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been shown to be advantageous, and may be worthy of consideration when die materials place limits upon compacting loads and temperatures. Some indication of the hot compacting behavior of a material may be obtained from its crystal structure and more exactly from the creep behavior at hot compacting temperatures of polycrystalline samples.

OFFICIAL ESTABLISHMENT OF CERN LABORATORY

August 1954

On 7 October CERN (European Center for Nuclear Research) entered a new phase of existence; with the recent ratification of the 1953 Paris CERN Treaty by all participating nations, the organization is now permanently established. The significance of the change is more than ceremonial; money can now be spent for equipment as well as for planning.

The CERN Council consists of two delegates from each of the participating nations (United Kingdom, France, Norway, Sweden, Denmark, West Germany, Holland, Belgium, Switzerland, Italy, Greece and Yugoslavia). At its initial session in Geneva on 7-9 October, it elected Sir Ben Lockspeiser of the United Kingdom as chairman, it declared CERN officially established, and a Committee of the Council (Sir Ben Lockspeiser, Chairman) and Committees on Scientific Policy (W. Heisenberg, Chairman) and Finance were appointed. Prof. Felix Block was officially appointed Director-General of the Laboratory, and he announced temporary appointments of the Division Directors (including Adams - proton synchrotron; Bakker - synchrocyclotron; Moller - theory; Kowarski - scientific and technical services). Amaldi is temporarily continuing as Secretary General.

Reports were given by the Division Directors on progress to date. The 25 Bev proton synchrotron theory group is studying the effect of non-linearities in the magnetic field. Both static and dynamic field measurements on model magnets are underway, and the design of the radio frequency system has progressed quite far. Dr. Hugh Bradner of Berkeley is at Geneva for six months to assist in the design of the 50 Mev injection linear accelerator; it is hoped to make this identical with the first 50 Mev section of the Harwell accelerator, and to have it built by Metropolitan Vickers.

An unusual problem has arisen with respect to the proton synchrotron magnet. The 100-meter radius equilibrium orbit is required to be plane to 0.25 millimeters or better. This precision is at the limit of current surveying techniques. Not much seems to be known about ground motions of this magnitude over long periods of time, and concern is felt because Geneva, nestled in the Alps, is in a geologically new and unstable area. The magnet is to be mounted on jack screws for leveling, and it is not yet known whether it will be necessary to drive the jack screws by a servo system to maintain the required orbit flatness.

The design of buildings for the proton synchrotron and synchrocyclotron is essentially complete, and excavation for the latter is well underway at the laboratory site at Meyrin, just outside Geneva. The magnet and coils for the synchrocyclotron are now being ordered and this 600 Mev machine is expected to be in operation in about three years.

The proton synchrotron group is now at Geneva and the synchrocyclotron group will establish itself in Geneva this month. The theory group remains at Copenhagen for the present.

CERN now employs 149 persons, of whom 73 are scientists and technicians. It occupies a chateau (Villa Cointrin), and several temporary buildings adjacent to the Institute of Physics of the University of Geneva, pending completion of laboratory space at the permanent site.

Prof. I. I. Rabi, Prof. P. Auger, and M. de Rougemont, who played a significant part in the creation of CERN, attended this Council meeting. The establishment of the first international physics laboratory is an important event and has already led to a quickening and enlivening of support for pure nuclear research in the many participating nations.

THICKNESS OF THE GREENLAND ICE CAP

October 1954

From 1949 to 1952 seismic measurements have been made on the Greenland Ice Cap by the excellently equipped French Polar Expeditions. The object has been to obtain knowledge of the physical characteristics of the cap and especially of its thickness and to get a general idea of the form and nature of the underlying bedrock.

The velocity of propagation of sound in the ice varied from 3800 to 4000 m/s. Underneath the ice, two rocky layers have been found. In the first layer, which has a thickness of 250-300 m, the velocity is 4800 to 5000 m/s; in the second layer the velocity is about 5450 m/s. At one station a velocity of 6650 m/s was observed in a layer. The velocity of sound in the ice and the rocky layers was determined by refraction shooting and the thickness was obtained by reflection shooting.

The thickness of the ice was determined at about 400 points spread out on several profiles in the southern half of Greenland and along one profile in the northern part of the ice cap. Two E-W cross sections show that, in the north and central parts of the cap, the bedrock forms a dish-shaped basin with the rock elevation of central Greenland being only 200 m above sea level. The bedrock of the southern part of Greenland forms a plateau with an elevation of about 1000 m. The ice volume of the entire cap is computed to be 2.7×10^6 km^3.

MILLIMICROSECOND PULSES

October 1955

Mr. J. B. Gunn, working with Dr. A. F. Gibson (Radar Research Establishment), is studying conduction in Germanium under high fields and the action of point contacts. In order to render the heating effects negligible, it is necessary to use very short voltage pulses. To this end, a novel method has been developed for the generation of millimicrosecond pulses.

These are obtained by firing a fast thyratron into a spark gap, which sharpens the leading edge of the pulse. The resulting pulse travels along a short circuited coaxial transmission line tapped near the end for a signal output whose width is determined by the time for the pulse to travel the remaining distance and return. A second tap on the line, farther away from the end, feeds the sweep circuit of a CRT through a lossy line that removes enough of the high frequency components to approximately linearize the first part of the pulse (the remainder being cut off by the reflected wave). By this means, rise and fall times estimated as 0.3×10^{-9} sec have been obtained and it is possible to obtain roughly square millimicrosecond pulses.
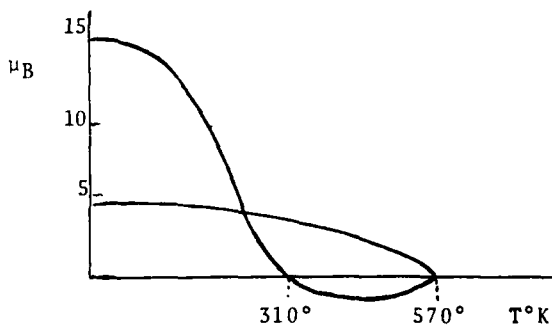
FERRIMAGNETIC GARNETS

May 1956

By far the most numerous and best known examples of ferrimagnetic materials are the ferrites, a series of oxides having the chemical formula $MO \cdot Fe_2O_3$, where M represents a divalent metallic ion. The ferrites have the spinel crystal structure which consists of a cubic close-packed oxygen network with the metallic ions arranged in the tetrahedral and octahedral interstices in the ratio 1:2; the magnetic properties of the ferrites are intimately associated with this crystal structure. A satisfactory explanation of these properties was first provided by Néel (Grenoble). He suggested that the magnetizations of the ions in the tetrahedral sites was antiparallel to the magnetization of the ions in the octahedral sites. Thus the observed spontaneous magnetization in ferrites is due to the incomplete cancellation of two oppositely directed magnetizations. Néel also gave the name _ferrimagnetism_ to this phenomenon. A great deal of research has been carried out on ferrimagnetic ferrites, partly because of their intrinsic interest and partly because of their possibilities as commercial magnetic materials.

A new series of ferrimagnetic compounds having the garnet structure has now been discovered at the University of Grenoble. This is the first time that ferrimagnetic materials with such a structure have been observed. The usual garnet formula is $A_2B_3Si_3O_{12}$ where A and B are trivalent and divalent metallic ions, respectively. In the ferrimagnetic series, the formula may be written $Fe_2B_3Fe_3O_{12}$ or $5Fe_2O_3 \cdot 3B_2O_3$ where B is a rare earth ion and all metallic ions are trivalent. It should be mentioned that in previously published work on "rare earth ferrites" of the supposed formula $Fe_2O_3 \cdot B_2O_3$, the samples were actually mixtures of this compound and the corresponding garnet compound. This fact was discovered in some elegant x-ray crystallographic investigations by Bertaut and Forrat at Grenoble.

The crystal structure of the ferrimagnetic garnets is cubic with a lattice parameter of about 12.4 Å; the unit cell contains eight "molecules" of $Fe_2B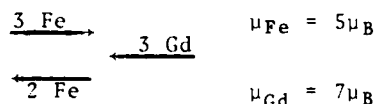_3Fe_3O_{12}$. The Fe ions in the garnet A positions are surrounded by an octahedron of oxygen ions, while the Fe ions in the Si positions have tetrahedral coordination. The rare earth, or B, ions have eight equidistant oxygen neighbors.

Pauthenet has measured the saturation magnetization as a function of temperature for compounds with B = Er, Y, Dy, Gd, and Sm. The curves for Gd and Y are shown in the accompanying sketch; the results for other rare earths are qualitatively similar to those for Gd.

The curve for Gd is suggestive of ferrimagnetism with a compensation point. Néel has worked out a theory which supports this idea but the detailed picture is considerably more complicated than in ordinary ferrimagnetism. According to Néel, the strongest interaction in the garnets is a negative interaction between Fe atoms on octahedral and tetrahedral positions; this accounts for the ferrimagnetic transition at 570 K. (It is probably significant that the tetrahedral-octahedral distance is about 3.5 Å, which is the same as the corresponding distance in ferrimagnetic spinels.) In addition, there is a weak negative interaction between the Fe magnetization and the Gd sublattice. Thus below 570 K, the Gd ions become magnetized antiparallel to the ferrimagnetic Fe moment. At 310 K, the Gd and Fe magnetizations are equal, and the net magnetization

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of the material is zero; below this temperature, the Gd magnetization predominates. According to Néel's model, the magnetic arrangement of 0 K should be as shown:

$$\underrightarrow{3\ Fe}$$
$$\underleftarrow{3\ Gd}$$
$$\overleftarrow{2\ Fe}$$

$\mu_{Fe} = 5\mu_B$

$\mu_{Gd} = 7\mu_B$

This leads to a predicted saturation moment of $21 - 15 + 10 = 16$ Bohr magnetons per $Fe_2GdFe_3O_{12}$ unit. The theoretical result is in excellent agreement with Pauthenet's measured value of $15\mu_B$.

Yttrium has no magnetic moment, so that for B = Y, there should be no compensation point and the saturation magnetization should be $5\mu_B$. Again, the experimental results are in excellent agreement with theoretical predictions.

The saturation magnetization of the Gd compound is about two Bohr magnetons per metallic ion, which compares favorably with any of the commercial ferrites. It is not likely that the Gd garnet itself will have any commercial importance because of the cost of gadolinium and the low magnetization at room temperature. It is of course possible that substitutions of the type employed in ferrites will produce materials in which the compensation temperature is raised or eliminated. In any event, the unique properties of the ferrimagnetic garnets will make them a fruitful field for future magnetic investigations.

A more detailed discussion of this topic will appear in a forthcoming ONRL Technical Report.

NEW COMPOUND CONTAINING BERYLLIUM AND HYDROGEN

July 1956

It is not unusual for new compounds to be discovered by the careful study of a reaction carried out under a new set of conditions. Such a result has recently been obtained by J. Goubeau and W. Hub (Technische Hochschule, Stuttgart) during their study of the liquid phase, thermal decomposition of beryllium diethyl. On heating at 100°C this liquid produced ethane and ethylene as the primary gaseous decomposition products. The production of ethylene was initially faster than that of ethane. However, the rate of ethylene formation decreased with time and that of ethane increased, so that at the end of the reaction the rate of ethane formation exceeded that of ethylene. Other gaseous products, if present, were formed only in small amounts.

The non-volatile end product of the thermal decomposition gave upon hydrolysis with water a large quantity of gas. This consisted primarily of hydrogen and methane with small amounts of ethane and ethylene. From the end product a white solid was isolated. This was composed of carbon, beryllium, and hydrogen, which upon hydrolysis gave hydrogen and methane. To obtain further information on the structure of the product, it was hydrolyzed with heavy water. The gases obtained were completely deuterated methane and HD in a mole ratio of 1:4. No mixed methanes were observed. From this observation and analytical data the tentative formula of $(HBe)_4C$ has been assigned to this substance. Although various mechanisms have been considered to explain its formation, these have not been experimentally demonstrated.
(R. Roberts)

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February 1957

Because of its geographical position and its strange language, Finland is somewhat isolated from the remainder of the Western European community; in particular, it is probably less well known to Americans than any other European country outside the Iron Curtain. Like the other Scandanavian countries, Finland has a great respect for learning and its educational system is one of the best in the world. The principal centers of higher education are the University of Helsinki, Finland Institute of Technology, Turku University, and Åbo Academy. The first two are state supported and the latter two are privately supported. The University of Helsinki is the oldest of the four institutions, having been founded in 1640 at Turku and moved to Helsinki when the capital was moved; the other three date only from the twentieth century. At Åbo Academy, instruction is in Swedish (Åbo being the Swedish name for Turku). There are about 14,000 college students in all Finland, 10,000 of them at the University of Helsinki. Considering that the total population of Finland is only about 4,000,000, the figure is a creditable one. For example, the United Kingdom, with twelve times the population, has only about six times as many college students as Finland.

The existence of a Swedish-speaking minority in Finland is important not only in education but in many other facets of Finnish society. The constitution recognizes both Finnish and Swedish as official languages; both are taught in the elementary schools and public signs are generally bilingual. This is a great boon to the English-speaking visitor, since Swedish has some resemblance to English and German while Finnish is utterly incomprehensible. Although the Swedish group comprises only about 8% of the population, it is considerably above the national average in wealth, education, and general prestige; hence its influence in the country's affairs is greater than its actual size. There is a general and perhaps natural tendency towards segregation of the two groups--although the word should not be construed to imply inequality or

antipathy. As an example of this tendency, two scientific societies have been formed despite the small population. They are the Finnish Scientific Society, which was founded by the Swedes over a century ago, and the Finnish Academy of Sciences, which was founded by the Finns in 1908. In the past, memberships in the two societies were almost mutually exclusive, but at present there are several scientists who are members of both organizations. Most of the scientific research in Finland is published in the journals Societas Scientarium Fennica: Commentationes, and Annales Academiae Societarium Fennicae, which represent the two societies.

Typical of the Finnish respect for learning is the Suomen Akatemia, or Finnish Academy. The Academy consists of twelve distinguished scientists and artists who are appointed by the President of Finland. The members receive the top government salary and are completely free to engage in creative work of their own choice. The current president of the Academy is A. I. Virtanen, who received the Nobel Prize in biochemistry in 1945.

Finland has never been a wealthy country, and it suffered a great deal of damage during World War II. The attempts toward recovery since the war have been severely hampered by such factors as the tremendous casualties incurred in fighting both the Russians and the Germans, the loss of some of the best agricultural districts, and the size and nature of the reparations demanded by the Russians. In such a situation, scientific research naturally suffers from a lack of personnel and funds, but these difficulties are gradually being overcome. New scientists have been trained since the war and the improvement in economic conditions since the completion of the reparations payments to Russia has made more money available for research.

One other factor which has greatly improved the outlook for scientific research in Finland should be mentioned. Finland alone among the

European countries has insisted on paying its World War I debts to the United States, and in 1949 the United States Congress, in recognition of this amiable stubbornness, passed Public Law 265 which provided that money so paid should be put into a special account for the support of Finnish educational and scientific activities. Specific items for which the fund may be used are (a) (a) American books and scientific equipment, and (b) travel and other expenses for Finns who wish to study or do research in the United States and for Americans who wish to study or do research in Finland. Some noticeable consequences of this law are that Finland sends a greater proportion of its graduate and postgraduate students to the United States for training than does any other European country, and that Finnish laboratories now have a considerable amount of American-made scientific equipment (such as a Collins cryostat) which is not found in wealthier European countries. The Finns are deeply appreciative of this help and the American visiting scientist will hear it mentioned many times.

Relatively few scientists from other countries visit Finland, and the Finns are quite conscious of their isolation in this respect. It is most desirable that American scientists who have research interests in common with those of some Finnish laboratories give consideration to Finland as a place for spending sabbatical or fellowship years. The language is not as formidable for scientists as for the casual visitor, since most Finnish scientists speak English and since German is understood (though without enthusiasm) in many of the shops. Exclusive of the mutual scientific benefits, contact with this friendly and vigorous people should prove a rewarding experience.

Some recent ONRL Technical Reports which deal with research in Finland are ONRL 98-56 (limnology and oceanography), ONRL 37-56 (psychology), and ONRL 1-57 (solid state physics). (J. S. Smart)

SPUTNIK AT CAMBRIDGE

December 1957

Western reaction to the launching of the Russian earth satellite, Sputnik, has on occasion followed the wry perscription, "When in trouble, when in doubt; run in circles, scream and shout!" Such is not the case, however, at the Mullard Radio Astronomy Observatory (Cambridge University) where Mr. Martin Ryle was the first in Britain to plot the orbit of the satellite. Without question, Ryle has been the British hero in that by midnight of the same day of the Russian launching announcement, Ryle had rigged an improvised antenna system near the Cambridge University rugby field, just behind his own home, and made his first estimate of the orbit.

A nephew of the philosopher, Gilbert Ryle, Martin Ryle spent the last war devising countermeasures to the German radar defenses. Since then he has been in the forefront of the relatively new science of radio astronomy, his most recent contribution being an extensive list of over 2,000 "radio stars".

Ryle's improvised antenna is a dipole accurately surveyed N/S with a 4 wavelength separation between the antenna elements. It operates at a frequency of 40 mc/s, the higher of the two Sputnik radio transmitter frequencies. Such an antenna system produces an interference pattern in space for which the loci of the various surfaces of constant phase difference are represented by a set of confocal hyperbolae of revolution. By measuring the time intervals between the various signal-minima received as the satellite passes through such an interference pattern, it is possible to determine the orbit. This is so because there is a unique relationship between a particular set of such time intervals and the particular

orbit followed by the satellite. In practice Ryle has a set of plots representing the intersection of the interference hyperbolae system with a family of spheres spaced at various altitudes above the earth's surface. By marking the particular set of satellite time intervals on a linear rule, and knowing the time when the satellite crossed the interference-system center, Ryle fixes the set of times to coincide with a particular set of hyperbola-sphere intersection graphs. Such a plot is sketched in Figure 1.
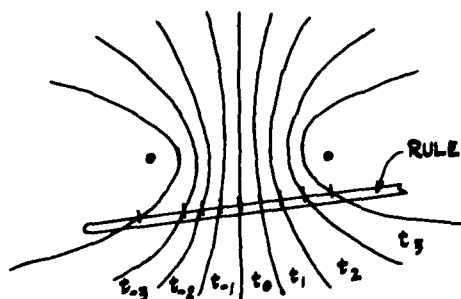

Fig. 1. Hypobolae Orbit Determination

Ryle's first erroneous conclusion that the satellite was falling rapidly towards the ground sprang from his initial assumption, made for purposes of calculation, that the earth was flat in the neighborhood of his aerials.

An independent method for the determination of the satellite's orbit is to measure the Doppler shift of the frequency of the received radio signal transmitted by the satellite. A graph of this received signal would appear as in Figure 2. (NOTE: It is generally unsymmetrical.)
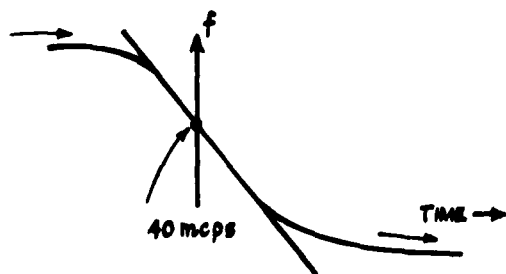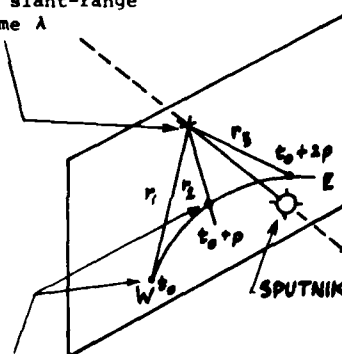

Fig. 2. Doppler Frequency Graph

The slope of this graph at the center or rather the actual transmitted frequency, when multiplied by the appropriate factor, gives a direct measurement of the slant-range from the antenna system to the satellite. By taking three such measurements, say from three successive transits, it is then possible to determine the point through which the satellite orbit passes in the plane perpendicular to the orbit. As time passes the receiving station is carried beneath the satellite orbit due to the earth's rotation and thus a triangulation of this point of intersection is possible as indicated in Fig. 3. In actual practice the resulting orbit must be employed in an interaction procedure in order to determine accurately the orbit's ellipticity.

Point of
intersection
$r \lambda$ = slant-range
at time λ

Cambridge at
times indicated.
p = satellite period

Fig. 3. Doppler Orbit Fix

Ryle's refined calculations provided the following data. The orbit of the satellite (Sputnik I) is an ellipse of eccentricity 0.059. Its plane is inclined to the equator at an angle of 65° (Ryle's first measurements by the two methods gave values of 64°25' ± 30' and 65°1' ± 10' respectively). Perigee is 170 km (105 miles) above the earth's surface at 40° North Latitude and apogee is at 40° South Latitude at an altitude of 990 km (615 miles). On 10-11 October the

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period for each orbit was 96 minutes 2 seconds which was decreasing at a rather constant rate of 1.85 seconds per day. Because of the earth's rotation each successive transit is 24° West of the preceding one. Due to the oblateness of the earth, i.e., its elliptical axial cross section, the orbit exhibits a new daily westward precession of 3°50'. It has been proposed, incidentally, that the 65° inclined orbit might have been chosen because it may exhibit this precession most strongly.

On the records of the received satellite-radio signal Ryle found a marked periodic amplitude variation superimposed upon the interference-pattern of maxima and minima. The frequency of this perturbation was approximately 15 rpm at 40 mc/s. This perturbation could be caused either by rotation of the satellite or by rotation of the plane of polarization of the satellite radio waves resulting from the Faraday Effect experienced by the radio waves traversing the ionosphere. Such an effect must be present due to the interaction of the electrical ionization and the earth's magnetic field. Now the Faraday Effect displays an inverse-square frequency dependence; thus, by measuring the apparent

perturbations at the satellite's two frequencies of 20 and 40 mc/s, a factor of 4 should exist between the two perturbation frequencies. Ryle measured, as was stated, 15 rpm at 40 mc/s and 62 rpm at 20 mc/s. This result certainly would support the second, that is Faraday Effect, explanation. To further check this result, Ryle also monitored the 40 mc/s second harmonic (i.e., 80 mc/s) and confirmed his conclusion as another factor of 4 was found to enter leaving a residual rotation of about 2 rpm which he attributed to actual satellite rotation. The prescience exhibited by the Russians in selecting the two frequencies they did (separated by a factor of 2), is well illustrated in this Faraday calculation.

Further indication of the planning behind the selection of the particular orbit chosen for Sputnik is that in this orbit the radio transmitter is dipped in and out of the ionosphere, thus permitting accurate calculations of various ionospheric phenomena. "I don't know whether the Russians planned (...this particular orbit...) but, if they did, I think it absolutely marvellous," said Ryle. His own magnificent improvisation may well, also, be so described. (G. C. Sponsler)

FLUID DYNAMIC RESEARCH IN AACHEN

July 1958

Fluid dynamic research is carried out by a number of groups located in or near Aachen, Germany. These include the Lehrstuhl für Mechanik of the Technische Hochschule Aachen, directed by Prof. F. Schultz-Grunow; the Institut für Theoretische Gasdynamik of the Deutsche Versuchsanstalt für Luftfahrt (DVL) - Prof. Klaus Oswatitsch; the Institut für Angewandte Gasdynamik of the DVL - Prof. A. Naumann; and the Versuchsanstalt für Binnenschiffbau, located in Duisburg, directed by Prof. W. Sturtzel.

Lehrstuhl für Mechanik der Technische Hochschule Aachen - The T.H. Aachen with over 6,000 students and 75 professors is probably the largest

technical university in Germany. Although it was much smaller in the pre-World War II era, it is graced by the heritage left it from the period during the '20s when Theodor von Karman created there a world famous research center in aeronautics. There are now a number of professors at the T.H. concerned with fluid dynamics, but probably the most active as far as research is concerned is Prof. F. Schultz-Grunow, who is in charge of the Lehrstuhl für Mechanik. This most energetic man currently presents lectures to about 2,000 students; as a result he has a staff of 20 assistants. Schultz-Grunow has broad interests in the field of mechanics, particularly

fluid mechanics, and his research program involving a number of unusual interests, is probably the most distinctive of its kind in Germany today.

Schultz-Grunow is quite interested in non-Newtonian fluids. He has studied the time rate of change of shear stress in a fluid viscosimeter clutched to a flywheel, and also the behavior of thixotropic materials in a concentric cylinder viscosimeter. There he found that such materials behave as solids where the stress is sufficiently high and as liquids where stresses are suitably low. Perhaps most interesting, he has found that in a shear flow of a mixture of toluol and polystyrene, the latter molecules (which are quite large) are repelled from a bounding wall of the flow. This was deduced theoretically and later demonstrated experimentally.

Other research concerns the stability of the viscous flow between coaxial rotating cylinders. As is well known, such flow was shown to be unstable by Sir Geoffrey Taylor in the case where the inner cylinder is rotated. Now Schultz-Grunow claims to have proved that theoretically in the absence of eccentricities and vibrations of the cylinders, unsteady flow cannot exist in the case of concentric cylinders where the outer cylinder alone is rotated. He is now conducting experimental studies of the effect of eccentricity on the flow stability.

Shock tube research has been carried out for a number of years under the sponsorship of the Air Force Office of Scientific Research by Schultz-Grunow and his principal assistant, Gröning. Strong shocks have been produced in argon in a small (15' long, 2" sq) tube driven by H_2. Measurements have been made of the degree of ionization and of relaxation times and an interesting attempt has been made to measure the thickness of the boundary layer behind these strong shocks by measuring the capacitance of the gas across the tube. A new and larger tube (4" dia) is being prepared and an interferometer is being installed.

It is interesting to note that Schultz-Grunow's shock tube research supported by U.S. funds stands almost alone in Germany, and that otherwise he has imaginatively chosen to study problems in fluid dynamics some distance from the beaten path.

DVL Institut für Theoretische Gasdynamik - The DVL is the principal German aeronautical research establishment. Its reconstruction began with the creation of institutes connected with the T.H. Aachen (see ONRL Technical Memo 3-57). One of these institutes is concerned with theoretical gas dynamics and is directed by Prof. Klaus Oswatitsch, who returned to Germany about two years ago from a position he held from shortly after the end of the war in the Royal Technical Institute in Stockholm. Oswatitsch is not a regular member of the staff at T.H. Aachen but does teach aerodynamics there. The offices of his DVL institute are quite separate from the T.H. His staff now consists of about seven young people; a gradual expansion is planned.

Work is being done or contemplated on the application of Oswatitsch's integral equation method to transonic flows, the behavior of shocks intersecting curved boundaries, incompressible flow past delta wings, supersonic boundary layer flow on a concave surface and supersonic strip theory for M>2. Some interest in magnetohydrodynamics exists, stimulated by the recent residence in Aachen of Prof. S. J. Pai of the Univ. of Maryland. Oswatitsch hopes to have other U.S. research workers spend some time in his institute.

Despite its youth this institute's activity is manifest. At the 1958 GAMM meeting in Saarbrucken, not only did Oswatitsch himself present an invited main lecture on Similarity Laws in Gas Dynamics, but two other members of his staff presented short talks. One of these, by Dr. J. Zierep, concerned rotationally symmetric cellular convection flows and the other by R. Schwarzenberger concerned a set of exact solutions (produced by hodograph methods) for compressible stagnation point flows.

DVL Institut für Angewandte Gasdynamik - This institute, headed by Prof. A. Naumann, is currently housed partly at the T.H. and partly elsewhere in Aachen. A rapid expansion is now planned probably involving a movement of the center of its activities to the Essen-Mulheim airport site where some other DVL institutes already exist.

Current activities in Naumann's institute concern: ram-jet aerodynamics, the detailed planning of new facilities for the Essen-Mulheim site, and the development of research instrumentation.

The existing facilities are located at the T.H. and consist, principally, of the heated (560°C) blowdown tunnel described in AGARD Report 69 by Naumann, Heyser, and Trommsdorff. At present the tunnel is blown through circular nozzles from high subsonic speeds to M 3.2; testing is done in the jet. A new nozzle, 30 cm sq for Mach numbers to 6 or 7 will be added. A small subsonic tunnel is presently also blown off the high pressure air supply. Impressive electronic instrumentation is generally employed. Tests to date include those on ram-jet inlets (Oswatitsch diffusers), two-dimensional flow spoilers, and circular cylinders. The ram-jet research, carried on in collaboration with the DVL Institute for Propulsion, headed by Prof. Leist and also located in Aachen, was apparently inspired by Trommsdorff, a wartime ram-jet developer who only recently returned to Germany from Russia.

Funds for the new facilities have been allocated and it is planned to first build at Essen-Mulheim a 2 m sq transonic tunnel and a 60 cm sq M 5 blowdown tunnel. A hot shock tube may later be built but first a small pilot tube will be experimented with in the T.H. Aachen laboratory.

Naumann's institute has attached to it a small theoretical group in the charge of Dr. Keune, who returned to Germany, as did Oswatitsch, after a long stay in Stockholm.

Versuchsanstalt für Binnenschiffbau Duisburg - This establishment is an institute of the T.H. Aachen devoted to research and testing of inland ships and barges. Its director is Prof. W. Sturtzel. This towing tank has a permanent staff of 30-odd persons, including a few of the 50 shipbuilding students at T.H. Aachen; these few students work and live at the Institute in Duisburg.

The relatively new facilities in Duisburg consist of a main tank 145 m long, 10 m wide, and of adjustable depth to a maximum of 1.2 m; a parallel deep-water tank, about 40 m long, 3 m wide and 2.75 m deep, a 40 m long shallow water (1.1 m depth) extension of the deep water tank, and a maneuvering tank, 25 m sq and 1.1 m deep. A single large carriage, capable of speeds up to 5.6 m/sec, serves the tanks. An interesting feature of these towing tanks is that a flow of the water therein may be arranged by means of a weir and pumping system; flow speeds up to 1.0 m/sec may be obtained in the large tank and 3.2 m/sec in the narrow tank. The Institute is equipped with model and machine shops.

The majority of the work is, of course, concerned with shallow water effects on powering, propulsion, and steering, and on Kort nozzles. Apparently about half of the work is done for industry and half is research supported by the Forschungsgemeinschaft.

Prof. Herbert Wagner - Lastly it is to be noted that Herbert Wagner has returned to Germany from the United States in order to take a post as a Professor of Mechanics at the T.H. Aachen. This scientist who was employed by the U.S. Air Force just after the war and later led a private research and development firm in California is very well known to students of mechanics for his notable early work done in Germany. It will be interesting to see in what way Wagner's creative talent will further strengthen the research effort in mechanics at Aachen. (M. P. Tulin)

DUTCH EXPERIMENTS ON ORIENTATION OF PORPOISES TO SOUND

October 1958

Important preliminary results of experiments testing the ability of harbor porpoises (Phocaena phocaena) to discriminate sounds in a directional manner have just been obtained by Dudok van Heel of the Zoological Station at Den Helder, Netherlands. Working with a single trained animal penned in a large enclosure in a canal on the island of Texel, he has succeeded in ascertaining the minimum angle at which the porpoise can discriminate between two underwater Asdic sound signals. These first measurements show this angle to be almost exactly four times as great as the minimum angle at which humans can similarly discriminate sounds in air.

During 1957 several harbor porpoises were captured in Danish waters and transported to the enclosure on Texel where the relative tranquility characterizing this somewhat isolated location reduced to a minimum extraneous distractions during the long period of training and experimental work. Two buoys with Asdic sound producing apparatus were placed within the large enclosure, and the animals were trained to swim to the one from which the signal came where they would receive food as a reward. After some months, the animals acquired the proper conditioned reflex; but by the close of this training period all but one of the porpoises became ill and died. Thus, the present experiments have been conducted with the lone survivor which appears quite content and healthy.

Van Heel's initial results concerning the minimum angle at which the porpoise is capable of discrimination in its orientation to sound are exceedingly provocative in light of the comparative velocities of sound in water and in air. If the assumption is correct that orientation to sound by vertebrates is facilitated because sound waves reach one ear slightly before they reach the other, then it would appear to be more than just coincidence that the minimum angle at which porpoises discriminate is four times as great as that similarly determined for humans, because the velocity of sound in water is about four times as great as it is in the atmosphere. It might then be deduced that the faculty for discriminatory orientation to sound by porpoises is approximately equivalent to that characteristic of humans, and that porpoises have therefore made little or no progress toward greater acuity in orientation to sounds throughout the ages after they substituted an aquatic existence for a previously held terrestrial one. I am not familiar with any similar experiments which may have been undertaken for terrestrial vertebrates more akin to cetaceans than are humans, but these preliminary comparisons lead to stimulating thought nonetheless.

No published account of these preliminary results is planned by van Heel, as he is most anxious to secure more porpoises for additional substantive data. However, the rather widespread interest in bio-acoustics among American workers leads me to mention these results now, even though they are very preliminary in nature.

Because of its importance to studies on hearing in aquatic mammals, attention is directed also to a very comprehensive, excellent publication in the Dutch language on the ear of whales. Prepared as a doctoral thesis by F. W. Reysenbach de Haan, "De Ceti Auditu: Over de Gehoorzin Bij de Walvissen", was published in 1956 by Drukkerij Fa., Schotanus and Jens, Utrecht. Anyone dealing with acoustics of aquatic mammals should see this book. (R. W. Hiatt)

NUCLEAR PHYSICS IN EUROPE

January 1959

There are approximately 123 institutes in Europe in which research in nuclear physics is done. A partial distribution is as follows: Germany - 25; England - 18; Italy - 15; France - 12; Holland - 8; Switzerland - 7; Sweden - 6; Belgium - 5; and Norway - 5.

It is probably safe to assume that the number of active people follows fairly closely the number of available laboratories in each country. We hesitate to attempt to order the countries in actual accomplishments and contribution since it may reasonably be pointed out that Denmark, with only one (Bohr's) institution until a few years ago, is still the Mecca of "classical" nuclear physicists (CERN at Geneva is developing into an alternative Paradise for people interested in high energy particles). Furthermore, Germany has still not caught up with the rest of the world in regaining apparatus and manpower during the last decade (there are very few experienced physicists 35-40 years old in Germany), but it is making great strides to regain its lost strength.

We cannot unequivocal'y link the activity in research with the state of economic wealth of any country since England and Italy certainly have a greater density of interesting projects than Belgium, where visitors this year surmised (possibly erroneously) prosperity from the omnipresent banks and large American cars. The influence of tradition, as well, must be invoked to explain the varying degree of interest and enthusiasm for research; there is little doubt that the spirit of Rutherford and Maxwell in England is still felt and that the large number of feminine physicists in France is due to Marie Curie. The predominance of any one country can be a transient state with the lifetime of one generation. The curve for Italy had a maximum a decade ago when Fermi worked at Rome, and France will certainly suffer from the decline and death of Joliot. Before the war, Germany was the "finishing school" for physicists, and much of the hope of regaining this title is reflected by the enthusiasm within the country for Heisenberg's new unified theory, and by the effort which is being invested in fusion research - probably the most intense in Europe.

Germany. We believe that this country will contend with England and Sweden for the lead in European nuclear physics research within the next decade. Germany has all the necessary ingredients - economic wealth, legendary technical competence, research administrators who are active and respected scientists, many established institutes, and of course an outstanding tradition. Probably no other western country offers as many financial benefits to students and since the war, the professors have followed the policy of deliberately seeking temporary appointments for their younger staff. While research programs still exhibit a phase lag with respect to the United States, almost every institute is in the process of acquiring an accelerator or reactor - ranging from a new pressurized Philips Cockcroft-Walton (Gottingen) to a 500 Mev synchrotron and synchrocyclotron (Bonn), and a 6 Gev electron synchrotron at Hamburg.

Some of the traditional autocracy of the professional system is being dispersed, and a new era is indicated by appointments of young men such as H. Schopper in Mainz, whose very simple but clear parity experiments have won for him wide respect. A newly appointed replacement for Walter Bothe at Heidelberg as head of the Max-Planck-Institute there, is W. Gentner, who was in charge of building the very successful CERN synchrocyclotron. This presages another institute building and possible accelerator at Heidelberg, which is already one of the most important nuclear research centers. The Hamburg accelerator program is directed by Prof. W. Jentschke, a very cordial and capable man of Austrian birth, who left Illinois with great reluctance after seven years. The transfer of Heisenberg's institute to Munich, where Prof. Maier-Leibnitz already has a strong research group working with a new reactor, will make this the third important center in Germany. Detailed descriptions of these institutes are given in ONRL-23-58.

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England. Engl_nd now has the larg-
est and most comprehensive program in
nuclear physics research in Europe,
but the further development of this
work is being attenuated by financial
limitations which reflect the economic
status of the country. The est_ _lished
centers such as Bristol, Harwell and
Liverpool are losing some of their best
men (to the States) and new groups
(Wilkinson, Oxford; Devons, Manchester)
are being built up only with difficulty.
A tight research budget makes competi-
tion for available funds almost bitter
at times. A budget proposal to the
government will be criticized by other
department heads and physicists as be-
ing unnecessarily lavish, with the re-
sult that corners must be cut and costly
time delays are incurred (cooperative
hydrogen bubble chamber project). A
short-circuit in the Birmingham synchro-
tron has been repaired in the most eco-
nomical manner, and the experimental
program there continues to be hampered
by the lack of sufficient space and
adequate beam engineering.

The thermonuclear program at Harwell
has received adequate support and ef-
fort, but has suffered greatly in pres-
tige from premature and exaggerated
publicity. A second breath after the
rapid postwar contributions made by
English physicists may be expected in
1961-2 when the 7 Gev proton synchro-
tron, 50 Mev proton linac, and the new
tandem Van de Graaff at Harwell are
expected to be in operation (ONRL-66-58;
35-58).

Italy. Once again we come to a
contradiction where, in this case, a
postwar dearth of money has in many
ways served to unify and advance the
contributions of nuclear physics. When
there was no money for experimental
equipment, young graduates could study
only theory or perform cosmic ray ex-
periments with emulsion detectors. Col-
laborative experiments were necessary,
and the mutual stimulation helped to
advance Italian physics to the forefront
for observations of interactions of
the new particles. Now these groups
are receiving some money, and the years
of training in theory are paying off
as the professors carefully choose ex-
perimental programs for their insti-
tutes. The contacts with international
groups have given a general awareness
of the most pertinent problems. The
largest institutes are located at
Bologna (Puppi) and Rome (Amaldi).

The only accelerator in Italy of ap-
preciable size is a new 2 Gev electron
synchrotron at Frascati (near Rome)
which should be ready to operate in
1959. Detailed descriptions of the
Italian groups are given in
ONRL-90-58.

France. Probably over 80 percent
of the money and effort in nuclear
physics is expended in Paris, and the
direction of the two largest groups
until recently was controlled by two
men: F. Perrin as head of the French
AEC (Saclay) and, until his death
this year, Joliot Curie as Director
of Orsay. The latter is the science
laboratory of the Univ. of Paris; and
it has been conceived on a grand
scale, with two cyclotrons, numerous
small accelerators, and a copy of the
2 Bev Stanford electron linac. Al-
though this surfeit of apparatus ex-
ists, there is a shortage of people
who understand and can use machines,
and the preference of Frenchmen for
their home soil has provided some iso-
lation from the scientific currents
flowing in other countries. The
Saclay laboratory has a small but good
group of nuclear research people who
tend to work on projects of interest
primarily to themselves. It would
benefit by more extensive national
and international interchange. Even
within Paris, the intentional isola-
tion of one university group from an-
other at times appears to be ridicu-
lous, and pride or rivalry between
laboratories seems to restrict the
cooperation which is essential to
progress in science.

Netherlands. Dutch nuclear re-
search is based on quality, rather
than quantity, and results from each
of the eight laboratories can general-
ly be relied upon to be carefully and
methodically achieved. After five
years of world-wide use of scintilla-
tion spectroscopy, a student at
Utrecht found a logical way to connect
the usual apparatus which permitted
at least a ten-fold improvement in
sensitivity, to the chagrin of most
other spectroscopists. The omnipres-
ence of the Philips Company serves
to catalyze projects at university
laboratories, sometimes with tangible
help, such as the company-operated
and maintained cyclotron at Amsterdam.

Switzerland. Some of the most
productive nuclear physicists in the
United States and elsewhere were born

and educated in Switzerland - a country which appears to offer little opportunity for the scientists it trains. The CERN organization is located in Geneva, but receives no particular patronage from the Swiss government. Here the European 25 Gev proton synchrotron, which will be very similar to the Brookhaven large machine, is nearing completion. The attractive location of the site (in a valley ringed with mountains) coupled with a quietly efficient administration has made CERN internationally popular, particularly with Americans even though the United States does not officially participate in the organization. The new cyclotron at CERN has already made history at a propitious moment by providing proof of a predicted mode for pion decay just before the last high-energy physics conference.

Sweden. The academic research laboratories in Sweden, and the apparatus inside them, are hardly equaled anywhere else in the world. The buildings are spacious and modern, and the equipment has been constructed with patience and care. An excellently engineered cyclotron is located in the chemistry department at Uppsala, and a new Van de Graaff has been given the beauty treatment at Lund. One may wonder slightly if these machines, as well as the unique Scandinvaian Isotope Separators and much of the other apparatus, are not admired a little bit as things of beauty rather than as beasts of utility. Nevertheless, a balanced research program is maintained in Sweden, covering work from slow neutrons to fast protons. During the next year a 2 Gev electron synchrotron at Lund should begin to produce K mesons. See ONRL-86-58.

Belgium. This country is unfortunately split by a factional dichotomy between French and Flemish cultures (the Walloons and the Flamands) along an east-west line a few miles north of Liège. The political battles between the Flemish and the French are confused by the existence of a large church party which spans both camps. Hidden somewhere in this strife are reasons for a state of relative apathy towards nuclear physics, as evidenced by a relatively negligible student enrollment increase in recent years. All of the nuclear physics research is sponsored by an interuniversity committee, and some of the publications in the northern sector are issued in Flemish, which essentially loses them to the scientific community. A beam of 12.5 Mev deuterons has been obtained from the cyclotron at Louvain since 1954, but it is only used for making radio-activity. Projects in nuclear spectroscopy, mass analysis, and energy level determinations are carried out at this, the largest laboratory in Belgium. In Liège, Prof. Morand's dust electrostatic generator is being slowly developed within manpower limitations.

Norway. Whereas Belgium has few students interested in nuclear physics, Norway has too many clamoring at the University doors for entrance. There are relatively few financial grants in aid, and there are hardly any jobs available in technical fields; yet, the students are flooding the technical schools. As in Switzerland, the graduates go to other countries to find jobs, and a good share of these people never come back. Atomic energy is not a cause for excitement because Norway still has an indefinite amount of unused waterpower to tap. The principal research groups are at the universities in Oslo and Bergen. Detailed descriptions of the laboratories are given in ONRL-86-58. (D. J. Zaffarano)

BONE MARROW INJECTIONS FOR RADIATION SICKNESS

February 1959

The use of bone marrow injections for radiation sickness at the Curie Hospital by Dr. Henri Jammet represents the first apparently successful attempt to graft bone marrow in human victims of nuclear radiation. Six Yugoslavs received a heavy dose of ionizing radiation when the reactor shield where they were working was inadvertently removed. The affected personnel were taken to the French atomic center at Saclay for studies to attempt to determine the amount of radiation received. Dr. Jammet, head doctor of the center, supervised this operation. Later the patients were removed to the Curie Hospital of which Dr. Jammet is also director. This was the first case of serious radiation treated by the French.

Although the doctors indicate that any measurement made after such a time lag is fairly inaccurate, it was estimated that five men and one woman had received severe dosages of radiation amounting to 800 roentgens for a period not exceeding 15 minutes. The white corpuscle count began to fall, and a bone marrow graft was performed by Dr. Jammet. Marrow was obtained from several donors under general anesthetic, and was removed from 12 places about the body. The marrow, undiluted, was then administered intravenously to the patients. Fairly severe shock resulted from this treatment.

One patient subsequently died from causes said by the doctors to be "other than failure of the transplanted bone marrow to produce new cells." Within four days of the graft, the white corpuscle count of the surviving patients had risen to 7000. On that basis the graft was considered successful. It remains to be seen whether the "secondary sickness" caused by antibodies produced by the transplanted marrow will prove fatal. The doctors estimated that this outcome will be known by 25 January 1959.

It is the opinion of the doctors at the Curie Hospital that this graft was successful for two reasons: (1) a sufficient quantity of the original bone marrow had been destroyed by the radiation dosage permitting the transplanted marrow to grow in the patients' bodies, (2) the marrow was administered in undiluted form.

It is further considered that this treatment, even if ultimately unsuccessful in this case, holds great promise as an eventual cure for leukemia, i.e., sufficient bone marrow of a patient could be destroyed purposely by radiation in order to permit a graft of this type.

Permission is being sought for an Office of Naval Research, London, representative to visit the Curie Foundation to see the patients and to talk with the doctors treating the cases. (J. A. O'Donoghue)

YUGOSLAV RADIATION VICTIMS

March 1959

This is a follow-up of the account in the February issue of ESN based on the fuller information obtained by a visit to the Curie Hospital.

The same dose was not received by all six victims. The most heavily irradiated man was estimated to have received 1000 rem of mixed neutron and gamma radiation. Four others, one a woman, were estimated to have received between 400 and 600 rem. The least heavily irradiated person, who left the vicinity of the reactor during part of the time that exposure was taking place, was estimated to have received about 200 rem. This man received no specific treatment.

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The 1000 rem victim received an intravenous injection of saline suspension of fetal liver (5 month, human) about 25 days following his exposure. Since there was no response to this, after several days a bone-marrow graft was carried out. Marrow was removed from a number of places on the donor's sternum, ilium, and sacrum. Each time the syringe was filled (10-15 cc), it was removed from the needle in the donor, attached to the needle in the recipient's vein, and injected. Salt solution or other diluent was not used.

This first patient died from gastrointestinal complications of radiation sickness within a week of the marrow transplant. However, the marrow graft seemed to have succeeded, since there was a rapid increase in his white blood cells and blood platelets before death.

The other four, except for the 200 rem patient, received marrow by the same technique described above. The marrow graft appeared to be successful in each case, as shown partly by the blood-cell response, but more cogently by the identification of donor blood cells in the recipients. This was done by agglutination tests with the minor blood groups M and N, which were intentionally left unmatched so that donor cells could be identified in the patients. The marrow transplants on the four survivors to be treated were carried out on the 25th of October; and a little over two months later, on the 30th of January, the patients were all doing well, and no signs of late immunological reactions had appeared.

As of 16 February, all the surviving Yugoslavs had been discharged from the Curie Hospital and had returned home. (J. A. O'Donoghue)

MECHANICAL TRANSLATION IN MILAN

May 1960

Under Prof. S. Ceccato (Centro di Cibernetica e di Attività Linguistiche, Università degli Studi di Milano), the problem of automatic translation of languages is being attacked from two directions, and work is also being done on the automatic recognition of objects perceived by a robot. Of the three lines of study, the most reasonable and most likely to be useful is the Russian-to-English translation effort being carried on under a USAF-RADC contract. One man, Ernst von Glaserfeld, has been hired for his intimate knowledge of English and another, Sergei Perschke, for his native Russian. Together, they have compiled an extensive table of the ways Russian prepositions of place must be translated into English according to the type of object and its case. They have exercised great care and have noted, for example, that in English things are generally put in drawers rather than into drawers. Considerable care will be needed, however, to avoid mixing American and British usages. At present they are working on the translation of verbs.

But for the suggestion of the Air Force that such very necessary work be done, the effort might have been concentrated on a scheme, due to Ceccato, which produces a list of possible grammatical uses for each word in a sentence, conditioned only by its predecessors. By the time the end of the sentence is reached, hopefully a unique use for each word has been determined. Applying this approach to a sentence in a natural language, one obtains a sort of equivalent sentence in an artificial language, from which the translation is derived.

IBM, Rome, and IBM, Paris, have expressed interest in Ceccato's mechanical translation work and are to try it out with the aid of their glass-disk memory. IBM and Euratom are also evidently interested in the mechanical-perception work, for which they will provide support.

The Centro di Cibernetica e di Attività Linguistiche was established five years ago, having been previously a private institute dealing with

methodology. It publishes the journal
Methodos. Because the Centro is inter-
disciplinary, Ceccato reports directly
to the Rettore Magnifico of the Univer-
sity. Ceccato gives an extra-
curricular course on the philosophy
of language (as he sees it), through
which he hopes to enlarge his present
staff of about ten. Several psychol-
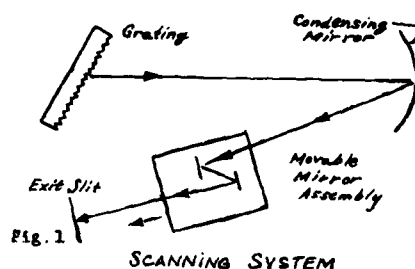ogists are to be added for the percep-
tion project. (N. M. Blachman)

August 1960

Infrared Spectroscopy at the
Weizmann Institute - Prof. J. H. Jaffe
is doing precise measurements of the
infrared spectra of gases at this In-
stitute. Over the past few years he
has built a combined infrared grating
spectrometer and hollow prism spectrom-
eter which enables him to do both index
of refraction measurements at and near
the rotational lines in the vibration
bands of light gases, and measurements
of pressure shifts in their vibration-
rotational spectra.

The main instrument housing is
about 11 m long and 1 m wide, and is
constructed of two 5-m pieces of tubing
abutting onto a center section. This
part is evacuated. One half of the
instrument contains a grating spectrom-
eter which is a normal Czerny-Turner
mount using an 8" x 5" grating. The
light output from the spectrometer goes
to a spectrometer of similar design
in which a hollow prism and reflecting
mirror have been substituted for the
grating. The source and detector op-
tics are outside the instrument, but
the optical path length is not too great
to add much atmospheric absorption.
The hollow prism instrument is used
only for index of refraction measure-
ments and not for measuring pressure
shifts.

An important feature of the instru-
ments is the use of a method of scan-
ning first developed for spectroscopy
by Rank of Pennsylvania State Univer-
sity. The light goes from the final
condensing mirror to the exit slit
through an optical path containing two
almost parallel mirrors. This mirror
pair is moved along the light beam.
If the mirrors were exactly parallel
there would be no shift. For slightly
out-of-parallel mirrors the scan can

be made very small for a very large
motion of the mirrors. Thus the prob-
lems which usually arise of rotating
the dispersing elements through very
small angles have been eliminated.
This system is shown schematically
in Fig. 1:

Fig. 1 SCANNING SYSTEM

Shifts of rotation-vibrational
lines with pressure are measured by
using two cells, one with and one
without the broadening gas, scanning
through the line and obtaining the
difference in peak positions. Differ-
ences of less than 0.001 cm^{-1} can be
measured, although the spectrometer
is used with a slit width which is
very much greater than this. By set-
ting on a wavelength with the mono-
chromator, and moving the scanner in
the prism section until maximum signal
is obtained, the index of refraction
can be measured to about one part in
10^7. Dispersion measurements can be
used to give the same data as are ob-
tained from intensity measurements,
but the instrumental effects can be
more accurate.

Measurements have been made of
the HCl overtone at 1.5 μ, and of the
HCN fundamental at 3 μ. Measurements
are at present being made on the

methane band at 3 μ. Dr. M. Hirschfeld and Dr. S. Kimel are working on this problem.

Although elementary theories of pressure broadening do not indicate that a wavelength shift should take place when a foreign gas is added to a sample, the modern theories show that a shift is expected and that it should also be a function of the rotational quantum numbers of the states taking part in the transition. Kimel, Hirschfeld and Jaffe have already reported some results of broadening of the 2-0 HCl transition, and have completed the series for the broadening gases Xe, A, Kr, Ne and He. They have also studied the 1-0 transition. The results for Kr, A, and Xe can be explained by interaction between the vibrating HCl dipole and the induced dipole on the rare gas, but the closer distance of approach to Ne and He seems to give a very different characteristic to the broadening curve. The theoretical work has been done by Mr. A. Ben-Reuven. The work has been extended to the HCN fundamental with the same gases.

Prof. Schnepp's Laboratory at the Technion - Prof. Otto Schnepp (Technion, Haifa) is working on the effect of environment on the spectroscopic properties of atoms and simple molecules. He returned last year from America where he worked on the Free Radical Program at the National Bureau of Standards.

Schnepp has commercial near-ultraviolet, visible and infrared spectrographic instruments. In addition he is building a vacuum ultraviolet spectrograph, which will be a normal incidence instrument with a concave grating used in an Eagle mounting. He feels that absorption spectra at high resolution can best be obtained using a condensed spark discharge as source, and for this reason prefers a spectrograph to a monochromator.

Much of the work involves measuring absorption spectra at low temperatures, and Schnepp has developed the cryostatic equipment necessary to condense the gases that he wishes to study in a matrix of an inert gas.

The interest in the spectra of simple species started when Schnepp and K. Dressler measured the spectra of solid krypton and argon in America. They found that the atomic absorption lines were very close to the ones obtained in gases. (This work will appear in J. Chem. Phys.) Schnepp then studied the electronic absorption spectra of solid ethylene and solid acetylene. He became interested in the study of the spectra of atoms dispersed in inert media. This work usually involves condensation of the species in the absorption cell together with the inert carrier. His first attempts were with manganese, and he found the resonance absorption quite easily. However, instead of a single line he found line splitting, which showed the effect of the lower symmetry of the site on the P state of the atoms. He has continued this work with magnesium and hopes to study the alkaline earths and the rare earth elements.

The technique used to obtain the samples is the following. A small oven heats the metal in the vacuum and an atomic beam is formed by collimating holes. The beam impinges on the collecting window which is kept cold. At the same time, the rare gas flows in through another connection and collects on the same window. Concentrations of metal of the order of 1% are obtained.

Schnepp and Dr. M. Folman have also studied the ultraviolet spectrum of benzene adsorbed on porous vycor. This material is transparent in the ultraviolet down to 2300 Å, and a relatively thin sample can be used to give a relatively large thickness of a monolayer. The technique has been used before in the infrared by Sheppard of Cambridge.

The advantage of these present techniques of isolation is that the electronic structure is ordinarily slightly perturbed by the enclosure of an atom in a matrix of a rare gas element. The spectra are thus easy to interpret and the perturbations due to the condensed gas can easily be studied. (D. Z. Robinson)

GROUND EFFECT MACHINES IN THE U.K.

November 1960

Five U.K. firms are actively engaged in the development of ground effect machines. They are Saunders-Roe, Ltd., Vickers-Armstrongs, Ltd., Hawker-Siddeley, Ltd. (Folland Aircraft), William Denny & Bros., Ltd., and Britten-Norman, Ltd. The development programs of these companies are indicative of a determined effort to exploit the capabilities of ground effect machines to the commercial advantage of British industry.

The current extensive activity is the direct result of the early experiments conducted by Mr. Christopher Cockerell, the British inventor of the Hovercraft. In 1953 Mr. Cockerell and his wife established a boat-hire and boat building business on the Norfolk Broads in the east of England. He soon became interested in the possibility of increasing the performance of standard cruising craft, and commenced experiments on air lubrication using a small planing hull. Experiment showed that the side plates, attached beneath the chines to retain the air film, added too much water skin-friction to permit the increase in performance he desired. Mr. Cockerell replaced the side plates with an air jet boundary, and the principle of the Hovercraft was born.

In 1958, the project was declassified, and financial support was obtained from the National Research Development Corporation (NRDC). NRDC is a national self-supporting non-profit organization acting under the Board of Trade. Its function is to develop inventions which are in the public interest. NRDC established a subsidiary called Hovercraft Development, Ltd., (HDL) to control the project, and Saunders-Roe, Ltd., was given a further contract which included the design and manufacture of a manned development machine, the now famous SR-N1.

The SR-N1 "flew" eight months from the commencement of its design, and it achieved its design hover height of one foot. It made its first public appearance on 11 June 1959, when it was demonstrated to a large group of technical personnel and representatives of the press. On 22 June, the craft crossed the Solent from the Isle of Wight under its own power to take part in "Remaground X," a beach landing exercise by the Royal Marines. The historic channel crossing on 25 July 1959, from Calais to Dover, was completed in 2 hours 13 minutes at an average speed of 13 knots. Development work continued quietly for almost a year before the press took note of a new development. The SR-N1 had been fitted with a small 880 lb thrust jet engine to provide additional propulsive power. On 23 April 1960, speeds in excess of 50 mph were demonstrated during runs on the Solent. On 18 May 1960, during runs on the River Thames, the SR-N1 demonstrated its new high speed capability to Members of Parliament.

Meanwhile, in the spring of 1960, Britten-Norman, Ltd., had undertaken an experimental ground effects machine, "Cushioncraft," which was constructed at Bembridge Airport on the Isle of Wight, a scant 12 miles from the Cowes plant of Saunders-Roe where the SR-N1 Hovercraft was built. The Cushioncraft was constructed with the financial assistance of Elders & Fyffes, Ltd., fruit growers and importers, who wished to examine first-hand the potential of ground effect machines in the transport of bananas from near-inaccessible inland plantations to seaports. On 24 June 1960, the Cushioncraft was exhibited to the press and was briefly demonstrated in hovering flight. Upon completion of experiments and trials in England, this small Cushioncraft is to be sent to plantations in the Cameroon region in Africa, where it will be used to examine the practicability of several alternate routes to the sea.

To accelerate the commercial development of the Hovercraft, NRDC has entered into a new agreement with Saunders-Roe, Ltd., for the construction of a second generation Hovercraft, the 25-ton 68-passenger SR-N2. Two other aircraft manufacturers, Vickers-Armstrongs, Ltd., and Hawker-Siddeley, Ltd., and one shipbuilder, William Denny & Bros., have executed agreements with NRDC for the construction of ground effect machines. Vickers-Armstrongs is undertaking the construction of a 5-ton experimental machine

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and a 25-ton machine. It is understood that the 25-ton machine will be an operational prototype of a larger, perhaps 100-ton, machine. The Hawker-Siddeley ground effects machine is being built by a member company Folland Aircraft, Ltd. William Denny & Bros., is reported to be working on a large passenger-carrying river craft with side walls which extend into the water and air curtains at the bow and stern to retain the air cushion. (W. E. Ditch)

November 1960

The influence of the sea on the history, culture, commerce and industry of Scandinavia is reflected in many fine museums, special exhibits and institutions. The writer has recently visited the following:

Bergen, Norway: The Institute of Marine Research, an official part of the Norwegian Directorate of Fisheries, has just moved to handsome new facilities at Nordnespynten. The new building is nine storeys high and is located at the tip of a breezy pine and granite peninsula which forms the southern border of Bergen's inner harbor. A magnificent view of the fjord, bay and offshore islands may be had from every floor; the structure overlooks the last resting place of Sir Hubert Wilkins' submarine "Nautilus" which was abandoned and scuttled here after his under-the-ice expedition of 1931. The laboratories and offices are of modular design; utilities are available overhead for center-of-the-room benches as well as along all exterior walls. Sea water is piped throughout. Director Gunnar Rollefsen has a staff of about 90 persons and has reserved four laboratory and office suites for visiting scientists. It is planned to build a pier at Nordnespynten so that Norway's oceanographic research vessels (four) may dock directly at the Institute.

Adjoining the Institute building is a new aquarium; Rollefsen is primarily responsible for its location and design. The aquarium, financed by public donation and private gifts, is situated on government property under the terms of an agreement which makes certain special facilities exclusively available to the Institute. It is expected that the public areas of the aquarium will soon be completed and opened to visitors. The guiding principle in the design and proposed collections is to present in orderly fashion the biology and ecology of marine fauna rather than a random collection of ocean curiosities. Lighting, design and decor are all aimed to make the visitor feel he has "broken the surface" and descended into the ocean depths; his "ascent" will be past a waterfall and fish ladder with salmon.

A significant portion of the aquarium consists of research facilities. One of the most unusual is a large toroidal tank with which it is planned to study the behavior of fish in simulated open sea conditions. The inner rim of the toroid is fitted with conventional glass viewing panels, but has a rotating observation platform whose speed can be adjusted to the swimming pattern of the fish under study. Sea water injectors are located at several levels in the tank; an elaborate system of valves, cross connections and reserve tanks permits establishment of currents of various speeds, with thermal and salinity gradients, discontinuities, etc. Lighting of the entire area is controllable so that illumination appropriate to the depth may be established. Diurnal variations in intensity may be programmed. Observations can also be made from the top of the tank and some surface conditions can be simulated. Sliding baffles permit conversion of the toroid into as many as 10 segmental tanks if desired.

Saltwater lines throughout the aquarium are plastic. Sea water intakes are located at the surface and at several different depths of the

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fjord (100, 200, 300 meters). Elaborate large-capacity heating and cooling machinery is being installed for temperature control of the tanks. Outdoor tanks for breeding experiments, etc., are also available.

Oslo, Norway: On the western side of Oslo, a large peninsula, Bygdöy, projects into Oslo fjord. This park and recreation area contains four unusual ship exhibitions. The Viking Ships are one of Norway's great national treasures. There are three, housed in a cruciform, churchlike building of striking design. Each ship occupies a wing of the building, and objects discovered on the Oseberg ship are displayed in a new fourth wing. The ships are believed to have been "yachts" rather than fighting vessels. They are of oak, about 60 ft long, clinker built, quite light and flexible. The width-length ratio is about 1:4.

Two of them, the Oseberg and Gokstad finds, are virtually complete; the bow, stern and upper strakes of the Tune ship are missing. All three were excavated from grave mounds between 1867 and 1904. They date from about 850 A.D. Restoration of the ships took many years. A variety of carts, sleds, kitchen equipment, etc., was found on the Oseberg ship; many of the items are elaborately carved, as are parts of the Oseberg ship itself.

"Fram" is the ship used by Nansen and Amundsen in their arctic and antarctic expeditions. It stands complete on keel blocks in a wedge- or tent-shaped building overlooking the harbor and Oslo fjord, and can be boarded from a balcony. The wooden sheathing on the hull is so thick that "Fram" has no portholes. Other mementos of the two men and their expeditions are also on display.

"Kon Tiki" is housed in a new building close to "Fram." The museum also displays a collection of Easter Island artifacts acquired by Heyerdahl. Like the Viking ships and "Fram," "Kon Tiki" is dramatically displayed. The raft floats on a plastic sea, in a hall with a dark blue tiled barrel vault. A spotlighted Easter Island monolith calmly surveys the raft from one wall. A ramp leads to a lower chamber from which the bottom of the raft can be seen; fish, including a 35-foot whale shark, are realistically mounted as though swimming under it. Another exhibit

is a full-scale replica of one of the Easter Island burial caves described by Heyerdahl.

The Boat Hall on Bygdöy has just been completed: it is also tent-shaped and stands adjacent to the "Fram" building. This hall contains about 20 Norwegian boats and is designed to show the historical development of the types used in various parts of Norway. The air is redolent with pitch and pine; smoking is not permitted. The influence of the Viking ship hull forms can be clearly seen in many of the boats displayed.

Stockholm: The National Maritime is one of the great nautical museums of the world. It was opened in 1938. The upper floor is devoted to the Swedish Merchant Navy, the ground floor to the Swedish Royal Navy, and the basement to technical aspects of shipbuilding. The collections are arranged chronologically; the Navy collection starts with portions recovered from "Elefanten," which was built in 1556, and finishes with models of the latest Swedish destroyers and torpedo boats. Each historical period is illustrated by models (including many contemporary shipwrights' building models), naval organization tables, ordnance, uniforms, contemporary drawings and paintings, etc. Some rooms contain entire ship compartments which have been moved intact to the museum [a gun bay from a 19th century frigate, the 'midship deckhouse of a merchant barkentine, the stern section of Gustav III's royal schooner "Amphion" (1778), etc.].

Recent developments at the Museum include great expansion of the section on technical aspects of ship building which allows extensive exhibits on hull design and construction, shipyard techniques, main propulsion plants, cargo handling equipment, navigational aids, etc. Another new exhibition occupies the central hall of the museum; it consists of items salvaged from "Wasa" (see below). Among them are an elaborately carved section of the beak, several gun ports embossed with carved lions' heads, a section of stern post, several bronze cannon, sketches of the ship, etc.

"Wasa": On 10 August 1628 the new Swedish first-rate ship "Vasa" (or "Wasa"), 64 guns, was warped from dock at the Royal Palace, Stockholm and set a few sails

(topsails and mizzen). It was her maiden voyage. The breeze was light. The trip was to be a short one out to the Stockholm archipelago. Thirty or 40 visitors were on board. Within less than an hour, the pride of the Swedish Navy was resting on the bottom--20 fathoms below the surface of Stockholm harbor. A light gust had capsized her about 800 yards from dockside.

At the court of inquiry the designer was able to show that he had narrowed the vessel by some four feet at the personal insistence of King Gustavus Adolphus, who had initialed the alterations. The ship was stated to be insufficiently ballasted. Attempts were made to raise the vessel, without success. In 1664 von Treileben, a Swede, succeeded in salvaging much of the ordnance. He used a leaden diving bell and long-handled hooks, drills, tongs and nets. An Italian description of this operation, with illustrations has been located. The vessel was then forgotten.

In 1920 a Swedish historian stumbled across some contemporary reports of the "Vasa" disaster and published them. Several years later these attracted the attention of Anders Franzén, a young Swedish engineering student, whose hobby was "collecting wrecks"; he collected 10 which he felt could reasonably be located. Now a civilian employee of the Navy, Mr. Franzén has pursued his hobby and located four of his "targets," including "Vasa." This he located in 1956, by patient hand sounding of the harbor during his free time. Preliminary dives indicated the ship to be in an excellent state of preservation (there are no teredo worms in the Baltic). The find stirred much interest, and the Naval Diving School transferred its training activities to the site. By cutting tunnels under the keel and by using a conventional wire sting and buoyancy tank technique, they successfully lifted the ship out of her bed of clay in the harbor bottom. She has been raised and moved in successive stages until she is now in 8 to 10 fathoms of water. Present plans are to have her break surface about 1 May 1961. Extensive experiments have been conducted on salvaged bits to determine the best method of preservation. It is planned to accommodate her in a special building; structure costs will probably dictate that her top hamper will be bobbed at the lower mast head level.

This Mayflower-era ship should be of enormous interest both to the professional naval architect and the casual visitor. Many details of the salvage operation, sketches, and photos of "Vasa" are to be found in Wasa - fynd och bärgning by Clason and Franzén (Bonniers & Norstedts, Stockholm, 1959). An English language press release entitled, "About the raising of the Swedish warship, Vasa, etc.," dated February 1959 by Commodore Clason, is available from the Marinens Pressdetalj, Marinledgningen, Stockholm 80. (J. H. Stover, Jr.)

NEW THERMIONIC CONVERTER WITH HIGH EFFICIENCY

April 1961

A new form of the thermionic energy converter has been invented by Prof. D. Gabor (Imperial College, London) which promises to give substantial improvements in efficiency and power density. The thermionic converter in its simplest form consists merely of a diode having an electron emitter with high work function and an anode or collector with low work function. Heat applied to the emitter can be converted directly to electrical energy. With such vacuum thermionic converters, overall conversion efficiencies of 4 to 7% have been achieved, at power densities of 1 w/cc.
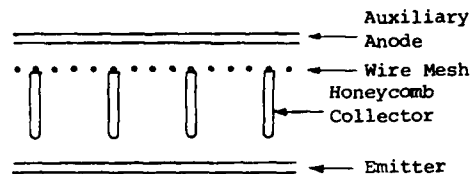
It has long been recognized that the current and hence the efficiency could be raised if the space charge were neutralized by positive ions, so long as the ions could be produced without too great an expenditure of

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thermal energy. In the past, space charge compensated converters have employed positive ions produced by the thermal ionization of Cs atoms either at the hot emitter or at an auxiliary hot electrode. In order to achieve space charge compensation, this method should theoretically require an additional heat expenditure of about 0.2 w/amp of compensated electron current. Experimentally, the expenditure has been considerably higher, however. Previous space charge compensated converters of this type have exhibited efficiencies of 15% (exclusive of radiation loss) with power densities of 7.5 w/cc.

Gabor's new contribution has been the development of a more efficient method of producing positive ions-- experimentally this has involved an energy expenditure of about 0.05 to 0.1 w/amp. His technique consists of diverting a small fraction of the electrons from the emitter-collector region to a separate accelerating region where they acquire a sufficient energy to ionize gas molecules. The majority of these ions return to the cathode-collector region where they neutralize the electrons which comprise the bulk of the originally emitted current. Such a neutralization is possible because each slow ion can compensate several hundred electrons. No ionization takes place in the cathode-collector region, the potential drop being only a small fraction of an electron volt. Interestingly enough, this low cost of compensation has been achieved by ionizing argon (ionization potential 15.7 v) or an argon-mercury mixture and could perhaps be further reduced to 0.02 w/amp by using caesium (3.9 v).

The device which Gabor has tested consists of a planar emitter, a massive honeycomb collector topped by a wire mesh which allows the small fraction of electrons to proceed to the ionizing region just above. Facing the mesh is another plane electrode which serves as the auxiliary anode.

Because of the increased efficiency of ion production, Gabor estimates from his initial experiments that an overall efficiency of 20-30%, including radiation and conduction losses, can be obtained using known materials. He finds a power density of 4-6 kw/sq ft can be achieved.

A unique advantage of this form of converter is the effectiveness of the auxiliary anode in controlling the discharge. The device can be made non-conducting if the auxiliary discharge is extinguished, and the discharge can be restruck in a fraction of a millisecond. By properly synchronizing the voltage on the auxiliary anodes of two such converters, one can generate alternating current. Gabor believes that the converter efficiency under ac conditions will not be greatly reduced; such a capability would be of great importance for any overall system efficiency.

A report of this work has just appeared in Nature, 189, 868 (18 March 1961). (H. Heffner)

STATUS OF NUCLEAR ENERGY IN ITALY

September 1962

Italy is a country with extreme poverty of natural resources; thus she presently imports 90% of the calories needed for consumption within the country; 50% of these imports are in the form of crude petroleum, and the money paid out to buy this petroleum amounted in 1957 to 70% of all foreign exchange disbursements; it is anticipated that the limit of economically

exploitable hydroelectric power will be reached by 1970.

This situation may be remedied by: (a) Changing the character of imports of energy sources so that the raw material is transformed into refined products and exported. This will bring back part of the foreign disbursements. In 1960 it was possible to recover 50% of the total expenditures for crude oil by exporting gasoline, oil, liquid gas, etc. (b) The full exploitation of the most advanced nuclear techniques as soon as nuclear energy is competitive for Italian conditions, thus providing an alternative to traditional sources of energy. This will tend to put an end to the drain on foreign currency reserves.

Prof. F. Ippolito, the Secretary-General of CNEN (Comitato Nazionale per l'Energia Nucleare) states that the guiding principle behind all CNEN's work in promoting and coordinating nuclear research in Italian industry is to reach such a degree of industrial experience and specialization so as to be able to design and manufacture any component whatsoever of at least one type of nuclear power station.

Italy will reach this goal in two steps. First, by buying the first reactors from abroad and subsequently replacing the nuclear cores in these "foreign" reactors with more advanced cores built in Italy. Second, after Italian industry has gained sufficient experience (in all phases of reactor technology), Italy will build her own plant. It is believed that this philosophy will advance Italian technology with respect to other countries because it will avoid diversification in the construction of "promising" reactor concepts. Diversification would not be possible in Italy because of financial and other limitations.

At present two nuclear power stations are being built: SIMEA (Società Italiana Meridionale per l'Energia Atomica) 200-Mw (electrical) Calder-Hall type is being erected at Latina, approximately 50 km southeast of Rome.

This represents the UK's first export reactor. The station should be ready for fuel loading in 1962. SENN (Società Elettronucleare Nazionale) 150-Mw (electrical) Int. General Electric Company boiling-water reactor is being constructed at Garliano, approximately 100 km southeast of Rome. Fuel loading should start in 1962.

A third reactor, SELNI (Società Elettronucleare Italiana), a 200-Mw (electrical) pressurized-water reactor designed by Westinghouse is in the planning stage. Construction of this reactor is being delayed because the Italian authorities concerned with safety have not yet approved the proposed site.

Experience gained with SENN and SIMEA indicates that if an improved line of reactors were built including at least an additional 1000 Mw (electrical), today Italy would be able to generate nuclear energy at a cost 20% greater than the minimum cost of an oil-fired thermoelectric plant, using imported oil.

The second-generation plant that Italy is designing is a prototype reactor, moderated by organic liquid having a capacity of 30 Mw (electrical). These efforts are correlated to some extent with similar activities of Euratom. In collaboration with industry, CNEN has launched its $14 million Organic Reactor Project (PRO) with the ultimate aim of designing a large power plant capable of producing power at competitive prices, using the uranium-thorium fuel cycle. PRO should be completed by 1964 and will be built in the Appenines between Florence and Bologna. Negotiations are presently underway in Italy to nationalize all nuclear efforts. Italy's nuclear power production program assessed under her multiple economic and political aspects might already today be called competitive or at least very close to it. This assessment is quite different from that of a country such as the US, where the technical and economic production costs outweigh most other considerations. (H. A. Sandmeier)

ELECTRO-POLISHING + REPLICAS = NON-DESTRUCTIVE METALLOGRAPHY

December 1962

No doubt Americans do more polishing than any other people. In view of the fact that this statement is still valid even if attention is restricted to the polishing of metal specimens for examination, it is surprising that the simple, rapid, cheap technique developed by P. A. Jacquet (Constructions et Armes Navales, Paris) for electrolytic polishing of metallic surfaces for non-destructive metallography is used so little in the US. Jacquet, the well-known pioneer and authority in this field, was awarded La Grande Médaille le Chatelier of the French Metallurgical Society at its annual autumn meeting in Paris, 15-19 October 1962, and gave the principal address* on past accomplishments and future perspectives of the electrolytic polishing technique.

The most attractive feature of Jacquet's portable apparatus is that it permits the polishing and inspection of specimens in situ without destroying or damaging the component. Figure 1 shows the complete apparatus set up for polishing a gear. Power is supplied from the unit on the left. The circuit is completed through the heavy-duty crocodile clip on the gear (anode). The water-cooled polishing probe with the synthetic cloth which has been soaked in the appropriate electrolyte serves as the other electrode. One of the two probes usually has a very small radius and can even be used on the inside of small cylinders, usually inaccessible gear teeth, turbine blade roots, etc. Very small surface areas and small volumes of electrolytes are

*With the exception of presentations by Jacquet, René Castor (Acieries d'Ugine, Savoie) and L. Colombier (Cie. des Ateliers et Forges de la Flore, Unieux, Loire), which were delivered at plenary sessions, all the 156 contributed papers were read and discussed at four sets of simultaneous sessions which ran during the week. The papers were about equally divided between the two main themes of this year's meeting: The use of vacuum and inert gases in metallurgy and high temperature metals and alloys.

involved; changing from one electrolyte to another can be accomplished easily and quickly. The many special electrolytes for a wide variety of materials are available from the same commercial source as the polisher.
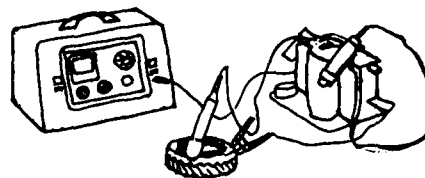

FIG 1

In order to fully exploit the remarkable versatility of this polishing method, Jacquet extended a technique developed earlier by Van Effenterre for employing a transparent replica (such as is used in electron microscopy) on large specimens. The dried replica lacquer (which is obtained with the polishing unit) can be stripped from the small polished area of a large specimen, gear root, etc. The replica method is particularly useful in those cases where a microscope cannot be brought up to study the polished surface because of inconvenience or inaccessibility--another obvious advantage is that it permits a crack to be followed around a sharp edge such as that of a turbine blade, since the replica lacquer can be applied to both surfaces near the edge and stripped off as one piece. The replica can be straightened out and easily mounted for view with a transmitted-light microscope or projector. A metallurgical microscope can be employed if a mirror is placed behind the replica or if the replica is first metallized. Large, complicated and expensive structures can be examined without mutilation or destruction. Jacquet, who has been working on the process for almost 35 years, is continuing to develop new electrolytes for more materials, and with Mme. Weill, is applying the technique to the study of several metallurgical phenomena.

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The polishing apparatus is manufactured and sold by the Société de Applications de Procédés Electrolytiques, 126, avenue Pierre Brossolette, Malakoff (Seine), France, and sells for about $500 in France; a modified smaller unit (one probe) suitable for universities costs $200. Laboratories in France, Great Britain and Japan each have between three and four dozen of the units and Germany has about a dozen; they are licensed for distribution and/or manufacture in these countries. There are probably less than six in the US at the present time,

although there has been some talk of distribution in the States in the near future. If the units are kept simple and functional and within the price range mentioned above, small laboratories and universities might well consider using them.

Jacquet's writings have been primarily in French, but he did describe some work on his process in the Proceedings of the ASTM, 57, 1957, and he is preparing an article for the January 1963 issue of Metals Progress. (D. S. Lieberman)

AN AVIATION FIRST

March 1963

The Ministry of Aviation (MOA), Hawker Aircraft Limited and the Royal Navy demonstrated the capability of the model P1127 (Vectored Thrust Aircraft) to operate from an aircraft carrier at sea during a scheduled flying trials period aboard HMS ARK ROYAL, 4-15 February 1963.

Hawker's chief test pilot, Bill Bedford, flew the P1127 aboard for the first time on Friday, 8 February--it was Bedford's first carrier landing--without incident.

Following initial contact with the ship and a high-speed, low altitude fly-by, the airplane was brought into the landing pattern and flown in a very conventional-appearing approach. But at about a half mile from touchdown, the resemblance to a conventional carrier approach disappeared. The aircraft slowed while maintaining altitude, and at the carrier's ramp a complete transition from aerodynamic to jet lift had been accomplished without apparent loss of heading or altitude, and without any observed indication of control deterioration. Bedford maneuvered forward at a walking pace to a position abeam the carrier's island; and with the precision demonstrated at last year's Farnborough Air Show, he descended the fifty-foot hovering height vertically to a gentle landing on deck.

Following the landing, a vertical take-off was accomplished from the spot abeam the island; and at hovering height, with 18 knots of wind over the deck, the aircraft was made to back up until it hovered over the arresting wire area of the ship. Then Bedford again moved forward abeam the island structure and completed another vertical landing.

Later, four short take-offs were accomplished at medium gross weight, each followed by transitions and vertical landings. Areas of expected maximum turbulence at the deck edges and aft of the smoke stack were investigated by Mr. Hugh Merewether, Bedford's back-up pilot. At hovering height, Merewether reported no problem; however, he cautioned that the possibility of developing high aircraft engine intake temperatures may exist if prolonged hovering in the stack was attempted.

With the Bristol-Siddeley Pegasus 3 engine installed, hovering in a direction more than about 25-30 degrees away from the wind direction could result in a thrust critical situation just prior to touchdown during a vertical landing. With the engine intakes angled to the so-called "free stream wind," intake efficiency is significantly lowered and the

attendant loss in thrust is apparent as the ground is approached.

Another problem related to thrust is the requirement to maintain sufficient forward speed so that the relative motion between airplane and carrier is zero. With the jet nozzles pre-set at an angle for shore-based hovering, say $82\frac{1}{2}$ degrees down from the fuselage reference line, as wind-over-deck is increased, so must the nose down trim be increased to provide a forward thrust vector to compensate and keep relative motion zero. But aircraft attitude becomes unacceptably nose low for simultaneous touchdown of nose and main landing gears. If the airplane is landed out of the wind, when the nose gear touches first, a pronounced weather cocking gyration ensues. Merewether demonstrated this condition on one of his landings.

Deck temperature rise resulting from the deflected jet nozzles was insignificant. Noise level from the aircraft measured above the flight deck and in some enclosed spaces was relatively low compared to other high performance jet aircraft embarked. Deck handling, taxiing and servicing did not appear to present any unusual problems.

A spell of unacceptable flying weather delayed operations after 8 February until 13 February, at which time Merewether made a short take-off (STO) with 8-knot wind-over-deck. He then made three 100-knot approaches to the deck (without landing), using the Deck Landing Projector Sight for glide slope information. Jet nozzles for the approaches were set 60-65 degrees down so that lift force was developed partially by the jets and partially by aerodynamic forces. Merewether reported no problems for the "conventional" approaches, and wave-off characteristics were satisfactory.

With the ship turned 90 degrees to the meteorological wind of about 6-8 knots and at a ship's speed of about 8 knots, Merewether approached and completed a decelerating transition oriented into the relative wind. After a tight circuit around the bow of the ship, he hovered the aircraft over the deck just forward of the #1 elevator, then completed a vertical landing while facing the aircraft into the relative wind. At touchdown the longitudinal axis of the aircraft was angled about 50-60 degrees with the centerline of the ship.

Bedford completed the demonstration, making an STO with 20-knot wind-over-deck for return flight to Dunsfold. Coverage of this aviation achievement was released to the press and television channels throughout the UK. (D. D. Farshing)

SOLAR PONDS

July 1963

The Negev Desert and the problems inherent therein are of paramount importance in present-day Israeli thinking and in future planning. It is not surprising that there is an active research program oriented toward making this lower half of the country fertile and livable. The Negev Institute for Area Research and the Dead Sea Research Institute in Beersheba are the two organizations primarily concerned with research which will "sweeten the seas and harvest the desert," as Ben Gurion has phrased it. However, interest in this activity permeates the lives of scientists throughout the country. Desalination is of course extremely important in Israel and the considerable effort devoted to this subject has led to what is reported to be the cheapest sea water conversion process in the world, in which the salt water is frozen and fresh water extracted. Israel is also the leader in the development of methods and devices for utilizing solar energy. Domestic heaters, refrigerators and generators for electricity have been built; attempts have been made to cool houses. Dr. H. Tabor, Director of the National

Physics Laboratory of Jerusalem and Consultant to the Arid Zone Institute, has been one of the more important figures in this area.

The cursed salt of the sea is actually exploited in a most novel and imaginative "solar pond" proposed by Dr. R. Bloch of the Dead Sea Works and developed further with Tabor. Salt water is much denser than fresh water, and the two will not mix if they are not stirred. Layers of high salt content are placed at the bottom of a shallow pond and fresh water at the top. If the bottom of the pond is blackened, the lower layers of dense water will be heated as the energy from the sun is absorbed. However, the hot salt-water will not rise because of its higher density, and hence an inverse temperature gradient is established which has proved to be stable, and the heat retained. A thermoelectric generator can then be employed, for example. Heat extraction and energy conversion, without disturbing and mixing the water layers, are the major problems.

During the past year, a solar pond of 625 sq meters and 1 meter deep has been operating near Sodom. Magnesium chloride, an inexpensive by-product of the Dead Sea potash facility, was used as the salt, and the density at the bottom layer was 1.3 grams per cc. It is thought that 6 megawatts of power can be produced per sq kilometer of pond surface on the average during the year and at a lower cost per unit than for nuclear power. Larger ponds are being planned, and research on the stability to wind and seasonal changes as well as methods of heat extraction and energy conversion are being continued. (D. S. Lieberman)

AN ION MICROPROBE FOR THE ANALYSIS OF SOLID SPECIMENS

May 1964

The electron microprobe developed by R. Castaing about ten years ago has already become an important tool for the chemical analysis of alloys and minerals. It is based on a refinement of the analytical x-ray spectrograph, utilizing the emission of characteristic x-rays by various elements under the impact of an electron beam. Since the frequency of these x-rays is a characteristic of the emitting element and since the relative intensities of the rays emitted by the components of a mixture or a chemical compound are proportional to the relative abundance of their constituents, the method permits both qualitative and quantitative analyses. Castaing's contribution to the spectral analysis by means of x-rays consisted essentially in the application of electron optics to the problem. In this instrument, the exciting electron beam is focused onto a small spot of the target, not larger than 1 micron in diameter, and by scanning the beam over the target area and simultaneous recording of the frequency of the emitted x-rays, it is possible to map the composition of the specimen with a resolving power of about 1 micron and an accuracy of about 1 percent.

In spite of its tremendous success, which opened completely new avenues for the metallurgist and the mineralogist, the electron microprobe has certain intrinsic limitations. One of them is due to the penetration of the exciting electron beam into the target with the result that the indicated composition is averaged over a certain depth. A more fundamental one is due to the fact that the frequency of the characteristic x-rays varies with the fourth power of the atomic number of the emitting elements. It is, therefore, rather difficult to resolve and record the spectra emitted by light and heavy atoms with the same x-ray spectrograph. To overcome this limitation, Castaing's latest models of the microprobe are equipped with two spectrographs, one using a quartz crystal for the heavier elements, the other a mica crystal

for the lighter elements. For the very light elements, say up to an atomic number of about 20, the characteristic x-rays are so soft that their absorption in air becomes a major problem. Castaing and his collaborator, Georges Slodzian, at the Laboratoire de Physique des Solides of the Faculté des Sciences at Orsay, have therefore decided to try a different method for the microanalysis of solids which overcomes at least in part the difficulties mentioned above.

The new method is based on the well-known phenomenon that a surface bombarded with a beam of positive ions will emit secondary ions as part of the process known as cathodic disintegration. These ions are formed of the atoms which constitute the surface of the sample. By application of the principles of ion optics, an image of the emitting surface can be produced on a screen, as shown in Fig. 1. An ion beam from a conventional high-frequency source, in general a beam of argon ions with an energy of 10 kev and a current of approximately 20 μa, impinges upon a sample area of approximately 0.5 by 0.5 mm. Secondary ions emitted by the sample surface are accelerated and focused by an electrostatic lens system to form a real image on a fluorescent

screen. A diaphragm (entrance pupil) at the crossover point of the rays eliminates those ions which possess a noticeable transverse velocity and improves the definition of the image, which is a composite picture containing all the different atomic species emitted by the surface. Introduction of a mass filter which will transmit only ions of a certain mass (or more accurately of a certain value of e/m) makes it possible to obtain a separate image for each type of secondary ion. These images will, therefore, show the distribution of the individual chemical elements and thus permit a point-by-point description of the composition of the surface.

The complete assembly is shown schematically in Fig. 2. The mass filter consists of an electromagnet whose field strength can be so arranged that it provides a deflection of 90° for ions of a given value of e/m, while those of other values of e/m are rejected by an exit slit. A second electrostatic lens forms a real image of the ions on the surface of an image converter where the impinging ions emit electrons. A corrector for the astigmatism produced by the magnetic lens is introduced in advance of the exit slit. By means
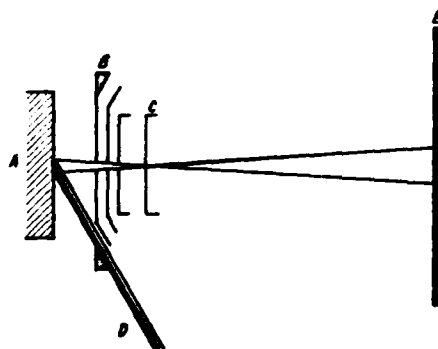

Fig. 1.

Fig. 2.

A - sample
B - electrostatic focussing lens
C - limiting diaphragm
D - incident ion beam

E - screen
F - deflecting magnet
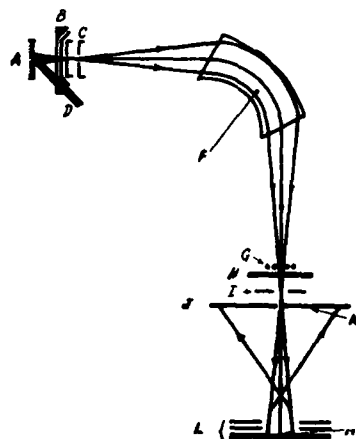G - corrector for astigmatism
H - selector slit

I - electrostatic lens
J - fluorescent screen
K - electronic image
L - image converter
M - ionic image

of additional electrostatic lenses, the electrons from the image converter produce an enlarged image on a fluorescent screen which can be photographed from the outside of the apparatus through a mirror inclined at an angle of 45° with the surface of the screen and located in the vicinity of the image converter. The image now appearing on the fluorescent screen represents the distribution of a certain element over the surface of the sample. By changing the current through the electromagnet, the filter can be adjusted to permit the transmission of ions of other values of e/m, and the distribution of various chemical elements in the surface can thus be photographed.

The spatial resolving power of the instrument depends essentially on the diameter of the entrance pupil and can, therefore, be increased at will by making this diameter smaller. This procedure, however, also reduces the intensity of the final image and a reasonable compromise is necessary. The resolving power depends also on the nature of the secondary ions used and on the precision desired for the quantitative analysis of the various elements. Setting the latter at 10 percent, it has been possible in practice to obtain a resolving power of 0.35 microns for copper and 0.03 microns for aluminum ions with an overall magnification of about 300 diameters.

The conversion of the ion image into an electron image does not only permit a reasonable magnification but also a strong augmentation of intensity. In practice it is possible to photograph the final image on the fluorescent screen with exposure times of around one second. Pictures taken with the instrument of a sample of an aluminum-magnesium-silicon alloy show clearly the distribution of the three elements along the surface of the sample. By comparison, one can also identify the presence of a phase Mg_2Si which appears in the form of dendrites on both the magnesium and the silicon images.

It might be interesting to state a few comparisons between the advantages and disadvantages of the electron and the ion microprobes. In the electron microprobe the relation between the intensity of the emitted x-ray and the abundance of the corresponding element in the sample is very direct and permits, therefore, a precision of chemical analysis to about 1 percent. In

the case of the ion probe, however, there is no distinct relation between the intensity of the secondary ions and the abundance of the corresponding atoms. As a result, calibration of the instrument with standard samples of known composition is necessary, and a precision of 10 percent for the chemical analysis seems to be reasonable. On the other hand, the ion probe has the advantage that it responds only to a layer of a few tens of Angstrom's thickness and gives, therefore, the true surface composition, while the electron microprobe averages over a much deeper layer because of the larger penetration of the electrons. Since the ion bombardment produces cathodic disintegration, the surface gradually wears off and a difference in composition with depth will appear as a function of the exposure time.

The ion probe will also permit a determination of the isotopic composition of a certain element. This feature might be used for the identification of elements which are otherwise difficult to separate. For instance, an image corresponding to the mass 58 may be produced by ions of Ni 58 or by ions of Fe 58. In the case of nickel, however, there will also be an ion corresponding to the mass 60 produced by the isotope Ni 60 which will not appear in the case of iron. The response to isotopic mass can be utilized in conjunction with the cathodic disintegration described above for experiments concerned with the determination of the rate of self-diffusion where no radioactive isotopes are available.

The difference in yield of secondary ions from different compounds of the same element can be used as an additional analytical tool. For pure copper, for instance, one finds a yield of 10^{-7} secondary ions per primary ion, but if the copper is present in the form of Cu_2O, the yield is considerably less. Comparison of the brightness of different parts of the picture permits, therefore, the identification of the compound from which the respective ions are emitted.

In summary, the method is particularly applicable for the detection of light elements and the identification of separate isotopes with high resolving power, particularly in the direction normal to the surface. On

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the other hand, the quantitative inter-
pretation of the results is more dif-
ficult than in the case of the electron
microprobe. More details are given

in a paper by R. Castaing and G. S
Slodzian, Journ. de Microscopie,
Vol 1, P. 395-410, 1962.
(I. Estermann)

ARBEITSTAGUNG

July 1964

The 1964 Mathematical "Arbeitstagung"
at the University of Bonn took place
from 12-19 June. Organized by Professor
F. Hirzebruch, these meetings, which
are kept small and informal, have been
highly successful in affording a stimu-
lating opportunity for the exchange
of information and ideas on recent
mathematical developments. An unusual
aspect of the Arbeitstagung is that
speakers are selected only after the
first (organization) meeting, in re-
sponse to suggestions from the parti-
cipants. While the talks given covered
a wide area, a central (but not exclu-
sive) theme of the Arbeitstagung might
be described as the theory of manifolds.

The famed "Poincaré Conjecture"--
that every closed, simply connected
3-manifold is homeomorphic to the three-
dimensional sphere* S^3--may become a
theorem. A proposed (but not fully
completed) proof was outlined, parts
of it in some detail, by Harken. The
proposed proof is based on the methods
and results of Papakyriakopoulos. A
feature is that the steps are so or-
dered that, for example, one is guaran-
teed that after certain types of singu-
larities have been removed, they will
not be reintroduced. Other types of
singularities require a related, but
more complicated, analysis. A differ-
ent proposed proof, also not yet com-
pleted, has been described by Poénaru
in lectures at Manchester and Cambridge.
If the conjecture should be established,
it would leave dimension four as the
only unsettled case for the "general-
ized Poincaré conjecture."

N. H. Kuiper described his recent
proof that all the homotopy groups of

the general linear group of Hilbert
space are trivial. More explicitly,
let H be a Hilbert space (of denumber-
ably infinite dimension) over the
reals, complexes, or quaternion, and
denote by GL the set of all bounded
operators on H with inverses which
are also bounded operators (defined
on all of H). With the norm topology,
GL is a topological group, and it was
proved in 1951 that it is connected,
i.e., its zero homotopy group is triv-
ial (one element). Kuiper's result
that all the homotopy groups are triv-
ial includes this as a special case.
His proof proceeds by explicitly con-
structing a "multi-step" homotopy.
Palais and Svarc had conjectured the
stronger result that GL is contract-
ible, and after Kuiper's talk a sug-
gestion was made of a recently devel-
oped method which, when combined with
the triviality of the homotopy groups,
proves GL contractible. Kuiper's re-
sult is an example of the fact that
there are important aspects for which
an infinite dimensional Hilbert space
is simpler than a finite-dimensional
one.

The theorem just described was
very relevant to the talk of Jänich,
a student of Hirzebruch at Bonn, who
showed how it could be used to improve
the results of his very interesting
thesis. We recall from the brief de-
scription of this thesis in ESN 18-5
of 14 May 1964, that the set of all
Fredholm operators on a separable
Hilbert space H form a Hopf-space
$\Lambda(H)$ [GL is obviously contained in
$\Lambda(H)$], and that for appropriate topo-
logical spaces X there is a homomor-
phism from the group of homotopy
classes of maps, $\Pi[X,\Lambda(H)]$, onto the
Grothendieck group K(X). After
describing this and other results from

*(the boundary of the four-dimensional
solid disk, or ball)

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his thesis, Jänich showed how, by using Kuiper's theorem, it can be proved that for compact X this homeomorphism is actually an isomorphism (even with respect to the ring structure):

$$\Pi[X,A(H)] \cong K(X).$$

Another interesting thesis from Bonn was described by its author, D. Gromoll. We recall from ESN 17-4 of 22 April 1963 that if an n-dimensional manifold M is δ-pinched, with $\delta > 1/4$, then M is homeomorphic to the n-sphere S^n [M is "δ-pinched" means (after normalization) that all the sectional curvatures of M are contained in the interval $(\delta, 1)$]. Gromoll has shown that for each dimension n there is a positive (computable) number ϵ_n such that, if $\delta > 1 - \epsilon_n$, then M is actually diffeomorphic to S^n. This is a corollary to a theorem which describes how, by squeezing δ toward 1, one can successively eliminate from consideration the various exotic differential structures on S^n, until finally the standard differential structure of S^n is the only remaining possibility (we omit the precise statement of this theorem).

R. Wood, a student of Atiyah now at Manchester, spoke of his results reformulating and generalizing the Bott periodicity theorem. The reformulation of Bott's theorem can lead to further striking results.

R. Palais described general techniques for computing the homotopy groups of infinite dimensional manifolds.

In addition, Wood and Palais each gave an expository talk on the index theorem for elliptic operators on manifolds with boundary.

Several of the talks were devoted to the applications or development of K-theory (see also Jänich's talk above). F. Adams showed how explicit, refined calculations in K-theory will yield the existence of a class of essential maps (cf. Hopf maps) from high to low dimensional spheres. D. W. Anderson described the improvements and results which follow from the introduction of a new function KC. F. Thomas described (joint work with James) the effective enumeration of isomorphism classes of vector bundles over certain classifying spaces. S. Weishu talked on characteristic classes in K-theory.

A. Borel gave an expository talk on the theory of automorphic forms for semi-simple Lie groups. He also gave a talk on pseudo-concavity for arithmetic groups, showing the power of this method, which involves an extension by him of work of Grauert and Andriotti.

S. S. Chern described his joint work with Bott on the equidistribution of sections of holomorphic vector bundles (in a special case this reduces to a part of Nevanlinna theory). W. Browder described his joint work with Livesay and Levine giving conditions to ensure that an open manifold is the interior of a compact manifold with boundary. M. Kneser described a theorem with applications to the calculation of cohomology for the exceptional Lie groups (p-adic case). A. Kosinski described some manifolds he has found which lead to various examples and counterexamples. R. Sacksteder described his work on the existence of exceptional foliations of co-dimension 1. J. Sampson described his joint work with Eells on poly-harmonic maps of Riemannian manifolds.

At mid-conference there was a break for the traditional Arbeitstagung Rhine excursion. (M. P. Gaffney)

FOUR GERMAN UNIVERSITIES RE-VISITED

December 1965

This reporter is a post-war product of the university system in Germany, where he was born and lived until nine years ago. Absent more or less continuously ever since, he enjoyed a recent opportunity to visit for two weeks four German universities and technical universities (Frankfurt, Darmstadt, Karlsruhe and Stuttgart). He realizes that neither the number of places visited nor the time spent guarantees anything like a representative sample, but since most of his observations point in the direction of a notable change, there may be some value in even a superficial report.

Two features of the staffing and administration of a German university institute used to be typical of the whole system: First, there used to be only one professorship ("chair") in each institute, and the holder of this position, who, as director, exercised full power in the institute, was almost invariably rather elderly and past the peak of his scientific creativity. [According to a report by the British Committee on Higher Education (Robbins Report, Appendix 5, P. 91, 1963), in 1957 the average age at which professorial status was reached was 45. This included assistant and associate professors as well as the holders of chairs.] Running his institute dictatorially for fifteen years or so, the director blocked the way for younger and more dynamic scientists who were still staying in touch with living science. How strictly this system was adhered to, even after World War II, is shown by comparing the numbers of professors and students over an interval of more than 30 years. In 1928 there were 3050 holders of professorial chairs as against 111,000 students. Thirty-two years later, in 1960, the number of students had almost doubled to 200,000 while the number of chairholder. had risen only imperceptibly, to 3160 (Robbins Report, Appendix 5, p. 92, 1963). The worldwide image of the German professor as an old man with a beard who is somewhat removed from reality had apparently survived WWII and was to endure forever.

Secondly, the age and lack of intellectual vitality of many full professors was especially detrimental, as the men at the top were able to run their institutes in a rather autocratic manner. The activities of the institute are determined to a great extent by the ideas of its director, with plenty of margin being granted to him by the traditional philosophy of academic freedom. In a system of higher education which tended to minimize formal rules and restraints (as reflected by the absence of "course requirements," "credits," etc.), the directors had little difficulty in maintaining full control of their institutes. Curriculum, seminars and colloquia, the selection of the staff members and their program of research, all these would reflect the particular scientific orientation and experience of the director. In this way a director of a typical institute would dominate the professional lives of perhaps eight staff members, in contrast to American universities, where there are perhaps three junior staff members to each professor.

It was therefore very gratifying to observe considerable improvement with respect to the age of the chairholders. The following remarks are based upon observations made at the institutes specializing in solid-state physics at the universities named above, but there have probably been corresponding improvements in other disciplines.

In all four universities, some of the institutes are run by full professors who are not yet 40 years of age. All of them have distinguished themselves recently in some up-to-date branch of physics, and most of them have spent a year or more in the US. Room was made for them by doubling or trebling the number of existing physics institutes and by endowing them so generously that they soon became the major centers of physics in their respective universities. It is interesting that these young directors were apparently in a strong bargaining position during the recruiting phase of their employment. The "deals" which some of them worked out with their respective state ministers of education resulted in substantial

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budgetary increases, reportedly by a factor of five in some cases. This indicates that the change in policy apparently comes from the top of the system.

Two full professors now sometimes share the authority within an institute. In order to lighten the administrative load, new professorial posts have been established, with the title "Wissenschaftlicher Rat" (Scientific Counselor).

The fact that younger and more dynamic scientists are now in charge of the institutes lessens somewhat the traditional concern over the fact that they still run their organizations in the traditional autocratic manner. The research program of the institute still reflects the director's own interest and specialty. There is little chance of advancement or of more-than-minimum funding for a staff member who indulges in his own specialty. This presented hardships for some older members of the faculty, who had to change their field of interest in order to hold on to their position.

However, a certain balance is guaranteed by the existence of as many as three institutes in solid-state physics alone at a single university. Furthermore, the field of interest of the young director will usually be something very much in the focus of interest anyway, so that a certain concentration of effort is far from objectionable. This is reflected in the up-to-date character of the research program, a large part of which is conducted by the MS and PhD candidates who are completing their thesis work under the supervision of the staff members. It seems to be a general requirement that the thesis work for the diploma (equivalent to the MS degree) should reproduce some very recent work published elsewhere. A typical diploma candidate will try to reproduce, improve or amend the experimental results reported in a recent Physical Review article. In their subsequent doctoral work they will then strike out on their own. Most of them are aware of the latest results and trends in their specialty, talk competently about it, and seem to float right into the mainstream of solid-state research. The final examination, however, throws them off their research track for some months by forcing them to memorize material foreign to their research. To make this questionable process

effective in all its stupidity, examinations in as many as four heterogeneous fields must be passed within one week or so, calling for the simultaneous presence of all this useless and soon-to-be-forgotten knowledge.

Another regulation, apparently dating from the time when German science was second to none, requires the publication of the candidate's research in German, at a time when a large fraction of German scientific journals are being printed in English! Many complaints were heard about this and most candidates plan to submit an abridged version of their theses in English as soon as possible, in order to make their results known to a larger group. The technical language around German research institutes is loaded with English expressions, anyway, which no one bothers to translate. This was true some years ago in the case of nouns of technical character, and it actually worked in both directions between German and English. Now, however, things are "chopped off," "switched," and so on--words for which there are perfect equivalents in the German language. Since this reporter, as far as physics is concerned, is able to speak only what is sometimes referred to as "Immigranto," he asked permission to deliver his lectures in English and apparently "got across," even at the graduate student level, since the subsequent discussion was very lively. This increasing predominance of English in scientific communication--in spite of stubborn, desperate French efforts to turn the tide--is explained not so much by a special suitability of this language as by the fact that the people who contribute most heavily to the field speak no other language.

The equipment funds of most laboratories seem to be adequate. Although larger items of equipment still seem to pass from group to group as the need arises, there is enough around for everyone's needs. Very little make-shift or home-made equipment is seen. The old university tradition of making as much as possible in the machine shop has apparently been abandoned.

The electronic equipment is to an almost embarrassing extent of US origin. Waking up from a long sleep in one of these laboratories, I would believe myself to be at an American

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university. Even when similar German equipment is available, the US version, even if slightly more costly, is usually preferred for reasons of superior quality and performance. Even large and expensive items do not seem to present financial problems; for example, in each of the four universities visited a Varian ESR spectrometer costing $50,000 is being used. Beckman and Perkin-Elmer spectrographs testify further to the generosity of the funding.

These big pieces, of course, do not come out of the annual budget of the institute. They are purchased with grants from the Deutsche Forschungsgemeinschaft (German Research Council). This Council receives funds from both the Federal and the State governments and distributes them for research projects in institutes of higher education. A Senate staffed with 27 members elected from the universities ensures cooperation with the universities and supervises the different specialist committees which decide on the grant applications. This body acts as a reliable and research-minded buffer between the treasury and the universities.

Research contracts with the German defense departments are rather unpopular. It is felt that they are offered only for work that is located on the far "D"-end of the R and D spectrum, so that there is no overlap with the research program of most universities. Private industrial laboratories, although better adapted to applied work, also see little advantage in taking on this type of work. Unreasonable clauses concerning patent and priority rights in these contracts make large-scale efforts in this sector uninteresting.

It must be pointed out, however, that the financing of research presents a picture which is rosy only in certain spots. The funding level is far from being homogeneous throughout the German universities. Whether an institute is funded generously or poorly depends primarily upon the man in charge. If one of the young directors was hired only after considerable recruiting efforts, he was usually in a position to strike a bargain with his minister of education; this could result in a substantial budget increase, as mentioned before. If the old director stayed on, however, he would still operate on a rather small budget, and

this would sooner or later put him behind his younger counterpart in the new second or third institute.

Building of new facilities, which is financed by the state governments, is progressing on a large scale throughout Germany. Institutes which are now accommodated in old or temporary buildings will in many cases soon move to new and more adequate quarters. Particularly impressive is the new campus of the Technische Hochschule Karlsruhe. Presently housed in former Army barracks, it will move next year into a number of multi-storey buildings which in overall appearance compare favorably with the new campuses of the University of California, to name just one example known by this writer. No complaints are to be heard about the building program. On the contrary, one often encounters the criticism that the universities were favored just a little too much in this respect, and that something equally energetic should now be done for the high schools, which are in urgent need of improved facilities.

It is interesting to note that these large-scale building programs provide only limited funds for the construction of student residences. According to the Robbins Report (Appendix 5, p. 97, 1963), only 10 percent of the 221,400 students in German universities in 1962 were accommodated in dormitories. This is in line with the German tradition, which considers a university to be primarily a place of teaching and learning, and plays little heed to the educational advantages to be gained from communal living. The German student continues to live in private lodgings, without the interdisciplinary contact that American dormitories offer. Although facilities are provided for dining and recreation, the German university of the near future will still occupy one end of the spectrum of possible educational attitudes, with the community life and the tutorial system of the British college at the other end, and the typical American university somewhere between.

These new facilities will be adequate for some years, since the number of students is declining. This is simply a consequence of the sharp reduction in the birth rate following the war. Student numbers will return to the 1962 level only after 1970.

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In view of the recent economic prosperity in Germany, it is amazing that there *is little hope of avoiding this* drop in enrollment by inducing a larger fraction of the population to seek a university training. No massive expansion of higher education can reasonably be expected in Germany in the near future. Since universities charge virtually no fees and stipends are easy to obtain, this unfavorable prospect is not due to financial factors. The reason can rather be found in a deep-rooted social tradition, which even WWII was not able to shake: Going to a university or influencing one's offspring to do so still seems to be appropriate only for certain selected groups in German society today, with such a tradition in their history and background. Although the German professor *enjoys a standing higher than* in most other societies, education is not so consciously recognized as the ladder of social advancement. An academic training does not really fit a young person for the hardships of life, more cruel now than ever, and the memories of large-scale academic unemployment between the two world wars emphasize this subconscious bias. The situation is not helped by the fact that, in a heavily industrialized economy which is approaching the American structure to a large extent, the operator of a bulldozer takes home as much money as most PhDs in physics. Little cooperation can be expected *from the* schools, which, particularly *in rural* areas, are highly decentralized, lack facilities, and are run very much in the old tracks as regards their attitudes toward higher education. In contrast, one cannot help but admire the American school bus system, which, even in remote areas, makes available adequate cultural and educational facilities.

One should be cautious about drawing any conclusions from such a small sample. If, however, some of the observations made on this short trip should reflect real changes in the whole system, physical research in German universities will *recover eventually from its post-war "low" and* will again play a more significant role. There will never be a return to the domineering position of German science in the twenties and early thirties. Science itself, and its interaction with the particular economic structure of which it is part, has changed too much in the last 25 years, but the German universities are aware of this change and seem to be engaged in a serious effort to eliminate some of their present shortcomings by adopting a more dynamic view of science. (B. O. Seraphin)

PLASMAS AT THE UNIVERSITY OF MILAN

July 1966

The Physics Institute of the University of Milan, headed by Prof. P. Caldirola, is a strong research center. Caldirola was initially a Professor of Theoretical Physics, but is now responsible for a professional staff of approximately 100 which is concerned with both the teaching and research activities in physics at the University. The Physics Institute moved into new quarters about three years ago, and the new buildings are both spacious and well-equipped.

In addition to his other duties, Caldirola directs a group of 12 physicists who are doing theoretical and experimental research in plasmas, and also a group of seven physicists who are working with lasers. It appears that the interest in plasmas was initially stimulated by a desire to learn more about radio and microwave propagation in the ionosphere. The group does not make ionospheric propagation studies, but according to Caldirola, diagnostic techniques are being developed that can be used for satellite-borne measurements of electron density. Most of the work is either theoretical and associated with the physics of plasmas, or is experimental and associated with

weakly ionized plasmas generated in the laboratory. Caldirola says that the group will soon investigate the physical mechanisms concerning a cyclotron resonance ion propulsion system. Such a system would employ microwave excitation and a static magnetic field. Caldirola plans to focus his attention on the energy balance of the resonance transfer and on a theoretical model for the prediction of the optimum conditions for energy transfer.

The largest research group (30 physicists) within the Institute is concerned with space physics and is under the direction of Prof. G. Occhialini. Prof. G. Tagliaferri is head of a low-energy group, which is developing a fixed-energy (about 50 MeV for protons), cyclotron that is being constructed in a separate building. A group under Prof. Loinger is concerned with the theory of fundamental particles, quantum electrodynamics, symmetries, potential theory and scattering matrices. Prof. Germagioli heads the solid state group, and efforts concerned with the use of facilities at CERN are under Prof. E. Fiorini. (Technical Reports ONRL-61-64 by N. Seeman and ONRL-2-66 by J. G. Grennan, describe the nuclear and high-energy programs at the University.)

The electron gyromagnetic frequency, ω_H, and the plasma resonance frequency, ω_p, are used frequently in the discussion which follows. They are angular frequencies, and the corresponding frequencies in cycles per second are $\omega_H/2\pi$ and $\omega_p/2\pi$, respectively. The gyromagnetic frequency ($\omega_H = eB/mc$) is directly proportional to the magnetic field and is the rate at which an electron gyrates in orbit under the influence of a steady, uniform magnetic field in the absence of an electric field. Gyromagnetic frequency is often called cyclotron resonance frequency because it is the angluar frequency at which electrons gyrate in a cyclotron, as long as the speed of the electron is in the non-relativistic range. The plasma frequency

$$\omega_p = \sqrt{4\pi n_e e^2/m}$$

is proportional to the square root of the electron density n_e and is the oscillation frequency of the plasma electrons about an equilibrium charge distribution.

Theoretical Investigations - The Plasma Group is strongly motivated toward the theoretical studies, possibly because Caldirola is himself a Professor of Theoretical Physics. Dr. O. de Barbieri is, with the possible exception of Caldirola, the leading theoretician in this group. Apparently de Barbieri's strongest interests are currently in non-linear phenomena of slightly ionized plasmas under the influence of an external magnetic field and of an electromagnetic wave.

Taking into account both elastic and inelastic collisions between electrons and molecules, Caldirola and de Barbieri have calculated (Radio Science, 69D, No. 1, 33-58, January 1965) the mean electronic energy due only to the absorption of the extraordinary wave of the electric field, and have shown that it is a maximum at the gyromagnetic resonance frequency. They have also calculated the electronic distribution function and the components for the complex dielectric permittivity tensor for an amplitude-modulated wave with carrier frequency near the gyromagnetic resonance frequency. Beat frequencies generated by plasma non-linearities were considered, but according to de Barbieri, more research is needed on this subject.

The electron distribution function and the complex dielectric tensor have also been calculated (Nuovo Cimento, 42B, 266-289, 11 April 1966) by another method. In this work, Caldirola, de Barbieri, and C. Maroli considered the conditions under which it is permissible to employ the usual expressions for the complex permittivity for the study of electromagnetic propagation in weakly ionized plasmas. The calculation starts with the Boltzmann equation for the electronic distribution function and uses a multiple-time-scale method to obtain a set of equations which describe the interaction processes between an electromagnetic field and a weakly ionized magnetoplasma; the calculation is restricted to cold and slightly ionized plasmas.

Analysis of theoretical problems concerning the propagation of electromagnetic fields in slightly ionized magnetoplasmas is continuing. According to de Barbieri, an electromagnetic wave which is initially transverse

can generate longitudinal waves, and the latter, in turn, generate transverse waves. He is continuing his studies on the physical mechanisms associated with the generation of these waves, and he feels that the generation of beat frequencies in plasmas can be explained by this process.

Plasma Generation with Radio Waves - Laboratory studies have been made on the creation of a weakly ionized plasma by propagating a radiofrequency wave through a low-pressure gas. An 84-MHz wave is sent between two rectangular plates between which is located a glass bulb filled with spectroscopic helium at pressures of 10^{-3}-10^{-2} mmHg. A magnetic field (0-40 gauss) is applied perpendicular to the electric field of the 84-MHz wave. Cylindrical, spherical and parallelepiped bulbs were used, none with overall dimensions exceeding 20 cm. When the gyromagnetic frequency of the electrons approaches (by variation of the magnetic field) the radiofrequency, breakdown is brought about by sharp increase of ionization. For this type of discharge, examined by Lax, Allis, and Brown (Journal of Applied Physics, 21, p. 1297, 1950), in the microwave range, only a low intensity of electric field is required for breakdown.

In a radiofrequency discharge, the energy supplied to the plasma is absorbed primarily by the electrons. Electron kinetic temperature can thus reach very high values, while atomic temperature, which is not directly influenced by the exciting fields, can be considered equal to the temperature of the plasma container. The energy of these electrons has been determined to be between 15 and 20 ev by a technique of optical spectroscopy proposed by Sovie (Physics of Fluids, 7, No. 4, 1964).

Measurements of the breakdown field, made by means of an rf voltmeter, as a function of applied magnetic field, have been made at different pressures and with different bulbs. For magnetic fields far removed from that required for gyromagnetic resonance, an electric field of approximately 15 v/cm produces breakdown. For a magnetic field such that the gyromagnetic frequency is approached, 4 v/cm and 9 v/cm were needed to cause breakdown at pressures of 4×10^{-3} and 2×10^{-2} mmHg, respectively. From graphs of electric field required for breakdown versus magnetic field, electrons-neutrals collision frequency can be calculated. It may be seen from equations for "effective field" (see above reference by Lax, et al) that collision frequency is equal to the half-width of the electric field versus magnetic field (expressed in $\omega_H/2\pi$) resonance curve

It was found that the collision frequencies for the three bulbs were different, indicating that the walls of at least two of the containers were controlling breakdown. From detailed analyses and the data on electronic energy and collision frequencies, it was concluded that the walls of the cylinder (length 20 cm and diameter 10 cm) do not influence the discharge for pressures between 10^{-3} and 10^{-2} 10^{-2} mmHg, providing the cylinder axis is oriented parallel to the magnetic field. Collision frequency was found to be approximately linearly proportional to pressure and of the order of 10^7 sec^{-1}. Since the cylinder walls do not affect breakdown, it has been possible to evaluate how gyromagnetic resonance controls breakdown of radiofrequency discharge in a range of pressure of the order of that existing in the ionospheric E-layer.

Photometric and Electron Density Measurements - Light emitted as a function of static magnetic field has been measured. The plasma was produced by a fixed-frequency radio wave (84 MHz) and the intensity of the light emitted by the plasma was measured with a photomultiplier. For an rf-electric field of 2 v/cm, maximum light was emitted with a magnetic field corresponding to $\omega_H/2\pi$ equal to 70 MHz; for a field of 10 v/cm, maximum light was emitted for a magnetic field corresponding to $\omega_H/2\pi$ equal to 65 MHz. Caldirola and others at Milan state that the magnetic field for maximum light emission seems to obey the hybrid resonance relationship

$$\omega_H = \sqrt{\omega^2 - \omega_p^2}$$

where ω is the radio-excitation frequency and ω_p is the plasma frequency (proportional to electron density).

The conductivity and dielectric permittivity of a plasma depend on electron density; therefore, the latter can be determined by performing an admittance measurement. To

accomplish this, a sample of the plasma-generating radio wave is fed to a dipole radiator, so that the complex reflection coefficient (with and without plasma) can be determined. The reflection coefficient is determined by means of a directional coupler from which magnitude of incident wave, reflected wave, and a combination (including phase) of the two is obtained. These measurements, in combination with various numerical calculations, provide an estimate of electron density.

Electron density calculations have been performed for different values of the electric field (plasma-generating radio wave) and for values of static magnetic field for which electron gyrofrequency is near the radiofrequency. As this visitor understands it, the electron density versus magnetic field obtained has the same behavior as that of the light intensity emitted as a function of magnetic field.

Diagnostic Method Using Plasma Resonances - A preliminary report has been published (Applied Physics Letters, _, No. 11, 300-302, 1965) by Caldirola and others on a method being considered for measuring electron density in a satellite. Considerable theoretical and experimental effort has been directed toward this problem since the first results were published. The method is related to that employed by T.H.Y. Yeung and J. Sayers (Proceedings of the Physical Society, 70B, 663, 1957) for an isotropic plasma. In that case the electric field close to (induction field) an antenna insulated from and immersed in the plasma is a maximum if the transmitted frequency is equal to the plasma frequency; at this frequency the dielectric constant is zero.

In the case of aniostropic plasma (magnetic field present) the dielectric properties are represented by a tensor, and there are four peaks in the induction field as a function of frequency. Assuming that the electrons-neutrals collision frequency is much smaller than the transmitted frequency, the peaks occur at frequencies corresponding to

$$\omega = \omega_P, \quad \omega = (\omega_P^2 + \omega_H^2)^{\frac{1}{2}},$$

$$\omega = \frac{1}{2}\left[\pm\omega_H + (4\omega_P^2 + \omega_H^2)^{\frac{1}{2}}\right].$$

The characteristic plasma frequencies have been studied and used as a diagnostic method for determining electron densities. In order to pick out the resonant frequencies, a sweep-frequency signal is sent into the plasma and received with a similar probe; the amplitude versus frequency of the received signal is studied. The instrumentation and measurement techniques are complicated by the fact that the received signal varies as a function of frequency not only because of the plasma, but also because of variations in the gains of the transmitting and receiving antennas. To alleviate this problem, measurements are made with and without plasma present.

For initial experiments the magnetic field was fixed (ω_H approximately 74 MHz). The plasma was produced in a cylindrical bulb (10-cm radius and length of 20 cm) by a transmitter with frequency near ω_H. The dipoles were perpendicular to the static magnetic field and were insulated from the plasma by a thin glass layer. Output powers available from the probe and plasma-generating transmitters were several milliwatts, and helium pressure in the glass bulb was 10^{-3}-10^{-2} mmHg. Four resonant frequencies were obtained for each value of electric field producing the plasma, i.e., for each electron density. Measurements have not been performed for several values of magnetic field and for several rf-electric fields producing the plasmas. The frequencies at which the peak signals occur are in good agreement with those predicted by theory.

Plasma studies have been at radiofrequencies, but steps are now being taken to extend the measurements to microwave and millimeter wave frequencies. (M. W. Long)

SOME GENERAL REFLECTIONS ON PSYCHIATRIC RESEARCH IN THE UNITED KINGDOM

January 1967

During the spring of 1967, it was the author's privilege to spend three months attached to ONRL with the mission of visiting various psychiatric research facilities in the United Kingdom in the hope of becoming acquainted with the direction, methods, and findings of their research efforts. While the detailed findings of the individual units have been set forth in a series of technical reports and ESN articles, some generalizations which might be of interest to the readers seemed to be indicated.

The first generalization that one would draw from visiting many units is the uniformly high quality of direction of all of them. The scientific staffs are equally select. This uniformity of quality is in contrast to the US where many centers are indeed first class, but some leave much to be desired. I visited no British units that were really naive or inept in their research efforts.

The second thing that strikes one is the small size of the units, 15 investigators comprising quite a large unit and some having as few as four. It appears that the directors prefer this arrangement, feeling that this gives them a greater integration and focusing of their efforts. Part of this may be making a virtue of necessity, but I think that, in fact, this does represent the directors' real wishes. The need for constant growth and aggrandisement which is felt in some academic medical circles in the US is at a minimum in the UK.

Third, the international views of the directors are also worthy of note. All of them have extensive transatlantic contacts and are in the US quite frequently. If a year elapses between visits to America, this is an unusually lengthy hiatus. They are, therefore, quite au courant on psychiatric research everywhere, since they also travel extensively in Europe and some even to the Far East.

The fourth item which comes to mind is the essentially lifelong commitment to a given effort by the directors; for example, Dr. Douglas at the MRC Unit at the London School of Economics has devoted more than 21 years of his professional life to a follow-up study

of a generation of children. This sense of one's post being for a lifetime makes possible all kinds of prospective longitudinal epidemiological studies which would fall to the ground in an environment where mobility between positions is considered routine.

Fifth, the MRC units are quite clearly built around the director who is chosen as an established investigator who still has great future promise, and the unit is shaped in his image, whatever title it may bear. This means that the director is clearly the crucial figure in development, and he chooses the staff and is the one who monitors their progress. Once the director is chosen and a unit established, there is minimal interference from MRC headquarters.

Generally, the budgets remain at a certain level, although there is usually a cost of living increase, perhaps 10%, annually. The budget for medical research, however, is extremely small by American standards; for example, Professor Henry Miller, Dean at the University of Newcastle upon Tyne, estimates that approximately £25 million per year is devoted to medical research, of which approximately £12 million comes from the MRC. Of this £12 million, maybe 5 to 8% goes into psychiatric research. What we are discussing, then, is an extremely small budget compared to that of the NIMH. It is abundantly clear that in terms of amount of payoff per unit of money expended, the MRC laboratories show up very well indeed. This may result, in part, from backing the man rather than using the yearly grant system which demands immediate results. On the other hand, the question arises as it does in terms of "elitism" in education or in the armed forces, as to whether in the face of enormous demand, it is enough to confine one's efforts to a few people of superb and unquestioned quality or whether it might be better to spread one's net wider, even though it might mean a fall-off of efficiency and the ratio of payoff to resources expended. Psychiatry certainly has no high national priority, nor should it necessarily; however, if what is true in psychiatric research is true in efforts more

immediately vital to the national in-
terest, then one would once again won-
der if, with the enormous demands of

the 20th century, one can afford to
back only sure things.
(R. J. Arthur)

TEN SINS COMMITTED IN THE NAME OF INTERNATIONAL SCIENTIFIC MEETINGS

October 1967

Every scientist beyond the age of adolescence knows the horrors of poorly arranged scientific meetings. This is an enumeration of those evils and, at the same time, it is a plea for improvement. Most of what follows has to do with international meetings, but many of my comments apply to domestic professional meetings as well.

Sin the First: Speakers try to cover too much ground. All human knowledge, or even just that part which you feel must be presented, cannot be covered in twenty minutes. Don't even attempt it. In international meetings, which include listeners for whom your talk is in a second language, this is even more critical.

Sin the Second: Speaking down to colleagues. This is more likely to happen in meetings in which English is not the native language of all participants. Also, perhaps more important, is that non-Americans often perceive us as talking down to them even though our intentions are otherwise. Try listening to yourself through a foreign colleague's ears and assume that he is at least as technically competent as you.

Sin the Third: Poor delivery. There is nothing wrong with reading a paper aloud, rather than giving it extemporaneously. Very few of us, however, know how to read aloud effectively. It is possible to improve our oral delivery. Don't mutter, don't race the clock, keep your sentences short and declarative. Use lists and enumerate your main points and conclusions.

Sin the Fourth: Mistreatment of language interpreters. (Skip this one if you never plan to participate in an international meeting.) Language interpretation is, in its own right, an extremely complex and difficult task. Most professional interpreters are highly competent and, given the proper

cooperation by their principals, they can do an amazing job of putting your words and ideas into other languages. But even the best interpreter needs his speaker's assistance. First, provide your interpreter with a copy of your paper. If possible, go over the paper with him and indicate which sections might be troublesome (e.g., technical vocabulary or structure). Mark those sections that might be omitted if you are pressed for time.

Second, don't speak at a rate that outpaces your interpreter. A rule of thumb is to assume that your normal conversational speaking rate is too fast. In many meetings it is possible to judge your effect on the interpreter by listening to him; sometimes the physical arrangement makes it possible to see your interpreter and this may provide additional clues about your rate of delivery. (At a recent international meeting the interpreters had to interrupt speakers more than once to ask them to slow down. In one case the speaker nodded agreement, dropped his voice to a loud whisper, and continued his mad pace.)

Third, meeting managers should check the condition of headsets and microphones before a meeting begins. It is a good idea to spend a few minutes at the start of a meeting explaining the operation of mikes and receivers; better yet, provide a simple diagram and post it in the auditorium. (We have emphasized the interpreter problem simply because it is so critical in achieving communication between scientists who don't speak the same language. Perhaps, if the PhD language requirements demanded spoken fluency in French and German, we could do away with interpreters. But, until that day....)

Sin the Fifth: Using poorly prepared slides. This one could occupy

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a major part of this article, but, since it is such a familiar problem, we will only mention it briefly. First, most slides contain too much information. Second, they are often poorly arranged and marked for the projectionist so that slides appear in any of the seven wrong ways it is possible to project them. Third, slides should not be used just because a system for projecting them is available: if you think your message can be made more effective, use slides; otherwise, don't run the risk of distracting your audience from the spoken word. Fourth, meeting managers should arrange room lights so that there is enough illumination during slides to permit note-taking by listeners. Finally, in deciding what size lettering to use on your slides, assume the worst case, i.e., viewers in the back row of the 30-ft, dimly illuminated room, and be sure letters and numbers can be read from a distance. (Extrapolated from the engineering psychology literature, letters should be 2 in. to 3 in. high under these conditions.)

Sin the Sixth: Strangulation of speakers by microphone cord. Although some audiences might secretly prefer it that way, speakers should have a reasonable assurance that they will not hang themselves on their mike cables. I have seen near accidents several times, and one solution seems to be an extra long cable; the ultimate answer, of course, would be a wire-less transmitter.

Sin the Seventh: Inadequate name tags. For many of us the most valuable part of a meeting is the new contacts we make with other scientists. For reasons that are obscure to me, I have almost never been given a personal label that could be read more than a few inches away. There is just no reason to continue this practice. My plea to meeting arrangements committees: abandon your typewriters and print our names and affiliations in half-inch letters. Please.

Sin the Eighth: Failing to provide sufficient breaks for informal contacts. This is related to the last point. Meeting participants need to be given enough time to relax with one another and to talk informally. Coffee and tea breaks are eminently

suited for this. Allow enough time for a second cuppa, too.

Sin the Ninth: Failure to provide enough information about meeting arrangements. Scientists I have observed are notoriously helpless when far from home. Right or wrong, they often complain about not being able to find out things. "Where is my room?" "When does the bus leave?" "What are the meeting room numbers?" "Who can sell me an extra ticket to the banquet?" Add as many questions as you can imagine: they will all be asked. My only suggestion here is that arrangement committees should assume that however careful they are in providing premeeting information, some considerable number of attendees will not get the word. Set up an information table in a conspicuous place; keep it manned throughout the meeting; and, if it is a multilingual group, be able to answer questions in at least the official languages of the meeting.

Sin the Tenth: Allusions to classified or proprietary data. This is a shocking thing on the rare occasions when it occurs. Audiences, particularly the non-American participants, tend to react very strongly to such remarks as "I can't say any more because the study was confidential." It should be enough to say here that there is absolutely no place in an open meeting for references of any kind to restricted data. Perhaps the "Call for Papers" should routinely proscribe classified allusions. It should not be necessary to make such a recommendation, but I have observed two such events recently and their effects were profoundly bad.

A final word. We are clearly well into the Jet Age of Professional Meetings. Publication delays and the overall proliferation of paper have reached such staggering proportions that face-to-face meetings are more critical than ever in the communication of scientific work. This note, then, is a plea for more effective meetings. Of course, neither you nor I have ever sinned, but we can help our colleagues who have strayed. (H. W. Sinaiko)

December 1967

The word tribology has come into general use in England to denote the sciences and technologies concerned with rubbing contact. Obviously this includes much of surface physics as well as bearing design and lubricant technology. The Ministry of Technology (Mintech) feels that tribology holds the key to much of successful machine design, and that millions of pounds per year can be saved through general application of good tribological practices. These savings would result from reductions of both maintenance personnel and downtime in industry. There would also be secondary benefits in improved quality of products to be sold abroad.

As a step toward good tribological practices, the Ministry of Technology has set up three tribological centers which will provide the necessary guidance for industry. The principal center will be at the Atomic Energy Authority (AEA) Reactor Engineering Laboratory (REL), Risley, Warrington, Lancs. Smaller centers will be set up at the Universities of Leeds and Swansea. The AEA center will exist as a department in the REL, and will be under the administration of Mr. Walter Long, Deputy Director of the Laboratory. Technical direction will be provided by Dr. W. H. Roberts, a physicist who is well known for his work on wear in sodium, water vapor, and carbon dioxide environments, at high temperatures. The initial budget will be roughly $500,000 per year for the first three years, and may rise to a higher level. The Laboratory is expected to do contract work for industry, and may ultimately match its endowment with outside income. Although much of their work will be research, it is expected that the staff will also do consulting and design work. Some believe that there are many problems which a good tribologist can handle without special studies, for prices as low as $150. But, neither Mintech or REL have had much experience with this or other problems of the consulting marketplace, and it is expected that their concepts will change as the center develops. For that matter no one knows yet how British industry will behave as a sponsor of research or as a patron of consultants.

The initial money will be used for building a staff, and it is hoped that mature PhD tribologists will be found, fully capable of working on their own. Similarly, it is hoped that a staff of technicians can be developed with the capability of running much of the experimental work with only nominal guidance. The present tribology group at REL comprises five professionals and is now expected to expand to about fifty.

The money for all of this does not come from new taxes, but from redirection of AEA funds. The AEA was begun with specific research and design chores, and has nearly completed these. When the fast reactor project is finished at Risely, there is not a faster-yet reactor waiting to be developed. Since the AEA has aggressively grabbed up much of Britain's technological man-power, it does not seem right to dump them into the streets now that the job is over. Furthermore, the AEA organization has proved itself effective in a tough job. Good working groups and well-equipped laboratories are not something to be wasted in a country suffering from technological inadequacies. So ideas have been sought as to how new tasks could be found for the AEA teams. Quite aside from tribology, centers have been set up in the AEA at Harwell for Ceramics and Non-Destructive Testing, along with a Materials Technology Bureau to provide consultant services in the fields of materials technology. Studies are being completed on how AEA expertise can be exploited in the field of instrumentation and control. The Ministry of Health is sponsoring work at Aldermaston on artificial limbs. This has obviously grown out of the AEA work on remote manipulators. Possibly other groups may develop around air-pollution control. Planners are looking into the complete redirection of AEA personnel to divers activities such as exploitation of the sea bed (pun intended). Spinoff obviously begins in earnest when one must spin to survive. No dervish could be better motivated.

Although the Risley tribology center is to be monitored by Mintech, the AEA is itself a separate agency, going directly to the Treasury itself for its money. On the other hand, the Minister of Technology, Mr. Anthony Wedgwood Benn, is a powerful member of the government, and technology is presently the chief subject of government planning and policy. Hence, what Mintech suggests has, of late, turned quickly into national policy, irrespective of the organizational structure involved.

As a case in point, we cite the Tribology Centers at Swansea and Leeds, noting that university sponsorship is ordinarily under the authority of the Minister of Education and Science, and the sponsorship of scientific research is in his care. On the other hand, matters which aid industry are the concern of the Minister of Technology. Hence, training courses for technicians, industrial training for practicing engineers, consulting services, and application-directed research may be sponsored by Mintech. The position of the Ministry is analogous to that of defense agencies which have so greatly influenced the universities in the US. The urgency is much the same; and, if the policy is sustained, the influence can be as far reaching. In any event, approximately $50,000 per year for each will initially be available to the University of Leeds and the University College of Swansea, with additional income to be derived from industrial work.

The Center at Swansea will be under the direction of Prof. F. W. Barwell, who is head of the Mechanical Engineering Division, and holds other faculty offices. Barwell has led the tribology group (now dissolved) at the National Engineering Laboratory, has been Director of Electrical Research for the British Railways Board, and has held numerous distinguished offices in technical societies. It is expected that the work of the Center at Swansea will be supported by other divisions within the Applied Sciences Department, these being the Metallurgy Division and the Chemical Engineering Division. Some of the first money will be spent to hire two PhD tribologists, without faculty duties, who would initiate liaison with industry and feed problems back to the faculty members and students. In addition, technicians would be hired to ensure the smooth flow of experimental work.

The Center at Leeds will be under the leadership of Prof. Duncan Dowson, who was named Professor of Fluid Mechanics and Tribology only two years ago, thereby becoming the first bona fide tribologist in the world. He is also chairman of the Tribology Group of the Institution of Mechanical Engineers. It is expected that the working arrangements at Leeds will be similar to those at Swansea, although based upon an existing tribological research effort already of respectable size, whereas the Swansea laboratories are just now in the process of being occupied.

Both Swansea and Leeds Centers will be concerned with the training of persons engaged in technology, at all levels from laboratory foremen to research directors. Presumably much of this training will consist of short courses, workshops, seminars and night classes. Since the AEA Center at Risley is not equipped for classroom work, a special arrangement for this has been made with Mr. J. Halling, who has just now been appointed Professor of Tribology at Salford University, Manchester, of which Risley is a suburb.

(R. A. Burton)

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SOME IMPRESSIONS OF SOVIET PHYSICS: LENINGRAD, MOSCOW, AND NOVOSIBIRSK

December 1967

This is a report of a three-week trip to the Soviet Union that the writer undertook last July and August, principally to attend scientific meetings in Leningrad and Novosibirsk. In addition, we report on visits to the University of Moscow and to the two largest and best-equipped physics research institutes in the USSR, namely, the A. F. Ioffe Physico-Technical Institute in Leningrad, and the P. N. Lebedev Physical Institute in Moscow.

In Leningrad we attended the "Fifth International Conference on the Physics of Electronic and Atomic Collisions" that was held in the historic Taurida Palace (Tavrichesky Dvorets), from 17 to 23 July 1967. The Conference, organized by the Ioffe Physico-Technical Institute under the sponsorship of the Academy of Sciences of the USSR and the co-sponsorship of the International Union of Pure and Applied Physics, was attended by more than 650 delegates representing 26 nations. There were presented 326 papers (including 17 invited lectures) distributed over five plenary sessions and 15 double parallel sessions. The official languages of the Conference were Russian and English with simultaneous translation into the other language.

The interested reader will find a more detailed account of the proceedings of this important meeting in a Conference Report (ONRL-C-18-67). Here we wish to confine our remarks to a brief analysis of the nations represented and the institutions that contributed. Counting together contributed papers and invited lectures, we find that the US had a total of 137 papers, whereas the USSR and the UK had 89 and 48, respectively. Thus, the US contributed 42% of the papers, and the USSR and UK jointly another 42%. What these percentages reflect, of course, is the fact that the larger centers of research in the physics of electronic and atomic collisions are to be found in the United States, in Russia, and in England, which are the countries with the greatest resources, both economic and in scientific manpower.

Returning to the Soviet contribution at Leningrad, we note that, of the 89 papers presented, a total of 39, or 44%, came from the Leningrad State University (23 papers) and from the Ioffe Physico-Technical Institute (16 papers), the host institution. Judging from past reputation and from the overwhelming number of papers presented, it is clear that these Leningrad institutions represent the two major centers of research in the USSR in the field of the Conference. However, when we recall that the Russian delegation at a similar conference in Quebec two years ago was under a dozen scientists, we may ascribe at least part of this preponderance to the fact that the Conference was held in Leningrad and that the question of freedom and ease of travel, which arises even within the borders of the country, did not affect the scientists of these two institutions. Other important centers of research in this field are the P. N. Lebedev Physical Institute in Moscow, the Institute of Chemical Physics, also in Moscow, and the Institute of Physics in Riga, which together contributed 20 additional papers.

Further, we note that, of the 22 institutions from the USSR represented at this meeting, six are universities and 16 are institutes of research. This distribution is not difficult to understand when one recalls that the scientific structure of the USSR is in many ways similar to the traditional structure that one finds in most countries of Western Europe, where every distinguished Professor usually heads his own institute of research. In the USSR the difference is that every institute director must also be an Academician, of which there are about 200 in the whole country. As is generally known, the all-powerful Academy of Sciences of the USSR controls all aspects of scientific education and research including the recruitment and distribution of scientists among the universities and research institutes, as well as the allocation of funds for teaching and research. Thus, we can assert unequivocally that the totality of the

research effort presented by the USSR at the Leningrad Conference is Government supported, mostly through the Academy of Sciences.

On the Sunday after the Leningrad Conference we were given the opportunity to visit the Ioffe Physico-Technical Institute, which was founded in 1918 by Academician A. F. Ioffe, and which is famous, among other things, for having had the great names of Kapitza, Kurchatov, and Artsimovich associated with its early development. During WWII the Institute moved to Kazan, and in 1943 Igor V. Kurchatov went to Moscow to organize and establish the now famed Institute of Atomic Energy which today bears his name. In 1944, Ioffe returned to Leningrad to help rebuild his Institute and to convert it into one of the finest physics research institutes in the Soviet Union. Under its present director, Academician L. A. Artsimovich, the staff of the Institute numbers more than 2000 people, of which 60% are professional scientists. Besides a very strong theoretical group of about 50 physicists and mathematicians, there are six major laboratories in the Leningrad site devoted to work in atomic collisions, solid state physics, plasma physics, low temperature work, microwave spectroscopy, and (low energy) nuclear physics, including the first Russian-built cyclotron that came originally from Kurchatov's Institute. The theoreticians are heavily committed to work in high energy physics and elementary particles, but there are also extensive programs in solid state physics, mostly semiconductors, and in atomic collisions. There is a second site of the Institute, 15 km outside of Leningrad, devoted to nuclear research: neutron physics, electron accelerators, research reactors, and controlled fusion devices, which, however, we were not given the option to visit.

Of the six major laboratories in the Leningrad site we chose to visit the Plasma Physics Laboratory, which is housed outside the Main Building in quarters that seemed to be in much need of repairs, inside and outside. We visited Golant's group working in microwave diagnostics, in particular the study of plasma turbulence through microwave excitation and consequent analysis of correlations. Next, we visited Berezin's group working with the TUMAN machine, which is a toroidal device designed to study the adiabatic magnetic compression of plasmas as well as their ohmic heating. Finally, we examined Vinagrov's device for the study of electron-cyclotron resonances. It was clear to us that plasma physics research is not a major concern at the Leningrad site of the Ioffe Institute, but we were duly impressed with the experiments in progress, particularly the study of plasma turbulence, which seemed to us very neatly done despite what on the surface looked like inferior electronic equipment.

From Leningrad we moved on to Moscow where we visited the University and the P. N. Lebedev Physical Institute, which is regarded as the first such institute within the USSR. It boasts of having six Nobel Prize winners in its roster, namely, Academician J. E. Tann and Professors J. M. Frank and P. A. Cherenkov (for the discovery of the Cherenkov effect, 1958); Academician L. D. Landau (for his work with liquid helium, 1962), and Professors N. G. Basov and A. M. Prokhorov (for their studies in quantum electronics, 1964). The staff of the Lebedev Institute is three times as large as the staff of the Ioffe Institute, and altogether the physical plant and the laboratories appeared to be in much better condition and more lavishly equipped than at Leningrad. There appeared to be six major laboratories devoted to lasers (Prokhorov), spectroscopy (Mandelstam), accelerators (Ravinovitch), quantum electronics (Basov), low temperature plasma (Sobolev), and optics (Suschinsky). In addition we noted a number of ancillary installations like, for example, the Liquid Helium Plant (which seemed to us the largest ever in a research institution), and the Laboratory for High Magnetic Fields, which we describe below.

At the Lebedev Institute we first visited Academician Prokhorov's so-called Laboratory of Oscillations, which has mostly to do with the theory and experiment of laser beams (they seemed to be all over the place) including the study of Raman scattering (from spherical waves), the scattering from quartz crystals at room temperature without damage to the crystal structure, the generation of mm and sub-mm waves, paramagnetic

resonance, semiconductors, and the creation of high temperature plasmas (up to 300 eV) by the technique of laser beam breakdown of gases (air, A, Ne). Next we visited Prof. Sobolev's Laboratory of Low Temperature Plasmas, where the principal attraction was a small stellerator with a vacuum chamber 10-cm diameter in cross section and 120-cm outside diameter. This stellerator is being used partly for the study of the structure of the vacuum magnetic field and the existence of closed magnetic surfaces, and partly, after creating a plasma through external injection, for the study of containment times, instabilities, anomalous diffusion, drift waves, and the effectiveness of electron-cyclotron heating, all in all a very well-conceived device affording very neat and clear cut experimental results, what one might call a precision instrument.

Finally, we visited Dr. Viselaga's Laboratory for High Magnetic Fields, which is a very impressive installation that operates as a National Laboratory for the entire country. It has the capability of producing steady state magnetic fields up to 100 kgauss by means of distilled water-cooled solenoids supplied by six generators in parallel producing 40,000 amps at 200 V, which is just under the 10 MW capacity of the installation. The closed-cycle distilled-water system operates at a pressure of 5 atm and supplies cooling water to the spiral wound solenoidal coils at a rate of 100 m^3 per hour. The working space in the center of the solenoid is a cylindrical cavity of dimensions $\frac{1}{2}$ in. diameter and 2 in. long, where samples are introduced for such studies as superconductivity, solid state plasmas, semiconductors, Hall effect, etc. The magnetic field can be varied from 0 to 100 kgauss in a matter of minutes if necessary, or in hours if desired, the whole operation in any case being carried out by remote control.

Lastly we came to visit the University of Moscow whose official name is "Moscow Order of Lenin and Order of Red Banner of Labor State University Named after M. N. Lomonosov." Built in record time between 1949 and 1953, the monumental structure was completed four years before the launching of the first Sputnik. It consists of a massive central tower 33 stories high, symmetrically flanked on either side by enormous 19 storey and 9 storey wings, sitting grandly on a bluff by the Moscow River, and rising above a gigantic fountain studded pool. It is the tallest building in the city and the most grandiose of the seven (similar) skyscrapers bristling with "Stalinist Gothic," elaborate curlicues, towers, and ornamentations. More than 30,000 undergraduates (about one-third co-eds) attend the University and upward of 15,000 resident students and faculty live in the building's dormitories. It is a self-contained community with stores, shops, restaurants, cafeteria, barber shop, beauty parlor, movie hall, bank, and a fully equipped clinic. The students receive a subsidy of 40 rubles a month and all the necessary textbooks gratis. There is no tuition and no student fees and, of course, all medical services in the clinic are free.

We visited dormitories, laboratories, and classrooms. The numerous laboratories seemed to be superbly equipped, and the storerooms attached to the lecture halls were crammed full with the finest collection of classical demonstration equipment that we have ever seen, all of which reflects present day Russia's stress and emphasis on science education and research. We discussed the undergraduate curriculum in physical sciences, which covers five years of study and such a multitude of difficult subjects that, it seemed to us, only the most talented students could hope to complete it. On the other hand, we were told that the admission selection is so strict, particularly in physics and mathematics, that better than 95% of the entering students successfully complete the course. We were also told that the most distinguished students (upper 5%) usually receive bids, before graduation, to join one institute of research or another to pursue further work towards the doctorate, and so they have a measure of choice as to where to go after graduation. The remainder of the students, not so fortunate to receive bids, will be sent to wherever they will fit best as determined by established committees of the Academy of Sciences.

The highlight of our visit to the Soviet Union was, of course, the

trip to the Scientific Center or Academic City (Akademgorodok) of Novosibirsk, in the heart of Siberia, where we participated in a "Symposium on the Physics of Shocks in Plasmas" which was held at the Institute of Nuclear Physics, 1 to 5 August 1967, under the sponsorship of the Siberian Division of the Academy of Sciences of the USSR. Attendance at this Symposium was by invitation only and comprised some 90-odd delegates, one-third from foreign lands, one-third from the USSR (but outside Novosibirsk), and one-third from the host Institute. Below we present a few remarks of a general character concerning this Symposium, together with our conclusions, but the interested reader will find a fuller account of the proceedings in a forthcoming Conference Report.

Novosibirsk was founded where the Trans-Siberian tracks bridge the Ob River, roughly half-way between Moscow and Vladivostok, a good seven time zones to the east of the Greenwich meridian. It is Russia's largest city east of the Urals, with a population well in excess of a million inhabitants, which since WWII has become one of the strongest industrial centers of the Soviet Union. The Academic City itself, which ten years ago was merely in the planning stage, is today an engaging community of 30,000 people living and working in a village that was literally hacked out of the raw taiga, the virgin forests of spruce and birch trees. Some 25 km to the south of Novosibirsk proper, this community has risen on the shores of an artificial reservoir that was formed by damming the Ob River when the huge hydroelectric plant of Novosibirsk was built, also ten years ago. In this way was formed the Ob Sea, 125 miles long, 50 miles wide, with several islands, and with an artificial (scientifically designed) beach with sand brought all the way from the shores of the Black Sea, the "Crimea of Siberia" as the local residents are wont to call it.

The whole development is extremely impressive. The village itself is reminiscent of a modern US Midwestern town or campus-like community, except that it is endowed with great scenic beauty. In the outskirts there are private homes on large plots in the forest, served by quiet, winding streets leading to the center of town with its modern apartment buildings surrounding the avenue of institutes, which is dominated by the Institute of Nuclear Physics. Here we find the Faculty of Sciences of the new University, with some 80 to 90 professors and several hundred students, and the 20-odd separate institutes of research: nuclear physics, hydrodynamics, mathematics, chemistry, geology, biology, genetics, cytology, etc., as well as the humanistic Institute of Siberian Affairs and the recently created Siberian Computing Center.

At the modern airport of Novosibirsk we were met by Prof. Roald Z. Sagdeev and some of his colleagues, who together had organized the Symposium we were attending. Sagdeev was the first "candidate" to be awarded the doctor's degree (under G. I. Budker) at the Academic City of Novosibirsk. He has risen rapidly to become Correspondent Member of the Academy of Sciences of the USSR, Dean of Physical Sciences at the new University, and Head of the Division of Plasma Physics and Controlled Fusion at the Institute of Nuclear Physics. Sagdeev is typical of the "young science sophisticates" who seem to populate the new scientific center. They are energetic, enthusiastic, and full of optimism for the scientific course of their new venture. Together with young (28 years old) A. A. Galeev, his most valued experimentalist, and V. I. Karpman (brilliant doctoral student of V. L. Ginzburg), his equally valued theoretician, Sagdeev has built up a research team that is universally recognized in the world of plasma physics as one of the best in their age group.

Upon arrival at the Academic City we met Prof. Gersh I. Budker, 1967 Lenin Prize winner, Academician in Charge of the Siberian Division of the Academy of Sciences of the USSR, and founder and Director of the Institute of Nuclear Physics, our host institution during the Symposium. Budker is a renowned nuclear physicist, well known in the US principally for his work on colliding beams. About seven years ago Budker and S. N. Rodionov conceived the design and construction of a proton-antiproton accelerator, a most daring project of colliding beams of protons and antiprotons which could produce energies up to 2500 BeV (or more than

10 times the projected energy of 200 BeV for the US accelerator being built at Weston, Ill.). The Novosibirsk machine, presently under construction, covers an area of two city blocks, and is expected to become fully operational by 1970 or 1971. At the time of the Novosibirsk Symposium, Budker made a strong bid to have the next International Conference on Controlled Fusion (which is usually held every three years: 1958, Geneva; 1961, Salzburg; 1965, Culham) at Novosibirsk in August 1968. Apparently this is going to be so, as announced by Dr. L. Agnew, Director of the IAEA (Vienna), in Stockholm two weeks later.

Returning now to the Symposium itself, we note that there were a total of 42 papers presented in four days, which altogether made for leisurely presentation and ample time for discussion, although the frequent need to translate from Russian into English or vice versa slowed the proceedings a bit. Of these 42 papers, 23 came from Soviet scientists and 12 from the US. The remaining nine papers were distributed among the UK, West Germany, France, and Italy. Of the 23 Soviet papers

seven came from Sagdeev's group at Novosibirsk, nine from the I. V. Kurchatov Institute of Atomic Energy in Moscow, and the balance of seven from various institutions ranging from Leningrad to Tbilisi in Georgia. Although the main theme of the Symposium was plasma shocks in general, there seemed to be a great deal of emphasis on so-called collisionless shocks. A brief appraisal of the Soviet contributions would allow us to conclude that they excel in the whole matter of turbulent heating of plasmas and that they are rapidly developing the technique for creating collisionless shocks. It also appears that they are quite advanced in toroidal field and orbit calculations, and that they have made most commendable progress in the theory of turbulence in plasmas. Finally, from the practical point of view, it is clear that the Soviet experiments have demonstrated the potential value of shock heating for controlled fusion purposes. (Alfredo Baños, Jr.)

POLYMERIZED WATER?

June 1968

Dr. Boris V. Deryagin (Director of the Department of Surface Phenomena, Institute of Physical Chemistry, Academy of Sciences of the USSR, Moscow) has from time to time come up with thought-provoking discoveries which are usually related to surface phenomena. He has demonstrated that in some fluids viscosity may show a significant augmentation near solid surfaces, with the effect extending out further than 100 Å in special cases. He has also weighed the molecular attractive force between flat and lenticular bodies as their distance of separation has been made very small. But now he has outdone himself in that he seems to have polymerized water. This discovery has been greeted with skepticism outside of Russia. However, in a recent visit to Britain he has won some scientists

over to his side. British Unilever Laboratories have confirmed his work in part, and Prof. J. D. Bernal (Head, Crystallography Department, Birkbeck College) is undertaking research on the structure of this new form of water, starting with samples brought by Deryagin himself. The material is formed by carefully controlled condensation of water vapor in capillary tubes a few microns in diameter. Its density is 40% greater than that of ordinary liquid water at room temperature, and its boiling point is over 200°C. More astonishing, it does not freeze at all, but goes glassy at -50°C. Its molecular weight is said to be 72, which would suggest the formula $(H_2O)_4$. At the moment no one knows how four water molecules could latch up into a

stable clump, but experiments show that the substance can be heated to 800°C without converting it back into regular water. When mixed with $(H_2O)_1$, the heavy form separates out at modest temperatures, which implies limited solubility. One may boil off the ordinary water from the mixture, leaving the heavy phase intact. Viscosity is said to be 15 to 20 times that of ordinary water.

So far Deryagin has only made small amounts (say, a few cubic millimeters), but he has hopes that a little engineering will make possible the production of larger amounts.

One may speculate as to its potential uses; but more information is needed before predictions will be meaningful. For example, if the agglomerated water shows the same high specific heat and high heat of vaporization as ordinary water, it would be attractive as a power cycle working fluid. If it is non-corrosive, it may make an ideal heat transfer medium. More important than this is its significance theoretically. Since no one had predicted this form of water, the theoretical unraveling of what has gone on will undoubtedly lead to new understanding of molecular attractions.

For those who are interested in looking further into the phenomena, Deryagin has published an English account of his earlier experiments on

water under the deceptive title, "Effect of Lyophile Surfaces on the Properties of Boundary Liquid Films," . Discussions of the Faraday Society, No. 42, 1966. He does not say much about the altered water and only notes in the abstract that "there is also discussed the direct experimental proofs of the ability of glass and quartz surfaces to change the physical properties of many polar liquids to a great depth." In the paper the apparatus is described as a chamber with an isothermal jacket, capable of being evacuated. The lower wall of the chamber bears a well which can be filled with water and maintained at a temperature lower than that of the jacket. In this way vapor pressure is held at a level below the saturation vapor pressure. Even so, if an empty quartz tube of 1 to 2 micron diameter is placed in the chamber, condensation will ultimately take place inside the tube, and the condensate will show markedly different properties from ordinary water. Although Deryagin attributes the difference in properties to wall effects, it is entirely possible that his experiment has only served to separate out a trace component that was present in the original water, and which was preferentially condensed in the tube.
(R. A. Burton)

A SECOND LOOK AT SILICON NITRIDE

November 1968

One year ago my colleague, Ralph Burton, visited Mr. N. L. Parr at the Admiralty Materials Laboratory (AML), Holton Heath, Poole, Dorset. At that time Parr was deeply engaged in the development of silicon nitride, Si_3N_4, and he was convinced that this was a material of the future. Burton's article was published in ESN-22-2, p. 26 and was very enthusiastic regarding the potential of Si_3N_4. In the intervening year Parr has moved up to the Ministry of Defence and the Si_3N_4 work has been continued by David Godfrey; much has been accomplished toward securing

statistical strength values over a wide temperature range, toward improved processing, and toward practical testing of this artificial material in many of the technological realms for which it had been touted. It is now possible to present a more balanced picture of the properties and potential usefulness of this material.

First, it must be emphasized that it is possible to prepare solid Si_3N_4 in several ways and that the properties of the product are dependent on the method of preparation.

The highest strength results from hot-pressing the pre-reacted powder. In this way bending strengths of 60-70,000 psi are observed when the theoretical density of 3.2 gm/cc is attained. Two facts must immediately be added. Some small amount of MgO (1-2%) is usually added to such materials to act as a binder and to aid in the hot pressing. Since MgO has a density of 3.6 gm/cc, a hot-pressed compact of Si_3N_4 (MgO) may exhibit a density of 3.2, yet still contain some small percentage of voids. It is also true that the temperature of testing should always be indicated when quoting the strength properties of (brittle) ceramics. In the case of Si_3N_4 the properties are essentially independent of temperature in the range 20-1200°C (regardless of the method of preparation). Recent studies have shown that the fall-off in strength for these materials is a factor of about 1/3 on going from 12-1500°C.

Si_3N_4 sans MgO, but perhaps containing the carbonaceous residue of an organic binder, may be prepared by die pressing, slip casting, or extrusion of Si powder. The subsequent firings to remove the binder and to obtain the chemical change were described in the previous article. The result is a reaction-bonded product with a density in the range 2.2-2.65 and transverse strengths from 17-29,000 psi. The strength is roughly proportional to the density: the pressed materials show the higher densities and consequently, strengths in the upper portion of the band.

Si_3N_4 may also be prepared by flame-spraying Si onto a salt-coated steel die to generate a complex shape. Soaking in water dissolves the salt and allows the Si shell to be removed. The flame-sprayed Si is lightly machinable as sprayed: several separately prepared components may be welded together by additional flame-spraying. When flame-sprayed Si is reaction-bonded, it will attain a density in the range 2.6-2.85, depending on the flame-spraying conditions selected. The highest bending strength measured for this material is 44,000 psi; more usual values are in the range 30-35,000 psi. Taking together 98 tests of reaction-bonded Si_3N_4 produced by several methods, but all showing densities in the range 2.6-2.85, one

obtains an average strength of 25,000 psi (at 1200°C).

The creep resistance of the hot-pressed material is not good; this is believed to be due to the added MgO and other impurities which have *apparently conferred some time-dependent plasticity to the grain* boundary regions. There does not appear to be any plastic deformation prior to fracture in short time tests up to 1200°C. The creep behavior may be improved by the addition of SiC as a dispersant. Since the Plessey Company have controlling patents on hot-pressing Si_3N_4 with additive MgO, Lucas have been studying the properties of hot-pressed high purity material. They are able to produce specimens none of which fail at less than 100,000 psi; the maximum strength thus far attained is 140,000 psi. They do not know why they are able to attain such high strengths.

Silicon nitride has two virtues which make it a stand-out ceramic; an extremely small coefficient of thermal expansion (about 2.5×10^{-6} per °C) and a near-zero dimensional change upon reaction processing. Let us consider the import of these two facts, in turn.

A material with low thermal expansion will, in general, have a high thermal shock resistance because it develops relatively small thermal stresses in a temperature gradient. The thermal expansion of Si_3N_4 is about 1/3 that of Al_2O_3, a typical refractory oxide. Hot-pressed Si_3N_4 also shows quite reasonable thermal conductivity, allowing it to dissipate a thermal gradient, thus reducing the danger of thermal shock over the longer term. The precise values of thermal conductivity as a function of density are not well known and are now being determined at AML. Even with this uncertainty it is apparent that the thermal shock resistance of Si_3N_4 is outstanding among ceramics.

Because only a very minor amount of sintering shrinkage occurs at the nitriding temperature, precision fabrication of parts without final grinding is feasible. The 22-23% volume change on reaction is apparently all accommodated in the voids. In fact, AML believe the nitriding

reaction takes place in the vapor phase between SiO and N_2. Because there is no densification by sintering during the reaction, the material ends up with no measurable residual stresses. This fact may account for the relatively good properties exhibited by this medium density material. At this time AML are making 17-inch-diameter discs which show a total shrinkage of 0.008 inch on reaction-0.05% dimensional change. This characteristic should also be exploitable commercially.

Typical areas of application which are being explored make use of the two virtues described above and the high resistance to oxidation shown by Si_3N_4 (essentially unaffected to 1200°C due to the formation of an adherent glass). Included are static and dynamic turbine and reciprocating engine parts, heat exchanger structural elements, high temperature gas bearings, and parts requiring contact with molten Al.

When Si_3N_4 is polished to a 5 microinch surface, the room temperature self-coefficient of friction is about

0.02 - the same as an oil lubricated bearing! This rises to ~ 0.07 at 400°C. I saw an unpolished air bearing made with 0.001-inch clearance operating at red heat.

Plessey have produced 6 x 6 x ½-inch hot-pressed tiles for evaluation as a lightweight body armor. Preliminary tests indicate these tiles will fracture an armor-piercing 0.30 bullet.

Because of its thermal stability, thermal shock resistance and low reactivity with Al, this material is excellent for molds, for precision and pressure die casting for Al and for valves to control the flow of molten Al. Oh yes, it is also an excellent crucible material in which to melt plutonium!

On balance, I believe that the developments of the past year have in no way detracted from the early promise shown by this ceramic material: it looks like it is here to stay. (Harry A. Lipsitt)

A SWEDISH UNIVERSITY SPINOFF

April 1969

In Europe one encounters quite a lot of discussion on how a small country should channel its efforts in research and technology to best suit the national needs. In Sweden a closely coordinated effort extending from university research to commercial manufacture is underway which appears to be very well conceived. This came to my attention during a recent trip to Stockholm. I found it most interesting to hear and witness some aspects of it, and perhaps some readers who are not already aware of it would be interested in a brief account.

The visit in question was to the Royal Institute of Technology (RIT) whose electronics research program is well known. Prof. Bertil Agdur of RIT has for a number of years been carrying out highly-regarded research in microwaves and plasmas, and I believe at the beginning of this decade was one

of the youngest professors in the field. RIT forms the strong academic base for the new effort we are considering here. The second major factor in the overall effort is the Institute of Microwave Techniques at RIT, which operates as a non-profit institute under a board of directors, with some 55 people financed from government sources with funds having greater than year-to-year longevity. The third part of the present story, which has only recently been put into operation, is Scandinavian Process Instrument Company (SPI), a profit-oriented corporation. In this venture the stockholders are Agdur and two large Swedish concerns, Incentive Corp. and Consumer Corp., involving worldwide connections and combined annual business exceeding some half-billion dollars.

Transfer of a research result into commercial development can be accompanied by transfer from the RIT to SPI of some of the people involved in the research. It is encouraging to this writer to see the determined application of principles of this kind, which are known, for example in the US, to be effective in avoiding disastrous communication gaps that so often interrupt the flow along an "innovative chain," to use a currently popular expression.

The first item to be fed into the pipeline has two characteristics which I feel to be important. It involves a field of expertise in the Institute, and is applied to a product of direct importance to a major Swedish industry. It is based on the art of dielectric measurements at high frequencies, and is applied in the forest products industry, to the measurement of moisture content in paper during commerical production.

In the new instrument which they have developed for this purpose, paper in wide strips moving through a mill is subjected to a bank of micro-wave cavity resonators whose rf fields pass through the paper. Varactor-tuned multiplier chains ending up in X-band have been developed in the Institute and are being adapted to these systems. A favorable feature of this application is that relatively small tuning ranges are acceptable and a high degree of tuning linearity is not required.

In the beginning there was no waiting market, and industry had to be shown and sold by determined effort and free installation and demonstration of experimental field apparatus. These pilot trials are said to have been successful and to have produced the desired results. Subsequently SPI has opened its doors to undertake its first product, involving final development, production and installation of such units in Swedish paper plants.

It appears to me that the right steps have been taken to develop a useful enterprise with excellent hopes for success, and that this example could provide ideas and inspiration to others in small countries.
(H. J. Shaw)

NORWEGIAN SEISMIC ARRAY (NORSAR)

October 1969

Thirty-two foreign visitors took advantage of a one-day tour, on the 23rd of August, of a portion of the new seismic array presently under construction in southeastern Norway. The visit was a scheduled field trip preliminary to the 6th UMC Symposium on Geophysical Theory and Computers in Copenhagen. The objective of the Norwegian organizers is to familiarize outside scientists with the existence of the network and of its capabilities as a research tool, particularly for problems of seismological classification. It is recognized that the research potential of the facility cannot be realized unless seismologists from other countries and institutions can be made interested enough to work on the kinds of problems suitable to the vast amount of data that will be generated – a not unfamiliar problem. The ultimate goal is to make NORSAR a sort of European center for seismological array research. An initial possibility is a modification of the Finno-Scandinavian seismic network, so that it can be treated as a continental array.

The excursion schedule proved to be a tight one in spite of the fact that the bus left the hotel at 7:30 AM and deposited the group at the boat dock at 5:00 PM, just in time to board the night boat to Copenhagen. Nonetheless, our Norwegian and American hosts did a fine job in introducing us to this new research facility. We visited the completed central terminal vault of the subarray at Nes, near Hamar, and the central computing center at Kjeller.

The history of NORSAR began in May 1967 when the USA proposed to the Norwegian government the construction of a seismic array of the LASA type in Norway. At the end of 1967 three small experimental arrays were in operation in the southeastern part of Norway, the data from which indicated to the planners that this granitic terrain was suitable for the siting of a large seismic array. In May 1968 the Norwegian Parliament agreed to the construction of such an array on Norwegian soil. They hope that the data from such an installation may help to demonstrate the feasibility of seismological monitoring of teleseismic underground nuclear tests and will consequently be a significant contribution to the completion of a nuclear test ban. ARPA is financing the construction and operational costs of the array, while the Kjeller Computer Installation (KCIN), acting as local subcontractor to the Norwegian Defence Research Establishment (NDRE), has the job of preparing and subsequently operating the Data Processing Center. The basic contract is between NDRE and the European Office of Aerospace Research, USAF. IBM is providing data processing equipment and software. Preliminary staffing was completed by the end of 1968 and training of personnel is proceeding apace.

NORSAR consists of 22 subarrays, each containing six SP seismometers and a three-component LP seismometer (the one exception is the Øyer subarray which consists of 12 SP instruments and which has been in operation since January 1968). The array diameter is around 110 km. The digital sampling rate will be 10 Hz for SP instruments and 1 Hz for LP seismometers. The standard data tape format will be 9-track, 1600 BPI. Much of the field work has been completed, i.e., drilling of boreholes, construction of subarray central vaults, cable trenching and installation of some seismometers. As may be expected, the cost of drilling and trenching in granite is an expensive operation. The cost of the installation phase is expected to exceed $5M, exclusive of instruments and electronics. The seismometers are furnished from the LASA array where the number of installed instruments has turned out to be excessive. The new computer hall was completed in June and the IBM computer was installed. By the middle of 1970 the remaining

seismometers will be installed, final checkout performed, and NORSAR is expected to be operational. At that time the Royal Norwegian Council for Scientific and Industrial Research will assume responsibility for the operation of the system. The Norwegians stressed that this is in no way a military operation and that all data will be freely available. Just how the funding for the operation of the system after mid-'70 will be accomplished is apparently not yet established. This would be a very large cost for a country such as Norway - they obviously expect some help.

One major difference between LASA and NORSAR is that the latter is surrounded by great basins of water which could, of course, affect the character of the noise. Data from the SP Øyer array has been studied by seismologists from the University of Bergen who find that below 0.7 Hz the seismic noise is dominated by sources in the Atlantic and on the Norwegian coast. The noise has a dominant direction of propagation from strong lows in the Atlantic with a velocity of around 3-4 km/sec. Lows in the Baltic contribute higher frequency noise. The noise coherence between sensors is much higher in the direction of dominant noise propagation, especially if a strong Atlantic low is close to the coast. Strong local winds have little influence in the micro-seismic range.

The foreign visitors were from the following nine countries: USA (9), UK (6), Sweden (4), Czechoslovakia (4), USSR (3), Denmark (3), (3), and one each from Nigeria, Finland, and Israel. Norwegian scientists involved in this program include Major Ø. Brandtzaeg, Head of NORSAR; A. Lillegraven, physicist of NDRE; S. A. Øvergaard, Director of KCIN; E. S. Husebye, NORSAR research seismologist; and O. Steinert, NORSAR research physicist.

The overnight boat trip to Copenhagen was a stroke of genius on the part of the planners because, in addition to being very pleasant and relaxing, it provided a good opportunity for the participants to become better acquainted.
(R. E. Hanson)

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September 1970

Trinity College, Dublin, founded in 1591, and the University of Dublin are synonymous, while University College, Dublin, founded in 1909, is one of three colleges of the National University of Ireland, the other two being University College, Cork, and University College, Galway. Trinity College has 4000 students, while University College, Dublin, has 9000. Trinity College is located in the heart of the city in a group of old buildings, some of which are outstanding examples of 18th century architecture, while University College, having outgrown its old buildings in the city, has partially moved to new buildings in the outskirts.

Trinity College - Rather heavy teaching schedules tend to reduce research productivity, but some high-grade research on dielectrics has been carried out by two brothers in the Engineering School of Trinity College. Dr. W.G.S. Scaife, Senior Lecturer in Mechanical Engineering, who started as an electrical engineer, has published interesting theoretical work and has apparatus for accurate dielectric constant measurement. Prof. B.K.P. Scaife, Associate Professor of Engineering Electronics, works in a laboratory made out of an old house adjacent to the College campus. For nearly ten years, he has been measuring the dielectric constant of liquids as a function of pressure. Other investigators have reported an apparent small decrease in the dielectric polarization with increasing pressure. Scaife has observed small variations with pressure, but has been gradually improving his apparatus and says that each improvement in the apparatus has brought about a decrease in the change of polarization with pressure. Indeed, at present, his curves show no trend in the polarization with pressure and no variation greater than the probable error of measurement, which is small. This is interesting in its bearing on the problem of intermolecular forces. Carbon tetrachloride, carbon disulfide, and ethyl ether have been measured. Glycerol and eugenol are under investigation. The latter, which has an OH, and OCH_3, and a $CH_2CH = CH_2$ attached

to a benzene ring is specially interesting because of the spectacular increase in viscosity which P. W. Bridgman observed it in (100-fold) when the pressure increased from 1 to 3000 atm. Scaife has been given an old but usable crystal-growing apparatus. For dielectric measurements, the crystals are coated with layers of gold so thin as to be green by transmitted light. The measurements on solids present the usual difficulties encountered by a careful worker.

Dr. D. C. Pepper, Professor of Physical Chemistry, has students working on polymers and, to a small extent, on semiconductors. For the polymer work, his laboratories are equipped with a membrane osmometer, a gel-permeation chromatograph, and a light-scattering apparatus. They are using catalytic oxidation in an attempt to make a high-temperature ladder polymer based on 2,6-dimethylphenol. As the polymeric material which they have obtained is deep orange in color, they are looking for the chromophore. In a semiconductor study, a graduate student is introducing a little nickel or other divalent metal cation into ferric oxide and will investigate the Seebeck effect.

University College - The new buildings of the Faculty of Science of University College, Dublin, are at present the largest complex of buildings in Ireland with a working area of 4-3/4 acres, over 200,000 ft^2, of which 80,000 are occupied by the Department of Chemistry. The academic staff of the Department numbers 21. The Head of the Department is a woman, Dr. Eva M. Philbin, Professor of Organic Chemistry. Dr. David A. Brown is Professor of Inorganic Chemistry, and Dr. David Feakins, an electrochemist, has just been called to the vacant Professorship of Physical Chemistry. Dr. J. Cunningham, one of the most active physical chemists, is leaving to become Professor of Physical Chemistry at University College, Cork. There are two post-doctoral Fellows and 47 postgraduate research students in the Department.

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The problems under investigation by the physical chemists include: reactions of gases on oxide-semiconductor catalysts; photochemically induced reactions on solid surfaces; effects of x-rays, ultraviolet light, and heat on decomposition reactions in solids; infrared and nmr spectroscopy; kinetics and mechanisms of reactions in solution; isotope separation; anomalous dispersion; solution and solid state electrochemistry; nucleation processes in the decomposition of solids. The problems under investigation by the inorganic chemists include: heterogeneous catalysis on transition metal surfaces, metal complexes of donor systems; transition metal alkoxides and mercaptides; vibrational analysis; metal carbonyl chemistry and structural studies; structural and bond theory of organometallic compounds.

Major items of equipment in the Laboratory include: two nmr spectrometers; seven ir spectrometers; a Zeiss PMQ monochromator and detector unit; a Unicam SP-500 spectrophotometer; a Bausch and Lomb spectronic 505; an esr spectrophotometer: an atomic absorption spectrophotometer; an automatic polarimeter; a mass-spectrometer gas analyzer; and four gas chromatographs; a Philips X-ray diffraction apparatus. Auxiliary services are provided by a small machine shop, a glassblower, and an electronics technician.

(C. P. Smyth)

BIOMATERIALS: FAILURES IN ARTIFICIAL LIMBS AND IMPLANTS

March 1971

The Bioengineering and Medical Physics Unit within the School of Medicine, University of Liverpool, was organized about 18 months ago. I had an opportunity to learn a little about it when I visited Dr. D. F. Williams, who received his PhD in Metallurgy from Birmingham in 1968. Associated with Williams is Dr. J.T.M. Wright, a mechanical engineer, whom I did not get to see. Williams' interests are in orthopedic implants and devices. He works closely with Prof. Robert Roaf and Mr. G. F. Osborne, orthopedic surgeons at Liverpool. Wright, who is investigating design and failure of heart valves, works closely with Mr. L. J. Temple, a cardiovascular surgeon. Attached to the group is a registered nurse who has a degree in industrial design and is making use of this particular expertise in the study and design of artificial limbs. As yet, the Unit does not offer degrees, but there are eight third-year undergraduate mechanical engineering majors who are conducting their departmental required research project with Williams or Wright. There are also two research assistants.

With the impetus arising from the thalidomide tragedy, biomechanical laboratories have been directing much effort toward problems associated with artificial limbs and appliances. Some of this research has led to sophisticated, powered artificial limbs, but the number of amputee patients so fitted is relatively small. The majority of patients are fitted with the familiar simple devices. The number of these patients who find it necessary to return to the fitting centers for repairs is shocking. With the cooperation of Mr. J. C. Brass, FRCS, Medical Officer at the Artificial Limb and Appliance Centre, Liverpool, a survey of failures in artificial limbs showed two primary kinds of failure: corrosion of sockets, and fracture of supporting members. This would indicate that both material selection and design are to be criticized.

With regard to materials selection, it is known that aluminum-copper alloys are not as corrosion resistant as pure aluminum. Internal stresses produced by the shaping operations often act as nucleation sites for stress corrosion cracking. Williams has observed numerous radial intergranular cracks at the ankle of an

artificial limb which had been in use six years and had been made of an aluminum-copper alloy. In a recent lecture to The Institute of Metals he noted that the United Kingdom remains one of the very few countries which continues to use aluminum alloys for this purpose.

The above-mentioned survey also revealed that seven children out of about 100 fitted with artificial limbs returned for a total of 114 repairs. Investigation indicated that design is the primary fault. Fractures of girdles and struts always occurred at the stress concentrations provided by rivets, holes and sharp corners. Apparently in the design of braces and artificial limbs for thalidomide children, little consideration is given to their abnormal gait which produces very high bending moments at various places in these devices. It is here that failure usually occurs as a result of high-strain, low-cycle fatigue.

In another study Williams has examined 130 damaged orthopedic implants removed from patients in the Liverpool area. About one-third of the implants were titanium, several were of the chrome-cobalt variety (Vitallium), and the remainder stainless steel. As has been found in all studies so far, where trouble has occurred, stainless steel seemed to be the material in use most often. For these studies, Williams has employed all the excellent metallurgical diagnostic facilities available in the Materials Science Department of the University, including scanning electron microscope and a new quantitative electron probe micro-analyzer. (In fact, while I was visiting in the latter department, some tissue taken from an area adjacent to a titanium implant was being examined for titanium take-up by means of the micro-probe.)

About 50% of the stainless steel implants which had been removed showed some degree of corrosion. For some time it has been known that 2.5-4.0% molybdenum is necessary to provide corrosion resistance to saline solutions. ASTM and the British Standards Institution (since 1958) recommend only molybdenum-bearing stainless steel for implants. Williams has examined implants used within the last few years containing no molybdenum whatever. In some instances, components of the implant had amounts of molybdenum ranging from 0 to 2 or 3% - leading to corrosive attack. Williams also has found a variation of the nickel content. Too low a composition of nickel renders these steels liable to a stress-induced martensitic transformation on cold working. Another metallurgical parameter that he finds to be carelessly allowed to vary is grain size - this was true in several titanium screws and plates.

Williams also calls attention to the need for better design of orthopedic implants. Weight bearing may cause excessive pressure between the individual components of a device leading to corrosion at the point of contact. In other devices a sliding contact is used which can lead to erosion as well as corrosion. Some devices show abrupt changes in cross section, sharp corners and even notches, all examples of poor mechanical design.

The general findings of Williams correspond to that of others. He emphasizes that many of the causes of failure of implants have been known for years so that it is time that the surgeon was provided with the best material and design available.

Williams and Wright have recently received a grant from the National Research and Development Corporation to study design of implants. In their study they will pay particular attention to the problem of interfaces and will try to eliminate all possibilities of crevice corrosion, fretting corrosion, galvanic corrosion and fatigue. (E. I. Salkovitz)

SUPERCONDUCTING MOTOR GOES INDUSTRIAL

March 1971

International Research and Development Company, Ltd. (IRD), a member of the Reyrolle-Parsons Group, is the largest UK-owned contract research institute. In 1963 the Ministry of Defence (Navy) [MOD(N)] sponsored at IRD a study of the feasibility of large superconducting motors, and in 1964 a development program was initiated. In June 1966, IRD operated a 50-hp homopolar superconducting motor operating at 2000 rpm. This development led in May 1967 to additional funding by the National Research Development Corporation (NRDC) for the development of a 3200-hp, 200-rpm prototype superconducting homopolar motor which would be suitable for commercial applications (see ESN 25-2;50). The motor was built and successfully tested at IRD in October 1969 (ESN 23-10;274). Due to limited facilities the motor could not be tested at full power. In order to run the motor at full power and to do long-time reliability studies it was arranged to have the motor installed at the Fawley Power Station, where it will drive a main cooling pump for a 500-MW turbo-alternator. As a result of this, the motor is now known as the "Fawley" motor.

At Fawley a number of setbacks have occurred, none of which are directly attributed to either the design or operating characteristics of the superconducting innovations. Labor disputes in the power industry produced some delay, but by far the most time consuming setbacks have resulted from a faulty compressor in the helium liquefier. I am told that more reliable compressors are available and that this problem should not occur in more advanced systems.

As a result of MOD(N) interest it is only natural that IRD and NRDC stress the potential application of superconducting motors and generators to ship propulsion.

On 18 February, Dr. Levedahl and Dr. Quant of the Naval Ship Research and Development Laboratory (NSRDL) at Annapolis, Mr. W. Sheer, NAVSEC and this writer visited IRD at Newcastle upon Tyne to discuss various problems and designs associated with rotating superconducting machinery. While this discussion was taking place IRD personnel at Fawley were doing their best to have the motor operating by the following morning. It seems as though the compressor had been very recently rebuilt or overhauled for the thirteenth time and the motor was being cooled to operating temperatures.

On the morning, 19 February, the group visited Fawley. Although insufficient helium was available to run the motor at full load, the decision was made to demonstrate the fact that the motor would indeed drive the pump. With Tony Appleton at the controls and 100 A flowing in the field coil (full load requires 720 A), the motor was started and successfully drove the huge water pump at about 60 rpm (motor is rated at 200 rpm). Thus the visiting scientists and engineers were privileged to witness the first industrial function ever performed by a superconducting motor. The huge grins upon the faces of Dr. H. Rose and Appleton as well as the other IRD personnel were very contagious. Appleton ran a number of control tests on the motor and everything worked perfectly.

Mr. Tanner and Mr. R. Evans of NRDC were particularly happy, and all that remains to be shown now is that the motor, under full load, does, indeed, have long-time reliability. Rose was particularly liberal in his praise of Mr. S. Bolshaw [MOD(N)] without whose efforts and foresight the current program would not have been initiated and supported. Rose emphasized the relatively short time span involved in (1) the enunciation of the high field properties of Type II superconductors (1961); (2) commercial availability of stabilized multi-filament superconductors (1965) and (3) the industrial application of a superconducting motor 19 February 1971.

If the Fawley motor or more advanced designs of large superconducting motors pass long-time reliability

studies, and if one can demonstrate that shipboard helium liquefication plants are reliable, the future use of superconducting motor-generator-sets for ship propulsion will be assured. (R. A. Hein)

MOLECULAR BIOLOGY IN SOUTHERN FRANCE--AN UNPOLISHED GEM OF A LAB

February 1972

Generally speaking there is no special trick in locating prominent scientific centers in Europe--anymore than in the United States. Most American scientists and engineers can probably name at least half a dozen off the top of their heads even if they have never left home. But to locate the small, good, up-and-coming centers is not so easy, so for this reason I am pleased to publicize the Department de Biochemie Macromoleculaire (DBM) in Montpellier which I visited (almost by accident) in November.

From Marseilles (where I had just seen the Laboratory of Microcalorimetry) by train takes less than two hours traveling through countryside very reminiscent of Southern California. Montpellier itself is a pleasant small city of about 100,000. Unfortunately, the central area is rather run down, as are many older European cities, but good restaurants and interesting buildings easily compensate for that shortcoming. Among its oldest buildings are the Cathedral of St. Pierre and the contiguous Faculty of Medicine--both date from 1364--making it one of Europe's oldest medical schools. While in Montpellier I learned that in bygone days the medical faculty had considerably more power than it does today including for example, the unique privilege of being able to ride their horses into the cathedral nave! (Presumably the right hasn't been extended to the Mercedes Benz cars they are more likely to own today.)

A University tradition, which started with the Medical School, is still strong and students now constitute a full sixth of the population. But the University is now located in colorful modern glass and steel buildings in a very pleasant suburb of Montpellier surrounded by lovely rolling hills and, most pleasant of all, hundreds of private villas. (Nowadays most continental Europeans live in tall, sterile apartment buildings.) The DBM laboratory I will describe is located in a rambling, two-storey, ranch-style building on a hill overlooking the University area.

Most of my time at DBM was spent talking with Dr. H. Ohlenbusch who has been helping Zuckerkandl since 1966 to build the laboratory into an American style department. (An American departmental plan differs from the usual authoritarian European arrangement which has one strong boss-- the "Herr Doctor Professor"--providing complete direction for a group of subservient staff members.) Although neither Ohlenbusch nor Zuckerkandl are Americans, they both had spent several years at Cal Tech and were able to convince the CNRS (Centre National de Recherches Scientifique) that the departmental model they saw there should be tried in France--at least on an experimental scale in Montpellier. I think that it is very much to the credit of both Zuckerkandl and CNRS that he, as a foreigner, was able to sell them the idea.

Considering the relative size of the CNRS and the DBM, one might think that Ohlenbusch's and Zuckerkandl's troubles would be over once they received a go-ahead from the CNRS. But no, for even with the best of intentions at the top of the CNRS the organization is so bogged down in bureaucracy that it is difficult to do anything through it. Thus, it took several years to get funds for their building during which time they occupied some of the acres of empty laboratory space in the nearby "scientific desert" of the University of Montpellier. (The quoted phrase came from two independent sources in Montpellier whose names do not appear in this report!) Finally, when money for their new building was forthcoming,

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they did not receive a penny for equipment. The following year the building was equipped by the CNRS but then, nothing was provided for maintenance so that even the cost of a blown fuse would have to come out of someone's private pocket! By now the financial situation is much improved since a small amount of uncommitted money has been obtained from the French Medical Research Council, the Volkswagen Foundation, etc. (Considering the international character of this laboratory, it would be a logical candidate to receive financial help from the European Molecular Biology Organization, EMBO. But to date EMBO has not come through with any support.)

In addition to their financial troubles Zuckerkandl and Ohlenbusch have had numerous other difficulties which, for the most part, we no longer have in the States. They discovered, for example, that the French analytical grade chemical reagents were of such poor quality as to be unusable. Also, pipettes, one of the backbones of all biochemical work, were not properly calibrated. As one might imagine, they lost a great deal of time before tracking down these sources of error. Electric power cuts are another problem at Montpellier where they average two a month. Recently Ohlenbusch has been making an inventory of the relative sensitivities of their equipment to short- and long-term power failures so they can install suitable emergency supplies.

Another serious, non-scientific, problem for the laboratory has been the presence of a few extreme left-wing technicians among the laboratory personnel. Very briefly, as I understood Ohlenbusch's comments, these individuals have generally been opposed to having a liberally organized laboratory structure with, for example, everyone on a first-name basis--they apparently preferred the old authoritarian discipline. In addition they have caused trouble by insisting on overly clearly defined, separate responsibilities for various laboratory technician positions, this means in practice nobody can "pitch in" to help clear up a problem if it isn't officially part of his job. The innocent days of working in science because you like it are obviously an ideal lost while making the transition from little science to big science! Ohlenbusch told me that for several years he tried discussing these

questions with the agitators but finally gave up in disgust at their total unwillingness to compromise on any issue.

But, despite all of these troubles the laboratory now has all of the ingredients to become a first-rate scientific center. These ingredients include real enthusiasm, ability and esprit de corp among the 15 professional permanent and visiting staff combined with a very well-equipped laboratory. What is needed now is a few years' time free of serious financial worries, perhaps a little more cooperation from their technicians and as many visiting scientists as possible to provide additional stimulation. (Americans are welcome!)

Till now I've said nothing about the interests of the laboratory, though from its name, Department of Macromolecular Biochemistry, you would be correct in guessing the general interests of the staff members center on proteins and nucleic acids. To be more specific three of the staff, Pechere, Previero and Zuckerkandl, are interested in general questions of protein structure and evolution. Pechere's work has been concerned with the structure, function and evolution of parvalbumins and acylphosphatase. Previero's group has been interested in polypeptide synthesis, specific polypeptide degradative procedures and the study of enzymatic mechanisms by introducing reversible chemical changes into enzymes. Another group headed by Zuckerkandl is interested in the theory of evolution of information-carrying macromolecules, the structure of fish hemoglobins and the role of ion balance in the synthesis of fetal and adult hemoglobin.

In addition there are four staff members with an interest in control mechanisms, genetics and differentiation. These include Grantham who is studying cell-free protein-synthesizing systems and Köhler who is looking at the mechanism of messenger RNA transport from the nucleus to the cytoplasma. Matioli is interested in the mechanism of red cell differentiation and in defective red cell genetic illnesses and finally Ohlenbusch himself (when he and Zuckerkandl are not occupied with administrative problems!) is working on the activation in vitro, and isolation of, a hemoglobin gene and the

physical chemistry and biology of nucleoproteins in normal and cancerous cells.

As I have already mentioned the DBM is very well equipped. This equipment includes all of the usual biochemical and biophysical hardware such as an analytical centrifuge, analytical electrophoresis unit, macro- and micro-spectrophotometers, a spectropolarimeter, a low-angle X-ray scattering instrument, a 60-MHz nuclear magnetic resonance spectrometer and an electron microscope. In addition they have worked out methodology for the culturing and isolation of bone marrow, blood, HeLa and KB cells and numerous cellular fragment isolation procedures, e.g., for cell nuclei, ribosomes, "informosomes," etc.

In summary I would say that, with any luck at all, the DBM should have a promising future and should be a stimulating place to visit and work for anyone with an interest in molecular biology. (John G. Foss)

COMPUTING AT DELFT

February 1972

In December 1971 we visited W. L. Van der Poel, Professor of Computer Science at the Technical University of Delft. Delft is located near Rotterdam and The Hague in one of the most densely populated areas of The Netherlands, the most densely populated country in Europe. Since it is also one of the most heavily industrialized countries in Europe, it is not surprising that the density of high speed digital computers in The Netherlands is also among the highest in the world. They have a mind-boggling array of computers such as CDC 7600s, CDC 6600s, IBM 360s and 370s and others. At the Technical University of Delft, with 10,000 students there are 22 computers, ranging from an IBM 360/65 to an ICL 1905 to a DEC PDP-10 to a large number of PDP-8s and PDP-9s. The IBM 360/65, located within the University's main computer center, has 0.75 million bytes of fast core memory, 1 million bytes of slow core, and two IBM 2314 high capacity disc units. The computer center operates a time-sharing system with 45 terminals and remote-batch processing. Principal languages are ALGOL 60, FORTRAN IV, and COBOL. The ICL 1905 is used for student jobs exclusively, and about 1800 students per year learn ALGOL programming using this machine.

Van der Poel's students are generally advanced undergraduates specializing in computer sciences. They have ready access to a number of minicomputers in Van der Poel's laboratory. The machines include a 16 K PDP-9, a PDP-81, a Programmatics line printer, 5 DEC tape units, 4 discs and 5 teletypes. Attached to the PDP-9 is a Tektronix 611 storage tube display. In addition, a PDP-11/45 with a Vector General CRT display is on order for delivery in 1972. Very few student computer laboratories in the US are as well equipped as Van der Poel's.

The laboratory is put to good use in Van der Poel's Systems Programming and List Programming courses. In these, students learn such languages as LISP, TRAC, SNOBOL and SPITBOL. They are all required to write nontrivial systems programs as part of their training. For example, we saw a demonstration of APL which was written in TRAC on the PDP-81. Another interesting project was the complete simulation of a PDP-81 on a PDP-9. Other student projects included a number of games, an alarm clock displayed on the Tektronix storage tube, and a large number of compilers, assemblers, link editors, loaders and virtual machines. Students emerge from Van der Poel's courses as well-trained specialists in software engineering, equal to any in the US.

Van der Poel is a pioneer in the computer field. He worked on relay

computers in 1947 and designed a number of early computers. These included the PTERA computer which was a tube-and-relay machine built between 1953 and 1958 for The Netherlands Postal and Telecommunications Service. Another early machine was the ZEBRA, a binary computer which was designed in The Netherlands and built by the Standard Telephone and Cables, Ltd., of England. The ZEBRA is one of the first examples of a functional bit-coding machine, a design concept which is beginning to find renewed favor in minicomputers such as the NOVA. Functional bit coding, as the reader might recall, is the idea that the separate bits of an instruction word are used functionally and can be put together in any combination. Micro-programming is almost a standard part of the minicomputers of the 70's.

It is interesting to note that the ZEBRA machine was one of the first to use a system of micro-programming by means of functional-bit coding. Van der Poel no longer designs computers, his main interests being in programming languages now. However, with a strong engineering background, the kind of computer science that Van der Poel teaches is firmly rooted in the practical, rather than the abstract, side.

With eminent scientists as Dijkstra of Eindhoven, van Wijngaarden of Amsterdam, and Van der Poel of Delft, it is not surprising that The Netherlands is regarded as one of Europe's leading centers in the computer sciences. (I. G. Kinnie and F. F. Kuo)

BALONEY AT BESANCON

July 1972

It is always very interesting to see research ideas spring up independently, and this is what I found in Prof. *Jean-Ch. Viénot's Laboratoire de Physique Générale et Optique* at the University of Besançon, France. A student of Viénot, Dr. René Bailly-Salins, had completed his doctoral thesis which was entitled "Laser à Rubis: Etude d'un Milieu Actif à Eléments Multiples et de la Sélection des Modes." In the States this means baloney, a baloney laser that is. Many who have watched the development of this type of laser may use the term *pejoratively* while others may use it descriptively in that the active medium is cut in slices and appears much as slices of bologna.
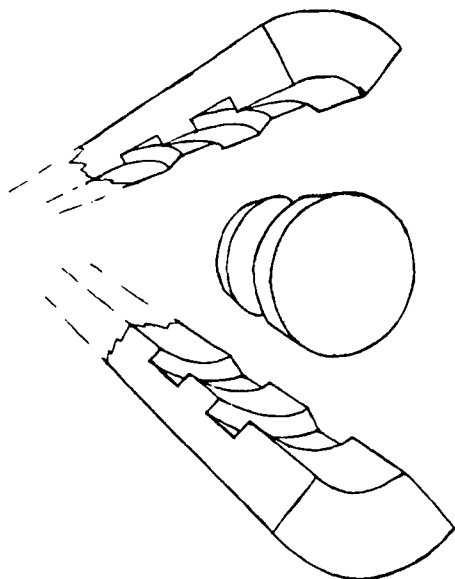
This particular form for a laser had occurred to Viénot sometime around 1965, and he apparently had no idea of similar efforts in the US. But it is not entirely clear that both efforts resulted from the same motivation. The US effort most certainly resulted from the problem of cooling the ruby as higher powers, hence higher diameters, were sought. In Viénot's case, the cooling of the ruby was certainly

appreciated, but the advantage of easing the requirement of crystal size may have been of equal concern. Just as in the US development, technical difficulties in mounting the ruby slices were paramount and in Viénot's case prevented laser action in the first attempts. A mounting technique was finally found which allowed laser action; and the technique, analysis, and operating characteristics of a baloney laser are the subjects covered in Bailly-Salins' thesis.

The laser consists of 20 discs of ruby each 3 mm thick and 12 mm in diameter mounted with 2 mm spacings inside a tube through which water flows. The discs are held between two cylinder sections of glass as shown in the figure. The 20 grooves (only two shown in the sketch) in the cylinder sections are cut with great precision at the Brewster's angle appropriate for the ruby and the coolant. The assembly is then put into a glass (or perhaps quartz) tube which is end-clamped with faces through which the coolant, water, is admitted. There is no apparent attempt to force

the water through the spaces between the ruby discs, and for this reason I had previously questioned whether there may have been some difference in motivation.

Precise construction details are not given in Bailly-Salins' thesis.

The optimum arrangement for the ruby discs is given a great deal of attention by Bailly-Salins. The Brewster angle condition for a birefringent material is analyzed in detail, the optimum transmission geometry is given in great detail, and the threshold as a function of the number of slabs is determined. If the product of the reflection coefficients of the two cavity mirrors be 0.6, the optimum number of discs is found to be 20.

In the long-pulse mode the laser gave close to 1-J output for 1000-J electrical input, gave very reproducible pulse trains, showed linear polarization greater than 96%, and had a line width measured with a Fabry-Perot interferometer of less than 25×10^{-3} Å.

Not part of the thesis but important to the analysis of the laser characteristics is a high-speed rotating mirror camera which has been constructed at Besançon [see Nouv. Rev. d'Optique appliquée 3, No. 1, 3 (1972)]. This camera is useful for laser analysis in

itself and also for laser characterization as it affects results in holography. The camera is unique in that it permits simultaneous recording of both streak and frame pictures on a single 35-mm film strip. The rotating mirror has a useful speed range of 500 to 5000 rps. The characteristics are given in the following table:

STREAK RECORDING

	Mirror Speed rps	
	500	5000
Recording Speed	3.78 mm/ μsec	37.8 mm/ μsec
Duration of Recording	0.665 msec	66 μsec
Image Width	10 mm	10 mm
Spatial Resolution	20 mm^{-1}	20 mm^{-1}
Slit Size	0.1 mm	0.1 mm
Time Resolution	26.5 nsec	2.65 nsec

FRAME RECORDING

Number of Images	120	120
Image Diameter	10 mm	10 mm
Spatial Resolution	20 mm^{-1}	20 mm^{-1}
Framing Frequency	180,000 images/ sec	1,800,000 images/ sec
Exposure Time per Frame	2.78 μsec	0.278 μsec
Time Interval Between Two Images	5.55 μsec	0.555 μsec
Duration of Recording	0.665 msec	66 μsec

The specifications for this camera are not out of the ordinary, but the ability to make both streak and frame photographs simultaneously does allow very interesting applications.

Perhaps it may be somewhat surprising I have not mentioned that work of Viénot which is best known, holography. The group at Besançon

is probably one of the largest in holography and a great deal is going on. Some is related to basic holography, techniques, and speckle analysis of vibrations. Also a great amount of attention is being given to optical processing particularly as it relates to transform techniques. This work seems to be finding its way into the literature quite quickly; so I have emphasized here those two pieces of work which are perhaps not so well known.

The facilities, equipment, and talent at Besançon is really first rate. Prof. Viénot leads a very large group in an institute noted for its great tradition in optics.
(W. J. Condell)

MARINE-BIOLOGICAL MIGRATION THROUGH THE SUEZ CANAL: THE INFLUENCE OF THE CANAL CLOSURE AND CURTAILMENT OF THE NILE FLOW

March 1973

The Red Sea and the Eastern Mediterranean have been separated by the Isthmus of Suez since the Pleistocene period. In Ancient Egypt canals connecting the Gulf of Suez to the south and the Nile or brackish lagoons to the north made shipping possible between the two seas. Only with the construction of the Suez Canal (completed in 1869), however, was a saltwater passage created. This passage presented the possibility for marine animals and plants, elements of the Atlanto-Mediterranean and the Indo-Pacific-Erythrean fauna and flora to penetrate into new regions. This saltwater bridge has been in existence now for over 100 years, and the colonization of the Canal itself and biological movements through this passage has been going on continuously.

Over the years many European scientists, and several expeditions, studied the faunal changes and migrations. Several Israeli marine biologists (especially Prof. Steinitz and Prof. Por of the Hebrew University of Jerusalem and Dr. Oren and Dr. Ben-Tuvia of the Sea Fisheries Research Station in Haifa) have been interested in this phenomenon; and although until 1967 they had no direct access to the Suez Canal itself, they were able to compile data from various outside sources and gain a partial picture of what was going on. In 1967 Steinitz published a tentative list of immigrants via the Suez Canal (Israel Journal of Zoology 16:166-169) and showed that far more marine animals and plants had moved via the Canal from the Red Sea to the Mediterranean than in the opposite direction. He listed the following numbers of species of various groups that have moved into the Mediterranean: two species of marine plants, two sponges, two hydroids, nine polychaete worms, one sipunculid, four copepods, two amphipods, one cumacean, 33 decapods, one stomatopod, one pycnogonid, 20 mollusks, four echinoderms, six ascidians and 26 fishes. Since 1967 the list has been extended to more than 100 species. On the other hand, only a few species of fishes are definitely known to have migrated from the Mediterranean to the Red Sea via the Suez Canal. This essentially unidirectional character of the migration has been known for many years and was previously explained as being due to a prevailing northward flowing current in the Canal. It has been shown, however, that there is no throughgoing current, and there are practically no currents at all in a 40-km segment of the Bitter Lakes. What then have been the reasons for this one-way movement?

The faunal exchange through the Suez Canal has been studied in recent years by a joint Smithsonian Institution-Hebrew University team, and considerable new information has been obtained, especially from the Bitter Lakes and from lagoons and open water of the northern Sinai. Por has recently published a paper in Systematic Zoology [20(1), 138-159, 1971] called "One Hundred Years of

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Suez Canal - A Century of Lessepsian Migration: Retrospect and Viewpoints." In this paper he reviews past and present work and points out that the fauna of the Eastern basin of the Mediterranean is an impoverished fauna of the Western basin. There are several historical and hydrological reasons for this phenomenon which has resulted in many species and genera never establishing themselves in the Eastern Mediterranean. The nutritive capacity of this basin is extremely low, and it can be said that "the Eastern Mediterranean is a zoogeographical 'cul de sac,' a tropical sea undersaturated with an Atlantic-temperature fauna." When the Suez Canal was opened, contact with the Red Sea - a typical tropical sea - made it possible for a zoogeographical equilibrium to be re-established and a start made in filling a peculiar "ecological vacuum" in the Eastern Mediterranean.

Dr. Ben-Tuvia of the Sea Fisheries Research Station has pointed out that most of the presently known Red Sea immigrants are very successful and widely distributed in their new home along the Levant coast. Of the 24 species of immigrant fishes, 13 are now common and 11 are of commercial value. Many invertebrates, such as decapods, gastropods and echinoderms have also become well established along the coast of Israel. It is felt that the successful establishment of newcomers may be explained by the fact that they either replace less successful native species or fill empty ecological niches.

Few Mediterranean species, on the other hand, have succeeded in establishing themselves in the Gulf of Suez and the Red Sea. The reason seems to be that the Red Sea is a tropical sea with a population at equilibrium with its environment. The Red Sea does not present an "ecological vacuum."

During the nearly 100 years that the Suez Canal was open to shipping, it was one of the busiest waterways in the world. It was suspected, therefore, that many species of marine forms would be passively transported through the Canal on the hulls of ships or in the bilge waters. Despite years of study, however, very few cases of such passive transport have been confirmed. New Indo-Pacific immigrants are being reported every year along the Israeli Mediterranean coast despite the fact that for the last 20 years that the

Canal was open to shipping not a single ship making the passage called at Israeli ports. In Cyprus, on the other hand, where many ships called after transiting the Canal, few Indo-Pacific immigrants are found. Passive transport of some species cannot be entirely ruled out, but it is now believed that only a few species with circumtropical range have used this method of dispersal.

Por believes that many ecological groups are excluded in principle from successfully migrating through the Suez Canal. These include bathyal or deep sea fauna since the deepest part of the Suez Canal is less than 18 m. Fauna of rocky bottoms, such as the extensive coral reefs and their associated fauna and flora of the Red Sea, would be excluded, for there are very few rocky outcrops on the bottom and shores of the channel. Organisms requiring clear transparent water would be excluded (at least when the Canal is open to shipping), for the water of the Canal is turbid due to the sediments stirred up by passing ships and the constant dredging operations. Also excluded from transit would be holoplankton species and benthic species with meroplanktonic larvae, for no currents for transport exist in long stretches of the channel. Stenohaline organisms could not stand the passage through the Canal for there are still areas of hypersalinity, especially in the Bitter Lakes.

Since the 1967 Six Day War, the Suez Canal has been closed to all shipping. In 1970, in a seminar presented at Stanford University, Prof. Steinitz of the Hebrew University of Jerusalem predicted that with no dredging to keep it clear the Canal would silt up completely in several places within a few years. To date this has not happened, and the protracted closure of the Suez Canal has created physical conditions facilitating the passage of organisms from the Red Sea to the Mediterranean. In an interview given to the Jerusalem Post in October 1972, Dr. Oren, Director of the Sea Fisheries Research Station in Haifa, predicted that this increased migration should benefit the Eastern Mediterranean. Oren noted that since the Suez Canal was closed, its waters have been clear and calm. This has facilitated the passage of

many species of Red Sea fish, and the clear transparent water of the Canal supports a larger plankton population than before. Over the years the high salinity of the Bitter Lakes has been reduced by contact with water of lower salinity, and this has further reduced the number of barriers to migration.

A second man-made alteration of the physical environment of the area that will influence future migration through the Canal and dispersal in the Eastern Mediterranean is the definitive damming of the Nile by the new High Aswan Dam. The Nile previously flooded annually and brought fertility not only to the river-side agricultural lands of lower Egypt but also to the waters of the Eastern Mediterranean. The Aswan Dam was completed in 1964, and since 1966, only one-fourth of the previous amount of Nile water reaches the Mediterranean. Prior to this stoppage of the Nile the influx of millions of cubic meters of freshwater tended to reduce the overall salinity in the sea off the northern Sinai, along the Levant coast and even along the southern coast of Turkey. At Haifa the average salinity of coastal waters has increased by 0.031% since 1964 and now amounts to 39.9 parts per thousand. Fisheries scientists in Turkey have noted a rise in salinity along the Turkish Mediterranean coast, and species of fishes that used to occupy coastal waters of the Eastern Mediterranean only as far north as Iskenderun are now found along the entire south coast of Turkey and up the Aegean Sea as far as Izmir. Salinities in all this area have been higher during the entire period after 1964 than they were previously. A new Turkish fisheries research laboratory (a branch of the Hydrobiological Research Institute of the University of Istanbul) is being established at Iskenderun to monitor these physical and biological changes.

In addition to this overall effect of the previous Nile influx, a more localized phenomenon influenced dispersal of immigrants passing through the Suez Canal into the Mediterranean. When the Nile flowed freely to the sea, an extensive area in the Mediterranean off the Nile Delta (to the west of the Suez Canal opening) consisted of brackish water. The salinity fluctuated with the amount of Nile flow, and during the autumn floods often reached a low of 25 parts per thousand. This so-called "Nile Barrier" of brackish water seems to have prevented the immigrants from the Suez Canal from dispersing westward along the African coast. The dispersal of immigrants in the Mediterranean has been primarily a long-shore advance of littoral species along the Levant coast to the east. Since 1966, the sea off the Nile Delta has had an almost constant salinity of 39 parts per thousand, very similar to that of normal Levantine sea water. The "Nile Barrier" therefore no longer exists, and this condition is expected to enhance the ability of immigrants to move westward along the coast.

The diminished Nile discharge is likely to have other effects of considerably more significance in the Eastern Mediterranean. Previously the Nile flow, especially the silt-laden autumn floods, was the main supplier of nutrient salts for the excessively poor Levant basin. In the future the fauna of this basin will find primary production even lower and will have to live within an even narrower trophic frame. (E. C. Haderlie, Naval Postgraduate School, Monterey)

April 1973

One of the first things I ever wanted to be (after garbage-truck driver, and only the unkind would try to link this to my later interests in psychology) was an airline pilot. The physical sensations of flight, the visual pleasures, and the technology of the cockpit have always drawn my attention and interest. So I was very glad to be able to attend a Symposium on "Flight Deck Environment and Pilot Workload" at the Royal Aeronautical Society in London on 15 March 1973, along with some 200 others including representatives from the Civil Aviation Authority, various commercial firms (British Aircraft Corp., Marconi-Elliott Avionic Systems, EMI Electronics, Hawker-Siddeley, etc.), military organizations (RAF Institute of Aviation Medicine, Royal Aircraft Establishment), a number of commercial airline pilots (BOAC, BEA, Aer Lingus, Air France), and several people with university affiliations. One might have thought that at least one representative from a related tribe, the Air Traffic Controllers, would be in the audience just out of curiosity (they would have heard a fair amount about themselves), but these two tribes are not entirely in harmony at present.

The Symposium was entirely focused on commercial airline operations. The unspoken assumption was, it seemed, that today's aircraft designs have created needs for air crew information processing and decision-making that push crews near their limits of capacity. And of course, the ultimate justification for concern has to do with safety. Nine papers were presented (three by Americans): The External Operational Environment (Bennett, CAA); The Internal Environment and Flight Deck Layout (two papers: Mercer and Pearson, Lockheed, and Wallick, Boeing); The STOL Pilot, His Problems and Requirements (Tennstedt, Eastern Air Lines); Establishing Priorities during Flight Deck Operation (Hopkins, British Air Line Pilots' Association); Biological Measures of Workload (Rolfe and Lindsay, Institute of Aviation Medicine); Techniques for the Evaluation of Cockpit Layouts and Activities (Shaw, RAE); Assessment of Pilot Workload (Howitt,

CAA); and The Need for Mock-Ups and Simulators (Wilson, Hawker-Siddeley, and Zeffert and Wilkey, British Aircraft Corp.).

Bennett [Head of Air Traffic Planning (AA)] talked disconcertingly about available air space in relation to traffic density trends (the former not increasing because of public resistance, the latter increasing significantly), and showed a most graphic film to illustrate his point, a time-lapse film of the radar representations of 24 hours' inflow and outflow at the three London airports; one knew that the 24 hours had been reduced to ten minutes, yet the film looked unbearably crowded with highly kinetic blips. His point was that the increasing density will require much more precise navigation than is now possible, that some sort of data-link system will replace tactical radar and voice communication, and the cost of these newer more expensive systems will most likely have to be borne by the public. And, of course, the newer kind of navigation system will require a different kind of information processing from the crew.

Pearson (Head, Human Factors, Lockheed) spoke wryly and with great humor of how the usual procedure is to design the machine and then search for an operator who will fit it. For evidence that this might not be the best approach, he cited a study of 224 pilots of whom 90% reported instances of design-induced disorientation experiences. Mercer argued that if the design of a plane is proper the pilot will be almost unaware of it, and suggested that the pilot(s) should have as few actions to carry out as possible. This trend, treating the human crew mainly as monitors instead of operators, came up repeatedly and could itself have been the subject of a symposium, as there seems a lot to be said both for and against it.

Wallick (Boeing's chief test pilot) developed the same theme, referring to the tendency for new information displays to proliferate and accumulate within the cockpit and

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the need to integrate various bits of information, automating wherever possible. The implication for the crew is again the role of monitor, similar, for example, to that of personnel who run large automated oil refineries (and growing distance from the traditional image of the independent pilot facing the elements).

Capt. Hopkins centered his remarks on the point that an effective pilot needs to have at all times a mental model representing basic flight characteristics of his ship; too much concern with the internal environment (i.e., monitoring of displays in the cockpit) can lead in the direction of detail awareness of individual parameters and away from a generalized picture of the aircraft in motion in relation to the earth. This to me was a paper with possibilities, from the point of view of the psychology of cognitive processes, exploring as it did the central value and importance of images in organizing information. However, it also illustrated nicely the professional pilot's view of himself as "captain of the ship" vs. "monitor of the electronic data processing equipment."

Rolfe and Lindsay gave an overview of techniques for measuring "workload" which I think contained some ideas and approaches new to most of this audience; the papers of Shaw (mainly cinematic ways of observing performance) and Howitt (physiological measures) amplified the topic. Rolfe concentrated on criteria for designing suitable measures and not on findings. Shaw demonstrated his descriptions with some films made in situ, one of which revealed a helicopter pilot trying to fly in a standard cockpit apparently designed for an intelligent octopus, with considerable difficulty. Howitt, an MD, emphasized that physiological measures are available, but that "workload" and "stress" cannot be reduced to a few such indices, and further that questions cast in such general terminology are unlikely to produce useful results. He and others suggested that researchers in human engineering need to have better questions put to them (but personally I suspect that a more fundamental issue is that of who determines what questions are important).

Perhaps more implicit than explicit in Howitt's remarks was the notion (a potential bombshell in such a discussion) that the professional pilot's workload on a typical flight is in the larger view really quite light; given this fact it would be difficult to find measures or to design experiments that would reveal significant results from changing cockpit layout or routines.

Zeffert in the final paper argued that more money should be spent on simulators, especially for human factors work prior to final design, illustrating his point with evidence of how useful such simulation had been in design of the Concorde.

If one visualizes the whole Symposium as an aircraft, say a 747, in flight, one is inclined to say that the crew were vague about the country in which the airport they were seeking lay, perhaps even unsure how they would recognize it if it should be in the vicinity. There was a feeling that things are changing and that one ought to deal with the changes as rationally as possible, but the identification of problems and thus of relevant clues to solutions seemed quite hazy to me. It seems that in a situation of competing languages, engineers have so far prevailed with an orientation toward hardware that does not readily permit the posing of questions important to pilots or human factors specialists. Perhaps worth emphasizing again, too, is the inherent conflict between the engineer, whose aim is to automate display and control aspects of the aircraft insofar as possible, and the pilot, whose professional self-image has been built on the cultivation of personal judgment and airmanship. For the pilot the trend toward automation is a trend toward job-impoverishment. Given all these circumstances, it should be difficult for the best thinking available to actually show up in cockpit designs.

Proceedings of the Symposium (papers and summaries of the discussion) will be available from the RAS (4 (4 Hamilton Place, London W.1, England), sometime in May, priced at £3.00. (J. T. Lester)

January 1974

In a recent issue of the Times Higher Educational Supplement (27 Dec 73), Prof. Terence Miller concluded an article on the theory of plate tectonics with this paragraph:

"The impact of this new unified theory on the earth sciences is surely comparable in scale and scope with that of Darwin's work on biology or with Einstein's on physics. If there is a sting in the tail, it is that a substantial proportion of the geophysical-oceanographic work could not have been done without funding through United States Navy contracts, and much of the biochronological work was oil-company based. It is to be hoped that these military-industrial connections will not contaminate the theory in the eyes of the intellectual doves."

The implication that the results of scientific research should somehow be regarded as suspect simply because of the source of support is not new. But it is still difficult to understand, and for this writer, impossible to accept. The assumption that a sponsor can influence the results of an investigator is basically a reflection on the integrity of the investigator, and to the scientists who are familiar with the role played by ONR in support of post-WWII research, is completely unrealistic. Oceanographers in particular are aware of the vital role played by Navy support in the continuing development of their field. This is true not only with respect to the U.S. Navy, but of the British Navy as well. It is now slightly more than one hundred years since the British corvette HMS CHALLENGER began her epic three-year voyage of exploration which marked the beginnings of modern oceanography. As a collaborative project jointly undertaken by the British Navy and the Royal Society, this voyage has always been to my mind an outstanding example of enlightened military support of exploratory research, which eventually proved to be mutually beneficial to both partners in many ways. For the scientists, it provided a wealth of information which took years to digest and analyze, resulting in a complete revision of existing theories on the nature of the ocean depths. The 50 volumes which contain the results of these studies present a fascinating subject of study for those interested in the history of science. On the other hand, for those who were (as today) reluctant to see Navy support used for anything other than practical problems, the voyage provided an example of how a project organized for purely scientific purposes could yield returns which in economic terms far exceeded anything which might have been anticipated. One example alone will suffice to illustrate this point. The annexation by the British government of Christmas Island, an uninhabited volcanic island in the Indian Ocean, was undertaken on the recommendation of one of the CHALLENGER scientists, John Murray, based on comparative analyses of rock samples collected during the expedition with samples from the island. In 1910, Murray was able to show that the total amount of income to the British treasury up to then from commercial exploitation of the phosphate deposits on the island amounted to much more than the entire cost of the CHALLENGER expedition.

One final historical note on this subject. The extensive field work by Charles Darwin which formed the basis for his great theory of evolution was carried out while he was serving as naturalist aboard HMS BEAGLE, which was - you guessed it - a Navy ship. (V. J. Linnenbom)

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| THE DYNAMIC NATURE OF RELEVANCE: |
| SOME VIEWS ON SCIENCE MANAGEMENT IN THE UK |

October 1974

The care and feeding of science and its practitioners continues to be a topic of lively discussion by British science editors, government research councils, R and D managers, officials of learned societies, and miscellaneous commentators on UK educational, industrial, and governmental research policies. Some remarkable ironies are evident in the current expressions of British opinion on this subject: for example, an industrial R/D management is advocating increased basic research while prestigious spokesmen for British science are advising their colleagues to strive for greater relevance. A recently published study of the changing relationship between "science" and "technology" may help one understand these apparent contradictions. It may also give some perspective on changing fashions in research motivation, and help set some limits on the debate about what kinds of research should be supported and why. The following is an effort to convey the flavor of the British discussions.

So-called "academics" presumably believe that "science for science's sake" is good, that scientists are like highly creative artists, and that society is best served if their work is generously supported and not over-managed. Voices from both the humanist and managerial camps have joined to attack these views. The humanists accuse science of being an amoral or immoral tool of the Establishment. From the managerial side, the familiar arguments are made that there is a limit on the money and manpower which can be dedicated to science; that these resources cannot be spent on "science for science's sake" but must be allocated on the basis of national and organizational priorities; and that planning of research and directing it towards relevant goals need not destroy scientific creativity nor choke off the flowering of genius.

Carrying these critical appraisals still further, a recent editorial in Nature (250, 693, 30 August 1974) suggests that if scientists are comparable to creative artists, they should--like their musician counterparts--be re-auditioned periodically to see if they

deserve to keep their chairs. The artist--be he painter, musician, or writer--seems willing to accept a rather ruthless existence, in which his survival depends on maintaining a high degree of productivity, as judged not only by the standards of his profession but also by the standards of contemporary society. Nature asks why, by contrast, scientists generally do not seem to be willing to live according to these rules (at least in Britain) but demand stability of support while reserving for themselves the right to do what they personally find interesting, no matter how uninspired or unnecessary their work may be.

A similar castigation of scientists' alleged "the-world-owes-me-a-living" viewpoint is expressed in a highly intemperate diatribe in the New Scientist ("About the Politics of Science," 8 August 1974, page 339). A strongly Marxist interpretation is put forth here that scientists are a recently developed subgroup of society's middle class (merchants, doctors, clergy, police, etc.), a class which originally evolved as mediators between the few tenths of a percent of the population who owned the world's wealth and the overwhelming number of the population who did the world's work. Out of these mediators, who neither owned nor created anything themselves but understood what had to be done and told the operatives how to do it--and in the process kept them controlled or resigned to their fate--came the scientists. These, in time, became more arrogant and self-absorbed and demanded unquestioned support from the rest of society. It is high time, the writer of the New Scientist article says, that scientists realize that the world's masters and its workers are both indifferent or hostile to science, the former because they are interested in achieving social control by any means whether or not it involves science, and the latter because they feel that science is one of the tools used to control them.

These current British writings differ only in vehemence and tone

from similar messages which have been directed at scientists worldwide over the past several years. Under their impact the defenders of "basic" research ("undirected" research, "fundamental" research or "science for science's sake," whichever term the reader prefers) have been beating a retreat in Britain as elsewhere. The "customer/contractor" relationship for administering research support recommended by the Rothschild Report (ESN-26-2; 28, February 1972 and ESN-26-7; 175, July 1972) is a well-known example of the reaction in the UK against "undirected" research. More recently, Sir John Kendrew, retiring President of the British Association for the Advancement of Science, indicated at the BA's annual meeting in September that scientists should change their attitudes and re-examine the premise that the prime motive for scientific research is the absolute good of pursuing knowledge for its own sake. He suggested that much present-day research might appear to future historians as mediaeval scholasticism now appears to us. Another speaker, Professor Frank Bradbury of the University of Stirling, President of the BA's General Section, suggested that the words "for the Advancement of Science" in the Association's title were out of tune with the times, and that the present dedication should be to the relevance of science rather than to its advancement.

Against this background the "1973-74 Annual Report and Accounts of the Central Electricity Generating Board" strikes an unexpected note. According to the Report, a cold-cash appraisal of the performance and problems of this nationalized industry, an assessment of the savings attributable to the work of its research laboratories over the 5-year period 1968-72 showed that the clearly quantifiable savings were "several times" the total expenditure on research during that period, and that the less quantifiable benefits indicated an even larger savings. The most intriguing part of the CEGB Report is the following statement:

"For some years there has been concern at the diminishing proportion of basic work being done in the laboratories, as experience has shown that an unexpected plant problem can be tackled more effectively when a store of knowledge of basic phenomena has been built up than when the problem has to be overcome on an ad hoc basis with inadequate scientific backing. Whilst the bulk of the work will continue to be supported by the user (at present this is over 90%) steps were initiated during the year to increase the proportion of basic work by reducing work of low priority in the more applied area."

Granted that the "basic" work referred to will not necessarily be completely undirected nor irrelevant to the CEG Board's interests, the unexpected reversal of roles which has taken place in this instance has a somewhat Alice-in-Wonderland aspect. One wonders if we may not be observing the dawn of a new era, in which industrial R and D executives will emerge as the most stalwart champions of basic research!

This jumbled picture becomes a little clearer, perhaps, when viewed in the light of J. Langrish's (Manchester Business School) study of the changing relationship between science and technology [Nature 250, 614 (23 August 1974)]. After finding, from an analysis of "key-ideas" and literature citations, that self-motivated science (represented by British university research) has at present little impact on technology in Britain (represented by British industrial research), Langrish asks if this has always been true historically. By investigating the organic chemicals industry, he finds that this has not always been the case. Science did have a strong impact on the chemical industry in the latter half of the 19th century, although as a matter of incidental fact the science was provided by German university research rather than by British. The science-technology relationship in this field changed with time, however. University chemists became more interested in the fundamental bases of their early discoveries, while industrial chemists were more concerned with using the earlier knowledge rather than with achieving a better theoretical understanding of it. The paths of university organic chemistry and industrial organic chemistry therefore began to diverge, ultimately reaching the present condition where university research ("science") has very

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little influence on industrial research ("technology").

Thus, Langrish concludes, it is not valid to look for a constant relationship between science and technology. This relationship is a dynamic one, and it may even be cyclic. If Langrish is correct, it is meaningless to argue whether technical innovations in general occur mainly because of "demand pull" (i.e., "relevant research") or "discovery push" (i.e., "undirected research" or "research for its own sake"). Both paths are taken, depending on the field and on the times; and if these parameters are ignored, the argument degenerates into pointless disputation.

There are, of course, better known examples of the changing science-technology relationship than the chemistry case documented by Langrish. One of these is the innovation of nuclear power, which was certainly a case of "discovery push." This innovation was the product of theoretical physicists and chemists who were motivated essentially by the desire for fundamental understanding. Since the early days of the discovery of fission, the interests of these scientists and the designers of nuclear power stations have diverged. Innovations in the nuclear power field are now more likely to be by "demand pull." In this example, again, it is clear that the impact of science on technology is time-dependent and is greatest in the early stages of a developing area. This well-known case also illustrates another point often made by the academic science community, that while undirected science may only occasionally produce results of practical benefit, the benefits are so large as to outweigh the cost of this research for many decades.

Langrish suggests that fundamental factors may now be operating to influence industry to turn towards basic research. He points out that new concerns are arising--resource depletion, environmental pollution, ecological questions, health and safety problems, to name a few--and "[therefore] industry will have to pay more attention to understanding what it is doing....It could be that in the future, many sections of industry are going to require an increasing reliance upon theoretical research aimed at understanding, as the empirical approach, which has been so successful, joins the quest for economic growth as a thing of the past." The timing of the CEGB statement on basic research makes it a case of almost instant verification of Langrish's prediction.

What is to be learned from all of this, if anything? It appears to the present writer that the strenuous effort of many (worldwide) science spokesmen and administrators to achieve readily demonstrable relevance is a belated response to social and economic forces that were very visibly building up for much longer than a decade. It is quite possible that the current strong focus on this objective is blinding many people to the dynamics of the science-technology relationship, a condition in which neither science nor technology will be well served. (J. H. Schulman)

TISSUE CHARACTERIZATION BY ANALYSIS OF ACOUSTIC BACKSCATTER VARIABILITY

April 1975

The medical profession has made good use of acoustic techniques for a very long time. The stethoscope and the carefully perceived thump on the chest are old standard tools. Much more sophisticated ultrasonic techniques, however, are moving into use and this is becoming a very exciting area for research and development activity.

The International Acoustic Congress held last summer recognized this importance by allocating two of its twelve invited lectures to this topic - one treating use of ultrasound in surgical and the other in diagnostic context.

A recent visit by Dr. Schulman (ONRL) to the Physics Division of

the Institute of Cancer Research, Royal Marsden Hospital in Sutton, near London brought their acoustics component, led by Dr. C. R. Hill, to my attention. This, in turn, provided an opportunity to highlight what appears to be a new dimension being explored in diagnostic work.

One of the most direct applications of acoustics has been in the production of picture-like sections made by transmitting successive pulses into the tissue and recording the echo energy as a function of time after ping. By use of appropriate electrical circuitry and mechanical linkages to register the position of the transducer, the results are displayed as intensity vs location in the cross section being visualized on a storage oscilloscope.

This is a field in which strong interactions between physicists and medical doctors are essential, and the Physics Division developed this in their earlier work, which is primarily related to radiology. As they expanded into acoustics, they quickly realized that concentration on "reflection" should be replaced by a broader view in which "backscattered" radiation from within the tissue volume is given high consideration.

Their first move was a very practical one, designed to educate and maintain their interaction with the medical workers. They built a more-or-less conventional scanning echo-type system for actual diagnostic use. At this time nearly all such systems presented a very high contrast (essentially black-white) display, focusing attention on boundaries and highly reflective regions. Hill realized that the entire volume of tissue would return backscattered energy to some extent, thus he gave his equipment more sensitivity and dynamic range than usual and provided a display with good smoothly variable intermediate grey levels between black and white. This allows viewing of the backscattered energy in a semi-quantitative way. As might be expected, the backscattering effectiveness is different for different tissue types, with, for example, tumorous tissue scattering back less energy than normal liver tissue in which it might be growing. This system is in use on a daily basis, and the doctors have learned to make good sets of pictures of adjacent sections with which they can construct essentially a full 3-D

representation of some particular organ, and have learned to recognize the dark, cloudy regions of lower scattering coefficient as significant deviations from the normal nearby tissue. Several equipment manufacturers have quickly moved into this and "grey scale" adapters and full scanning systems are now available commercially.

With this initial step complete, Hill and his co-workers turned to the natural research follow-on of looking with more care into the nature of the scattering process, particularly as to the way it is related to the structure of the tissue itself. Up to this point they had been merely polishing-up existing techniques. Here, however, they brought in the realization that the mere fact that tissues can be characterized by differing structures meant that, if one would design the acoustic signal differently (particularly using a rather narrower frequency band), then one should find, just as in x-ray (Bragg) scattering in crystals, that there is some characteristic angular dependence to the scattered radiation. Actually the situation is rather more analogous to x-ray diffraction studies of liquids, in which any existing characteristic local ordering, even of rather modest dimensions, shows itself through variation of scattering as a function of angle.

At this point the group's strong feeling for developing immediately useful diagnostic techniques asserted itself. Rather than transmitting into a sample of tissue from a fixed direction and moving the pickup transducer to receive the energy scattered out at different angles, they chose to use the 180° backscattered energy from a small volume and observe its fluctuations as they rotated the sample. While the former procedure would be the true analog of the usual x-ray diffraction experiment, the latter could more easily be adapted for actual examination of localized volumes within a particular organ.

The volume observed was defined by using a pulse 2 or 3 μsec long and gating the receiver to allow output only during the period for which energy would be arriving from a region centered on the axis of rotation of the sample. The output levels were measured through a filter of 20 kHz bandwidth (small compared to the pulse

bandwidth) at the center frequency of 1 MHz. Expressed in terms of dimensions in the sample, the acoustic wavelength is thus about 1.5 mm and the volume contributing to the return is of the order of 10 mm^3.

One finds that the results are indeed discriminating. As the sample is rotated there are peaks and valleys in the backscattered energy, with average peak-to-peak spacings of the order of 7° in liver, for example, and significantly different traces for other types of tissue. Most notably, a sample of liver containing cancerous growths showed a much smaller scale variation of intensity with angle. The most promising method for analysis is to make a Fourier transform of the intensity vs angle curve to produce an angular spectrum of the scattered power distribution, with some hope that this spectrum would be characteristic of the material being insonified.

As of this writing, Hill's co-workers have produced a modification of the mechanical scanning pantograph which guides the transducer in their operational pulse-echo system. This, with associated display circuit modifications, will allow the user first to make a high resolution backscatter picture-section through the organ involved and then to select a particular point which can be scanned by moving the transducer, in contact with the patient, through an angle of about 40° relative to the target point. Considering the nature of the traces seen thus far, this should give an adequate sample length. It is anticipated that the resulting signals will be fed directly to an on-line PDP-8 computer which will, with only a few seconds' delay, produce the angular spectrum for the tissue involved.

With this in operation the desirable statistical information to provide further confirmation and detail on this technique should begin to accumulate very soon. Hopefully the medical profession will thus gain from a very nice, direct application of basic physical principles.

(F. N. Spiess)

ASTERIX III – A HIGH POWER IODINE LASER

June 1975

The Max-Planck-Institut (MPI) für Plasmaphysik, located in Garching near Munich, is probably the largest research center in the world which is exclusively devoted to plasma physics. Their main thrust is in magnetic confinement controlled thermonuclear (CTR) fusion. One of their unique developments in this field is the Beltpinch. However, the ISAR-series of experiments, the latest one being a completed toroidal theta pinch, are very impressive too.
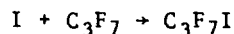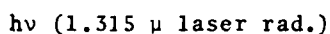
Compared to the magnetic confinement CTR, their effort in laser fusion is somewhat modest as far as manpower and financial resources go. Despite these limitations this research yielded a very impressive high-power laser, suitable for laser fusion research.

The name of this experiment is Asterix; it is an atomic iodine gas laser. At present Asterix III is under construction with the goal of achieving 1 kJ pulses of 1 nsec duration. The components of the system are more or less completed. Full operation at close to 1 kJ is expected by the end of this year.

Although the iodine laser was discovered in 1964 by Kaspar and Pimentel, it took up to 1970 before a closer look into its possible applications was taken. The fact that the iodine laser is suitable for pulsed high-power operation was recognized by Hohla and Kompa of the MPI for Plasma Physics.

It is a photochemical dissociation laser. The lasing species consists of excited iodine atoms. The dissociation and resulting excitation is accomplished by optical pumping of gaseous organic iodides, i.e., CF_3I or C_3F_7I. For the latter the following reaction is obtained:

$$C_3F_7I + h\nu \ (2800 \ \text{Å}) \rightarrow C_3F_7 + I^*(5 \ {}^2P_{\frac{1}{2}})$$

$$I^*(5 \ {}^2P_{\frac{1}{2}}) \rightarrow I^*(5 \ {}^2P_{3/2}) +$$

$$h\nu \ (1.315 \ \mu \ \text{laser rad.})$$

$$I + C_3F_7 \rightarrow C_3F_7I$$

A schematic diagram of Asterix III is given in the figure. The system consists of a mode-locked oscillator and three amplifiers. The oscillator delivers a mode-locked pulse train from which a single pulse is extracted by means of a pulse cutting system. The beam divergence is 0.8 mrad in keeping with the TEM_{oo} mode of the oscillator. The pulse length, which is dependent on gas pressure, varies between 3 and 0.7 nsec. The first amplifier has an ID of 2.5 cm and is located 15 m behind the oscillator. This distance is necessary in order to make sure that the slightly divergent beam, emitted by the oscillator, fills the diameter of the amplifier. The second amplifier has the same diameter. Both are optically isolated from each other by a Pockels cell. After passing through the second amplifier, the beam is expanded from 2.5 cm to 20 cm using an off-axis Cassegrain system. The distance between the second and third amplifier is about 50 m. A Faraday rotator is located between these two amplifiers for additional optical isolation.

The third amplifier consists actually of eight identical sections. Here the actual high-power amplification takes place. The input energy of 6 J is supposed to be amplified to about 1 kJ. The amplifier sections are stainless steel tubes of about 1 m length. The flash lamps for optical pumping are located internally and are directly exposed to the laser gas. This simplifies the design considerably. The first and second amplifiers are of conventional design, consisting of quartz tubes surrounded by flash lamps.

The small-signal gain, which is an exponential function of the cross section for stimulated emission, is quite high for the iodine laser. On the other hand, the energy storable in an amplifier per unit area is inversely proportional to the stimulated emission cross section. Therefore, in order to optimize energy storage, this cross section, which is also inversely proportional to the line width, has to be reduced. This can be accomplished by causing pressure-broadening of the lines through an admixture of a suitable gas. The selection of the gas and the correct pressure has to be based on the trade-off between the improvement caused by pressure broadening and the adverse effect caused by depopulation of the upper laser level by collisions.

W. Fuss and K. Hohla determined the influence of Ar, N_2, CO, CO_2, SF_6 on the cross section for stimulated emission and also the rate coefficients for collisional depopulation for some of these gases. As a result, CO_2 was chosen for Asterix III as an admixture. The CO_2 partial pressure is somewhat less than 700 Torr while the C_3F_7I pressure may be as low as 4 Torr.

The advantages of the iodine laser are that the laser medium is inexpensive and the properties of this medium can be tailored for a specific application, by changing gas pressures and admixtures. While performance similar to glass lasers can be expected, one does not have to worry about destroying the laser medium, since it is easily replaced. Operational experience so far shows that

Asterix III

no self-focusing takes place, at least up to a power density of 2 J/cm^2. The wavelength of 1.315 µm is very convenient; it can be handled with quartz. The expected efficiency is 0.5-0.8%, which, of course, rules this laser out as a possible candidate for a fusion reactor and restricts it to a research device. On the other hand, the construction cost for the Asterix III will be an order of magnitude below a comparable glass laser.

Late Dec. 1974, G. Brederlow, K. J. Witte, E. Fill, K. Hohla and R. Volk of the MPI announced that they measured the energy stored in one of the sections to be 160 J, which puts the total energy stored in all eight sections (when completed) to be 1.3 kJ. Considering that theoretically 66% of this stored energy can be recalled as laser output, an actual operation of around 0.8 kJ is reasonable to expect. (R. T. Schneider)

| INTERDISCIPLINARY APPROACHES IN SCIENCE |

September 1975

During my year as Physiologist with the Office of Naval Research, London, I reported on two new interdisciplinary areas, Bioelectrochemistry and Biorheology, and became interested in the role of interdisciplinary research in scientific progress. In particular, I was struck by the fact that as science has become more highly organized and automated (i.e., machine dominated), it appears to have changed its traditional patterns of development. As if to overcome the constraints imposed by the greater degree of organization, scientists have formed interdisciplinary research areas as a creative way of approaching complex problems. ONRL Report (ONRL-R-12-75) entitled "Interdisciplinary Approaches in Science - Bioelectrochemistry and Biorheology as New Developments in Physiology," contains a discussion of these ideas. The general aspects of the report have been condensed for this article.

From my observations this year, the activities of scientists do not conform to the pattern that has been described by leading analysts of scientific progress and development. The most frequently quoted opinions of K. R. Popper and T. Kuhn differ regarding the nature of scientific progress, but both agree that the old Baconian description of science as an inductive process (i.e., observation leading to hypothesis) is wrong. Yet, most of the scientific activity I saw is probably best described as Baconian.

Popper's ideas on scientific development are probably easiest to summarize in his own words "problems - theories - criticism" [K. R. Popper - Federation Proc. 22, 961 (1963)]. "Science . . . begins with theories, prejudices, superstitions, myths; or rather, it begins when such a myth is challenged and breaks down." This breakdown (i.e., the problem) leads to a proposed explanation (i.e., the theory) which is then tested (i.e., the criticism) under conditions where one deliberately tries to falsify the hypothesis. The criticism leads to a rejection or reformulation of the hypothesis and a repeat of the process. "Thus . . . knowledge grows as we proceed from old problems to new problems by means of conjectures and refutations . . . . The method of science is, very simply, that it systematized the pre-scientific method of learning from our mistakes." Popper sees the development of science as essentially evolutionary.

Kuhn on the other hand has focused on the revolutionary periods and the bold new steps in science (e.g., the overthrowing of the phlogiston theory in Chemistry, the Copernican revolution in Astronomy, the development of Quantum Mechanics), and views science as developing in major quantized steps. Between the revolutionary steps there are periods of "normal science" where scientists are busy doing research on the prevailing

paradigms. (Paradigm is a term that has been given different meanings, even by Kuhn, but scientists use the term interchangeably with theory or model.) Therefore, for most of their time, scientists are elaborating the consequences of a paradigm. Real scientific development occurs only when the contradictions that have arisen as a result of the normal science activity can no longer be tolerated and a new paradigm is presented to offer solutions for some of the outstanding contradictions. In summary, Kuhn suggests that the development of science is revolutionary and quantized.

(The two major points of view about scientific progress are really quite compatible, at least on a superficial level. Logically the structure of science must develop as Popper has indicated, and Kuhn agrees. On the other hand, Kuhn has shown that the rate of development is uneven.)

Bearing these ideas in mind, I tried to detect either of these processes at work, but most scientists I talked with described their activities only in terms of the technique they were using and the particular system they were applying it to. Very few mentioned the problem they were investigating. *No one said anything about a theory he was testing, let alone one he was deliberately trying to falsify.* The scientists were engaged in data gathering, but not for the purpose of testing, or elaborating a paradigm. Although their activity resembled what Kuhn has characterized as "normal science," it was deficient in the puzzle-solving aspect of that term. Hence, according to the Popper or Kuhn criteria there was very little, if any, science involved. The tentative conclusion I have come to is that, unlike the physical science of the past, recent developments in Biology suggest that the Baconian process in a modified form can describe the activity and even some of the significant progress in the field, e.g., the determination of the double helix structure of DNA.

This process--the inductive method, observations leading to hypotheses-- used to be synonymous with scientific method, but it was discredited largely because one cannot merely observe; it is essential to make observations in terms of some expectations. However, one does not need a terribly sophisticated hypothesis to focus one's

attention. For example, measurements can be made with a newly developed instrument to see if there are differences between the particular system under investigation and a previously measured system, or if there is a correlation between the new property and an older one. Indeed, it appears that this is often the "hypothesis" that is being "tested" by observation. And it is in this amended sense that the old Baconian description applies to much of the research that I came across this year. It is probably true for other fields of science as well.

There are a number of reasons which contribute to this situation, of which I will mention only two. First, the vital role of external funding in the development of any academic field today requires the scientist to spend a growing proportion of his time writing applications, reports, etc., in connection with the funding of his work; and since many evaluative procedures take scientific publications as evidence of productivity, the scientist is tempted to write papers and do experiments that will result in a quick publication, rather than pursue a scientific prob- *lem that may require a long-term effort before he can obtain his results.*

Secondly, just like his lay counterpart, the scientist has grown more and more dependent upon machines (i.e., scientific instruments) in his daily life. While these machines have greatly aided him in his work, they have also limited his maneuverability or the "free space" available for the formulation and testing of new hypotheses. A scientist with a laboratory full of expensive instruments that are maintained by specialized technicians must think in terms of problems that will utilize the abilities of his equipment and staff. As one electron microscopist said to me, when referring to the huge amount of equipment in his laboratory, "I have a hungry lion to feed, and if I stop he'll eat me up." The need to make work and to seek problems that utilize the complex machines and cadre of machine operators, have severely constrained the scientist.

Arthur Koestler, in The Act of Creation (Dell, 1967) has suggested that the common element of creativity in humor, art and science is the solution of a problem (i.e., when

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progress in a "situation is blocked" using the standard approaches) that involves switching from one way of thinking ("matrix of thought") to another that is not normally included in that context. He believes that creativity is brought about by the "collision of matrices," i.e., when two different ways of thinking about a situation are deliberately focused on a problem, and the conditions are ripe for an interchange. These ideas are in line with those of Popper, who has indicated that problems are the beginning of the scientific process, as well as with those of Kuhn, who has noted the importance of problems in creating the conditions for the changing of paradigms. However, Koestler's description of creativity suggests that one can promote creative responses by arranging a "collision of matrices." This idea, which is particularly important in a scientific world where activity is increasingly constrained, appears to have been utilized within the framework of normal science by the creation of new interdisciplinary areas of research, journals and scientific societies.

Organized interdisciplinary activity has been spurred on by a variety of reasons, some of which have little to do with science (e.g., political--a new society or journal generates new prestigious officers). But not all of these activities fulfill the criterion for creativity; most represent multi-disciplinary approaches, such as the teaming up of scientists from two or more disciplines, generally to apply the techniques of a non-biological field to a biological system. In sharp contrast, Bioelectrochemistry and Biorheology have the potential for demonstrating the creativity that is characteristic of ideal interdisciplinary research. The two branches of each hybrid discipline have a common origin and there are many possibilities for "collision of matrices" when one reunites them in areas where they have developed unique views of the same phenomena as a result of separation over the years.

The possibilities for creativity can be illustrated by considering the paradigms of the biologist, electrochemist and rheologist as applied to the natural membrane. The biologist considers the natural membrane from the point of view of its composition

(phospholipids and macromolecules) in a particular arrangement (a lipid bilayer matrix with adsorbed and penetrating macromolecules); he has developed ion-carrier and pore models as well as equivalent circuits for electrical events. The electrochemist has dealt with systems that require knowledge of ion activities and conductances, surface charges, electrochemical potential differences, etc., to describe electrical phenomena. When the electrochemist sees the biological phenomena, he is bound to suggest interpretations that have not been part of electrophysiology. The electrochemist will look at the same phenomena with a background that will not allow him to accept the biological constructs as explanations. This will be the "collision of matrices" that is apt to lead to new solutions.

In the same way, the rheologist looks at the natural membrane in terms of elastic and viscous elements and uses their related equations to explain the behavior that the biologist knows must be due to the intermolecular interactions within the membrane structures. The imposition of the rheologist's approach on the biological model is bound to lead to hypotheses assigning particular behavior to certain membrane components or types of organization.

In summary, it appears that scientists have evolved interdisciplinary research areas as a creative way of approaching complex problems to overcome many of the difficulties imposed by the growing organization of scientific activity. However, not all interdisciplinary combinations have the same potential for success. The most promising are those that involve disciplines which approach the same phenomena with different paradigms, i.e., those which truly involve a "collision of matrices." It is of special interest to ONR London that the two areas mentioned here for illustration are developing rapidly in Western Europe, a fact that might well concern administrators of scientific research in the US. It would seem highly desirable to establish a strong research capability in these areas in the US. More

importantly, over the long run, we might be well advised to re-examine our research structure and our procedures for selecting research fields for emphasis to see if they are not impeding the growth of vital aspects of our capability rather than encouraging them. (M. Blank)

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POLLUTANTS FOR EXPORT – NORWAY'S PLIGHT

April 1976

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Scandinavian countries, and in particular Norway, have a rather poor and acid soil. The soil acidity is further increased by leaching due to high rainfall and the presence of acid in the rain. The acidity in streams is especially high in April when the snow begins to melt. Unfortunately, the peak in stream and lake acidity coincides with fish spawning: high acidity interferes with oxygen absorption and the young fish suffocate.

It was suspected that sulphur dioxide gas (SO_2), released in the atmosphere by the burning of fossile fuels, might be a hazard to the environment; it was also recognized that SO_2 can travel considerable distances in the atmosphere. Over a decade ago, the issue was raised that as a result of such a release by the principal nations of Western Europe, rivers and lakes of Southern Scandianvia were becoming acidic to the extent that fish populations were being severely depleted. At one stage it was also feared that forest growth and yield might be affected adversely.

Political pressure was put on the UK government to reduce the UK sulphur dioxide emission. At that time (1969), it was not clear to what extent Norway was responsible for the problem and what fraction of the fallout came from other countries such as the UK, Germany, Poland and Russia.

In June 1969, the Organization for Economic Cooperation and Development (OECD) set into motion a series of meetings and planning sessions designed to assess and formulate an acceptable cooperative plan of action which would provide a rational means of combating the increased soil acidity content of countries like Norway. By the Autumn of 1971 an acceptable plan had been arrived at and was approved by the OECD

Environment Committee. In April 1972 the OECD Council accepted the plan with participation of Austria, Denmark, Finland, France, Germany, The Netherlands, Norway, Sweden, Switzerland and the UK. The overall measurements and studies were to be coordinated by the Norwegian Institute for Air Research (NILU) situated at Kjeller, near Oslo. The East European nations did not participate in the 1972 plan and, at present, Norway is trying to involve these countries in an expanded program whose aim would be ". . . to provide governments, through international cooperation, with information on the quantity and significance of large-scale geographical dispersion and deposition of air pollutants in order to enable evaluation of specific air pollution problems and trends in Europe. . . ." Since air pollution is intimately tied with industrial production, the East European countries and the Russians are not anxious to provide such information although they have suggested that the computation of transport and dispersal of pollutants inside Russia be done by Russian scientists. Other countries will be provided with information on pollutant fluxes as these cross the borders of Russia.

The UK felt it should formulate and develop its own independent program which should culminate in the development of a numerical model capable of determining the amount of SO_2 that leaves the coast of the UK, and of following pollutant trajectories. Once these trajectories are known, one could infer a great deal about the UK contribution of sulphur dioxide falling in Norway. Branch 14 of the UK Meteorological Office, and

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more particularly Dr. F. B. Smith and his collaborators, were assigned to this task.

A field program was set up to collect basic information which would be used in the numerical model. Only SO_2 would be measured since it is one of the major components of industrial pollution. Relatively simple meteorological situations were considered: these involved nearly straight, steady, westerly flows over the UK. The measurements were carried out, using the meteorological office research aircraft, by the members of the Meteorological Research Flight at RAF, Farnborough; the development of the sampling technique and actual analysis of the samples was done by the Health Physics and Medical Division group of the Atomic Energy Research Establishment (AERE), at Harwell, under the supervision of Dr. A. C. Chamberlain. Also, the Warren Spring Laboratory, Stevenage (Hertfordshire), which is a government establishment responsible for monitoring pollution of all kinds in the UK, made independent flights with the same objectives. Finally, all the work in the UK on that subject has been brought together and unified by a group under Dr. L. Reed, director at the Department of Environment, London. (Dr. Reed is also chairman of the OECD project.)

The objectives of the field program were: (1) to deduce the deposition of SO_2 at the ground, (2) to estimate the conversion rate of SO_2 to sulphate, and (3) to measure the efficiency of washout of SO_2 in the presence of rain. At least 500 ℓ of air had to be sampled to determine the sulphur dioxide content at any particular level, which took about 40 minutes of flight. The flight tracks followed the east coast of the UK and the west coast of Norway. Samples were taken at three levels within the mixed layer along the Danish coast and at five levels along the UK coast.

The determination of the distribution and magnitude of sources of sulphur dioxide (and their temporal evolution) was an essential goal of the field program. The UK was divided into 20 x 20-km squares in the middle of which an SO_2 source strength was assigned. The largest single contributor to the atmosphere's load of sulphur dioxide comes from power station emissions: 2×10^6 tons/year for coal-fired stations and over half a million tons from oil-fired stations. Industry is the next largest contributor. The total emission for industry and domestic sources, excluding power stations, can be figured on a rough basis if one allows 100 kg of SO_2 per member of the population. After having excluded power stations, Smith devised a simple scheme to obtain an estimate of the SO_2 source strength of a given city. Estimates of this kind, combined with knowledge of GNP, enabled Smith and his colleagues to account for the SO_2 emission sources located in East European countries.

The conclusions of this field program were: (1) SO_2 settles at a deposition velocity of about 0.8 ± 0.2 cm/sec and therefore about 30% settles to the ground (dry deposition) or sea before arriving on the western shores of Europe; (2) the fraction of SO_2 which is converted to sulphate is quite sensitive to the ambient relative humidity. Near a source of SO_2 the conversion is practically nil for relative humidity below 60% and tends to 100% as the relative humidity approaches 100%. When SO_2 is well mixed in the atmospheric boundary layer the conversion rate was estimated to be 1% per hour; and (3) the washout by rain appears to be very effective (wet deposition).

Using a simple numerical model which incorporated the finding from the field program, the group constructed the back trajectories emanating from Norway twice a day for three years (1972-1974). According to Smith's model the average contributions of the two countries for that time period were as follows:

	UK	NORWAY
Wet Deposition (%)	34.4	10.9
Dry Deposition (%)	22.2	32.2
Total Deposition (%)	30.7	17.4

These estimates show that the UK contributes significantly to Norway's plight. Yet, in more easily grasped terms, the UK contribution is less than 3 grams of SO_2 per m^2 per year, i.e., about a tablespoon per m^2 per year.

What can be done about it? One possible solution might be to provide

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the power stations with two types of fuels, one being low in sulphur. According to Smith's estimates one would need a 36-hour accurate forecast of trajectories to enable the power stations to convert from one fuel to another; because of the average error in trajectory computations (±200 km) and inaccurate forecasts, one would be able to favorably alter the situation only about 30% of the time. Also, only power stations in the London and southern UK areas are fuel operated; those in the northern areas rely on coal. The estimated cost for the UK to "desulphurize" power stations' emission is about $£10^8$-10^9. Thus, the solution which relies on switching the type of fuel used in power stations, does not appear to circumvent the problem.

Another solution might be to review the UK's policy on the height of the smokestacks. The UK has tended to favor the high-stack policy; stack height greater than 120 m enhances the plume rise and provides for a virtual source of pollutant fairly high above the ground (400-500 m). The great advantage of the high-stack policy is to reduce the concentration of SO_2 very substantially at ground level in the immediate vicinity of the stack. The disadvantage is that there is more SO_2 for export (so to speak). It was estimated that medium height stacks (between 50-120 m) would decrease long-range transport by 16% but increase local ground concentration by a ten-fold factor. The benefit to Norway if such a policy was adopted would be very marginal.
(A. Barcilon)

PATTERN RECOGNITION--FACT OR FICTION?

May 1976

Pattern recognition has been a subject of intensive study for perhaps 20 years, ever since electronic digital computers came into general use. Check readers and mail sorters are examples of some of the fruits of the study. The field of pattern recognition is, however, much wider than simple character-reading; it encompasses problems ranging from speech recognition and language translation to target verification and chemical analysis. Many of the problems are exceedingly difficult and progress in their solution has been slow. There has been much esoteric mathematical exercise on linguistics, information structure, feature extraction, estimation and classification theories, and the like, that seems to have contributed little to the solution of practical problems (see ONRL Report C-11-74). Questions have been raised about the usefulness of abstract mathematical theorems. Is pattern recognition a fact or mostly a fiction? The Electronics Division of the Institution of Electrical Engineers (IEE) recently sponsored a half-day colloquium to assess the situation.

The format of the colloquium was a series of twelve 10- and 15-minute talks given by invited speakers on subjects of their own choosing. Short discussion periods followed groups of three to five presentations. Because the program was long and the presentations were short, it was difficult for the speakers to give details or even to get their essential ideas across in some cases, and it was equally difficult for the audience to discern coherence in the presentations.

The talks can be divided roughly into two groups: one group dealt with the general problems of pattern recognition and the other discussed special applications. Dr. W. K. Taylor (University College, London) pointed out that pattern recognition may be regarded as a two-stage operation; namely, pattern-vector synthesis, and pattern classification. The synthesis operation begins with input transducers such as photodiode arrays for optical character-recognition, filters for speech processing, and spectrometers for chemical

analysis. After appropriate normalization and *weighting processes*, multidimensional pattern vectors are formed whose tips are points in a pattern space. An ideal pattern-vector synthesizer should produce close clusters of points for patterns in the same class and widely separated clusters for different classes. The second operation of classification is to contain a cluster or set of clusters within suitably shaped hypervolumes made up of elementary hypercubes of appropriate sizes. Each hypercube is realizable in hardware as a single column of a resistor-programmable read-only-memory (R-PROM). In the simplest case there is only one sample vector (point) per class and the R-PROM is programmed to produce one hypercube centered on each point. This method has been applied for recognizing characters and spoken digits with an error rate of less than 1%.

Dr. B. G. Batchelor (University of Southampton, UK) noted that pattern recognition literature abounds with elegant mathematics. Numerous papers set out to prove that a certain learning process will eventually reach some desired state but fail to specify how long convergence will take. These mathematical treatises ignore the practical problems of analyzing *data on a* computer with a limited capacity and therefore relegate pattern recognition to the realm of fiction. He advocated the use of artificial data in an experimental approach and argues that since artificial data could be generated with precisely known properties, the probability *density function (pdf)* at any point in the pattern space could be determined. Bayes' optimal decisions could then be calculated and used as an absolute standard to assess the usefulness of a learning procedure. Artificial data would also be of great value in developing pdf-estimation techniques *and mode-seeking procedures*.

Professor I. Aleksander (Brunel University, Uxbridge, UK) was of the opinion that pattern recognition faces the danger of becoming a fiction if the emphasis is solely on software implementation and that it will in any case be an economic disaster if the theoretical methods and programming techniques, no matter how clever they may be, cannot be cheaply implemented. He discussed techniques based on random-access-memory (RAM), read-only-memory

(ROM), and programmable read-only-memory (PROM) implementations. At the heart of the techniques is a RAM network which is trained to perform the recognition task. Each RAM in the network acts as a variable-logic device and processes an n-tuple of the entire pattern, the desired recognition of such an n-tuple being signaled to the RAM through the *data* input terminal. Better than 90% accuracy for hand-printed character recognition and zero-error results for automatic identification of mass spectra were reported. After good results have been found using RAMs in an adaptive mode, they can be translated into ROMs or PROMs *working in a fixed or* alterable mode respectively.

For automatic recognition in a multiple-object environment, Dr. C. E. Pykett (Royal Radar Establishment, Great Malvern UK) introduced the idea of "implicit windowing." Within the framework of linear algebra, this *corresponds to representing a given input state as a multi-dimensional vector* in the state space, which is then projected into all possible subspaces corresponding to a single object. The projected vectors can consequently be classified as single objects in the normal manner.

Efforts at improving the efficiency of pattern recognition were reported by Dr. M.J.B. Duff (University College, London) who explored the potentialities of cellular logic arrays for parallel processing, and by Dr. A. P. Anderson *et al* (University of Sheffield, UK), who examined the possibilities of enhancing the visual perception of a back-scattered microwave image by an appropriate filtering operation on the *"Human-modulation* transfer function." However, both efforts are still in a preliminary stage and no outstanding results have been achieved yet.

Several speakers cited *examples* of special applications of pattern recognition. Dr. J. S. Severwright (Royal Military College of Science, Shrivenham, UK) described an automatic vehicle-sound recognition system based on the acoustic radiation characteristics of vehicle body structure. *A fuller description of Severwright's* work has been given in a previous issue (ESN 30-3:118). Another application of pattern recognition is in the area of industrial automatic

inspection; in particular, the on-line, real-time identification of defects present on rapidly moving surfaces. This is a difficult task involving the conversion of surface defects to electric signals, the elimination of noise, the removal of redundant information, etc. Using a statistical decision process, Dr. L. Norton-Wayne and his co-workers (The City University, London) have achieved a 90% reliability in recognizing a sample of defects from five classes. The speaker did admit that their results, though encouraging, were not yet conclusive.

P. J. Pobgee and R. S. Watson (National Physical Laboratory, Teddington, UK) described a new piece of hardware for signal verification, called the "CHIT" (which is the acronym of *cheap input terminal*--British patent 1310683, US patent 3885097). CHIT consists essentially of two orthogonal resistive strips separated by an air gap. Writing pressure on the upper strip deforms it into contact with the lower strip. Electrodes are connected across the ends of the strips so that a uniform voltage gradient is developed along its length and the voltage at the point of contact will be proportional to its distance from a reference point. The coordinates of the contact point are expressed in binary digital form using an analog-to-digital converter. It is claimed that CHIT allows both positional and temporal information to be obtained at low cost. Signature verification against a reference is not done on a point-by-point matching basis. Each pattern is reduced to a set of functions, or measures, of time and position, and ten measures have been found to be adequate for author discrimination. A 96% success was reported in experiments involving thousands of signatures. In one experiment subjects were asked to imitate several target signatures.

Although many of these fraudulent attempts were visually acceptable, all were rejected by the system.

There seems to be little doubt that pattern recognition is a fact in some special applications and in a restricted sense. Inasmuch as the invited speakers of the IEE colloquium were all active workers on pattern-recognition problems, their admission of the futility of their own work was not really expected! One thing was clear as a result of the talks and the subsequent discussions; that is, theoreticians should not be satisfied merely with existence theorems and proofs of convergence. If the problems of implementation are ignored, the formalism of the theorems and proofs becomes nothing more than the scenario of a fiction. I am reminded by what Dr. N. J. Nilsson said in the preface of his book, *Problem-Solving Methods in Artificial Intelligence* (McGraw-Hill, 1971): "Artificial intelligence is (or soon will be) an engineering discipline since its primary goal is to build things. Thus it makes no more sense to look for a theory of artificial intelligence than it does to look for a theory of civil engineering." Perhaps the same statement will hold if the words artificial intelligence are replaced by pattern recognition.

Is pattern recognition a fact or a fiction? I put this question to Professor E. R. Caianiello who is the Director of the respected Laboratorio di Cibernetica of the Italian National Research Council at Arco Felice (near Naples). His answer was: "It is 20% fact and 80% fiction." There may be many who do not agree with this assessment; but the advantages of re-assessing the situation periodically until the respective percentages are reversed seem quite obvious. (D. K. Cheng)

Over the past year there have been about 30 ESN articles reporting on various aspects of European space research. Included were overviews of the programs of some of the research groups as well as the progress individuals have reported at conferences and meetings. It was the intention for each of the notes to provide significant information on specific subjects, and readers are referred to these notes if such details are their prime interest. While these notes in total also serve to give some flavor of the total European space research program, it is the intention of this article to present in a more concise and complete manner some observations on the total program and on the ways in which it has been changing.

First of all, it should be recognized that the program in each European country is different from that in the others in terms of the type of work that is in process as well as in terms of its administrative support structure. As a result, the general observations in this article apply in varying degrees to each country. It cannot be stressed enough to those in the US that Europe is not an entity composed of countries differing only as much as New York, Texas, and California. Instead the languages, traditions and governmental structures and priorities differ markedly from country to country. This is true even in the space research area where the European Space Agency (ESA) is providing a focus for such activities in Europe.

While ESA itself is reasonably new, having been established in 1975, it is in large part a restructuring and combining of the earlier European Space Research Organization (ESRO) and the European Launcher Development Organization (ELDO). These organizations were formed in 1964 and were responsible for launching seven satellites. This was less than a quarter of the number of satellites launched in European national programs in the same period. However, the importance of the ESA program relative to the space programs of individual European countries will undoubtedly markedly increase. This is due to a number of factors, the most

important probably being that the ESA member countries (Belgium, France, Denmark, Germany, Ireland, Italy, The Netherlands, Spain, Sweden, Switzerland and the United Kingdom) each have committed themselves to support ESA each year with an essentially fixed buying-power amount of funds. These are international commitments of the individual governments and are not subject to short-period fluctuations in governmental policies. Instead the mandatory contribution by each member country is determined by the country's gross national product. These funds are used for the scientific satellite program and general operations but, in addition, member countries can fund "special projects" (i.e., Spacelab, application satellites, and launch vehicles) at levels commensurate with their level of interest. The net result of this stable yet flexible approach has been that the ESA program has been able to proceed on a relatively even basis. At the same time, however, inflation and shifting governmental priorities coupled with the substantial contributions to ESA have resulted in the phasing back of most strictly national space programs. As one example, it is unlikely that Germany will continue their national satellite program which in the past was responsible for the Azur, Wika, Aeros, Symphonie and Helios satellite programs.

Another factor which is tending to strengthen ESA is the continuing shift in space science from the flight of individual experiments on small satellites to the flight of complete observing facilities that can be used for a variety of studies (i.e., the US Space Telescope and the laser atmospheric sounding facility described in ESN 30-7:338). In many cases these larger facilities are beyond the capability of an individual European country either fiscally or technically. They can, however, be implemented by ESA since it provides a mechanism to combine the resources of many countries. It is likely that the availability of the US space shuttle will accelerate this shift toward

facilities since it can carry instruments about ten times larger than those now being flown into space and return them to earth for refurbishment and subsequent reflight.

The national programs in the future will largely be directed toward the flights of sounding rockets and balloons, as opposed to the flights of satellites, and the provision of experiments for satellites, baloons, and the space shuttle. Within these national programs, baloons will receive increased emphasis. In addition to their use in earth observation programs, they will be employed in a wide range of astrophysical investigations. In fact, it is expected that essentially all of the astrophysical research programs on sounding rockets will be phased out. They will initially be replaced by baloon experiments and later by a combination of balloon and shuttle experiments. This will leave the scientific sounding-rocket program mainly oriented toward auroral and magnetospheric studies. Even in these areas, however, it is likely that the program will also be phased back. There is only one area in which increased sounding-rocket efforts are likely. This is in materials research that uses the "zero g" capability that sounding rockets can provide to conduct studies in areas such as crystal growth, composite materials, fluid physics, and the properties of pure metals. As described in ESN 30-8:347, a substantial effort in this area will probably be initiated by Germany. Even this, however, will probably be a transient program increase which will last only until the space shuttle will be available for such experiments, in about 1980. In fact, it was the future availability of the shuttle which was largely responsible for the generation of this materials sounding-rocket program. This is just one facet of what will almost certainly be an increasing effort in Europe to get experiments ready for flight on the space shuttle. It will partly be due to the attractive technical capabilities of the shuttle, but it will also be forced by the major effort Europe is currently expending in developing the Spacelab for flight in the shuttle and the implied subsequent need then to use the Spacelab and shuttle. The Spacelab itself will fly in the shuttle's cargo bay and will be required for support services by

all experiments, both European and US, that are to operate in space using the shuttle as a base (ESN 30-8:349).

The sounding-rocket/shuttle program is just one example of the very close relationship between the US and European space programs. This coupling exists even though Europe has the technical capability of implementing essentially all aspects of space missions except satellite launches, and a launcher development program is now in process. The reasons for this close relationship are multiple, but one of the primary ones is that the constrained European fiscal resources mean it is very unlikely that they will embark upon a space program that duplicates one planned by the US. Thus, their planning of which new projects to start vitally depends on the content of the US program. Another reason is that with the increased sophistication of space missions even ESA cannot do some of the larger projects by itself without putting its entire program out of balance. As a result ESA must conduct such projects jointly with the US or some other country. The two new ESA projects which seem to have the best chance of approval, an instrument for the US Space Telescope Project and one of the two spacecraft for an out-of-the-ecliptic plane mission, are both of this cooperative type. A final reason for the coupling is that technical capabilities exist in the US program that European researchers need to use to stay in the forefront of their research areas. Thus, many of the research groups depend on US satellites as the carriers of their experiments.

Such factors combine to make essentially all levels of people engaged in space work in Europe very dependent on an accurate knowledge of the plans and directions of the US space program. This dependence coupled with their physical separation from the US and the different timing of their project approval process has created a situation in which minor perturbations, or even rumors of these in the US program, have caused misunderstandings and overreactions.

As to the technical content of the European space program, it is clear that in many countries the space capabilities developed to support

scientific experiments are finding increasing use in a variety of applied areas. These range from using the space-instrumentation technology for ground-based applications, to developing ground systems to interface with space systems (such as data buoys, receiving stations and earth observation data analysis facilities) to designing new space systems to exploit the use of space. These applied systems cover a broad spectrum and include the materials work already mentioned, meteorological satellites, and a number of communication satellites including ones for domestic telecommunication, air traffic control, and maritime communications. In several countries the growth of space applications has resulted in decreased support for the more basic space sciences. So far this decreased support has been most strongly felt in the sounding rocket area.

Finally, in a number of countries all the members of research laboratories now have essentially permanent rights to their positions. This has resulted in situations such as draftsmen refusing to draw figures for publications since it is beneath their competence (or dignity), etc. The result is that the scientists often end up doing a variety of peripheral tasks to make the program proceed. Also, the size of a group is no longer an indication of its capabilities, since as many as half could be unproductive. Another effect of such government job policies has been that groups have been maintained even when their programs have been terminated. The net effect is that there is appreciably more space-research capability in Europe than is being used. These many partially utilized groups are actively looking for projects in which to participate. The first choice of nearly all of them very probably would be to engage in cooperative programs and experiments with US institutions. There is a variety of reasons for this including the relatively easy working relationships that normally exist, the high technical capabilities in the US program, and the lack of a significant language barrier. However, if such US cooperative possibilities are not forthcoming, then cooperative ventures with countries such as the USSR will probably be increased to fill the vacuum (of space). Auf Wiedersehen!
(L. H. Meredith)

TRIBOLOGY--TECHNOLOGY OR TAUTOLOGY?

September 1976

Problems associated with friction and wear probably date back to the days when cave men used to drag their trueloves by the hair over unpolished surfaces. It was not until 10 years ago, however, that it was found to be necessary to lump these problems, and their related disciplines, into what was called a "new industrial technology." The origins of the movement were in the UK where the extent of industrial difficulties due to friction and wear was seen to be sufficient to justify direct government intervention. In 1966 the Department of Education and Science (DES) established a Working Group, under the chairmanship of Dr. H. Peter Jost, to identify the problems further and to advise on methods for their solution. Among many ideas spawned by the DES Working Group was the naming of the game: Tribology (stemming from the Greek tribos--to rub).

In celebration of the 10th birthday of Tribology, we have endeavored to discover the motives for its conception, and to examine some of its offspring in order to evaluate the success of the movement and learn from the UK experience. Our report, titled "An Industrial Technology Called Tribology--the UK Experience and Its Implications," is available through the usual channels (see back of this issue). We warn the potential reader, however, that the nature of our quest was such as to lead us

down politico-economic paths, and the report reflects the subjectivity inherent in such ventures--it is something other than a listing of current approaches to research in friction and wear.

The DES Working Group chose to illustrate the extent of tribological ills in UK industry in the form of money to be saved by "proper" design and maintenance--some £515 million, about 1.5% of the 1966 GNP. This was somewhat unfortunate, because the unprovable prediction has tended to be used as a measure of proof by supporters of tribology as well as by its detractors. The prognosis of huge financial gains did have something of a shock effect on the government, however, which promptly perpetuated the Working Group in the form of a Committee on Tribology. This Committee produced its final report in 1972, but it continued to exist as a sub-Committee of the UK Committee for Industrial Technologies. More important than the vision of £515 million in potential savings, to us anyway, were some of the causes listed for these deficiencies: the interdisciplinary nature of things tribological, and the inadequacy of communications between researchers (largely academic) and the industrial practitioners who were not deriving sufficient benefits from research.

A central theme of the Committee on Tribology was one of awareness. This is evident in the work of its sub-committees and working groups, the most important of which were concerned with education and training, research and liaison, and information and publicity. Today in the UK, and to some extent throughout the world, there is indeed a noticeable increase in awareness of tribological problems. The energy and dedication of those involved with the activities of the Committee have contributed to an exercise in technological public relations that deserves high marks. In the educational field, a "Basic Tribology Module" has been defined as representing a minimum coverage of tribology which should be present in the education of all mechanical engineers. Ambitious programs of a continuing-education nature have been developed and presented to industrial groups, and a *Tribology Handbook* has been published (M. J. Neale, ed., Butterworths, 1973). These and many other products have been

distributed within the UK with a liberal measure of enthusiastic salesmanship.

A particularly significant idea of the DES Working Group, later endorsed by the Committee on Tribology and implemented by the UK government, was to establish "Centres of Tribology." These were seen to be needed as a means of spanning the gap between industry and academia. In the US and elsewhere, the Centre operation might be viewed as an approach to Technology Transfer. With government underwriting, three Centres were established in 1968: two were sited on University property at Leeds and Swansea, and the third was based within the Reactor Engineering Laboratory of the UK Atomic Energy Authority (UKAEA) at Risley in central England. The Centres were to have cut their governmental purse strings by the end of their first four-to-five years of existence. Because of the nature of the relationship between the UKAEA and the Centre at Risley, it is difficult to assess the extent of its fiscal independence. With the exception of government contracts for specified projects, however, the Centres at Leeds and Swansea no longer receive government funds.

The Tribology Centres have been major focal points for our study, and their activities are described in our report. In general, the operations are modest, with staffs of 20, 15, and 3 at Risley, Leeds, and Swansea, respectively. Major portions of the activities of the Centres are devoted to trouble-shooting for industry and testing various machinery components for their wear and friction characteristics. Within the Centre at Risley, there is a European Space Tribology Laboratory--a valuable entry by the UK into the European space program. With a few exceptions, mostly at Risley, there is not much in the way of research going on (some projects are underway in nearby university engineering laboratories), and this is in spite of one of their original assignments ". . .to undertake research on a commercial basis." Also, in spite of their charter, the Centres now work independently of each other and often are in competition for the limited industrial business in tribology. Partly because of these factors, we sense that the

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Centres have not been completely successful in bridging the gap. On the side of the Centres "facing" academia, there is a need for more in-house research. On the industry side, even after 10 years of hard-sell, there is still a lack of commitment to tribology as a legitimate technology deserving of long-term investment.

In our visits to laboratories outside of the Tribology Centres, such as the one at Imperial College, we have seen a measure of high-quality interdisciplinary research in friction and wear that tends to belie the need for a new government-initiated industrial technology. In fact, we were left with the impression that many of the more successful lubrication and wear programs extant have not been "tribologized."

In our view, the two dominant and bona fide influences that cause people to think in terms of new organizational frameworks such as industrial technologies are (1) the interdisciplinary nature of real-world problems, and (2) the persistent communications problems that exist between industry and the largely academic research activities. That these influences exist today, as they did in 1966, is something of an indictment of the engineering community, and especially its academic underpinnings. We are not convinced that the formulation of tribology-like industrial technologies are nature's way to a solution to these problems.

The key is design, with all the interdisciplinary real-world orientation that the name should imply. Much of the responsibility for the stimulation and advancement of design, with all the "ologies" contained therein, lies with educational institutions and sponsoring agencies. The difficulty of the problem is in proportion to its importance. (R. H. Nunn and H. Herman)

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RICHARD D. MATHIEU	1970-1971	WILLIAM J. GORDON	1976-Present
ROBERT H. OWENS	1970-1971	MARTIN LESSEN	1976-Present

BIOLOGICAL SCIENCES

DANIEL H. MOORE	1949-1951	J. R. KINGSTON CAPT, MC, USN	1962-1964
GEORGE H. SMELSER	1951-1952	S. W. HANDFORD CAPT, MSC, USN	1963-1964
JOHN L. NICKERSON	1952-1953	C. E. MEYERS CAPT, DC, USN	1965-1966
T. K. RUEBUSH CAPT, MC, USN	1953-1955	CLARENCE N. PEISS	1965-1966
JOHN O. HUTCHENS	1954-1955	MITCHELL WEISSBLUTH	1967-1968
HERMAN I. CHINN	1955-1957	LEONARD M. LIBBER	1967-1969
O. SCHNEIDER CAPT, MC, USN	1955-1957	GEORGE A. HOTTLE	1970-1971
D. E. GOLDMAN LCDR, MSC, USN	1956-1957	RALPH R. SONNENSCHEIN	1971-1972
J. A. ENGLISH CAPT, DC, USN	1956-1958	ZAREH HADIDIAN	1958-1960
HARVE J. CARLSON	1956-1958	W. E. LUDWICK CAPT, DC, USN	1958-1960
J. A. O'DONOGHUE CAPT, MC, USN	1958-1959	ABRAHAM M. SHANES	1958-1960
AUGUSTUS T. MILLER	1960-1961	J. H. STOVER, JR. CAPT, MC, USN	1959-1962
JACKSON W. FOSTER	1961-1962	ARTHUR W. FRISCH	1972-1974
E. A. WALSH CAPT, DC, USN	1961-1964	MARTIN BLANK	1974-1975
		JOHN B. BATEMAN	1975-Present

PSYCHOLOGICAL SCIENCES

HENRY A. IMUS	1951-1952	JOHN A. NAGAY	1965-1966
CLARENCE H. GRAHAM	1952-1953	H. WALLACE SINAIKO	1967-1968
WILLIAM D. NEFF	1953-1954	NEWELL H. BERRY CDR, MSC, USN	1968-1969
LEE J. CRONBACH	1955-1956	JOSEPH ZEIDNER	1968-1969
FRANK A. GELDARD	1956-1957	IVAN N. MENSH	1969-1970
D. FARNSWORTH CDR, MSC, USN	1958-1959	JAMES T. LESTER, JR.	1972-1974
JOHN E. RASMUSSEN CAPT, MSC, USN	1964-1967	JAMES W. MILLER	1975-Present