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BIOLOGICAL SCIENCES

by J.B. Bateman

URSI AND BIO-RADIO SCIENCE: A HELSINKI SYMPOSIUM

Returning from Helsinki after listening to all but 3 of the 60 papers and looking at the 20-odd poster exhibits, that together made up the Open Symposium on the Biological Effects of Electromagnetic Waves during the recent XIX General Assembly of the International Union of Radio Science (URSI), I noticed a report in the London Evening Standard headed: "Eye Damage Fear on Micro Ovens." The article was prompted by an unique New York lawsuit claiming microwave oven leakage as the cause of cataracts in the two plaintiffs. The reporter went on to mention that although there is a microwave oven boom in cafes and restaurants in London, health authorities have no equipment for measuring radiation leakage. In any case, he noted, safety standards are controversial, with permissible levels of exposure differing about one-thousandfold between the USSR and the West.

The Russians are being too cautious, it is sometimes said; but perhaps we in the West have been too lax. Of British complacency there can be little doubt, if failure to take part in the URSI Symposium is a fair sign. Not a single paper came from the United Kingdom. By the same token, the problem is being taken very seriously in the US and Canada, with 59 communications out of 83 (including posters), against only 13 from the USSR, Poland, and Czechoslovakia, and 11 from West Germany, Finland, Sweden, Denmark, France, and Italy. So it was very much an American show, and if any step was taken toward the desired East-West *rapprochement*, it was taken behind the scenes. While many of the US reports dealt with painstaking (and often fruitless) efforts to repeat results on microwave hazards generated in the USSR and satellite countries, the small Russian team offered little that was new. Its members were handicapped by the dominance of the English language and the American addiction to homely colloquialisms beyond the reach of the foreigner trying to recall his high school English. To this extent the Symposium was a disappointment. On the other hand, it was clear that the US organizations most closely concerned have become more alive to the dangers of the nonionizing pollutant, even if the Russians should be shown to have overreacted.

It is not, of course, simply a matter of leaky microwave ovens. As C. Romero-Sierra (Queen's University, Ontario) said, "the electromagnetic environment will soon be a dominating one." W.R. Adey (V.A. Hospital, Loma Linda, CA), speaking for D.R. Justesen (V.A. Hospital, Kansas City, MO) referred to "the constant rain of microwave energy" and the urgent need for proper standards in anticipation of the large increase in pollution that will occur if tidal turbines and stratospheric solar power stations are developed. Can we reconcile future benefits with the accompanying dangers?

It is also not simply a matter of avoiding or defusing danger. The biological effects of nonionizing fields are not studied solely for the benefit of the environmental hygienist. There are possibilities of application in medicine, in agronomy, in theoretical cell biology, among the many subjects touched on in the Symposium and ably summarized by Romero-Sierra in a "State-of-the Art" talk. This diversity betokens a field profusely vegetated but in need of a little judicious weeding. Perhaps this will be accomplished by a new organization infelicitously christened The Bio-Electromagnetics Society. I am sure its founders do not intend to corral the word "electromagnetic" for their own limited uses. Equally, I cannot believe that they would be so immodest as to engulf the established fields of radiobiology and photobiology, but they are vulnerable to such misinterpretations. Perhaps in reality the banner matters less than what goes on beneath it, and among the Society's first achievements, I understand, will be publication *in extenso* of the proceedings of the Helsinki Symposium and organization of the next meeting, to be held near Paris in 1979.

In the rest of this article and a forthcoming one I shall follow a frankly personal bias on the principle that scientific attractiveness, like beauty, lies in the eye of the beholder. It seems to me that there are two widely separated, but ultimately converging, areas especially worthy of current attention. The first is the empirical identification of the inimical effects on man of chronic exposure to nonionizing fields

too weak to be sensed or to impose a significant thermal burden. The second is the search for comparatively simple systems which demonstrably suffer the immediate consequences of the primary biophysical events that underlie these harmful phenomena. From this standpoint the more or less acute results of thermal loading by microwaves, even though not yet fully catalogued or understood are of less interest. I do not mean to suggest that the distinction can be sharply drawn. There may well be a twilight zone in which local resonances or standing waves, giving rise to "hot spots," produce effects quite different from those observed when extra heat is supplied by other means. The audible click produced by pulsed microwaves is a good example still under investigation (J.C. Lin *et al.*, Wayne State Univ., Detroit, MI).

I shall mention here some of the Symposium papers dealing with the effects of weak radio waves and extremely low frequency (ELF) fields on man and other animals, reserving the discussion of work on partial systems for an article in a later issue of *ESN*.

Establishing long-range effects of radio waves on people occupationally exposed is by no means easy, for many of the symptoms are subjective. The etiology of clinical signs may be obscure and the range of objective biochemical and physiological measurements available may be very limited, for obvious reasons. The problem is still more difficult for the population at large in outdoor city environments where the levels of radiation are often still quite low but subject to wide variation and are high in the vicinity of radio, television, and radar transmitters. Naturally much reliance has been placed on experiments with animals but, as M.G. Shandala (KNIIOKG, Kiev, USSR) pointed out, this introduces the new problem of extrapolation to man. There is also a difference of approach between East and West which may account for some of the disparate conclusions drawn. We in the West are dedicated to the conventional concepts of laboratory experimentation. The Russians, on the other hand, embrace what Adey, speaking for Justesen, called "the admirable construct of ecological validity" involving real-world modeling and prolonged exposure to multi-path fields, with the attendant difficulty of determining whether observed changes are due to the radiation or to a combination of incidental stresses. He might have said that incidental stresses are almost as difficult to avoid in the laboratory, and just as insidious. V. Riley and D.H. Spackman (Pacific NW Res. Foundation, Seattle, WA) showed that anxiety stresses may produce some of the effects that have been ascribed to radio waves, and M.F. Gillis and W.T. Kaune (Battelle Pacific NW Labs., Richland, WA) described experiments from the results of which one might suspect that animals "know" when they are placed in a 60-Hz field because of tactile stimuli caused by vibration of hairs.

The Russian approach was described also by Shandala. The emphasis, he said, should be on detection of changes in the standardized fuctional state of the organism rather than on the possible intrusion of pathological events. Sub-threshold fields cause changes which either remain within the normal limits of variation or which can be brought back within those limits by adaptation. However, Shandala claims that pathological changes can be produced at power density levels which are still far below the accepted US threshold of 10 mW/cm^2: for example, at 50 $\mu W/cm^2$ UHF (0.3 - 3.0 GHz) the "immune response" is depressed and at 50-500 $\mu W/cm^2$ tissue proteins become immunologically foreign. Again, between 30 and 50 $\mu W/cm^2$ chromosomal aberrations occur, haploid cells increase, and fetal abnormalities are produced in pregnant rats.

Little was added to the many existing reports on human beings accidentally or intentionally subjected to insensible fields. B. Servantie (Hôpital Ste.-Anne, Toulon Naval, France) reported loss of weight, neurovegetative ailments, blood hypercoagulability, and pituitary insufficiency in a person after exposure for three years to "*champs diverses*" at about 1 mW/cm^2. Adey (for Justesen) mentioned that the "neurasthenic syndrome" characteristic of prolonged exposure to weak fields could be produced by an acute rise of brain temperature of about 1°C. The analogy contributes little to the question of chronic effects. W.D. Masterson (Univ. of Texas at Dallas, TX) found that small nonhomogeneous increases in the geomagnetic field modified the functional balance between right and left brain, while weak uniform fields caused changes in skin temperature

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and conductivity, probably by way of the hypothalamus.

The reported work on animals covered a wide range of zoological types, ambient field characteristics and recorded data, in such an inevitably spotty manner as to conjure up an image of a clear sky viewed soon after dusk. A balanced summary would be difficult. My own bias is toward behavioral and neurophysiological approaches on the supposition that the central nervous system is sensitive to electric and magnetic disturbances, fortified by the fact that it is here that correlations between changes induced by microwaves and by ELF fields are most likely to be encountered. At the other end of my value scale are those measurements of chemical, hematological, and immunological parameters that appear to have been made because the necessary techniques are there, like Everest, and not because there has been good reason to suppose that anything of interest might be discovered. But then, science would lose its charm if the unexpected never happened.

The Russian contributions included an interesting survey by J. Kholodov (USSR, affiliation not given) of the effects of magnetic fields and microwaves on the locomotor activities of fish, birds, and mammals. Typical results included large dose-dependent decrease of activity in birds exposed to power densities from 2 to 1000 $\mu W/cm^2$. Evaluation of this work must await the appearance of Kholodov's book, in preparation. Performance data on wild mallard ducklings exposed to an amplitude-modulated 450-MHz field at 1 mW/cm^2 were given in the abstract by the absent R.G. Medici and G. Lesser (Univ. of California, Brain Research Institute, Los Angeles). Stimulation was greater at a modulation frequency of 16 Hz than at 3 Hz. Shandala *et al.*, less adventurous than Kholodov, confined themselves to rats, finding that during regular exposure for a month to power densities of 500 $\mu W/cm^2$ at 2375 MHz exploratory activity was suppressed. Upon removal of the field overcompensated recovery occurred, with increased activity that persisted for 5 months. The confidence limits were large. The remaining Russian paper came from I.P. Loss *et al.* (KNIIOKG, Kiev), who found notable differences in various behavioral and biochemical factors among rats exposed for 20 hours daily to microwaves at 60 $\mu W/cm^2$, to intermittent simulated turbojet screw noise at 80 dB, to both, or kept as controls. The combined effects seemed to show some reinforcement rather than strict additivity.

The effects recorded by the Western contributors tended to be zero or unimpressively positive. De Lorge (Naval Aerospace Med. Res. Lab., Pensacola, FL) found the vigilance of rats exposed to 5.62 GHz in 0.5- and 2-μs pulses at 600 Hz to be unaffected until thermal action supervened at a power density around 27 mW/cm^2 and a specific absorption rate (SAR) of about 6 W/kg. On the other hand, M.I. Gage and W.M. Guyer (US EPA, Res. Triangle Park, NC) found that the response rate of rats to a food stimulus decreased in a constant field of 2450 MHz, while J.C. Monahan and W.W. Henton (Bur. Radiol. Health, FDA, Rockville, MD) found that rats moved out of a 2450-MHz field when free to do so. Thermal effects may have been responsible. I was interested in the finding from both laboratories that the animals' sensitivity to the UHF field became greater at higher ambient temperatures. The device of providing a suitably controlled supplementary stress in order more convincingly to detect radiation effects would be worth adopting in many kinds of experiment.

In the very low-frequency range rats have been shown by R.D. Phillips *et al.* (Battelle Pacific NW Labs., Richland, WA) to have definite preferences for being in, or out of, a 60-Hz field, depending on field strength (25-100 kV/m) and other factors. However, subtle pleasant or disagreeable field-associated perceptions have not been excluded. D.M. Weissfeld, speaking for D.M. Koltum, himself, and Y. JoSeto (Tulane U., New Orleans, LA) said that the electroencephalograms and the visually evoked potentials in rats conceived and raised in a vertical 60-Hz field, 20 kV/m, differ from those of the controls, tending to become normal when the field is turned off.

Other microwave studies dealt variously with mutagenesis, skeletal muscle, and egg production. E. Berman and H. Carter (EPA, Res. Triangle Park, NC) found no evidence for dominant lethal mutations in rats exposed for various periods pre- and post-partum to 425- or 2450-MHz fields, and no change of reproductive efficiency in the male off-

spring. The power densities were near or within the frankly "thermal" range, 5-28 mW/cm^2. Perhaps it should not be assumed that the same results would be obtained at lower power densities, more prolonged exposures, or different frequencies, but a comprehensive screening program would be formidable. Rather high fields, 10 mW/cm^2, were also used by A. Portela *et al.* (Inst. de Investigaciones Biofisicas, Jafatura III, Buenos Aires, Argentina; Brown Univ.; Nat. Inst. of Gen. Med. Sciences, US) who determined the electrophysiological properties of sartorius nerve-muscle preparations from frogs that had been subjected for long periods to 2.88-GHz fields in 0.67-μs pulses at 900 Hz. The data, analyzed with the aid of a new method of integrating the Hodgkin-Huxley equations, showed no differences in the various membrane excitation parameters from those of preparations from control animals and no differences in their temperature coefficients. Thirdly, J.A. Tanner (Nat. Res. Council of Canada, Ottawa) found that hens exposed continuously to 7.06 GHz at 0.18-360 μW/cm^2 produced more eggs than those not so treated but suffered deterioriating health with many deaths from avian leucosis and tumors of the central nervous system. One wonders whether the two effects were interrelated and whether either was really caused by SHF radiation.

Two attempts to check alleged changes in the permeability of the blood-brain barrier (BBB) during microwave irradiation were described. Spackman, Riley *et al.* (given by Riley) used 4 substances as chemical tracers. Two (fluorescein and galactosamine) penetrate the normal BBB to some extent while the others (homocystine and isoglutamine) do not. Irradiation of mice at 918 MHz, continuous or pulsed at 10 μs and 100 Hz, at quite high power densities (2.5-132 mW/cm^2) produced no demonstrable change: the first 2 substances entered the brain at the normal rate while the second 2 were always excluded. Studying the same question with dogs, and using as tracer plasma albumin tagged with 131-iodine, B. Chang *et al.* (Duke Univ. Med. Center, Durham, NC) sampled the cerebrospinal fluid in the cisterna magna after 20 minute exposures to 1.0 GHz at several power levels between 2 and 200 mW/cm^2. Except for 4 dogs out of 11 at a single power density (30 mW/cm^2) the results were negative. I am unenthusiastic about the conclusion from the occasional atypical result that the minority four exhibited "a microwave power window effect."

The hematological study reported by H.A. Ragan and R.D. Phillips also suffered from the irreproducibility of what were considered to be statistically significant effects. One is tempted to ask, in connection with this and the preceding comment, whether it is not an abuse of statistics to separate the results of successive identical experiments into those that appear to be mathematically "significant" and those that do not. But it is no doubt legitimate to wonder whether uncharacteristically wide variability may mean that something interesting, and perhaps worth pinning down, is indeed going on. In any event, these careful experiments did not succeed in demonstrating convincingly any consistent change in the hematological properties, serum chemistry, and bone marrow hematopoietic plaque-forming titer occasioned by prolonged exposure of mice to 2450-MHz continuous field or 2800 MHz pulsed at 2-3 μs, 100 Hz and 5-10 mW/cm^2.

A preliminary observation that may prove to be very interesting was mentioned almost in passing by C-K. Chou (Chou *et al.*, Univ. of Washington, Seattle, WA) while describing an elaborate study of the effect of continuous and pulsed 2450-MHz fields on rabbits at 1.5 mW/cm^2 administered for 2 hours daily for 3 months. No changes in electroencephalogram, body weight, blood chemistry, and hematology were found and no histophathology was detected. Yet the extremely sensitive dose-dependent hyperthermia produced by apomorphine, characterized by hyperactivity and pupillary dilation, seemed to be modified by the microwaves.

There is a long way to go before the effects of weak fields on man can be considered firmly established and understood, but there are now enough positive results amid a sea of negatives to guide us in choosing the lines of further research. It is, however, unfortunate that most of the work described at Helsinki, even that emanating from the East, has been done at power densities too high for the suspicion of thermal mechanisms to be confidently ruled out. It is as if the investigators want to make the best o both worlds. The attempt may satisfy the sources of largesse,

with their thirst for publishable proof that something is happening, but in the long run the result can only be to obscure the issue.

As for the properties, as revealed in Helsinki, of isolated cells, organelles, and other biological sub-systems as sensors of nonionizing fields, these will be discussed in a subsequent article. (J.B. Bateman)

ENERGY

MAGNETIC CONFINEMENT AT THE MAX-PLANCK-INSTITUTE OF PLASMA PHYSICS IN GARCHING

On a recent visit to the Max-Planck-Institute of Plasma Physics in Garching I had the privilege of speaking with Prof. Arnulf Schlüter about their program in thermonuclear research in general and the magnetic confinement program in particular. Ever since the development of the TOKOMAK in the USSR, most of the leading plasma physics laboratories throughout the world have been exploring this device as the most promising avenue for the possible production of fusion energy. At the Max-Planck-Institute there is such a program in progress along with continuing investigation of the stellarator device that was first proposed in Princeton and is now almost abandoned elsewhere. The TOKOMAK is a containment scheme for a hot plasma in which the confinement configuration is a torus. The TOKOMAK currently being built at Garching is called the ASDEX, which is an acronym for axisymmetric diverter experiment. The purpose of the experiment is to explore means of diverting plasma and impurities from the main toroidal confinement configuration so that the plasma can be analyzed and the impurities removed. ASDEX's torus has a major radius of 1.64 m and a minor radius of 0.40 m. The constant azimuthal field supplied by the principal magnetic windings is 28 kgauss, the plasma current induced in the configuration is 500 kA, and the discharge time is of the order of 1 sec. There are additional diverter coils inside the casing of the ASDEX machine which are intended to divert plasma out of the principal torus configuration. TOKOMAK differs from previous machines in that the plasma is not pinched in order to heat it to high temperatures, but rather the heating proceeds by ohmic dissipation of energy in the plasma. Dr. Helmut Niedermeyer led me around the laboratory and showed me the ASDEX in process of construction. Suffice to say that though the ideas are simple, the execution is extremely complicated. Niedermeyer explained that besides ohmic heating there will also be a facility for heating the plasma through the injection of neutral atoms into the plasma. These atoms will have energies of 50 keV per atom. In addition to neutral atoms, it is proposed to inject large molecules of hydrogen in which the atoms are bound by Van der Waals' forces. These large molecules or droplets each consisting of a few thousand atoms of hydrogen will have energies of 500 eV per atom during injection. Additional injection of pellets of frozen hydrogen are proposed for refueling the machine. It is important that these pellets be injected at the proper velocity so that they neither penetrate through the toroidal confinement configuration completely nor are vaporized and ionized at the outside of it.

Dr. Dieter Meisel conducted me around an earlier TOKOMAK at the laboratory called the pulsorator. This TOKOMAK, which copied the original Russian configuration faithfully, has a discharge time of approximately 120 msec and is used principally for diagnostic studies. The pulsorator also has stellarator windings to provide very small asymmetric applied magnetic fields.

The stellarator, which is still being used actively at the Max-Planck-Institute, is not being run as initially intended. There is very little magnetic pinching, and the stellaratory windings introduce an asymmetric component to the confinement magnetic field of the order of 2% of the rotationally symmetric or toroidal field. The discharge time in the stellarator is 400 msec and the confinement time is about 10 msec. The effective minor radius of the machine is 11 cm, and the aspect ratio of the toroidal confinement zone is about 20. The maximum field strength is about 40 kgauss.

In the TOKOMAK experiments the magnetohydrodynamic (MHD) stability of the confinement is being studied. The most serious instability or tearing mode is that which produces an elliptical minor cross section to the confinement configuration, and it is found that this in-

No need to ref. the other articles

stability is stabilized by a stellarator field. Once the magnetically confined plasma is stabilized against this elliptical mode, the higher modes of instability can be identified and studied. At this point it seems that a small stellarator field improves the confinement time by a factor of 2 to 5 over a pure TOKOMAK field.

Schlüter has been carrying on a theoretical investigation of the MHD stability of confinement configurations. In this regard he has developed programs and codes for numerical experiments on plasma instability, and the comparison of the experimental results with his theory is truly remarkable: Results that he has obtained theoretically are in direct coincidence with those obtained in the laboratory.

Although we must continue to hope for the success of the Max-Planck-Institute and similar research establishments in providing us with a new energy source, it would be extremely foolhardy for us to place our full dependence on this as a solution to our energy problems. Rather, we must also concentrate on available technology and perhaps a change in life styles to conserve as much depletable energy as possible at this point. (Martin Lessen)

ENGINEERING

INSTITUTE OF RADIOENGINEERING AND ELECTRONICS OF THE ACADEMY OF SCIENCES OF THE USSR (MOSCOW)

During a recent visit to the USSR as a member of an Institute of Electrical and Electronic Engineers delegation participating in a scientific and technical exchange program with the A.S. Popov Scientific-Technical Association for Radio Technology and Electrocommunications (The Popov Society), I visited a number of educational and research institutes working in the field of radio engineering and related fields. The Institute of Radio Engineering and Electronics, one of these, employs 422 people and is housed in serviceable but seemingly old quarters situated quite close to Red Square. Entry to the building is through a security control gate not unlike typical industrial/military secure areas in the US.

Our host at this particular institute was Prof. Yuri V. Gulyaev, the Deputy Director and Head of the laboratory. Gulyaev is young (fortyish), impressive, speaks excellent English, is well acquainted in the Western World, and has a most engaging personality. He discussed two main themes of the laboratory's activity: electromagnetic wave propagation and electronic devices. In the former area interest extends from long waves through the optical region of the spectrum. Attention is devoted to atmospheric and space propagation, active and passive studies of the Earth, planetary atmospheres, and radar studies of planets. In the area of optical fibers attention is focused on graded quartz fibers with losses less than 2 dB/km and on 100-μm-diam. hollow, gas-filled fibers. Data rates of the order of 50 Mbit/sec have been achieved with light emitting diodes (LED), and of the order of 500 Mbit/sec with laser sources.

In the area of electronic devices emphasis is on the generation, detection, amplification, and signal processing of electromagnetic waves in the MHz to GHz regions. The effort includes development of surface acoustic wave devices, and Gulyaev noted that pulse compressions up to 10^4 have been achieved. He also pointed out that, "Surface acoustic wave device production amounted to $300 million in the US last year." The figure appears to me to be grossly high, but then maybe this merely reflects an argument he uses to justify his budget to his management. (A little such amplification in both the Soviet and US parts of this loop might well enhance research budgets in both places, but it isn't likely to attenuate the arms race!) The Institute is also studying sensitive detectors including Josephson junctions and SQUID configurations of Josephson junctions. Noise equivalent powers of 10^{-13} to 10^{-14} W/$\sqrt{\text{Hz}}$ were mentioned along with an estimate that 10^{-20} might be attainable in the superheterodyne configuration. Also with regard to detectors, Gulyaev commented that it is possible to make a magnetic-field-tunable maser using the quantum size effect (QSE). QSEs occur when one (or more) specimen dimension becomes comparable to the charge carrier (De Broglie) wavelength. Such effects are expected to play important roles as electronic devices are further microminiaturized. Although the QSE was "discov-

ered" at the Institute of Radioengineering and Electronics, that Institute is just now starting to undertake investigations of inversion layer QSEs in semiconductors, an area that has been actively pursued for many years in the US.

This topic triggered an interesting discussion on the formal meaning of the word "discovery" in the USSR. Gulyaev indicated that discoveries are granted and registered there just as patents are granted and registered. The distinction between discoveries and patents would appear to center on the degree to which the advance is either a new phenomenon or an application of known phenomena. One of Gulyaev's colleagues was quick to point out that discovery number 133 (out of some 150 to date) is the acousto-magneto-electric effect, which was discovered by Gulyaev, who received a monetary prize for his own personal use and of magnitude "sufficient for purchase of an automobile." Another renowned "discovery" is that of the electron-hole liquid in semiconductors.

When queried regarding the funding of the Institute, Gulyaev pointed out that, in addition to the institutional funding base, contract funds are awarded to the Institute for the performance of specific tasks for industry and for development organizations. In spite of this the Institute had recommended in 1964 that industrial organizations should have their own laboratories to short-circuit unwieldy research-development-engineering-production sequences.

Several individual laboratories of the Institute were toured, and the researches are listed below after the name of the investigator (transliterated to the best of my ability):

Vystavkin is investigating the properties of variable-thickness Dayem bridges (Josephson junctions).

Tsarkin is studying electron spin resonance (ESR) and nuclear magnetic resonance (NMR) in superparamagnets. His interests include dynamic nuclear polarization and spin-spin interactions. He uses a microwave pump to increase the paramagnetic susceptibility by as much as a factor of 10^3.

Bascharenov conducts both active and passive remote sensing studies via satellite (0.8-, 1.3-, 3-, 8-cm wavelength) and via aircraft (8 channels from 0.08 to 40 cm). His interests center on the depth and condition of Antarctic ice and on temperature and salinity as they relate to radio brightness. He also conducts studies of agricultural crops and of subsoil character. At 2- and 20-cm wavelengths he determines subsoil water down to 2 m in depth.

Persikov has developed equipment for drawing both solid and hollow optical fibers.

Shakovskoi described investigations underway in Katernikov's laboratory, which participated in the scientific investigations of the first Sputnik (1957) and of the Project Luna Moon landing. Using 40-cm wavelength radar sets in the Crimea, they conduct measurements of Venus and Mars to determine surface roughness, rotation rates, and orbital parameters (to an accuracy of 400-500 m).

Vorshilov conducts satellite experiments to determine the nature of the atmospheres and ionospheres of Mars and Venus. Good correlation with Mariner data was obtained. Plasma was detected in the vicinity of the Moon. Plasma occultation studies of the Sun were conducted.

Yjudski and Illiansov are investigating quantum size effects (QSE) in semimetal single crystals. Bismuth crystals of thickness of the order of 1000 Å are grown epitaxially on mica substrates at 10^{-6} Torr. The size-quantized discrete charge carrier energy levels (subbands) are verified by observation at low temperatures of (a) oscillatory dependence of electrical resistivity on thickness, (b) oscillatory behavior of the second derivative of the electron tunneling current-voltage characteristic, and (c) oscillations in the electrical resistivity versus pressure. This last manifestation of QSE is observed at temperatures as high as 77 K.

Stepanov has developed a nonvolatile semiconductor memory device. It makes use of an Au-doped n-type Si substrate. Depending upon the magnitude and sign of the voltage applied between an ohmic contact and a Schottky barrier contact, a highly conducting filament is either created or destroyed, evidently by melting. Switching is between 1 Ω and 10^6 Ω at 5 to 7 V. Switching time is 10^{-3} to 10^{-6} sec. The device deteriorates after about 10^4 cycles. These are not impressive characteristics as far as memories are concerned, but the device could perhaps find application as a means to disconnect faulty circuits and to connect to functioning replacement circuits in a self-repairing system. De-

tails are published in *Microelectronika* 6, 20 (1977).

Divin and Kogan are developing point contact Josephson junction detectors as wideband radiometers for astronomy studies. Maximum sensitivity is observed at a wavelength of about 2 mm. Noise temperature is about 0.1 K and noise equivalent power is about 10^{-14} W/$\sqrt{Hz}$. An extended report of visits to Electrical and Electronic Engineering Establishments in the USSR will shortly be available as an ONR London Technical Report. (Ted G. Berlincourt, Office of Naval Research, Arlington, VA)

ELECTRONICS IN POLISH AND ROMANIAN UNIVERSITIES

A recent visit to Poland and Romania as a National Academy of Sciences exchange scientist offered the chance of forming some impressions of education in these countries in engineering and particularly electronics. As both countries are Communist, it was expected that the governing structures of their schools would be similar, but each has its own traditions and some background history is therefore important.

Poland dates back to the 970s when Miesko founded the 1st Polish royal line. Partition in the late 18th century brought more than 120 years of servitude before independence in 1919 after WWI. Falling prey to Nazi Germany in 1939, Poland did not become a sovereign state again until 1945. It now has an area of 313,000 km^2 and a population of 35 million, which is 90% Roman Catholic. There are 106 women to 100 males, and 50% engineers, 64% medical doctors, 80% dentists, and 84% pharmacists are women, and about 1000 hold senior university posts. The oldest university, the Jagiellonian Univ. in Cracow dates back to 1364.

About 400 BC the territory now identified as Romania was inhabited by a Thracian tribe, the Dacians, since which time it has seen many invasions and migrations. Roman colonization from 98-271 AD left its mark, and the Romanians are essentially Latin, although their religion, Romanian Orthodox, is Byzantine in origin. Independence as a monarchy was finally achieved in 1877, and the country was proclaimed a Republic in 1947. It has an area of 237,000 km^2 and a population of 22 million.

In the European tradition higher technical education in both countries is conducted in independent schools, not in colleges within universities. In Poland these schools are known as Technical Universities and in Romania as Polytechnic Institutes.

Engineering degrees offered are similar in the two countries but not the same and include:

(1) Poland—Mgr inż. (Magister inżynier)
Romania—Ing (Diploma Engineer)
requiring a thesis, and equivalent to a Master's degree

(2) Poland—Dr. inż.
Romania—Dr. ing.
requiring a defended doctoral dissertation based on original research among other requirements

(3) Poland—Dr. hab. inż (Dŏktor Habilitowany of Engineering)
Romania—D.Sc. (Doctor of Science)
a doctoral degree similar to the British DSc and a step higher than the PhD.

There are four faculty ranks in both countries corresponding to the Professor, Associate Professor, Assistant Professor, and Instructor, the senior level in Poland being further divided into two grades namely Ordinary (Prof. zw.) and Extraordinary (Prof. nadzw.) the former being the higher. Ceilings on the number of Profs. and Assoc. Profs. on a faculty are 12% in Poland and 16% in Romania. Salaries are low by US standards, but contract research permits some augmentation, and in Communist countries there are no taxes and the government provides education, health care, and pension.

In Poland, there is a technical university in each large city, but a separate Electronics Faculty exists only in Warsaw (Waszawa), Danzig (Gdańsk), and Breslau (Wroclaw). The Technical Univ. at Warsaw with 23,000 students is the largest of all the universities in Poland. Its Electronics Faculty is divided into five Institutes; Basic Electronics, Automatic Control, Radioelectronics, Electron Technology, Telecommunications, and Computer Science, and in recent years the annual output

of this Faculty alone has averaged about 110 Inż's, 240 Mgr. inż's, and 26 Dr. inż's. The Institute of Basic Electronics has a teaching staff of about 95 with 4 Professors, 5 Docents and 20 Adjuncts. Currently it has 12 research groups working on synthesis of active systems, topological methods of linear network analysis and design, nonlinear network theory, analog electronic circuits, pulse and digital electronics, biocybernetics, microwave and solid-state electronics, optoelectronics, measurement of nonelectrical quantities, digital measurement systems, parameter measurements of nonlinear networks, and reliability problems.

In Danzig, as in Warsaw, most of the city's historical buildings and landmarks have been painstakingly rebuilt and restored since WWII. Here electronics is one of 9 faculties in the Technical University. It has about 1,000 students and and consists of 3 Institutes; Telecommunications, Cybernetics, and Electronic Technology. Telecommunications has a total staff of 200, and its teaching duties are distributed among 6 Chairs: in microwaves, electroacoustics, radio communication, wire communication, theory of electronic circuits, and information system theory. Prof. dr. hab. inż. Krzysztof Grabowski's microwave laboratories have research projects in passive MIC (microwave integrated circuit) devices, automation of microwave measurements, receiver-noise elimination, frequency stabilization of X-band radio link, and wave propagation in anisotropic media. One staff member is interested in the problem of detecting underground running water by radiation measurements and apparently can detect radiation near 1.42 GHz over underground running water at some locations.

Breslau was not visited, but the electronics institutes at the Technical Universities of Łódź and Cracow were. Łódź, an industrial city, has a population of 800,000 and is the second largest city of Poland, with many textile factories. Here there is no separate Electronics Faculty, but there is a 4-year old Institute of Electronics with a teaching staff of 46. This Institute has been involved in instrumentation work, as well as in the design and fabrication of 5-kW, 20-25-kHz ultrasonic generators and of testing apparatus for TTL circuits. Some work on microprocessors and computer-aided design is also being carried out.

Cracow, a prosperous city of 700,000 was the seat of the Polish monarchy from the 11th to the end of the 16th century. It is rich in historical, cultural, and intellectual heritage, and by some miracle escaped the havoc of WWII. It's Technical Univ. is 32 years old with 6 faculties, but it does not have a separate Electronics one. The Institute of Electronics, established in 1974, is a part of the Faculty of Transport and has a teaching staff of 37 with a main interest in electric machines, automatic control, and digital and analog circuit modules.

In Romania there are four polytechnic institutes: at Bucharest, Timişoara, Cluj, and Jassy, while electrical engineering is also taught at the universities in Brasov and Craiova.

The Polytechnic Institute of Bucharest has about 25,000 students and is the largest university in Romania (cf. Warsaw). Its original buildings are rather old, but a much more spacious campus with impressive new structures is now being built in another section of the city. The Department of Electronics is a part of the Electrical Engineering Faculty and has a teaching staff of 3 Profs., 4 Assoc. Profs., 4 Asst. Profs., and 10 Instructors who have published a large number of textbooks in Romanian, a casual examination of which indicates a coverage and treatment comparable to those in English at the same level. Ongoing research projects in the microwave area include synthesis and optimization of antenna arrays, frequency-scanned X-band waveguide slot arrays, digital radar speed measurement, high-power magnetrons and circulators.

At Timişoara (the first town in Europe to have electric street lighting) there are 5 faculties, in electrical, mechanical, chemical, civil, and agricultural engineering. The Electrical Engineering Faculty with 2,000 students comprises 4 departments: electrotechniques (electric machines), energetics (power transmission and distribution), applied electronics and telecommunication, and computers. The Computer Department is particularly active with the work divided into hardware, software, automata, and process control.

Cluj with a population of 300,000 is the second largest city (now challenged by Timisoara) in Romania. The Polytechnic Institute, founded in 1948, has 3 faculties, in electrical, mechanical, and civil engineering. Electrical Engineering with 800 students is divided

into 3 departments: electrotechniques, automation and computers, and electronics. Active work is being conducted on incremental-motion control systems and devices, measurement of nonelectrical quantities, and a software system for computer control and optimization.

Jassy, a city of 250,000 in the northeast, is only 15 km from the Russian border. Engineering education here has the oldest tradition in Romania having begun early in the 19th century. The present 'Gh. Asachi' Polytechnic Institute has 6 faculties and an enrollment of 14,000. The Electrical Engineering Faculty has 4 academic departments: electrical measurements and machines, electronics and computers, power utilization and automation, and electroenergetics. Electronics and Computers has a teaching staff of 18 with synthesis of sequential schemes, electronic systems for industrial control, nonlinear circuits, and software design for special problems as areas of specialization.

Compared to the US, the engineering curricula in Poland and Romania put much more emphasis on the student's ability to design and actually produce some hardware, such as a multipurpose measuring instrument or an automatic control device. This emphasis is important here for an engineer is often required both to design and make a product.

Comments. While the formal courses for the 4½-year Polish Mgr. inż. or 5-year Romanian Ing. degree are comparable to those for an MSEE degree in the US, student academic load is heavy, varying from 34 to 38 contact hours a week, exclusive of workshop activities. Entry to the technical universities is by examination, and an aspiring freshman has only one opportunity a year as the examinations are concurrent. The acceptance ratio is about 2.5 to 1.

By US standards laboratory and library facilities are poor, especially in Romania. There are few sophisticated instruments, even for research, and lack of adequate financial resources (in particular, foreign exchange) is a serious problem. There were no minicomputers or time-sharing computer terminals in sight. At Bucharest, no viewgraph or slide projector was available for a seminar although visual aids were available in Poland.

There is, however, no lack of enthusiasm and dedication on the part of the faculty in either country despite the difficulties and frustrations. Poles and Romanians are frank and generous people, and I was always received cordially and with warmth. I firmly believe that science and technology are independent of national boundaries, races, or political philosophy and that exchange of ideas and practices will encourage knowledge diffusion and progress. A more detailed account of my visit will be available in an ONR London report. (David K. Cheng, Syracuse Univ., Syracuse, NY)

CRYOGENIC TECHNOLOGY—ENGINEERING AND MATERIALS

Two International Conferences on Cryogenics followed each other in rapid succession early in July 1978. The first was the Seventh International Cryogenic Engineering Conference held at the Imperial College of Science and Technology, London (4-7 July 1978) which highlighted the increasing impact of cryogenic technology. The second, the International Cryogenic Materials Conference held in Munich the following week, was primarily concerned with nonmetallic materials for use in support of this technology.

Over 250 conferees at the London meeting exchanged ideas and discussed future trends in cryogenic engineering. These ranged from sophisticated scientific experiments on spacecraft, included terrestrial applications such as power generation and transmission as well as food preservation, and extended to that fundamental ingredient of living—health.

In order to obtain the sensitivity required by complex data-gathering instrumentation planned for installation in future space vehicles, it is necessary to cool x-ray, infrared, or similar sensors to liquid helium temperatures. Presentations discussed the problems and current approaches involved in utilizing liquid helium in these and other applications. For example, the cryogenic system must be able to function in zero gravity and at the same time