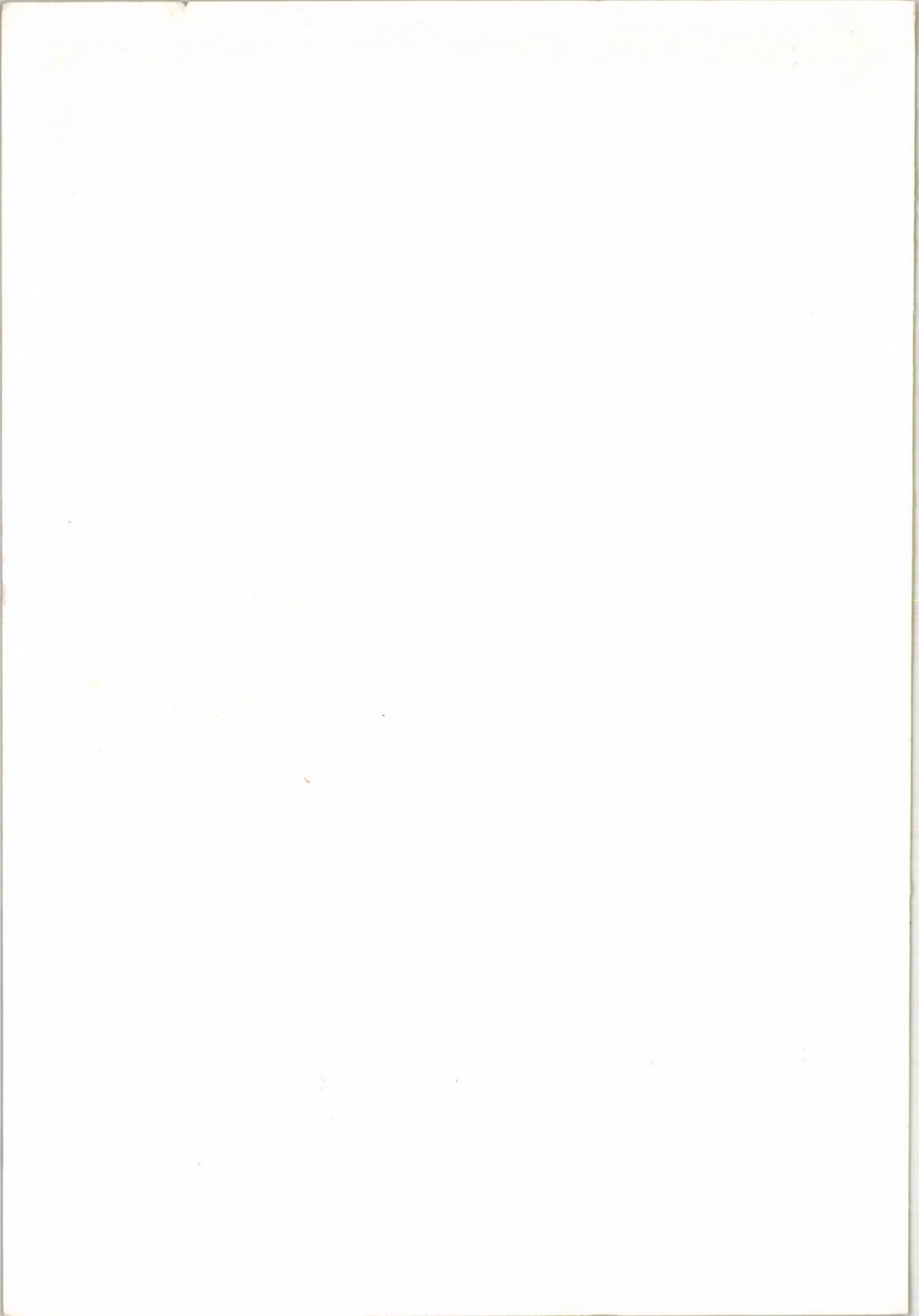# Central Research Institute for Physics

of the Hungarian Academy of Sciences

YEARBOOK

'77

YEARBOOK 1977

MTA ∘ Központi Fizikai Kutató Intézet

Central Research Institute for Physics
HUNGARIAN ACADEMY OF SCIENCES
BUDAPEST

CONTENTS

PREFACE

The year 1977 marks several noteworthy scientific
achievements of the Central Research Institute for Physics;
readers need only turn to the relevant sections of the Year-
book for information on them. However, having said this, it
should be pointed out that much of these achievements can
fully be understood only from the original publications since
solely the bare outlines can be given here. As with earlier
Yearbooks, this short preface allows just a few examples to
be given to illustrate the research activities of the insti-
tute.

Studies of great interest have already been carried
on for some years by our researchers within the scope of the
Intercosmos programme of the Socialist countries. Last year's
most prominent feature was the successful collaboration with
the researchers of the Space Research Institute, Moscow, in
explaining the origin of the Venetian night-time ionosphere.
The explanation evoked a considerable international stir.

It is with particular pleasure that I point to an
accomplishment in the thermonuclear programme the initiation
of which was announced in an earlier Yearbook. Our institute's

team developed a special scintillation-ionization chamber for the determination of the soft X-ray spectrum which, combined with up-to-date computer techniques, enabled them to perform measurements on the Tokamak-10 equipment of the Kurchatov Institute, Moscow. The spectrometer works with such a high efficiency that for four successive Tokamak discharges the statistics were sufficient for observations of variations in time. It turned out from the measurements that the spectral intensity increases anomalously in the range below 1500 eV. Another noteworthy contribution of our researchers to this programme was the development of a computerized data collecting system for the superconductive magnets of the Tokamak-7.

In the field of solid state research the fully automated preparation of almost defect-free bubble memory gadolinium-gallium-garnet substrates as well as the elaboration of the technology for growing epitaxial layers are among the results of major importance. The successful work of our solid state physicists in the preparation and analysis of metallic glasses is also worth mentioning, particularly as regards the improvement of stability conditions.

Because of the limits one has to set to texts of this nature and because one has no wish to highlight certain achievements at the expense of others, it is with regret that I have to reject the temptation to deal with advances in reactor research and in computer techniques.

Even so, I feel that I cannot give up mentioning what has been done in our laboratories by utilizing computer techniques in cardiology. A method has been elaborated which
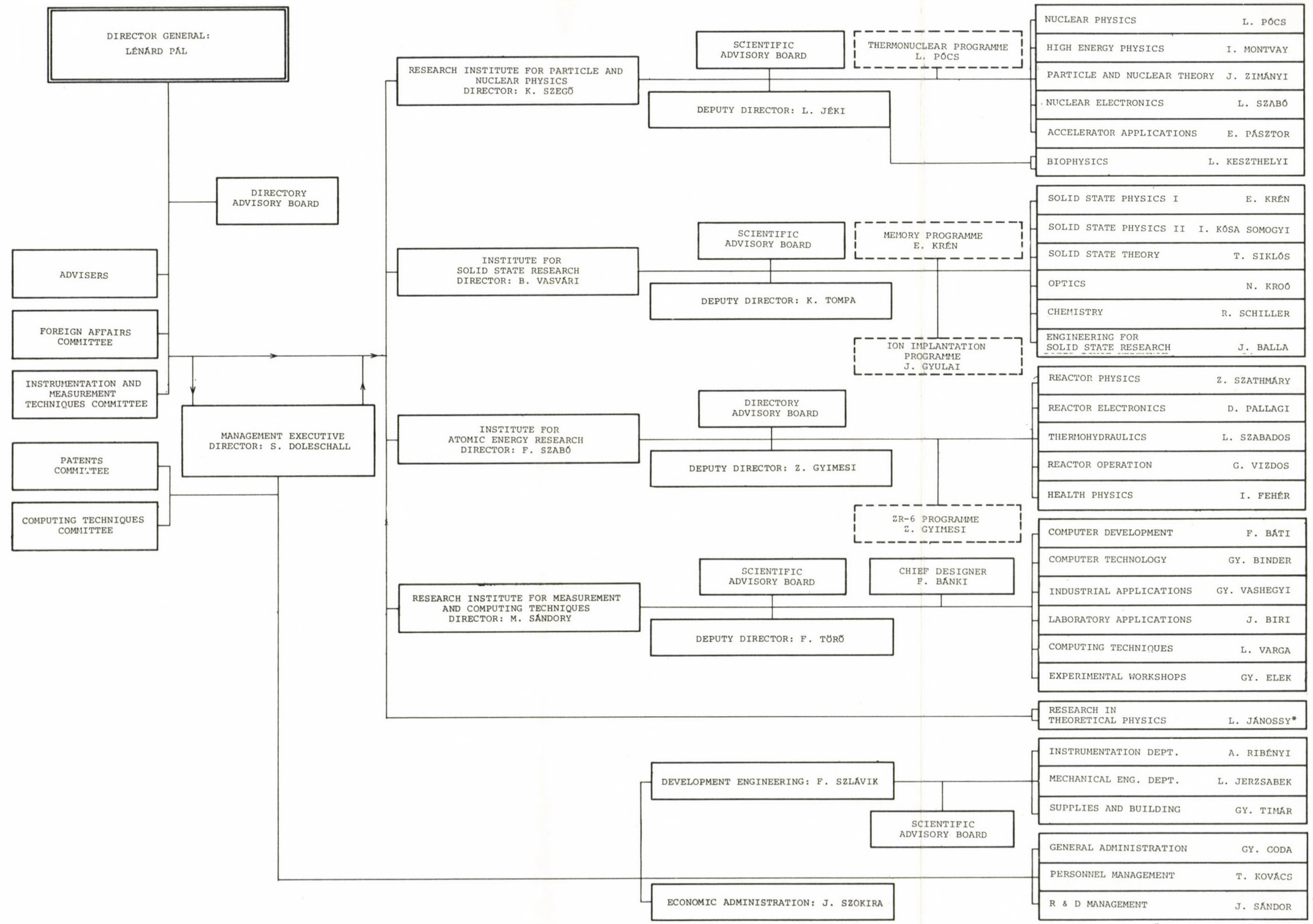
permits the most important spatial and time parameters of
cardiological processes to be mapped from the electrical
and mechanical signals of the heart. I have, in fact,
chosen this result since it demonstrates unequivocally
that almost any techno-scientific problem can be solved if
specialists of other disciplines are encouraged to partic-
ipate in the work of a research centre of suitable complex-
ity. With this in mind, it seems that before long it will
be a thing of the past to compare the expediency of research
establishments concerned with one special discipline with
that of establishments engaged in interdisciplinary activ-
ities.

Finally, I should like to use the opportunity af-
forded by this Preface to end on a personal note. After hav-
ing worked for more than a quarter of a century in the Cen-
tral Research Institute for Physics I take my leave of the
Yearbook's readers. In my new post, as president of the
State Office for Technical Development, I shall continue to
take an interest - stemming from a deepfelt commitment to
science - in KFKI's activities which I am sure will lead to
further valuable contributions to scientific knowledge.

L. Pál

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| RESEARCH IN THEORETICAL PHYSICS | L. JÁNOSSY* |

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*Deceased 2nd March, 1978

FUNDAMENTAL PROBLEMS OF PHYSICS

L. Jánossy* , A. Ádám, P. Kálmán, P. Király, A. Werner, Mária Ziegler-Náray

Investigations were continued on the consequent wave mechanical description of the processes of excitation and de-excitation of atoms. The interaction between electromagnetic radiation and an atom has been investigated, also taking into account self-interaction. From the calculations of a simplified case some interesting preliminary results have been obtained.

The long-standing question of the classical or quantum nature of electromagnetic radiation was further studied. The most recent experimental claims in this field were given much attention in our weekly seminars - also attended by members of the Optics Department and by other interested physicists. A Ph.D. thesis was written on the somewhat related problem of the semi-classical description of the Lamb shift. A survey of theoretical expectations for the scattering of electrons by strong electromagnetic fields (laser beams) has been started in collaboration with members of the Optics Department.

Earlier work on the behaviour of one-dimensional wave packets falling on a pair of thin potential barriers was continued and brought to a conclusion. Work was started to extend the results to more realistic three-dimensional problems and to give a microscopic description of radioactive decay.

The very fundamental problem of the dimensionality of physical space was tackled in collaboration with a research group in the University of Denver, Denver, Colorado, USA.

Research was done on the generation of cosmic magnetic fields by the dynamo mechanism - a process playing a fundamental part in cosmic electrodynamics.

Earlier work was continued on the nature and origin of extremely energetic cosmic ray particles. A comprehensive survey on the experimental and theoretical aspects of cosmic ray anisotropy was started in collaboration with members of the Cosmic Ray Department of our institute and with research workers of the University of Durham, Durham, England.

Members of the group gave accounts of their work in several lectures and seminars both in Hungary and abroad. A number of research papers have been submitted to various journals. Professor Jánossy was invited by the School of Theoretical Physics of the Institute of Advanced Studies, Dublin, Ireland. During his stay there he presented three seminars on wave mechanics and on the propagation of light.

Members of the group continue to participate in the physics-mathematics education experiment in secondary school teaching. Experimental teaching is in progress in two schools and a number of booklets relating to this work have been prepared as the basis for a secondary school textbook. The first volume of a projected three-volume university textbook on vector analysis is already in print and a textbook on electrodynamics is in preparation. University lectures are held regularly.

PUBLICATIONS

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2. L. JÁNOSSY: An unpublished idea of D.R. Hartree and its extension. Acta Phys. Hung. $\underline{41}$, 211 (1976)

3. L. JÁNOSSY: Again the Kennedy-Thorndike experiment. Acta Phys. Hung. $\underline{41}$, 305 (1976)

4. P. KIRÁLY: On the origin and propagation of ultra high energy cosmic rays (Abstract). Proc. 15th Int. Cosmic Ray Conf., Plovdiv, Bulgaria, $\underline{2}$, 315 (1977); KFKI Preprint (1977)

THESIS

P. Kálmán   The Lamb-shift in $j = \frac{1}{2}$ states of one-electron ions.
                   (For Ph.D. degree)

RESEARCH INSTITUTE
FOR PARTICLE AND
NUCLEAR PHYSICS

HIGH ENERGY PHYSICS

RESULTS

THEORETICAL PARTICLE PHYSICS AND FIELD THEORY

A. Frenkel, P. Hasenfratz, P. Hraskó, M. Huszár, J. Kuti, Júlia Nyiri, J. Polonyi, K. Szegő, K. Tóth

The quantization of fields has been studied in curved space-time in connection with Hawking's effect. The radiation of black holes after semi-classical quantization has been investigated in great detail and work is continuing along these lines.

The relationship of the group theoretical aspects of the infinite momentum limit with phenomenological applications in deep inelastic lepton-nucleon scattering has been studied.

The theory of magnetic monopoles was revisited with the main emphasis being placed on the relativistic theory. The latter has been reformulated with the help of the method of canonical quantization. It is shown that Dirac's condition $2eg/\hbar c = n$ remains the necessary and sufficient condition in the relativistic theory. A system of a spinless charge and a spinless monopole possesses an intrinsic angular momentum $\hbar n/2$. A gedanken experiment in which this angular momentum might be observed has been described.

The quark bag model of hadrons remains one of the principal subjects of the group. The so-called CERN-bag has been further studied with an application to baryon spectroscopy and $SU(3)$ breaking effects in multiparticle production.

The original quark bag model and its modification by our group was the subject of a review article and has been submitted to Physics Reports. The main emphasis is gradually being shifted towards the conventional field theoretical background of the quark bag model with some hope for phenomenological applications in the future.

The non-relativistic quark model with confinement potential has been applied tó baryon spectroscopy. Further work is in progress in this direction.

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2. A. FRENKEL, P. HRASKÓ: Invariance properties of the Dirac monopole. Ann. Phys. (N.Y.) 105, 288 (1977)

3. A. FRENKEL: Reformulation of the relativistic theory of the Dirac monopole. KFKI Report 77-95 (1977)

4. A. FRENKEL: On the possible connections between quantum mechanics and gravitation. In: Quantum mechanics, a half century later, J. Leite Lopes, M. Paty, Eds., D. Reidel Publ. Co., Dodrecht, Holland, Boston, USA, 1977

5. P. HRASKÓ: Quasiclassical quantization of the magnetic charge. Am. J. Phys. 45, 838 (1977)

6. P. HASENFRATZ, J. KUTI: The quark bag model. KFKI Preprint (1977)

7. K. SZEGŐ: The effects of SU(3) breaking in the CERN-bag model. Nucl. Phys. B 120, 156 (1977)

8. G. PREPARATA*, K. SZEGŐ: Geometrodynamics for quarks and hadrons,the baryon status. Phys. Lett. B 68, 239 (1977)

THEORY OF RELATIVITY AND ASTROPHYSICS

B. Lukács, Z. Perjés, A. Sebestyén

Besides the current investigation in cosmological models we succeeded in constructing the Bonnor counterparts of the Tomimatsu-Sato series of solutions. In addition, we have investigated a tetrad formalism similar to that of Penrose and Newman, but adapted to the stationary vacuum problem. A concise system of first-order differential equations has been established that supports the hope of finding new static and stationary solutions.

An exact solution of the Einstein-Maxwell field equations de-scribing the behaviour of a Schwarzschild black hole immersed in electro-magnetic radiation field has been derived. The energy dissipation of the black hole is compensated by a flow along a wire-like singularity.

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*

CERN, Geneva, Switzerland

Investigation of the twistor model of hadrons has been continued. An extension of the early twistor model with interactions is being developed.

PUBLICATIONS

1. B. LUKÁCS: On the Bonnor counterparts of the Tomimatsu-Sato solutions. KFKI Report 77-79 (1977)

2. B. LUKÁCS, Á. SEBESTYÉN: On the rescaling problem of space-times admitting groups of conformal motions. Int. J. Theor. Phys. 16, 419 (1977)

3. B. LUKÁCS: Finite homogeneous relativistic elastic sphere in its own gravitational field. Nuovo Cimento B 40, 169 (1977)

4. Z. PERJÉS: An irradiated Schwarzschild object. Gen. Rel. Grav. 8, 689 (1977)

5. B. LUKÁCS, Z. PERJÉS: Time-dependent Maxwell fields in a stationary geometry. Proc. Marcel Grossman Meeting, 1975, Trieste, Yugoslavia, 1977

6. Z. PERJÉS: Perspectives of Penrose theory in particle physics. Reports on Math. Phys. 12, 198 (1977)

PHENOMENOLOGY OF PARTICLE DECAY PROCESSES

I. Montvay, J. Spitzer, J.D. Tóth, L. Urbán

A phenomenologically oriented quark model was developed for the description of strong and weak decay processes involving hadrons. The model is based on relativistic oscillator wave functions with the simplest possible spin structure. The Okubo-Zweig-Iizuka rule for SU(3) couplings is incorporated. The mesonic form factors, the strong two-body decays of vector and tensor resonances and the SU(3) properties of the weak decays of mesons were described within the framework of the model. Special attention was devoted to the recently discovered heavy particles with charmed quarks.

A simple model based on constant transition amplitudes and neglecting spins (including meson resonances and SU(3) symmetry) was extracted from the quark model. The multiparticle production aspects of heavy hadron decays were investigated.

PUBLICATIONS

1. I. MONTVAY, H. SATZ*: Bose-Einstein clustering and critical hadron temperatures. Nuovo Cimento A 39, 425 (1977)

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* Bielefeld University, Bielefeld, FRG

2. I. MONTVAY: Quantum statistical chain decay of fireballs. Nuovo Cimento A **41**, 287 (1977)

3. I. MONTVAY, L. URBÁN: Some new particle decays and the quark model KFKI Report 77-5 (1977)

4. I. MONTVAY, J. SPITZER: Confined quarks and the decays of "old" and "new" vector and tensor mesons. KFKI Report 77-45 (1977)

5. I. MONTVAY: Multiparticle decays of new heavy particles. KFKI Report 77-77 (1977)

6. I. MONTVAY: The SU(3) - properties of semileptonic and nonleptonic decays of mesons. KFKI Report 77-91 (1977)

EXPERIMENTAL PARTICLE PHYSICS - COUNTER TYPE MEASUREMENTS

G. Eszes, G. Jancsó, D. Kiss, I. Mannó, E. Nagy, L. Szente, L. Urbán, Gy. Vesztergombi

The group has taken part in the analysis of data obtained by the BIS on-line spectrometer of Serpukhov, USSR, in collaboration with teams from Dubna, Berlin, Sofia and Tbilisi. Upper limits have been obtained for the cross-section of inclusive charmed particle production in 40 GeV nC interactions; these charmed particles subsequently decay to $\Lambda\pi$, $\kappa\pi$, $\Lambda\pi\pi$, $\kappa\pi\pi$ final states. In parallel the cross-section of the diffractively produced system was also determined.

Two members of the group continued their research activities at the CERN Intersecting Storage Ring (ISR). One of them participated in the CERN-Hamburg-Orsay-Vienna Collaboration where the following new results have been obtained:

  i/ The differential cross-section of large angle pp elastic scattering has been accurately measured beyond $-t=4$ GeV^2. It has been shown that at $-t=6.5$ GeV^2 a change of slope occurs.

  ii/ It has been shown that in the pp $\to \Delta^{++}$ n charge exchange reaction at ISR energies the ρ Regge pole takes over the role of the π-pole which gives a good description of data at lower energies.

  iii/ A signal of the existence of the pp $\to (\pi^+\pi^-)$p Double Pomeron Exchange has been demonstrated and the corresponding cross-section has been estimated.

Another member participated in the British-French-Scandinavian-MIT Collaboration. It has been shown that the major part of the correla-

tions between secondaries emitted in pp collisions at ISR energies can be explained by the decay of vector meson resonances.

Two members of the group worked on the preparation of the μp deep inelastic scattering to be carried out in collaboration between CERN, Dubna, Munich and Saclay, and a third member joined an analogous experiment of the European Muon Collaboration.

PUBLICATIONS

1. E. NAGY: On the inverse of the Pomeranchuk theorem. KFKI Report 77-20 (1977)

2. K.F. ALBRECHT* et al. [including D. Kiss, I. Manno, E. Nagy, L. Szente, L. Urban, Gy. Vesztergombi]: Observation of the diffractive production of the $\Lambda K^+\Pi^-$ system. KFKI Report 77-48 (1977)

3. H. De KERRET** et al. [including E. Nagy]: Evidence for a change of slope in large -t elastic proton-proton scattering at $\sqrt{s}$=53 GeV. Phys. Lett. B $\underline{68}$, 374 (1977)

4. H. De KERRET** et al. [including E. Nagy]: Experimental evidence for double Pomeron exchange at ISR energies. Phys. Lett. B $\underline{68}$, 385 (1977)

5. H. De KERRET** et al. [including E. Nagy]: A study of the charge-exchange reaction pp → $n\Delta^{++}$ (1232) at ISR energies. Phys. Lett. B $\underline{69}$, 372 (1977)

6. G. AICHNER* et al. [including D. Kiss, I. Manno, E. Nagy, L. Szente, L. Urban, Gy. Vesztergombi]: Observation of a narrow peak in the $\Lambda^0\Pi^+\Pi^-$ system at 2082 MeV/c. EPS Conference on Particle Physics, Budapest, Hungary, 1977. Europhysics Conference Abstracts Vol. 2C, p. 22

7. G. AICHNER* et al. [including D. Kiss, I. Manno, E. Nagy, L. Szente, L. Urban, Gy. Vesztergombi]: Search for charmed particles in the mass range of 1.8 - 2.5 GeV/C^2. ibid. p. 49

8. G. JANCSÓ et. al.: Evidence for dominant vector-meson production in inelastic proton-proton collisions at 53 GeV C.M. energy. Nucl. Phys. B $\underline{124}$, 1 (1977)

9. M.G. ALBROW** et al. [including G. Jancsó]: Studies of proton-proton collisions at the CERN ISR with an identified charged hadron of high transverse momentum at 90°. I. On forward particles in high p_I reactions. CERN Preprint, November 1977

STUDY OF ELEMENTARY PARTICLES IN A BUBBLE CHAMBER

E. Dénes, T. Gémesy, K. Hajdú, G. Jancsó, L. Jenik, S. Krasznovszky, G. Pintér, I. Wagner

Investigations of inclusive reactions have been continued.

Results on the momentum and angular distributions of π^+ and π^- mesons were obtained in interactions of π^- mesons with carbon nuclei at 40 GeV/c.

On the basis of 3400 events we observed a difference in π^+ and π^- spectra, this difference is connected with the presence of leading pions. The ratio of Feynman x distributions for $\pi^- N$ and $\pi^- C^{12}$ interactions at equal energies has been analysed (see *Fig. 1*).
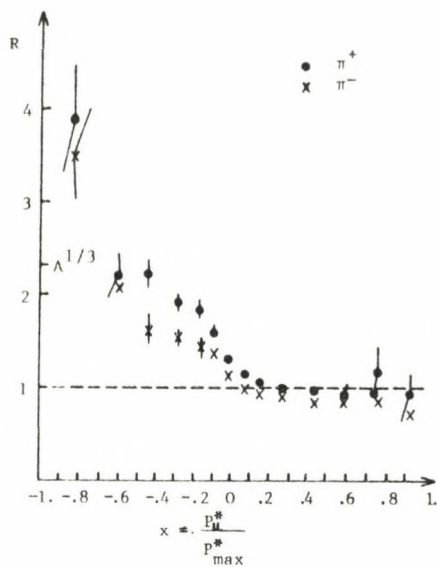
<u>*Fig. 1*</u>

The dependence of the ratio

$$R = (\frac{1}{\sigma_{in}} \frac{d\sigma}{dx})_{\pi^- C^{12}} / (\frac{1}{\sigma_{in}} \frac{d\sigma}{dx})_{\pi^- N}$$

on the Feynman x

In the working volume of the 2 m propane bubble chamber three thin tungsten (A = 184) plates were placed. The experimental average

multiplicities of the secondary π^- mesons, "grey" particles and fast protons with $P_p \geq 700$ MeV/c in the interactions of incident α-particles and protons with tungsten at 2.20, 4.20 and 5.60 GeV per nucleon were obtained. The comparative analysis of the changes in the average multiplicities depending on the kind of incident nuclei and energy was carried out. It was shown that the rise in the average multiplicities of secondaries in αW interactions was different in comparison with NW-collisions (see *Fig. 2*).

In the year 1977, the basic equipment of the RISK spectrometer (including the two big streamer chambers) experiment has been successfully tested; additionally, the essential on-line and off-line programs have been adapted to the CDC-6500 and R-40 computers.

The software on the R-40 computer of our institute and our scanning tables have been prepared for the start of the evaluation of streamer chamber pictures.

Fig. 2

The dependences of the ratios of the average multiplicities $\langle n_{\pi^-}\rangle$, $\langle n_g\rangle$ and $\langle n_g^f\rangle$ for αW and $N_\alpha W$ interactions on the momentum per nucleon of an α-particle

PUBLICATIONS

1. BUDAPEST - BUCHAREST - DUBNA - CRACOW - SOFIA - TBILISI - TASHKENT - ULAN-BATOR - HANOI collaboration:
   [including: T. Gémesy, L. Jenik, S. Krasznovszky, G. Pintér, G. Jancsó, K. Hajdu]: Investigation of interactions of π^- mesons with carbon nuclei at 40 GeV/c. Yad. Fiz. <u>25</u>, 1013 (1977)

2. ALMA-ATA - BUDAPEST - BUCHAREST - VARNA - WARSAW - DUBNA - YEREVAN - CRACOW - MOSCOW - PRAGUE - SOFIA - TBILISI - TASHKENT - ULAN-BATOR collaboration:
   [Including: T. Gémesy, L. Jenik, S. Krasznovszky]: Investigation of secondary particle multiplicity in proton and α-particle interactions with tungsten (A = 184) in the 2 - 5 GeV/nucleon pulse range. Dubna Preprint P1-10779 (1977)

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FLUCTUATIONS OF $\sim 10^{14}$ eV COSMIC RAYS

G. Erdős, T. Gombosi, J. Kóta, A.J. Somogyi, A. Varga
Visiting research worker: A.J. Owens[*]

The extensive air shower experiment on Musala Peak has given evidence for a non-solar diurnal anisotropy. The experiment has been run for several years with but a few major data gaps, and extreme care has been taken in interpreting the data in order to eliminate spurious drifts. To verify the techniques used to eliminate these spurious drifts, we have performed a power spectral analysis of the flux observed at Musala.

A power spectrum was calculated for each of 4 different epochs, using the nested variance method, then the four similar spectra were weighted and combined to give the "raw spectrum" *(Fig. 3)*. We used the corrected 3-hour average fluxes which meant that all the known, non-random variations were subtracted. Random fluctuations could arise from statistical Poissonian noise and from jumps in the counting response due to changing counter tubes. By removing their contributions from the "raw spectrum", we obtained what we called the "observed spectrum".

The "observed spectrum" exhibited a power law frequency dependence $P(f) \alpha f^{-1}$, with the low frequency component being reduced as
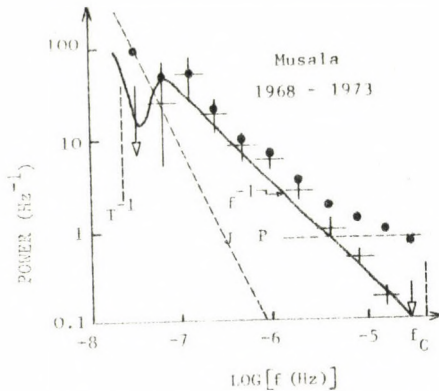
Fig. 3

Power spectra of the Musala fluctuations. Filled circles are the raw spectrum of n_r. Poisson noise level ("p") and contribution of counter-tube jumps ("j") are shown. Heavy bars give "observed spectrum", i.e. the raw spectrum minus p and j spectra with 1σ confidence intervals. Solid curve is predicted result for a f^{-1} spectrum with linear trends subtracted, displayed vertically for clarity. Aliasing frequency is f_c

linear trends were taken into account and subtracted at the correction. We concluded that the true power spectrum of the Musala fluctuation - corrected for Poissonian statistics, long term counter drifts, and linear trend

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[*] Kenyon College, Gambier, Ohio, USA

subtraction - is

$$P(f) = A / f$$

with $A = 4 \cdot 10^{-6} Hz^{-1}$. This spectrum was observed over the entire frequency range analysed ($2 \cdot 10^{-8} Hz < f < 5 \cdot 10^{-5} Hz$).

The detailed investigations showed that this fluctuation could not be produced by meteorological effects or tube-changing. Neither were their power spectra consistent with the f^{-1} power law, nor did the coherence calculations give any positive evidence.

The physically more exciting possibility of the fluctuation's originating in space far from the earth either in interstellar or in interplanetary space has been examined too. Interstellar scattering by random magnetic fields may introduce spatial fluctuation of cosmic ray density which, due to the apex motion of the solar system, would be observed as temporal fluctuation. This process, however, fails by several orders of magnitude to explain the Musala fluctuations. Another possible source we examined was the "scintillations" of the high-energy cosmic rays in the electric field that they see as they approach earth. This model gives the approximate time scales of the observed fluctuations but, even if primary cosmic rays were heavy nuclei, an unreasonably large value of the average interplanetary magnetic field strength would be required to match the observed magnitude.

The 0.5 per cent amplitude of the Musala fluctuations poses a difficult problem in finding a plausible source, as does the unusual 1/f spectrum. Nevertheless, our power spectrum analysis also gave the reassuring result that the residual, non-Poissonian fluctuations grouped at low frequencies so they could not have any noticeable effect on the anistropy derived from the Musala data.

PUBLICATIONS

1. G. ERDŐS, T. GOMBOSI, J. KÓTA, A.J. OWENS[*], A.J. SOMOGYI, A. VARGA: Fluctuations of $\sim 10^{14}$ eV cosmic rays. Proc. 15th Int. Cosmic Ray Conf., Plovdiv, Bulgaria, 1, 441 (1977); KFKI Report 77-51 (1977)

2. T. GOMBOSI, J. KÓTA, A.J. SOMOGYI, A. VARGA, B. BETEV[**], L. KATSARSKI[**], S. KAVLAKOV[**], I. KHIROV[**]: Further evidences of the anisotropy observed at Musala station. Proc. 15th Int. Cosmic Ray Conf., Plovdiv, Bulgaria, 10, (1977), (in press); KFKI Preprint (1977)

[*]   Kenyon College, Gambier, Ohio, USA
[**] Institute of Nuclear Research and Nuclear Energy, Sofia, Bulgaria

3. G. ERDŐS, A.J. SOMOGYI, A. VARGA: Analysis of data obtained with fast-
   timing angular distribution measurements. Proc. 15th Int. Cosmic Ray
   Conf., Plovdiv, Bulgaria, 10, (1977), (in press); KFKI Report 77-50 (1977)

THEORETICAL INVESTIGATIONS IN COSMIC RAY PHYSICS

G. Erdős, J. Kóta, A.J. Somogyi

Recent positive evidence for the anisotropy of 10^{12}-10^{14} eV
galactic cosmic radiation has given extensive grounds for speculation
on the three-dimensional structure of this anisotropy. A particularly
interesting development has been the appearance of a second harmonic in
the Musala and Norikura experiments demonstrating that the observed
variation cannot be interpreted as a result of an anisotropy vector only.
Having investigated whether experimental results can be reconciled with
a pitch - angle distribution favoured by theoretical arguments we conclud-
ed that pitch - angle distribution, although not entirely excluded, can
be considered as improbable. This statement, based on the phase difference
between the first and second harmonics, relies crucially upon the correc-
tion for the peculiar motion of the solar system.

We have pointed out that all components of the vector and tensor
anisotropies (except for the vector component parallel to the rotational
axis of the earth) can be determined separately even from one measurement
if the anisotropy consists of vector and tensor terms only and, furthermore,
if the principal axes of the tensor anisotropy point along known direc-
tions. Attention has been called to the fact that the direction of net
cosmic ray flow may well differ from that estimated on the basis of the
first harmonic only.

Various mechanisms for generating the second harmonic have also
been suggested and discussed. The experimental evidence gathered so far,
however, is insufficient to distinguish among these.

In the field of solar modulation we continued our studies on the
distribution of the energy loss suffered by galactic particles in the solar
system. By using the time - reversed technique, reformulated transport
equations were set up and equations of moments were deduced. We have
studied the force field approximation and discussed the effect on it of
the shape of the galactic spectrum and the second order effect of convec-
tion.

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   distribution or what else? Proc. 15th Int. Cosmic Ray Conf., Plovdiv,
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INVESTIGATION OF THE UPPER LIMIT OF THE SOLAR MODULATION SPECTRUM

G. Benkő, K. Kecskeméty, J. Kóta, G. Neuprandt, A.J. Somogyi

Cosmic ray measurements made at moderate depths underground
enable us to study the energy region where the solar modulation of ga-
lactic cosmic rays ceases. Based on the data of our underground muon
telescope (at a depth of 40 m w.e. underground) operating since 1958,
we continued the investigation of the upper limiting energy of modula-
tion.

The main aim was to determine the variation of upper limiting
energy in the period 1958-63. On analysing the first harmonic of solar
diurnal variation we found good agreement with the predictions of the
co-rotational model which showed that the radial flow was small. A clear
correlation between the upper limit and solar activity was established.

The semidiurnal anisotropy examined simultaneously supported
the validity of the model of symmetric density gradient perpendicular
to the ecliptic plane. Both the first and second harmonics can be ex-
plained in terms of the model according to which the modulation takes
place only in a narrow region around the ecliptic plane.

Sidereal variations around 10^{11} eV may either originate from
solar modulation or indicate genuine galactic anisotropy. So far we
have preliminary results and it is hoped that detailed study of our
results together with other measurements, will contribute to the better
understanding of the origin of the sidereal variation.

In order to examine the effect of interplanetary shock waves
on $\sim 10^{11}$ eV particles we have also started the study of transient modula-
tion for the same period.

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SPACE RESEARCH

G. Benkő, T. Gombosi, G. Huba, K. Kecskeméty, J. Kóta, Erzsébet Merényi,
Annamária Szentgáli-Páldi, A.J. Somogyi, A. Varga

Within the framework of the INTERCOSMOS organization we continued
the processing of low energy cosmic ray data obtained by the Prognoz-4
and Prognoz-5 satellites as well as the physical interpretation of cosmic
ray, magnetic field and solar wind plasma information collected by Prog-
noz-3 and Prognoz-4. This work was carried out in cooperation with sci-
entists of the Nuclear Research Institute, Moscow State University, Moscow,
USSR and the Space Research Institute, Moscow, USSR.

We paid particular atten-
tion to the analysis of two complex
solar energetic particle events. In
the first one, solar flare generated
particle fluxes were modified by fast
co-rotating solar wind streams,
while in the second case coronal
and interplanetary cosmic ray pro-
pagation following an eastern flare
was studied.
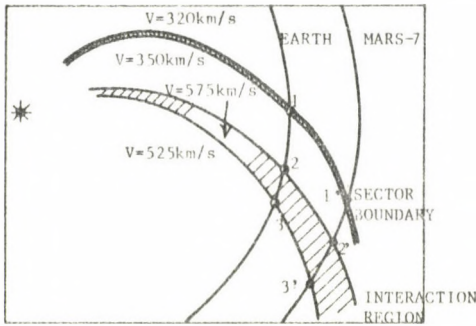
Fig. 4

*The discontinuity structure of the
interplanetary medium during the
solar energetic particle event of
3-5 November, 1973*

The general characteristics
of particle intensities registered
on board Prognoz-3 and Mars-7 during
the period 3-5 November, 1973 can be
well understood in terms of the model
shown in *Fig. 4*. When the flare oc-
curred on the Sun both spacecraft
were in a magnetic sector with ne-

gative polarity and relatively slow bulk velocity. From the early phase
of the event until the passage of the sector boundary (marked by 1 at the
Earth, 1' at Mars-7) the protons showed the usual diffusion behaviour,
characteristic of western hemisphere flares. The sector boundary was fol-
lowed by a region with positive magnetic polarity, where the particle in-
tensities showed exponential decay. The unusual behaviour of the event
began at 11:40 UT on 4 November when a magnetic disturbance passed the
Earth and - according to our model - at about 01:30 UT on 5 November, it
passed Mars-7. Before the first discontinuity, a peak of accelerated par-
ticles was detected which was followed by a plateau extending approximately
to the second discontinuity. The intensity decreased at both spacecraft
after the interaction region had passed. It is rather difficult to determine
the origin of energetic particles forming the intensity plateau observed

near the interaction region. A detailed analysis of the intensity profiles and anisotropies supports the opinion that the particles were continuously accelerated by the interaction region - though the mechanism of this process is not clear.
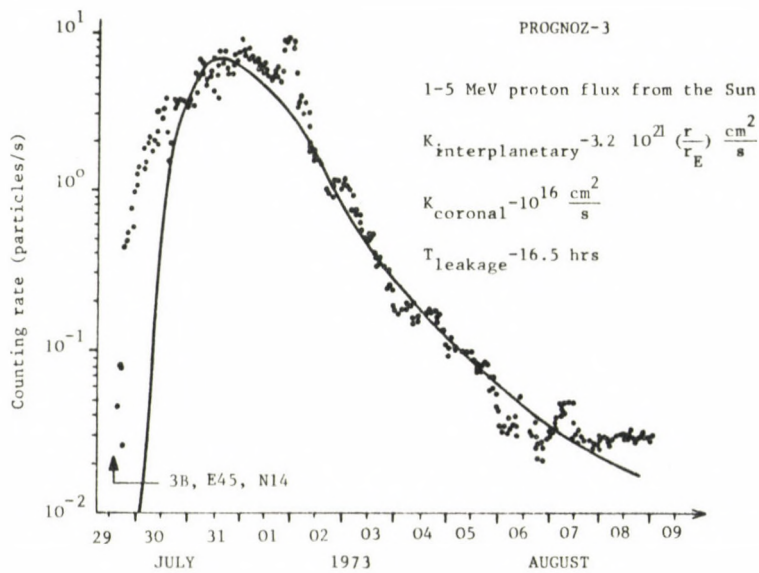

PROGNOZ-3

1-5 MeV proton flux from the Sun

$K_{interplanetary} - 3.2 \ 10^{21} \ (\frac{r}{r_E}) \ \frac{cm^2}{s}$

$K_{coronal} - 10^{16} \ \frac{cm^2}{s}$

$T_{leakage} - 16.5 \ hrs$

3B, E45, N14

Fig. 5

Fifty minute averages of proton fluxes in the energy range 1-5 MeV and the model approximation (solid line)

Intensity profiles of protons and electrons of various energies were analysed as well as the energy balance between the flare-produced phenomena following the 3B flare at E45 on 29 July, 1973. We were able to describe the general behaviour of particle intensities by a model using coronal diffusion along the Sun's surface with a constant diffusion coefficient and a Krimigis' type interplanetary diffusion and no convection or deceleration. To estimate the parameters a computer program was developed. The best fit for 1-5 MeV proton intensities is shown in *Fig. 5*. The solid line represents the model approximation. As can be seen from *Fig. 5* the initial phase of the particle event is not described by our model. This fact is a consequence of our neglecting the possibility of any fast propagation process in the corona.

In cooperation with scientists of the Space Research Institute, Moscow, we continued the analysis of data obtained by wide-angle plasma detectors of the Venera-9 and -10 space probes. One of the outstanding results of this work is the determination of equidensity patterns in the vicinity of Venus (see *Fig. 6*). In the near internal region the distribution of the equidensities qualitatively corresponds to the theoretical calculations carried out under the assumption of the flow around an obstacle of collisionless neutral gas plasma freely expanding to the corpuscular umbra. However in the far internal region the equidensities are very stretched; it suggests that there is a field - apparently a magnetic field - preventing plasma from filling the region behind the obstacle and supporting plasma disturbance at considerable distances from the obstacle.

The most interesting result of our collaboration was the explanation of the origin of the Venetian night-time ionosphere. We pointed out that the night-time electron densities determined from the radio occultation experiment depend on the intensity of electron fluxes with energies of 0-300 eV measured at altitudes of about 1500-2000 km.
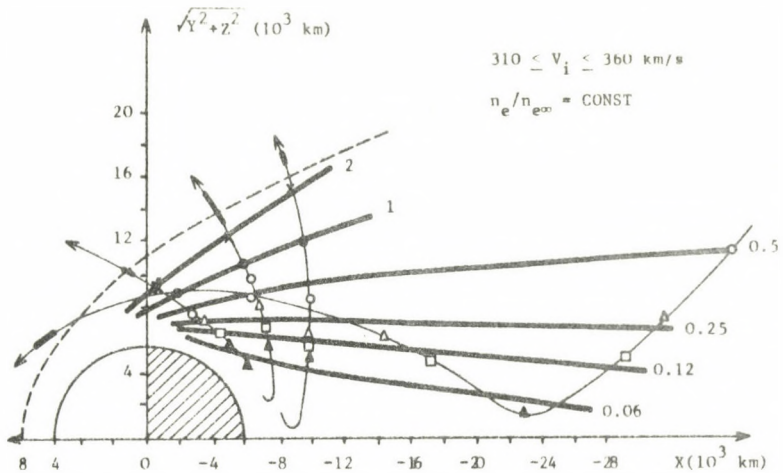
Fig. 6

The equidensity surfaces near Venus

The ion production rate in the ionosphere, due to electron fluxes measured in the optical umbra of Venus, was calculated under the assumption of a flat and one-component night-time atmosphere of Venus consisting of neutral CO_2 molecules. Our calculations show that electrons with energy of several tens of eV interacting with the CO_2 neutral atmosphere will produce an ionization maximum at altitudes where the density is about $2 \cdot 10^9$ cm^{-3}. Figure 7 shows two measured and calculated electron density profiles; the difference is rather small.

Last year we finished the measurements on the large photoemulsion stack exposed to cosmic radiation on the IK-8 satellite (experiment BFB-S). Our investigations have so far been concerned with the properties of the high-energy ($>10^{11}$ eV/nucleon) nucleus-nucleus interactions. We dealt with this problem in several papers and pointed out the existence of high energy nucleus-nucleus collisions with multiplicities substantially less than predicted on the basis of the assumption of free nucleon-nucleon collisions. This indicates that there exists a class of high-energy ($>10^{11}$ eV/nucleon) nucleus-nucleus interactions which cannot be interpreted in terms of simple superpositions of independent nucleon-nucleon interactions.
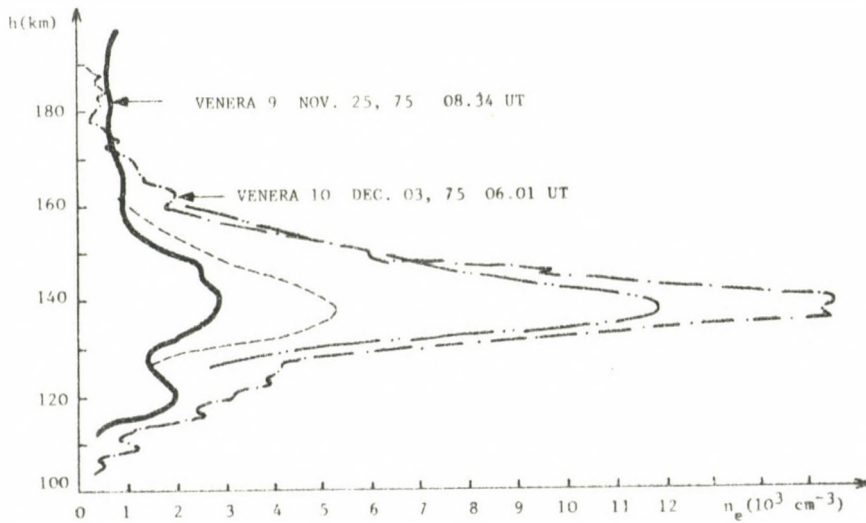
Fig. 7

*The comparison of calculated and measured electron density
profiles on 25 November and 3 December, 1975 (measured curves
are indicated by arrows)*

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   MARS-7 and PROGNOZ-3. KFKI Report 77-38 (1977); Proc. 15th Int. Cosmic Ray
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   I.A.SAVENKO*, I.P. SHESTOPALOV*, A.J. SOMOGYI: Study of coronal and in-
   terplanetary propagation of solar particles following the E45⁰ solar
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   interactions of cosmic rays in an emulsion stack combined with ionisa-
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** Space Research Institute, Moscow, USSR

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    Kosice, Czechoslovakia

FOREIGN RELATIONS

Lectures by visiting scientists

K.R. Schubert   (University of Heidelberg, Heidelberg, FRG)
                  Does the double pomeron exchange exist in nature?

A. Tounsi   (Université de Paris, Paris, France)
                  Statistical bootstrap and pion consideration

E. Futó   (University of Kosice, Kosice, Czechoslovakia)
                  Using PATCHY on R-40

C. Glassneck   (Joint Institute for Nuclear Research, Dubna, USSR)
                  The use of fast processes in physical experiments

V.N. Gribov   (Nuclear Physics Institute, Leningrad, USSR)
                  1. Non-Abelian gauge theory
                  2. On Reggeon calculus
                  3. Quantum chromodynamics

A.J. Owens   (Kenyon College, Gambier, Ohio, USA)
                  1. Why the cosmic ray anisotropy varies
                  2. Power spectrum analyses I., II., III.

M.A. Forman   (State University of New York at Stony Brook, New
                  York, USA)
                  Meteoritic evidence for the Maunder minimum in solar
                  activity

P.A.M. Dirac   (Florida State University, Tallahassee, USA)
                  Does the gravitational constant vary?

N.G. Antoniou   (Istituto Nazionale di Fisica Nuclear Frascatti,
                  Roma, Italy)
                  The critical Feynman-Wilson gas and hadron dynamics

I.M. Halatnikov   (Landau Institute for Theoretical Physics,
                  Chernogolovka, USSR)
                  Cosmological model including dissipation

G. Brauer   (Central Research Institute for Nuclear Physics,
                  Rossendorf, GDR)
                  Positron annihilation experiments in Rossendorf

J.P. Merekov   (Joint Institute for Nuclear Research, Dubna, USSR)
                    Inclusive production of anti-particles on nuclei at
                    high energies

Staff members on study tours

E. Dénes   (Joint Institute for Nuclear Research,
                    Dubna, USSR)   3 years

I. Manno   (Joint Institute for Nuclear Research,
                    Dubna, USSR)   6 years

I. Wagner   (Joint Institute for Nuclear Research,
                    Dubna, USSR)   4 years

Gy. Vesztergomi   (Joint Institute for Nuclear Research,
                    Dubna, USSR)   8 years

J. Nyiri   (Joint Institute for Nuclear Research,
                    Dubna, USSR)   2 years

L. Urban   (Annecy Laboratory of Particle Physics,
                    Annecy, France)   2 years

Gy. Benkó   (Lebedev Physical Institute, Moscow, USSR)
                    (High Altitude Observatory of the
                    Lebedev Physical Institute Tien-Shan, USSR)   4 months

Conference organized

                    EPS European Conference on Particle Physics
                    Budapest, 4-9 July, 1977

Guest scientists and fellows

A.J. Owens   (Kenyon College, Gambier, Ohio, USA)   9 months

V.N. Gribov   (Nuclear Physics Institute, Leningrad, USSR)   1 month

J. Scherk   (Ecole Normale Superieure, Paris, France)   1 month

G. Hosek   (Institute of Nuclear Physics, Řež,
                    Czechoslovakia)   1 month

NUCLEAR PHYSICS

RESULTS

THEORETICAL NUCLEAR PHYSICS

Gy. Bencze, I. Borbély, L. Csernai, P. Doleschall, T. Dolinszky, I. Lovas, J. Révai, J. Zimányi

As a new alternative to the calculation of bound state wave functions, a method has been proposed that is based on the separable expansion of the interaction operator on a harmonic oscillator (HO) basis. Thus the computational simplicity of HO wave functions is retained, while the bad asymptotic behaviour obtained by simple HO expansions is cured. The method was tested in single-particle 1s and 2s states in a Woods-Saxon potential. For weakly bound states it proved to be significantly better than the standard expansion technique.

A procedure has been developed for the solution of the two-centre problem with realistic potentials: first, we make a separable approximation to the single particle potentials and then the two-centre problem is solved exactly. The only approximations are introduced at the first stage in a well controllable way. As an example, we have calculated the single-particle energies and wave functions in the field of two ^{16}O like Woods-Saxon potentials in terms of their distance.

The two-body input to the Karlsson-Zeiger integral equations of the three-body scattering includes half-off-shell phase shifts for the elementary interaction. The phase equations now obtained supply the half-off-shell quantities in terms of on-shell phase functions, even for non-local interactions, in the form of linear differential equations. The Faddeev equations imply the two-body information in the form of completely off-shell phase shifts. The general off-shell phase equations developed here for their calculation are linear and imply as input on-shell as well as half-off-shell phase functions.

The numerical solution of the Faddeev equations with separable
S-,P- and D-wave interactions gave good agreement with the experimental
data. This fact indicates that the elastic scattering is not sensitive
to the off-shell properties of the N-N interaction. The calculations of
the break-up process have shown an unexpected sensitivity of the break-
up to the higher partial wave components of the N-N interaction.

There are several combinatorial problems in N-particle scatter-
ing theories which are independent of the way the dynamics is treated.
The most typical of these problems is the enumeration of the coupled
equations in the various formulations for systems consisting either of
distinguishable or of identical particles. This problem has been solved
for several formulations in the general case of an arbitrary number of
particles. A general algebraic theory of identical particle scattering
has also been worked out which is applicable to a wide class of exact
N-particle scattering theories.

A two-Hilbert-space form of Abstract Scattering Theory has been
introduced that is specifically applicable to multichannel quantum scat-
tering problems. Carefully reviewed topics include general physical foun-
dations of the theory, as well as the invariance principle, the asympto-
tic completeness of the wave operators, representation of the scattering
operator in terms of the transition operators and the fundamental equa-
tions that these transition operators satisfy. In addition, outstanding
problems such as the difficulties inherent in Coulomb interactions have
been pointed out. The channel coupling class of equations by Benze and
Tandy has been discussed with particular attention to the spurious solu-
tions to these equations.

The analicity structure of polarization observables in the
$z = \cos\vartheta$ plane has been studied. The kinematic behaviour at $z = \pm 1$
and the residue of the transfer pole for general spins and vertex orbit-
al momenta were obtained. The importance of the singularities of the
scattering amplitude in quasifree scattering was studied. Peripheral
model formulae were developed for the description of the as yet unexplain-
ed "collinearity effect" in the d/d,d/pn reaction.

The high energy A(p,p'd)B reactions have been considered for a
long time as a possible tool for the investigation of the two-nucleon cor-
relations in the nucleus. By studying this problem, we have found that
there exists a kinematic region where the contribution process from

$$p + A \to p + (B + n + p') \to B + (p + n + p') \to B + d + p'$$
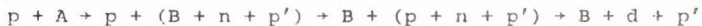
dominates over all competing processes. The cross section of this "quasi-

elastic" collision can be obtained from the measured data in a reliable way since cross sections of all other processes can be considered as constant in the region concerned. On the other hand, the cross section of the quasi-elastic collision can be expressed in terms of the two-nucleon correlation function and the reaction amplitude of the process p+n+p'→d+p'. This three-nucleon collision is just the inverse of the experimentally observable deuteron break-up. Consequently, the amplitudes are connected by time reversal. In this way there is a possibility of expressing the A(p,p'd)B cross section in terms of the experimentally observable deuteron break-up cross sections and the two-nucleon correlation function. Thus, the unknown correlation function can be extracted at a cost of minimum theoretical assumptions.

Aimed at studying the appearance of the pygmy resonance, finite range (Gaussian) and δ-force have been diagonalized on the basis of 27 particle-hole states with $J^{\pi} = 1^-$ in ^{116}Sn. Depending on the range of the force, 3.9 to 7.1 % of the total transition rate has been found in the 6-9 MeV excitation energy region, which comprises the unperturbed energies of the basis states that contain neutron threshold states.

For the description of the energetic few hundred MeV/nucleon heavy ion reactions, a simple analytic solution has been found to the non-linear hydrodynamic equations corresponding a free isentropic expansion into vacuum. A break-up concept is introduced yielding well defined break-up time, density, and temperature. The inclusive particle spectrum has been calculated for this model.

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***** Niels Bohr Institute, Copenhagen, Denmark
+ Institute of Nuclear Physics of the Hungarian Academy of Sciences, Debrecen, Hungary
++ Institute of Nuclear Physics, Moscow, State University, Moscow, USSR

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ISOBARIC ANALOGUE RESONANCES

Ilona Lovas-Fodor, J. Sziklai

The $g_{9/2}$ IAR in the ^{56}Fe$(p,\gamma)^{57}$Co reaction has been found in two fragments at E_p = 3735 and 3728 keV bombarding proton energies. At high level densities the differential type of measurement was performed, i.e. the excitation function for each stronger γ-transition was measured in the energy region of interest *(Fig. 1)*.

To identify the IARs the Coulomb energy displacement was taken into account as well and at the position of the possible candidates angular distribution measurements were carried out.

The measurements were performed in cooperation with research workers of the Zentralinstitut für Kernforschung, GDR.

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*** Zentralinstitut für Kernforschung, Rossendorf, GDR
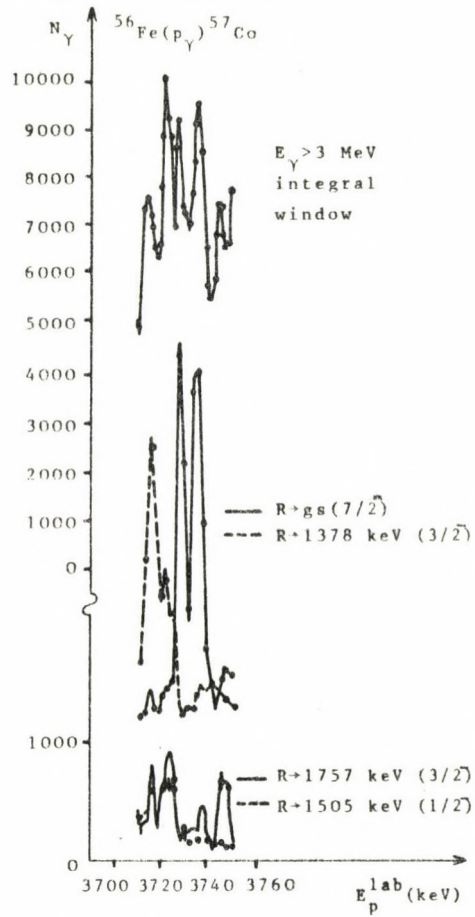
Fig. 1

Excitation function of the $^{56}Fe(p,\gamma)^{57}Co$ *reaction*

COUPLED-CHANGE EFFECTS IN DIRECT REACTIONS
COUPLED-CHANNEL EFFECTS IN DIRECT REACTIONS
Gabriella Pálla

Coupled channel calculations have been performed for the reaction
$^{40}Ca/^{6}Li,d/^{44}Ti/3^{-}/_{3.94}$ assuming coupling of α-transfer with inelastic
scattering in both the entrance and the exit channels. It is shown that
the higher order processes strongly influence the cross sections in parti-
cular when the direct transition is hindered by nuclear structure effects.
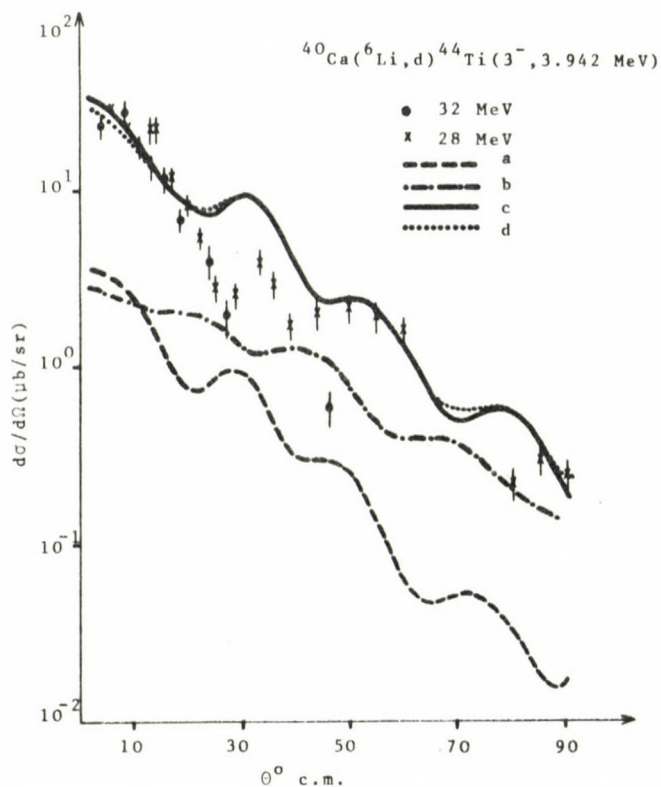
Fig. 2

ZR-CCBA predictions and experiment
a) DWBA, b) inelastic excitation in exit channel,
c) inelastic excitation in the entrance channel
d) inelastic excitation in both entrance and exit channels

The α-transfer strength observed previously was consistent with the two-step reaction mechanism including inelastic excitation of the collective 3_1^- octupole state of both the target and the final nuclei *(Fig. 2)*. The coupled channel analysis has resulted in new spectroscopic information, namely the relative spectroscopic factor $/^{44}Ti/3^-/; {}^{40}Ca/3^-/,\alpha/$, which could not be provided by the usual DWBA method.

PUBLICATION

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NUCLEAR FISSION STUDIES

J. Kecskeméti, Gy. Kluge, A. Lajtai, G. Petravich

The measurement of the energy spectrum of neutrons from the reaction $^{235}U(n_{th},f)$ has been continued in the 0.01 - 2 MeV energy region using the TOF method with a gas scintillation detector and a glass scintillator detector of ^6Li content as fragment and neutron detectors, respectively. The time distribution of the γ-ray background was measured making use of a glass scintillator detector of ^7Li content. The fission neutron spectrum of ^{235}U was determined relative to the reference spectrum of neutrons from the spontaneous fission of ^{252}Cf, measured in the same geometry. It was found that in the case of ^{235}U the surplus of neutrons in the low energy region (E < 1 MeV) relative to a Maxwell distribution describing the high energy region, was about 5-10 % larger than that for the ^{252}Cf.

Using the above method the measurement of the energy spectrum of neutrons from the reactions $^{239}Pu(n_{th},f)$ has been started. The experiments are carried out in cooperation with the Institute for Physical Energetics, Obninsk, USSR.

PUBLICATIONS

1. P.P.DYACHENKO[**], E.A. SERYOGINA[**], I.S. KUTSAEVA[**], V.M. PIKSAIKIN[**], N.N. SEMENOVA[**], M.Z. TAVASENKO[**], A. LAJTAI: On the neutron spectrum of ^{252}Cf spontaneous fission in the low energy range. At. Energ. 42, 25 (1977)

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[*]   Universität Hamburg, I. Institut für Experimentalphysik, Hamburg, FRG
[**] Institute for Physical Energetics, Obninsk, USSR

2. V.M. PIKSAIKIN*, P.P. DYACHENKO*, A. LAJTAI, N.N. SEMENOVA*: Search for delayed low energy neutrons for spontaneous fission of ^{252}Cf. Yad. Fiz. <u>25</u>, 495 (1977)

3. A. LAJTAI, J. KECSKEMÉTI, D. KLUGE, G. PETRAVICH, P.P. DYACHENKO*, V.M. PIKSAIKIN*: Spektr mgnovennyh neitronov deleniya ^{235}U teplovymi neit-ronomi v diapazone energii ot 30 keV do 1 MeV. III. Konferenciya po neitronnoi fizike, Kiev, USSR, 1977. Vol. 3, p. 26

QUASI-ELASTIC INTERACTIONS OF INTERMEDIATE ENERGY PROTONS

J. Erő, Z. Fodor, P. Koncz, Z. Seres

The (p,nd) reaction on ^{6}Li and ^{7}Li nuclei has been investigated by 660 MeV protons in a kinematically complete experiment. Deuterons at an angle of 6.5° to the beam were detected in coincidence with neutrons flying in a backward direction according to the kinematics of the quasi-elastic scattering on two-nucleon clusters. The cross sections $d\sigma/d\Omega_d d\Omega_n$ of these reactions for neutrons of energy greater than 20 MeV have been determined as being 0.1 and 0.16 mb/sr^2 for ^{6}Li and ^{7}Li, respectively. These values are 2.4 % and 7.0 % of the cross sections of the correspond-ing (p,pd) reactions.

In the ^{7}Li(p,nd)^{5}Li reaction about 50 % of the events led to residual nuclei of low excitation energy. Neutrons from these processes may be regarded as products of an exchange scattering of protons on di-neutron clusters in the p-shell of the ^{7}Li nucleus. According to a crude estimation the cross section of this elementary process is about 4 % of the free p-d scattering at the same angle. In the reactions leading to highly excited states in residual nuclei the neutrons were produced by multiple scattering processes inside the nucleus.

In the ^{6}Li(p,nd)^{4}Li reaction the residual system was created mainly with high excitation and a clear quasi-elastic character has not been observed.

PUBLICATION

1. D. ALBRECHT**, P. KONCZ, Z.V. KRUMSTEIN**, Yu.P. MEREKOV**, G. CHEMNITZ**, N.N. KHOVANSKY**, B.A. KHOMENKO**, HONG SUNG MU**, Z. SERES: Ustroistvo dlya izmereniya parametrov sistemy rastyahki puchka sinkhrociklotrona Laboratorii yadernykh problem OIYAI. Preprint JINR 13-10559, Dubna, 1977

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* Institute for Physical Energetics, Obninsk, USSR
** Joint Institute for Nuclear Research, Dubna, USSR

INVESTIGATION OF POSITION-SENSITIVE MULTIWIRE PROPORTIONAL CHAMBERS
L. Vályi

  The physical and operational properties of neutron sensitive multiwire proportional chambers (MWPCs) and drift chambers have been systematically investigated.

  The sensitive area of the MWPCs is 300x200 mm^2. The distance between sensing wire planes and HV planes is 2 mm and 3-5 mm for the neutron sensitive chambers and drift chambers, respectively; the spacing between sensing wires and potential wires is 10-25 mm. The characteristic operational data are as follows:

Resolution (for 5.9 keV X-rays)	∿15 %
Efficiency (for ^{90}Sr β-rays)	∿100 %
Plateau width	∿200-300 V

PUBLICATION

1. L. VÁLYI: Atom and ion sources. Akadémiai Kiadó, Budapest, and John Wiley and Sons, London, New York, Sydney, Toronto, 1977

MÖSSBAUER STUDIES ON CONDENSED SYSTEMS
Judit Balogh, I. Dézsi, I. Földes Jr., B. Molnár, D.L. Nagy

  Mössbauer measurements have been performed on ^{57}Fe and ^{57}Co doped $LiTaO_3$ single crystals in cooperation with the Universität des Saarlandes, Saarbrücken, FRG. The measurements were done at temperatures from 4.2 to 979 K. In some spectra, depending on the treatment of the sample in various atmospheres, the coexistence of Fe^{2+} and Fe^{3+} ions was observed. At room temperature and below, the spectra of Fe^{3+} showed paramagnetic hyperfine splitting which is characteristic of long spin relaxation times.

  In *Fig. 3* the temperature dependences of the quadrupole splitting ΔE of Fe^{2+} in $LiTaO_3$ and that of previously investigated $LiNbO_3$ are shown. The lines were obtained by least squares fits with a ligand field calculation supposing axial symmetry in T_{2g} approximation. From the fits for the energy of the lowest lying orbital doublet 274 cm^{-1}, for the coefficient of the spin-orbit coupling -80 cm^{-1} and for the lattice quadrupole splitting -0.07 mm/s were obtained for Fe^{2+} in $LiNbO_3$ while the corresponding values for $LiTaO_3$ are 233 cm^{-1}, -80 cm^{-1} and 0.00 mm/s.
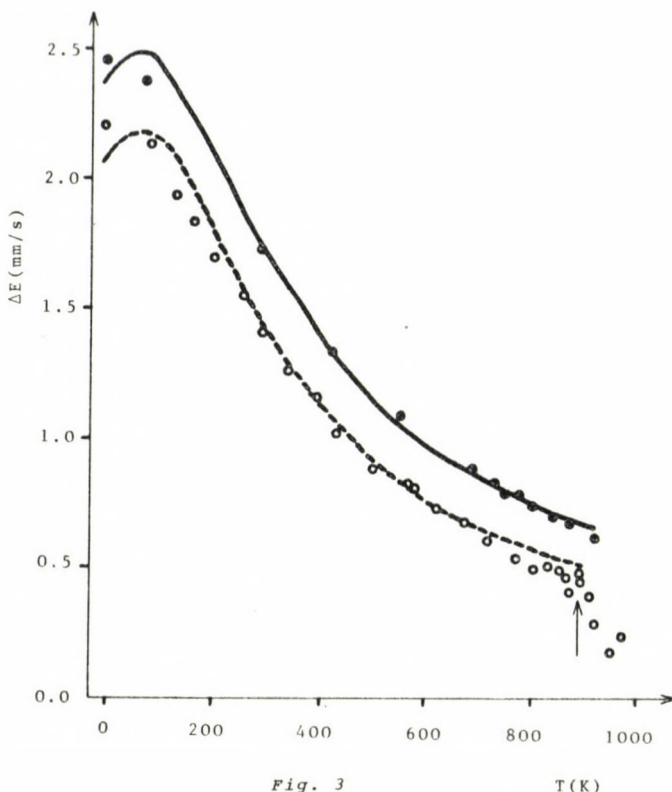
Fig. 3

Temperature dependence of the quadrupole splitting ΔE of the Fe^{2+} in LiNbO$_3$ (filled circles) and in LiTaO$_3$ (open circles). The arrow shows the ferroelectric Curie temperature of LiTaO$_3$

From the comparison of the values of the trigonal splitting with existing quadrupole coupling constant data for the location of the Fe^{2+} ions a random distribution along the trigonal axis is the most probable.

The local symmetry of Fe^{2+} ions in frozen aqueous solutions has been studied in cooperation with the Universität Erlangen - Nürnberg, Erlangen, FRG. In spite of the fact that the Mössbauer resonance lines are rather narrow at different temperatures in zero applied magnetic field they become very broad in an applied field of 50 kG. The spectra cannot be described in terms of a unique ligand field but a preliminary evaluation shows that probably the basic symmetry is trigonal. For the continuation of these studies and for measurements in alloys a superconducting solenoid producing magnetic fields up to 53 kG was installed in the frame of the above cooperation.

The temperature dependence of the hyperfine field distribution in amorphous alloys was studied. The rapid temperature decrease in magnetization characteristic of amorphous alloys is often attributed to short-range exchange interactions. The temperature dependence of the hyperfine field distribution in an amorphous $Fe_{80}B_{20}$ (METGLAS 2605) alloy measured by Mössbauer technique disagrees with such an explanation. It was shown that for this alloy each magnetic moment follows the same magnetization curve, i.e. the temperature dependence of the magnetization is determined by long-range interactions. This work was performed in cooperation with I. Vincze of the Institute for Solid State Research.

PUBLICATIONS

1. I. DÉZSI, U. GONSER[*], D.L. NAGY, W. KEUNE[**], H. BUNZEL[*], H. SPIERING[***], I. FÖLDES Jr., S.K. DATE[****]: The quadrupole interaction of Fe^{2+} ions in $LiNbO_3$ and $LiTaO_3$. Proc. Int. Conf. Mössbauer spectroscopy, Bucharest, Romania, 1977. p. 159

2. I. DÉZSI, Á. BALOGH, J. BALOGH, Zs. KAJCSOS, D.L. NAGY: Mössbauer and positron annihilation studies on Cu_xZn_{1-x} alloys. ibid. p. 377

3. J. BALOGH, I. VINCZE: Temperature dependence of the hyperfine field distribution in an amorphous ferromagnet. ibid. p. 421; KFKI Report 77-80 (1977)

MÖSSBAUER STUDY ON SUPPORTED PtFe CATALYSTS

I. Dézsi, D.L. Nagy

Visiting research worker: *Matild Eszterle*[*****]

Transmission Mössbauer spectroscopy has been used to elucidate the interaction between Pt and Fe atoms influenced by the Fe/Pt ratio in highly dispersed (30-70 % surface/bulk atom) PtFe catalysts prepared with [57]Fe supported on silica.

From the Mössbauer spectra recorded after reduction with H_2 gas of the sample at low iron concentration (0.32:1 Fe/Pt atomic ratio), it is concluded that the formation of Fe is complete. The isomer shift is in agreement with that of dilute PtFe alloy. The partial reversibil-

ity in the room temperature oxidation-reduction cycle using O_2 and H_2 indicates alloy formation between the two metals. The surface PtFe agglomerations smaller than 100 Å are responsible for catalytic activity and strong adsorption.

At high iron concentration (2.24:1 Fe/Pt atomic ratio), the reduction of iron in catalyst is not complete after the same treatment but Fe^{3+} and Fe^{2+} remain on the surface.

The reversibility of the room temperature oxidation-reduction process is the consequence of the presence of platinum but the smaller isomer shift of reduced iron indicates that PtFe agglomerations are partly covered by non-alloyed iron. This simple model can explain the decreased catalytic activity, adsorption, and the change of selectivity.

This work was done in cooperation with L. Guczi of the Institute of Isotopes of the Hungarian Academy of Sciences, Budapest.

POSITRON ANNIHILATION STUDIES
Á. Balogh, I. Dézsi, Zs. Kajcsos, B. Molnár

Positron lifetime studies have been performed in different phases of 4 n-octyloxibenzoicacid -4- nitrophenylester liquid crystal over the 25-91°C temperature range. The results suggest that there is no high probability for positronium formation or significant change in the τ_1 lifetime values which could be correlated with the solid-smectic phase transition, whereas a change in τ_2, I_2 does occur in the vicinity of the nematic-isotropic phase transition.

Detailed positron lifetime measurements have been performed on water-dioxan liquid mixtures in the concentration range of 23-35 vol. % dioxan to show the formation of clusters between the water and the dioxan molecules, indicated by optical investigations. These measurements have been performed in cooperation with G. Brauer of the Zentralinstitut für Kernforschung, Rossendorf, GDR.

The measured spectra were analysed by a 2-term fit. The first component results from the annihilation of para-positronium and of free positrons, whereas the longer lifetime component is due to the pick-off annihilation of ortho-positronium. Cluster formation has been found at mol ratios (1:15) and (1:10) *(Fig. 4)*.

Positron lifetime measurements have been performed in the amorphous and liquid phases of glycerine-water solution over a broad temper-

ature range. The effect of various quenchers and inhibitors at different concentrations was investigated in both phases. The results support the validity of the spur model.

Positron lifetime measurements have been performed on some elements to complete the literature data. The results were in good agree-ment with the calculations based on the dynamic screening of the posit-ron charge by the metallic electron gas.

PUBLICATIONS

1. A. BALOGH, I. DÉZSI: Further positron lifetimes of some elements. Phys. Status Solidi 81, K81 (1977)

2. I. DÉZSI, Zs. KAJCSOS, B. MOLNÁR: A new source-preparation technique for positron lifetime measurements in liquids. Nucl. Instrum. Methods 141, 401 (1977)

THEORETICAL PLASMA PHYSICS
Á. Ág, G. Párizs

The effect of the electrostatic turbulence on the macroinstabilities in a collisionless magnetized plasma is investigated. In the turbulent dispersion relation the inhomogeneities in density and in magnetic field, a drift motion and a temperature anisotropy are taken into account. In the isotropic case in very strong magnetic fields the turbulence is found to be ineffective. In the case of temperature anisotropy, provided that the fluctuating electric field is strong enough and the vertical wave numbers of the turbulence ($k'_\perp$) and the macroinstability ($k_\perp$) are in the vicinity of the inverse Larmor radius ($k'_\perp r_L \sim 10\text{-}100$, $k_\perp r_L \sim 10^{-1}\text{-}10$), the effect may be large. This effect is a correction in the dispersion relation that influences the damping and the frequency shift.

The radial diffusion of a cylindrical plasma filament is investigated where the diffusion coefficient is a simple power function of the number density. Self-similar solutions are produced.

Soliton potentials propagating in a thin cylindrical plasma have been calculated. Potential wells of soliton type have been found both in the positive and the negative range of potentials.

For the simple nonlinear wave-wave interaction an unstable limiting cycle has been found by numerical integration. The limiting cycle encloses the well known stable focus.

SOFT X-RAY EMISSION OF THE PLASMA OF THE TOKAMAK T-10
G. Hordósy, G. Hrehuss, B. Kardon, I. Szentpétery

The soft X-ray radiation of a hot plasma arises from the scattering and capture of the thermal electrons on the plasma ions. The spectral intensity distribution consists of a thermal (exponentially decreasing) continuum with characteristic lines superimposed. The absolute intensity of the continuum radiation is a sensitive measure of the effective atomic number Z_{eff} of the plasma while its slope closely relates to the electron temperature T_e.

To resolve the characteristic lines of the contaminating atoms (or partially stripped ions) the VUV diffraction spectrometers are the most suitable. They cannot be used, however, for the measurement of the thermal continua owing to their too low efficiency.

As an acceptable compromise between resolving power and efficiency in the soft X-ray region a Policarpo-type scintillation-ionization chamber, as developed in the Institute for plasma diagnostical purposes, has been tested and used at the Tokamak T-10 in the Kurchatov Institute, Moscow, USSR *(Fig. 5)*.
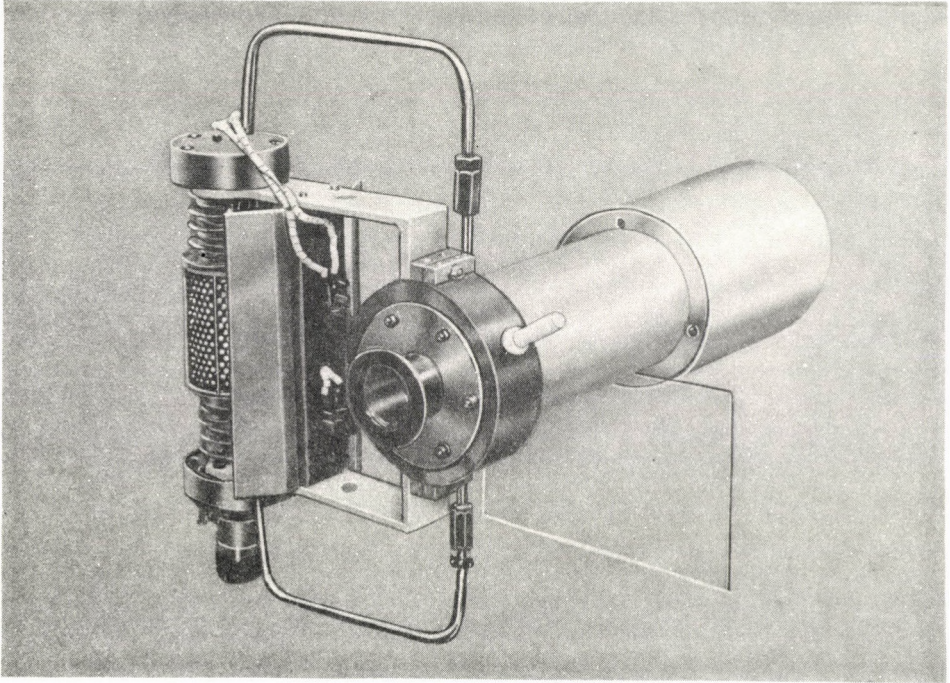
Fig. 5

The scintillation-ionization chamber

The efficiency of the spectrometer is so high that even the time-evolution of the spectra with good counting statistics can be measured in four successive intervals of each Tokamak discharge. Also the detailed time dependence of the integral radiated power can be measured by means of a separate display circuit so that this measurement and the recording of the spectra can be performed simultaneously by a single spectrometer. In the same way, the well known saw-tooth relaxation oscillations of the plasma can be demonstrated as well.

In order to be able to check its performance, the scintillation ionization spectrometer has been replaced by a commercial Si(Li) spectrometer of high quality (Kevex Micro-X, "Windowless"). Similar
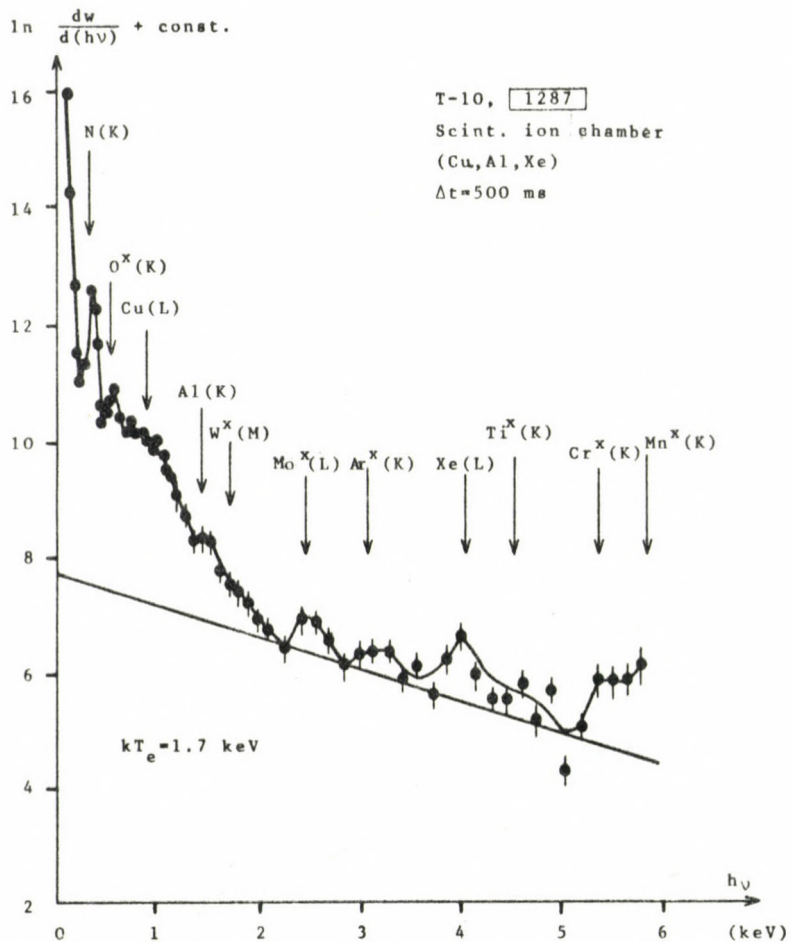
Fig. 6

Spectra measured by

a) scintillation-ionization chamber (discharge No 1287)

40
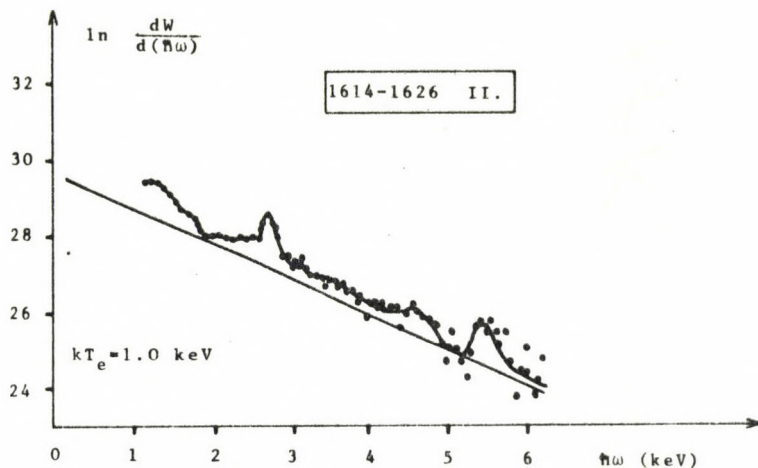
b) Kevex Si(Li) spectrometer (summed spectra
of 13 individual discharges)
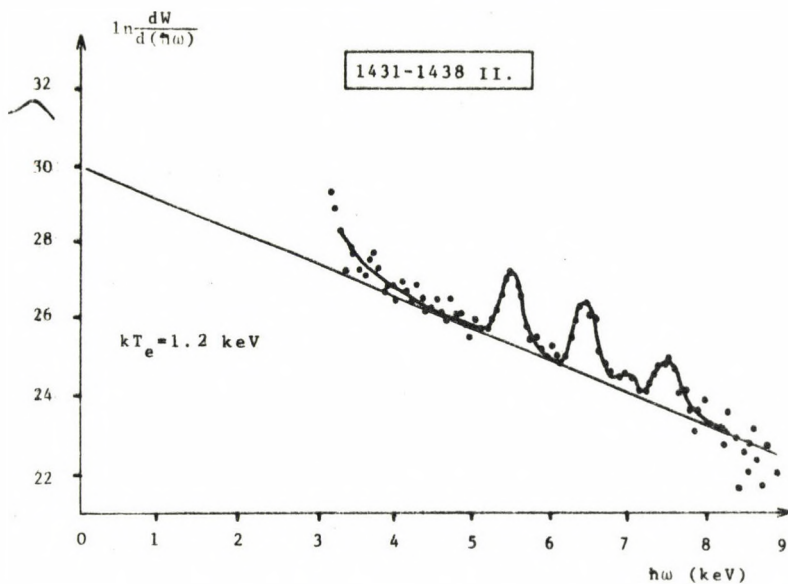
c) Kevex Si(Li) spectrometer with thick window
(summed spectra of 8 discharges)

detectors are used, more or less regularly, at some large Tokamaks such as PLT, TFR, etc. The spectral resolving power is in favour of the Si(Li) detector at quantum energies higher than about 2 keV and is comparable at lower energies (Fig. 6). On the other hand, the overall efficiency of the semiconductor spectrometer system turned out to be lower by a factor of about 4.

The anomalous enhancement of the spectral intensity in the region $h\mu$ < 1500 eV has been clearly demonstrated. Its gross structure and time development agree with what has been suggested, quite reccently, by the PLT group on the basis of indirect measurements. VUV-spectra measured by the TFR group show a large number of intensive characteristic lines distributed over the region in question. They arise from carbon, oxygen, nitrogen and from the heavier elements of the first wall and limiter. Some of them could be resolved, at least partially, in the present measurement (Fig. 6). We note, however, that in some cases the enhancement becomes strongly attenuated. The correlation of this anomaly and also of the intensity of the resolved Cr, Fe, Ni and Mo lines with the parameters of the individual discharges has not been established as yet and is to be investigated further.

This work has been performed in cooperation with the Plasma Physics Laboratory (Department T-10) of the Kurchatov Institute, Moscow, USSR.

LASERS FOR PLASMA DIAGNOSTIC

J.S. Bakos, I. Földes, P. Ignácz, Zsuzsa Sörlei, J. Szigeti

Phase objects such as plasmas can be investigated - among other methods - by the interferometric technique which delivers easily the space distribution of the plasma density. For the determination of the three dimensional density distribution many interferometric measurements have to be performed by object beams distributed in a wide solid angle. In view of this, holographic interferometry is the popular method for the simultaneous recording of the large number of interferometric patterns formed by different object beams.

Plasma produced by a giant pulse ruby laser in air of atmospheric pressure was investigated. The second double pulse ruby laser was used for taking the holographic interferometric picture of the spark. The first pulse of this second laser takes the hologram of the scene 200 µs before the spark. The delay of the second pulse to the time of the spark
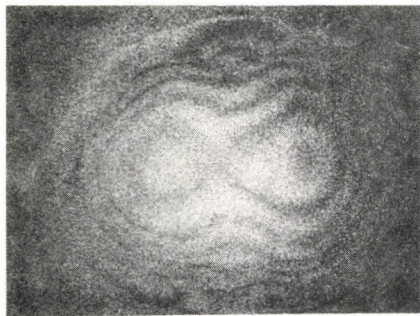
a)
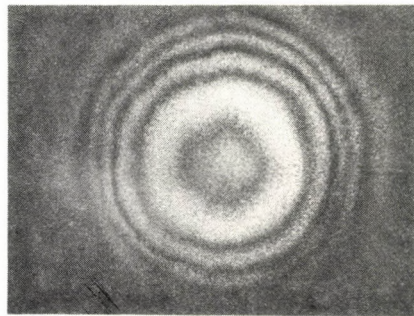
b)
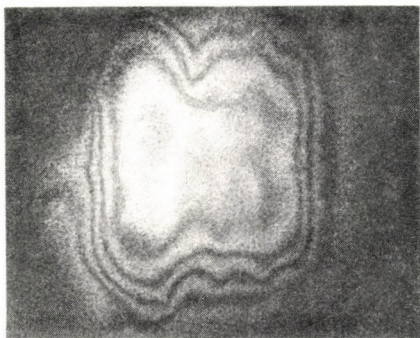
c)
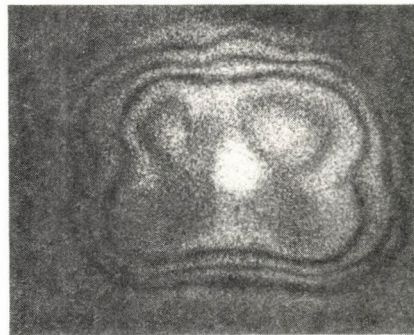
d)

Fig. 7

Holographic interferometric pictures of laser produced spark;
a) Δt=5 μsec, b) Δt=37.5 μsec, c) Δt=75 μsec, d) Δt=110 μsec

can be varied. In this way the time history of the laser-produced dis-
charge can be recovered by taking the second hologram on the same film
at a different time after the spark.

Figure 7 shows four pictures of the discharge at the time in-
dicated and so shows the time history of the spark development. The pic-
tures were taken on a shot by shot basis. The complicated turbulent be-
haviour of the spark in its late shock wave period can clearly be seen
on the pictures. Continuation of the work for shorter time domains is
in progress.

PUBLICATIONS

1. J. BAKOS, Zs. SÖRLEI: High power DFB laser tunable in the 7420-10500 Å
   range. Opt. Commun. 22, 258 (1977)

2. J. BAKOS, Zs. SÖRLEI: High power DFB laser. Int. Konf. f. Laser und
   ihre Anwendungen III. Dresden, GDR, 1977. Abstract D-38

3. J.S. BAKOS: AC Stark effect and multiphoton processes in atoms. Phys.
   Reports C 31, 211 (1977)

BIOPHYSICAL RESEARCH

*I. Demeter, P. Hargitai, Vera Jánossy, L. Keszthelyi, Z. Szőkefalvi-Nagy,
L. Varga*
Visiting research worker: *Katalin Hollós-Nagy**

Last year we successfully applied the PIXE (particle induced
X-ray emission) method for trace element analysis and utilized our own
nuclear method (based on the $^{14}N(d,p)^{15}N$ nuclear reaction) for the de-
termination of the protein content of certain biochemical preparations.
Experiments were recently performed for the simultaneous application of
these two methods for determining the quantity of trace elements relat-
ed to the protein content of the sample.

We have continued our preparatory experiments for studying the
optical properties of the axon membranes during their excitation.

Details of work performed are given below:

1. Lincocin has an inhibiting effect on the protein synthesis
in the chloroplasts of green plants. Bean leaves treated with lincocin

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have shown Mn deficiency symptoms. It seemed possible that the Mn content proteins did not get synthesized as a result of the effects of lincocin. Proton induced X-ray emission analysis measurements were performed to determine the Mn content of the chloroplasts isolated from the leaves. When comparing the X-ray spectra of lincocin-treated chloroplasts with those of control chloroplasts, the Mn intensity showed decreasing trends in relation to the relative constancy of the other elements (Fig. 8).
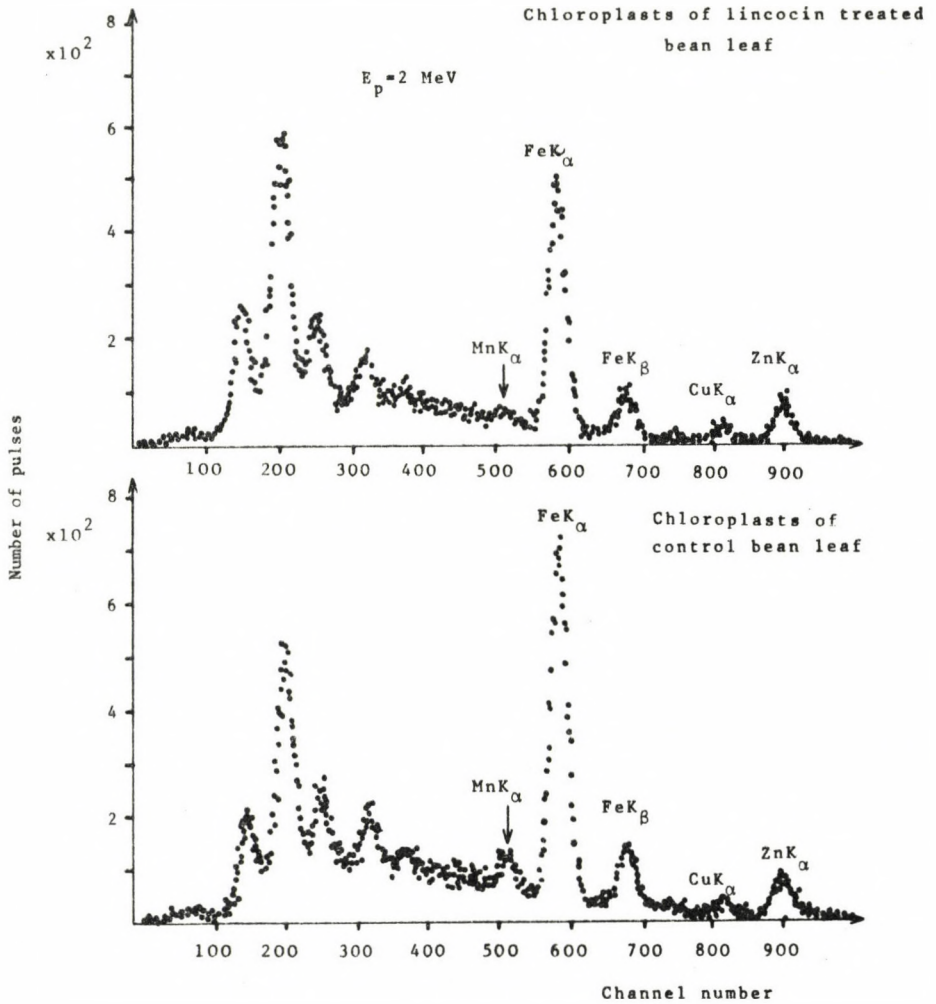
Fig. 8

X-ray spectra of lincocin-treated and control chloroplasts

The experiments are carried on in cooperation with the Department of Plant Physiology of the Eötvös Loránd University, Budapest.

2. Superoxide dismutase (SOD) enzymes play important protecting roles in living cells by eliminating O_2^- released in different biochemical reactions (for example in photosynthesis). Their prosthetic groups contain Mn, Fe, Ni, Cu or Zn ions. SOD was isolated and purified from *Anacystis nidulans* unicellular alga (by the Institute of Plant Physiology at the Biological Center, Szeged). The ion content was measured with proton induced X-ray emission analysis and by using the $^{14}N(d,p)^{15}N$ nuclear reaction the protein content was determined. This enzyme proved to contain Fe. On the grounds of the quantitative assessments of these two measurements the molecular weight could be calculated, this being 38000±8000. It shows good agreement with other methods (for example SDS electrophoresis, gel filtration). In contrast to the above measuring techniques the displayed method is advantageous because of its high sensitivity, its need for very small amounts of material (the bombarded material was ∿0.4 picomol protein which contained $2.2×10^{-11}$g Fe), and in addition the purity of the preparation can also be controlled.

3. The trace elements in biological samples are mostly bound to proteins, this is the origin of the importance of our new step forward in determining the quantity of trace elements related to the protein content of the sample. We determine the protein content according to the above mentioned nuclear reaction by bombardments with deuterons and simultaneously we detect the characteristic X-rays induced by deuterons. The intensity of the X-ray lines related to the number of protons obtained from the nuclear reaction is proportional to the quantity of trace elements related to the protein content of the sample. Since deuterons are not very advanced bombarding particles for X-ray analytical purposes of high sensitivity, it is necessary to perform another PIXE analysis applying protons as bombarding particles, on the sample. The result of this measurement can be related directly to the protein content by the spectrum of the X-rays induced by the deuterons. This method was first applied for analysing hair samples.

4. We have elaborated an optical measuring system to study nerve excitation processes. The monochromatic light from a high pressure xenon lamp is focused on the object and the quantity of the absorbed, scattered or fluorescent light is measured via photon counting by a photoelectronmultiplier. It has proved possible to illuminate the object for short flashes synchronously with the excitation and to follow the (excitation) process in time.

PUBLICATIONS

1. I. DEMETER, L. KESZTHELYI, Z. SZŐKEFALVI-NAGY, L. VARGA, K. HOLLÓS-NAGY: Simultaneous determination of protein and metal ion content of metal-loproteins. KFKI Report 77-74 (1977)

2. I. DEMETER, L. KESZTHELYI, Z. SZŐKEFALVI-NAGY, L. VARGA, K. HOLLÓS-NAGY, Á. NAGY*: Ion content of sinaptic vesicles. KFKI Report 77-75 (1977)

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4. L. KESZTHELYI: Contribution of parity violating effects to intramolecular interactions. Phys. Lett. A $\underline{64}$, 287 (1977)

5. W. MEISEL**, L. KESZTHELYI: Determination of hyperfine fields from perturbed angular distributions of Mössbauer scattered radiation. Hyperfine Interactions $\underline{3}$, 413 (1977)

6. Cs. BAGYINKA**, W. MEISEL**, L. KESZTHELYI: pH dependence of Mössbauer spectra of itoic acid-$FeCl_3$ and DBH-$FeCl_3$ complexes. Proc. Mössbauer Conf., Bucharest, Romania, 1977. p. 305

PARTICLE ACCELERATORS: DEVELOPMENT AND OPERATION

G. Bürger, L. Gyimesi, E. Klopfer, P. Kostka, Z. Mészáros, J. Roósz

During 1977 the EG-2R, 5 MeV pressurized Van de Graaff ion accelerator was available for nuclear and solid state physics and biophysical measurements in the energy range of 1.0 - 4.8 MeV for 2750 hours. Up to 5 µA analysed and stabilized beam current of protons, deuterons and $^4\text{He}^+$ ions was given at any target place. The short-time relative energy stability is about 1.5×10^{-4}.

Between May 12th and Oct. 10th the operation of the accelerators was interrupted and a new switching magnet with 6 different beam lines, a new quadrupole focusing lense and turbomolecular pump were installed, the ion optics was improved. The accelerating tube and the analysing magnet were turned through 40 degrees, according to the new direction of the 0° beam line.

The accelerator team has taken part in the preparations for receiving a Tokamak-type thermonuclear device, the training of the staff, the building of laboratories, as well as in the testing and manufacturing of parts for a new Cockroft-Walton heavy ion accelerator.

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* Central Institute of Physical Chemistry of the Academy of Sciences of the GDR, Berlin, GDR

** Biological Research Center, Szeged, Hungary

FOREIGN RELATIONS

Lectures by visiting scientists

    G. Brauer   (Zentralinstitut für Kernforschung, Rossendorf, GDR)
                            Recent positron annihilation studies in Rossendorf

    J. Fröhlich   (Universität Graz, Graz, Austria)
                            Coulomb corrections

    M. von Hellermann (Universität Essen, Essen, FRG)
                            Plasma diagnostics by laser

    B.B. Kadomcev   (Kurchatov Institute, Moscow, USSR)
                            Thermonuclear research

    L. Mathelitsch   (Universität Graz, Graz, Austria)
                            Relations between deuteron form factors and wave
                            functions

    Yu.Ts. Oganessyan (Joint Institute for Nuclear Research, Dubna, USSR)
                            Super-heavy elements

    F. Pauss   (Universität Graz, Graz, Austria)
                            Calculation of polarization observes

    H. Tuczek   (Universität Essen, Essen, FRG)
                            Plasma physical researches in Essen

Staff members on study tours

Gy. Bence	University of Maryland, College Park, Maryland, USA	3 months
L. Csernai	Zentralinstitut für Kernforschung, Rossendorf, GDR	6 months
I. Dézsi	University of Leuven, Heverlee, Belgium	1 year
P. Doleschall	Tandem Accelerator Laboratory, Uppsala University, Uppsala, Sweden	1 month

J. Erő	Joint Institute for Nuclear Research, Dubna, USSR	3 years
Z. Fodor	Joint Institute for Nuclear Research, Dubna, USSR	2 years
D. Horváth	Joint Institute for Nuclear Research, Dubna, USSR	4 years
Zs. Kajcsos	Institut für Festkörperforschung der KFA Jülich, Jülich, FRG	1 1/2 years
D.L. Nagy	Universität Erlangen-Nürnberg, Erlangen, FRG	3 months
G. Pálla	Institut für Experimentalphysik, Universität Hamburg, Hamburg, FRG	2 months
J. Révai	Joint Institute for Nuclear Research, Dubna, USSR	4 years
Z. Seres	Joint Institute for Nuclear Research, Dubna, USSR	1 year

Guest scientists and fellows

C. Chandler	University of New Mexico Albuquerque, New Mexico, USA	2 months
Khalid Al-Ani	Nuclear Research Institute, Baghdad, Iraq	5 years
Jihad Muhlem	Tichren University Latakia, Syria	3 1/2 years

Conference organized

International Symp. Nuclear Reaction Models '77, 26 June - 2 July, 1977, Balatonfüred, Hungary

THESIS

| Khalid Al-Ani | Mössbauer study of the Morin transition in α-Fe_2O_3 diluted with trivalent metallic ion. (For Ph.D. degree) |

TECHNICAL DEPARTMENT

RESULTS

INSTRUMENTS AND SYSTEMS

J. Deme, Gy. Erdélyi, G. Farkas, F. Ferenczy, I. Hernyes, J. Jani, J. Koch,
Gy. Kozma, L. Leveleki, L. Lohonyai, A. Montvai, I. Náday, J. Nagy, J. Pazonyi,
M. Sándor, L. Szabó, S. Szalai, S. Szamosujvári, I.T. Szücs, Gy. Thaler,
M. Tóth-Bodonhelyi, J. Urbán, I. Veress, J. Windberg, A. Zarándy

The development of CAMAC systems and modules has been continued for high energy and nuclear physics measurements.

The development and installation of the PANNI apparatus for carrying out positron annihilation measurements was completed. The PANNI is a CAMAC-based system controlled by an autonomous controller, performing the programmed setting of the angular position of a detector rotating around a radiation source, changing the polarity of the magnetic field across the sample automatically, controlling and checking its temperature. The measured data are registered by a multi-channel data acquisition system belonging to the apparatus.

The development of a CAMAC memory module with a capacity of 1K of 24 bit words was completed. The module, constructed of LSI circuits, was designed primarily for the temporary storage of data in CAMAC systems.

The development of the CAMAC analogue nuclear instrument family (CAMALOG) has been continued. In 1977 the design work of the dual sum and invert amplifier and the biased time-to-pulse height converter modules was finished.

The system design of the Environmental Radiation Protection Control System for the Paks Nuclear Power Plant was completed. In its final implementation the system serves for controlling the emission and the distribution of radioactive pollution caused by accidental failure of the reactor. The control system consists of seven data-collection sta-

tions, a meteorological station and a central data handling and control unit. The prototype of the data collecting stations was built and it was put into experimental operation in the institute. The checking of the central data handling unit has been begun with the help of a simplified measurement programme.

The development work on a wire tension measuring instrument used in manufacturing multiwire proportional chambers has come to an end. The instrument provides an easy and simple way of measuring the force stretching the wires of the chamber with an accuracy higher than 1 %. Several units of the wire tension meter have been manufactured for use in Hungary and in institutes abroad (CERN, Saclay, JINR).

Several digital delay modules have been made for the fusion programme. The instrument is used for setting the delay times, necessary in experiments with Tokamak devices, in a very wide range and with high accuracy.

In connection with the fusion programme a new vacuummeter was developed. This instrument is constructed of high quality components and is capable of measuring vacuums between 1 and 10^{-8} Torr.

In the space research programme the design of the data acquisition system of the TÜNDE device has been continued. The device will be put in a satellite to be launched in the Intercosmos programme. Three versions of the circuit have been worked out: two of them are based on low power TTL and CMOS integrated circuits, the third is a microprocessor version.

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FOREIGN RELATIONS

Staff members on study tours

| F. Ferenczy | Joint Institute for Nuclear Research, Dubna, USSR | 4 years |

I. Hernyes   Joint Institute for Nuclear Research, Dubna,
                  USSR   2 years

L. Lohonyai   Joint Institute for Nuclear Research, Dubna,
                  USSR   1 1/2 years

I. Veress   Joint Institute for Nuclear Research, Dubna,
                  USSR   3 months

G. Farkas   Institut für Hochenergiephysik, Zeuthen,
                  GDR   1 1/2 years

INSTITUTE FOR
SOLID STATE
RESEARCH

SOLID STATE PHYSICS

RESULTS

THEORETICAL SOLID STATE PHYSICS

*J. Bergou, P. Fazekas, G. Forgács, J. Kollár, Nóra Menyhárd, E. Praveczki,
T. Siklós, Gy. Solt, J. Sólyom, P. Szépfalusy, I. Tüttő, F. Woynarovich,
A. Zawadowski*

The theoretical study of quasi-one-dimensional systems was con-
tinued this year. A generalized Ginzburg-Landau theory was derived for
the charge density wave phase transition in strongly anisotropic quasi-1D
systems. The region of validity of the mean field approximation, where
critical fluctuations are neglected, was determined. Comparison with
experiments tends to favour a repulsive intrachain backward scattering
in TTF-TCNQ. The Tomonaga model of one-dimensional systems was studied
by using generalized Ward identities. Another model, the so-called box-
model, was also investigated. The possible charge orderings were determin-
ed.

By studying the dynamics of nematic liquid crystals, we were
able to show that the relaxation rates of the rotation around the long
and short axes are of the same order of magnitude.

We have continued our earlier studies on the two-roton resonance
in superfluid He^4. It was shown that this resonance exists also for large
values of the wave number. The neutron scattering experiments have been
interpreted using an attractive effective interaction between the rotons.
The finite width of the two-roton resonance at T=0 has been explained by
a hybridization between the two-roton and two-phonon states.

In cooperation with the Theoretical Physics Laboratory of the
Joint Institute for Nuclear Research, Dubna, USSR, and the Theoretical
Department of the Institute Boris Kidrič, Vinča - Beograd, Yugoslavia,

the character of ferroelectric phase transitions in the quantum limit has
been investigated in the framework of the general theory worked out pre-
viously by the same researchers.

Dynamic critical phenomena have been investigated below the crit-
ical point by the renormalization group. Critical damping of the spin
waves has been determined and it has been pointed out that the longitudi-
nal total magnetization in isotropic antiferromagnets exhibits a non-
hydrodynamical behaviour in the long wavelength limit.

For the discussion of real space renormalization transformation
for systems which are nearly two-dimensional, A. Migdal has introduced
recursion equations of a new type called Migdal's recursion equations.
It has been possible to generalize Migdal's procedure in such a way that
the method becomes an approximative scheme which can be improved sys-
tematically. We have applied this generalization to a nearly two-dimension-
al harmonic rotator model and later to models with any number of components
of the basic spin variable.

In the theory of dilute alloys the low temperature Fermi liquid
theory of the Kondo effect had been studied until now only for a non-
degenerate impurity level and in the case of a special Hamiltonian. We
have developed a Fermi liquid theory which is valid for the most general
cases and have derived definite values for the ratio of different physical
parameters in the s-d limit in the case of a half-filled impurity level.

We continued the investigation of the electrical and magnetic
properties of layered transition metal compounds, with special emphasis
on the question of antiferromagnetism in close-packed lattices such as
the triangular lattice.

Properties of ferromagnets below T_c have been calculated by
applying a microcanonical high-temperature expansion.

In the field of optical interactions and laser physics the
scattering of light on diatomic molecules has been investigated further.
The interaction of light with free electrons and the possible nonlinear
effects have been considered with special emphasis on the high intensity
interactions (e.g. nonlinear inverse bremsstrahlung). The stability and
the glow-to-arc transition of a high voltage hollow cathode discharge
with internal anode system have also been investigated for laser purposes.

We have studied the lattice dynamical effects connected with
impurities in metallic lattices. The displacement field arising around
an impurity atom influences the value of the heat of solution and de-

57
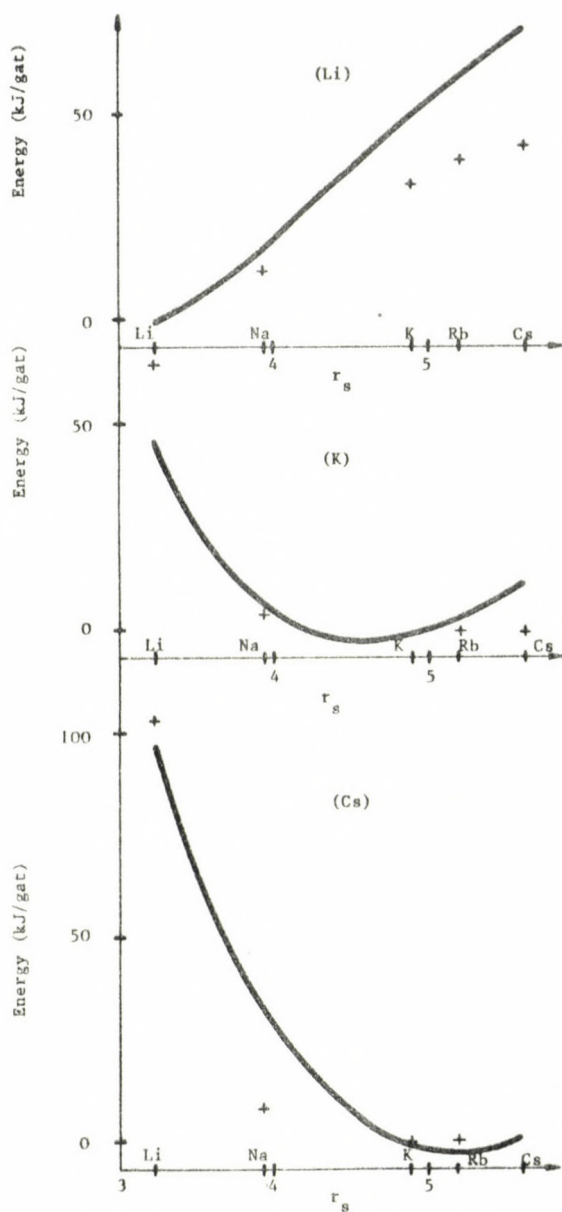
Fig. 1

Energy of solution [kJ/gat] for Li, K, and Cs impurities
in alkali metals. The points are the experimental data
for liquid alloys (r_s is the atomic radius)

termines, through its asymptotical behaviour, the concentration dependence
of the volume. The results obtained with the aid of the functional density
formalism refer to the electronic distribution around voids and to the
heat of solution of impurities *(Fig. 1)* in liquid solvent while on ap-
plying the pseudopotential method to solid solutions both the heat of
solution and the displacement field have been determined. The results
are reasonably good for the actual case of dilute solutions of the alkali
metals. A result of considerable interest concerns the calculation of the
displacement field, stating that pair forces and three-body interactions
together set up the deformation field, even in the lowest order calcula-
tion that does not neglect the periodicity of the lattice.

We have continued the study of the cohesive and magnetic properties
of metals. The *ab initio* calculation is based on the method of canonical
bands in which the potential was constructed according to Mattheiss' rule.
The results are in good accordance with the experimental values.

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RESEARCH ON MAGNETISM

L. Gál, G. Pető, I. Szabó, Gy. Zimmer

In the study of dynamic behaviour of magnetic domains by high-speed photography, the construction of a single-exposure sampling optical camera-microscope has been completed. A 4 ns, 10-20 µJ light pulse is generated by the combination of a Lambda Physik Model M 100A flowing-nitrogen gas laser and a home-made, longitudinally excited Rhodamin 6G dye laser and it is directed into an NU2 polarizing research microscope (Carl Zeiss, Jena) used in transmission mode. A sample of the response of magnetic domains to a sudden change in the magnetic field around the transparent magnetic "bubble" garnet sample is recorded either photographically or on video tape with a silicon target vidicon sensor. The timing of the light flash with respect to the magnetic field pulse is defined by the program unit. The initial and final states of the domain structure are recorded as well.

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The cylindrical or stripe-like static domain pattern distorts considerably in dynamic experiments. The dynamic shape of dumbbell-like domains are shown to be associated with the motion of vertical wall twists commonly known as Bloch lines. The speed of the wall motion can be extracted from the wall position versus time curves obtained by taking many pictures with different delay times. The speed versus drive curves differ from the ones obtained by more conventional means because the wall does not in general stop when the effective field driving is reduced to zero.

In the technological research programme on thin films, a new method - the double quartz technique - was developed for the measurement of the stress in thin films. By this method the stress in the RF sputtered Permalloy and SiO_2 was examined as a function of the technological parameters. The optimum parameters were determined too. The sandwich layers of bubble memories were deposited in accordance with these optimum parameters.

Those technological processes likely to give rise to thin films with special properties were examined. The simultaneous ion bombardment by noble-gas with the growing of the film seems to be the most suitable method. The bombarding ions with energy higher than 20-50 eV can produce a special order in the film. Preliminary experiments have been started on this topic: magnetic thin films were deposited with continuous ion bombardment of Ar and Kr gas ions.

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BUBBLE DOMAIN MEMORY RESEARCH

Éva Baka-Vázsonyi, A. Balaskó, M. Balaskó, G. Csath, L. Farkas, L. Gál,
L. Gosztonyi, Gy. Juhász, Gy. Kádár, B. Keszei, G. Konczos, E. Krén, J. Paitz,
Márta Pardavi-Horváth, G. Pető, I. Pintér, G. Serfőző, I. Szabó, Éva Szabon-
Haraszthy, B. Szigeti, J. Vandlik, Katalin Zámbó- Balla, Gy. Zimmer, Éva
Zsoldos-Ravasz

The group working on bubble memory devices has continued to devel-
op the different technological steps of the production process. The
following results have been obtained so far.

Gadolinium-gallium-garnet (GGG) single crystals of good quality
were grown in large quantities by the Czochralski method. The garnet melt
composition was $Gd_{3.05}Ga_{4.95}O_{12}$ giving low dislocation and iridium in-
clusion density. The crystal quality was controlled by using light po-
larization microscopy showing dislocations and strains in the bulk GGG
crystal.

The GGG crystal growth process was automatized by measuring the
weight-change rate of the melt and by feeding this back so that it causes
a change in thermal power thereby maintaining optimum conditions during
a growth. A TPA/i-CAMAC computer-controlled system was constructed and
successfully used for GGG crystal growth with the aim of providing complete
automatization.

The rotation rate, the position of the crucible, and the thermal
gradient all have a marked influence on crystal quality and diameter. The
optimum conditions for the growth process were carefully investigated.

Preliminary experiments were carried out for growing GGG crystals
with a diameter of 50 mm and a length of 300 mm.

The slicing and polishing technology was further developed. At
the beginning of the year a new laboratory was put into operation with
a capacity of 200 wafers of optical quality per week. X-ray methods have
been used for the orientation and qualification of the substrates.

Magnetic garnet films were grown on the GGG substrates by using
the technique of dipping from supercooled melt, i.e. the liquid phase
epitaxy (LPE) method. The growth technology for SmGa:YIG and SmCaGe:YIG
was worked out for 5 μm bubbles. The mobility of bubbles and the temper-
ature sensitivity of bubble parameters were found, somewhat paradoxically,
to be better for the SmCaGe:YIG produced with more difficulty. Two new
LPE growing apparatuses were put into operation.

The properties of the magnetic garnet films from a series of
successive LPE growths can be seen in Table I.

TABLE I

PROPERTIES OF LPE GARNET FILMS

Material Parameter	$Y_{2.6}Sm_{0.4}Ga_{1.2}Fe_{3.8}O_{12}$	$Y_{1.92}Sm_{0.1}Ca_{0.98}Fe_{4.02}Ge_{0.98}O_{12}$
Film thickness $|\mu|$	5.4	5.3
Periodicity of stripe domains $|\mu|$	10.5	10.3
Bubble collapse field $|Oe|$	101	107
Coercitivity $|Oe|$	0.4 – 0.7	0.5 – 1.3
Saturation magnetization $|4\pi M_s, Gauss|$	195	206
Density of magnetic defects $|cm^{-2}|$	10 – 40	10 – 40

The quality of LPE films was carefully checked using classical magnetic, FMR, magneto-optical and optical methods. The productivity of the LPE growing process was 70% at 10% tolerance of the main parameters.

The surface region of the LPE garnet films was ion implanted to alter its easy axis from the normal to the horizontal direction thereby preventing multiple Néel lines which give rise to hard bubbles. The technology of $^{20}Ne^+$ ion implantation was worked out and used.

Microcircuits for bubble memory applications provide the manifold function of bubble propagation, generation, replication, transfer or gating. Magnetic bubble memory chips have a Permalloy T-bar, conductor and detector patterns. In our laboratories the thin film deposition technique together with photolithographical technology was utilized for producing 4 Kbit bubble memory chips with uniform and accurate micropatterns. Replicating details in the mask are about 1,5 μ.

The first dielectric layer is a 2000 Å layer of RF sputtered (or vacuum evaporated) SiO_2, which acts as an electric insulator. Following this, Permalloy magnetoresistive detectors, Al(Cu) conductors, are processed. The second SiO_2 layer acts as a spacer and insulator and is deposited by RF sputtering. The final 4000 Å Permalloy film is vacuum evaporated. The mechanical (adhesion), electrical and magnetic properties and the defect distribution (pinholes) were carefully checked and the thin film deposition process has now been optimized.

Magnetic bubble memories have a high bit density and large capacity per chip.

In the photolithographical process the first step is the photoresist coating of the LPE film surface made by a Convac ST 450 wafer coating machine. After a prebake process the exposure follows in a contact type aligner and care is taken to make intimate contact between mask and wafer. By investigating the exposure time, development rate, the chemical etching of Permalloy and the postbake process, we have elaborated a satisfactory method for the 4 Kbit bubble memory micropattern fabrication *(Fig. 2)*.

In cooperation with the Complex Computer Control Institute, Moscow, USSR, and the Industrial Research Institute for Electronics, Budapest, the design of components and configuration have been elaborated in a mask computer language for the manufacture of 4 Kbit masks.

The main components of the bubble memory device (propagator, detector, T-bar elements, chevrons) were carefully examined by an automatized chip tester equipment developed in our laboratory.
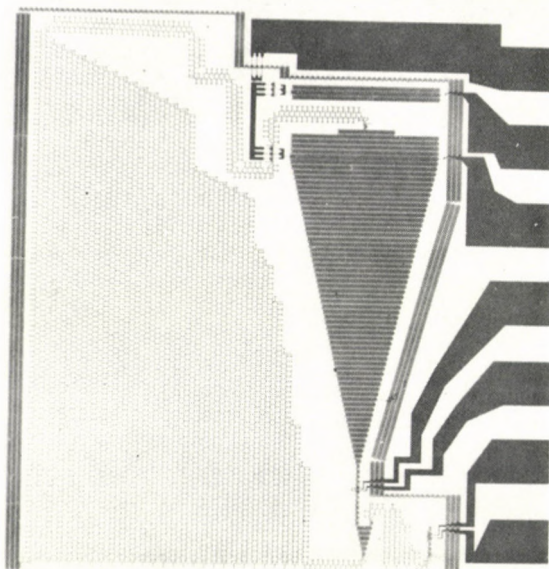
Fig. 2

4 Kbit bubble memory chip

In cooperation with the Hungarian Optical Works, Budapest, a draft agreement has been formulated for the mass production of bubble memory devices.

OPTICAL MEMORY RESEARCH
Gy. Ákos, Gy. Bencze, Gy. Eisler, A. Hámori, Cs. Iványi, G. Kiss, Gy. Nagy, P. Varga, Vu duy Phu, Cs. Zakar

I. Design considerations of an archive holographic memory

The process used for holographic storage and data retrieval is as follows:

1. The page composer converts the series of electric signals into an array of bright ("1") and dark spots ("0").

2. Fourier transforms of such arrays are recorded on subholograms situated side by side.

3. For reading purposes, the required subhologram is illuminated and the reconstructed array is converted into electric signals by a photodetector matrix.

We have analysed a model of an archive holographic memory in which

1. The writing and reading units are separated, the amplitude distribution of the reference and reconstruction beams is different.

2. The data are stored on separate photoplates with a capacity about 10^8 bits, the plates can be loaded into a reading device.

3. Access to the required subhologram is perfected by positioning the plate.

4. The size of the subhologram is limited by a diaphragm in front of the plate.

The parameters of the analysed model are:

1. The storage density is limited by the Rayleigh criterion. With decreasing subhologram size there is a spread of the bright spots in the reconstructed array, the signal of the photodetector cell at a dark spot can grow significantly. The measure of the spread is the contrast, the ratio of the signal at a bright cell to the signal at a dark cell surrounded by bright cells.

2. The error rate of a holographic memory is determined by the grain noise. Signals at the bright and at the dark cells cannot be fully discriminated due to the statistical fluctuations. An error rate of 10^{-7} can be realized only if the contrast ratio is min. 100 and the signal/average noise ratio is 60.

3. The cost of the reading device depends on the cost of the positioning mechanics and the cost of the reading laser. Low cost can be achieved by simple mechanics and low power laser.

4. The reading data rate depends on the signal amplitude which, for a given laser power, can be increased by less truncation of the Gaussian reconstruction beam by the diaphragm. However

in this case, the effective subhologram size decreases and also the contrast may be less.

5. The aberration of the writing optics and the inaccuracy of the positioning of the plate leads to a further loss of the stored information; this becomes apparent in the reconstructed array in the form of decreased contrast ratio. To diminish the influence of these inaccuracies a space is introduced between the subholograms.

The main relationships between the parameters are illustrated in *Fig. 3*. Some parameters for the design of the memory are fixed: the
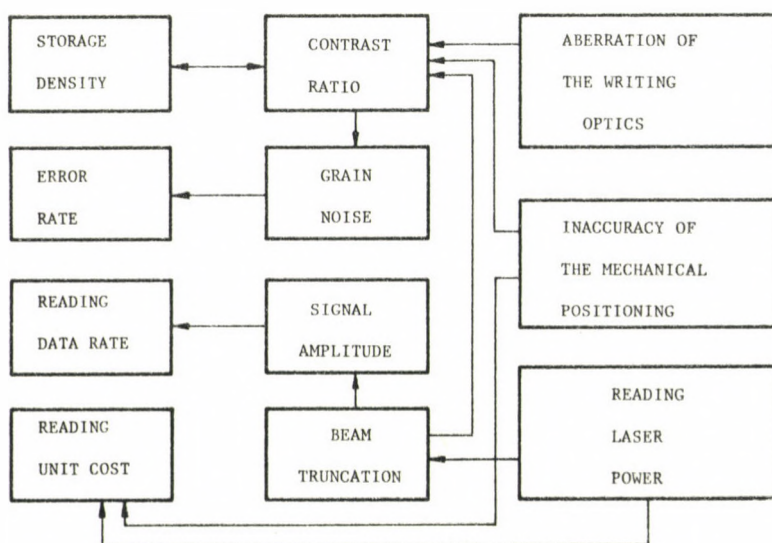
Fig. 3

*Relationships between the parameters of the
archive holographic memory*

writing optics has $\emptyset=50$ mm, $f=100$ mm; the spread in the Fourier plane due to the aberration is 10^{-2} mm, the inaccuracy of the positioning mechanics 3×10^{-2} mm, the reading laser power 5 mW; detector matrix size 32x32 cells with 0.88 duty factor between the cells.

The free parameters are: the duty factor of the page composer, the size of the subhologram, the truncation of the reference and reconstruction beams.

The problem of the design is whether a combination of these free parameters exists for which the optimal contrast ratio, the signal amplitude and storage density simultaneously have appropriate values.

The calculations were performed in two steps: for an ideal system without optical aberration and without mechanical inaccuracy and for the real system to understand the effect of these parameters separately.

With the variations of the free parameters we obtained the following results:
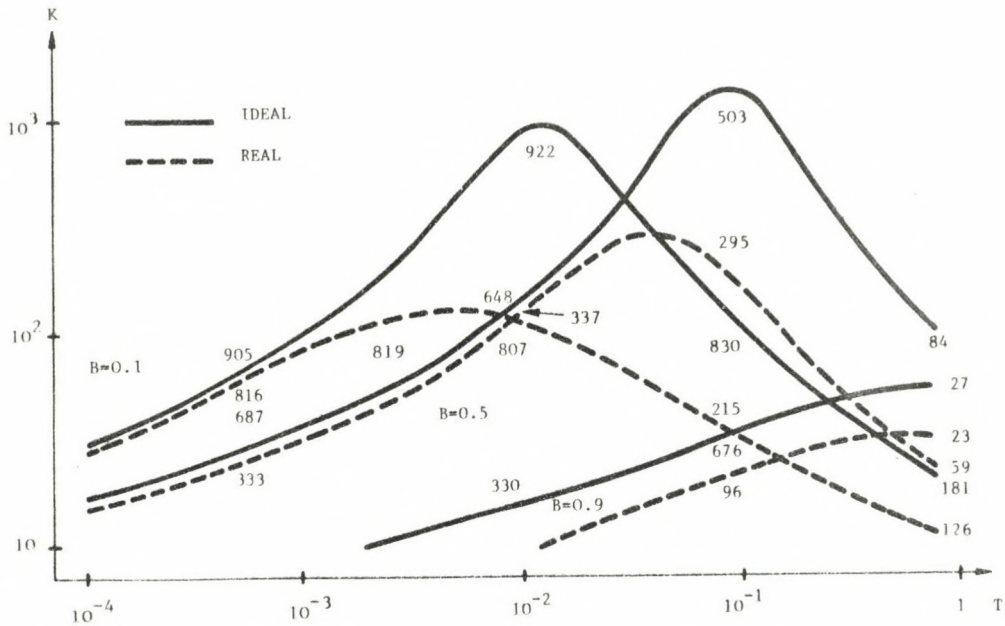
Fig. 4

Dependence of the contrast ratio (K) on the truncation of the reconstruction beam (T) with the B parameter of the duty factor on the page composer. The numbers along the curves are the relative signal amplitudes

1. To obtain high storage density (2.3 Mbit/cm^2) and high contrast ratio (>100) we have to use a subhologram size according to a threefold Rayleigh criterion.

2. To obtain higher signal amplitude we have to use a nearly uniform reference beam. In our case the intensity at the edge of the subhologram was 80% of its maximum value.

3. We have a significant maximum for contrast and signal amplitude if the duty factor on the page composer is less than 70% and the truncation of the reconstructed beam is taken properly *(Fig. 4)*.

When the duty factor on the page composer is 10% the apparatus has some interesting features:

1. Contrast maximum and signal maximum occur simultaneously.

2. The signal maximum has its highest value.

3. The signal amplitude in the ideal and the real systems are close to each other.

II. Inspection of IC-photomasks by holographic subtraction

In the manufacturing process of integrated circuits (IC), photolithographic masks are used. A typical IC photomask may comprise a matrix-like array of hundreds of nominally identical chip features. Defects as small as a few μm-s may yield dozens of defective or wholly inoperative IC devices. The photomasks must therefore be inspected for defects. Up till now this inspection has been done manually by a skilled human operator with the aid of a microscope though there are attempts to develop automatic mask inspection systems.

To overcome this problem a holographic-subtracting technique was developed for inspecting the photomasks. The essence of our method is the following: As a first step a so called étalon hologram is prepared containing the information of a single faultless chip feature. During the inspection the reconstructed étalon image is subtracted optically from the image of a chip feature contained in the mask to be inspected. The resultant image field shows the errors as bright spots on a dark background. The total mask can be inspected step by step. The image of the defect-free chip feature is stored redundantly by the nature of the holographic process, consequently it is much less sensitive to dust and scratches than the original étalon. Therefore this étalon hologram can be used for checking the masks practically permanently. Preliminary ex-
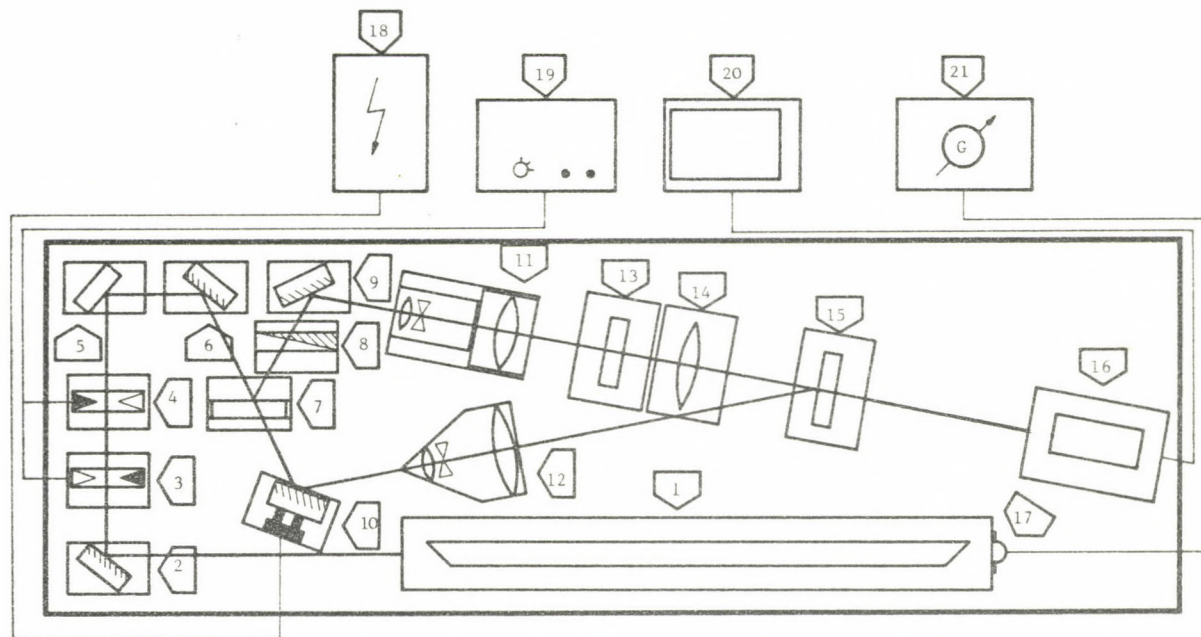
Fig. 5

Experimental arrangement of the subtraction measurement: 1: laser;
2,5,6,9: mirrors; 3,4: shutter; 7: beam splitter; 8: attenuator;
10: piezo ceramic optical path difference controller; 11,12: beam
expanders; 13: mask to be inspected; 14: imaging lens; 15: étalon
hologram; 16: TV camera; 20: TV monitor

periments have been done in our laboratory and the applicability of the method has been proved. The experimental arrangement is shown in *Fig. 5*. To record the étalon hologram a mask with a faultless chip feature has to be placed into plane 13 *(Fig. 5)*. During the inspection the mask to be inspected is placed into plane 13. The interference pattern of the images of the chip feature to be inspected and the étalon feature is detected by a CCTV-system (16, 20). The subtraction of the images can be achieved by means of attenuator 8 and the optical path difference controller 10. A typical experimental result is shown in *Fig. 6*.

a)

b)

c)
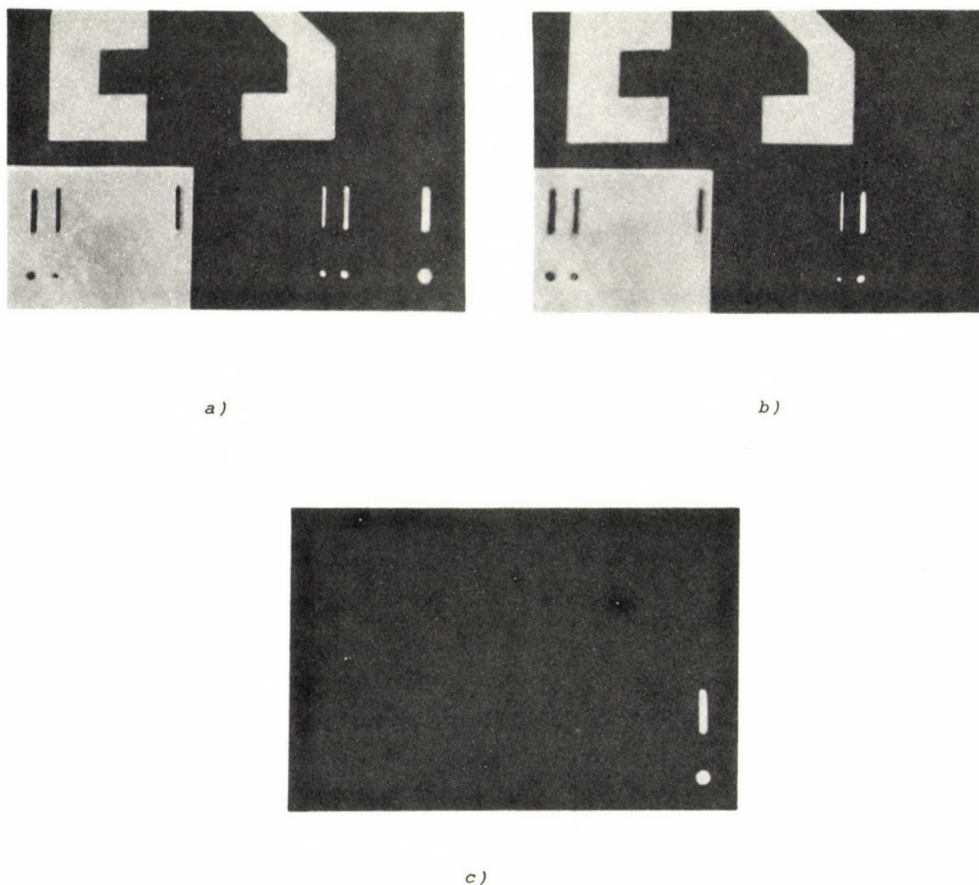
Fig. 6

a) The faultless feature; b) the feature to be inspected;
c) the subtracted image (the width of the vertical line
16 μm)

III. Electronic polarimeter

We have developed an electronic polarimeter, which measures the rotation of the plane of polarization of a polarized light beam without applying mechanical movements. The time of measurement is short and the change in the intensity in the light source has no influence on the accuracy.

The principle of operation is the division of the incident light beam to be measured into two beams by a Wollaston prism. The difference in the intensities of the two secondary beams is proportional to the rotation of the polarization plane. The proportionality is linear within ±10 degrees. The device consists of the measuring head containing the Wollaston prism, two high sensitive photodiodes and precision amplifiers and the electronic unit containing the electronic circuits that produces the sum and difference of the two beam intensities, the normalization, the numeric display and the analogue and coded output of the result (Fig. 7).
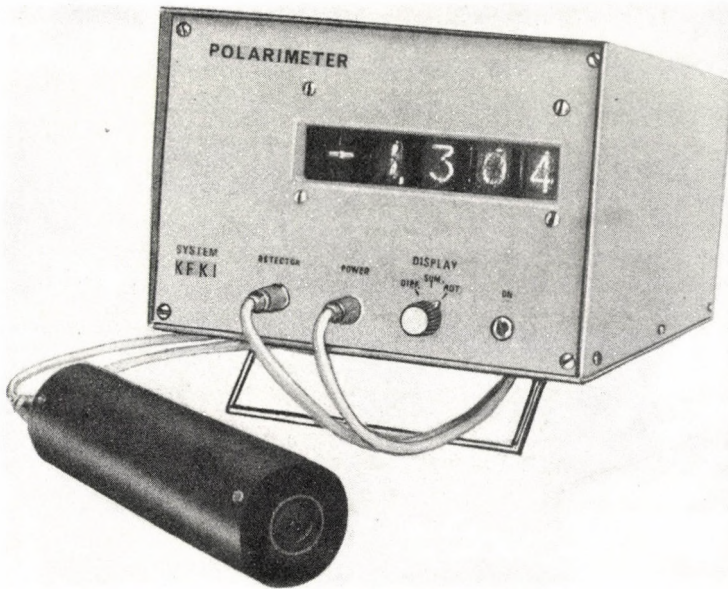
Fig. 7

Electronic polarimeter

The possible application of the device covers chemical analysis, pharmaceutics, medical research and diagnosis, and so on.

The main characteristics are:

Range of measurement ±10 degrees

Accuracy	0.01 degree
Stability	better than 10^{-4}/day
Output	4 digits display; analogue; BCD
Time of measurement	10^{-4} s
Sample rate	5/s

Dimensions and weights:

measuring head	$\emptyset$ 40x120 mm; 0.2 kgf
electronic unit	120x150x220 mm^3; 1.2 kgf

IV. A positioning system for optics

For adjusting optical parts in the experimental set-up, a system of mechanical elements is under development. The system satisfies the following requirements:

1. Holders with 0-6 degrees of freedom can be built up in a short time from a minimal number of elements.

2. The change of one of the coordinates (linear or angular) does not affect the others (invariant adjustment).

3. There are two classes for accuracy: normal and interferometric.

A holder with six degrees of freedom is illustrated in *Fig. 8*. Two types of elements and some fixing parts are used. The specifications of the elements are as follows:

	Translator	Rotator
Accuracy class	Interferometric	Normal
Range	2.5 mm	360° coarse, 10° fine
Scale resolution	0.2 or 1.0 µm	30"
Reproducibility	0.07 µm	3"
Dimensions	132x93x40 mm	95x148x20 mm
Load capacity	10 kgf	2 kgf
Weight	0.9 kgf	0.5 kgf
Clear aperture		$\emptyset$ 40 mm
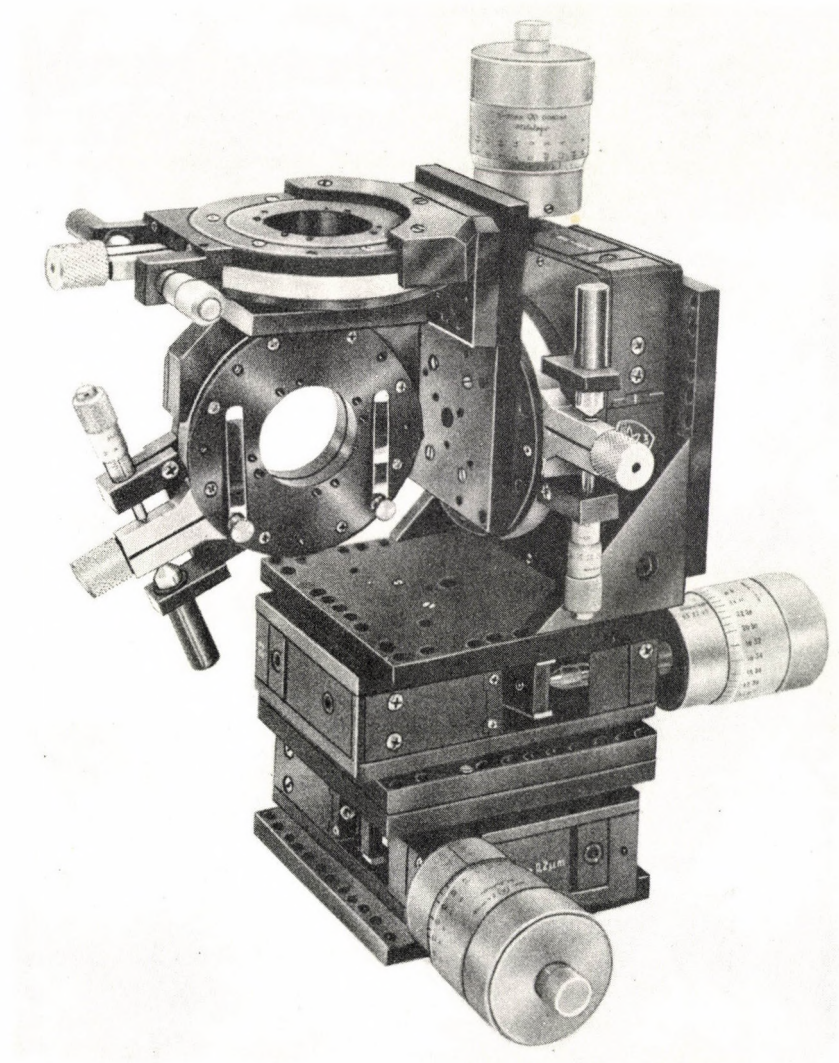
Fig. 8

Positioner with six degrees of freedom

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ION IMPLANTATION PROGRAM

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L. Királyhidi, R. Kósza*, E. Kótai**, T. Lohner, Á. Majoros, A. Manuaba,
G. Mezey, T. Mohácsy, T. Nagy, D. Pacher, E. Pásztor, P. Révész, P. Riedl,
B. Sallay*, Vera Schiller*, Katalin Solt, Le hoang To

The comprehensive research carried out follows three different directions, viz. development of implanters and ion sources, application of implantation in MOS structures, and phenomena in implanted semiconductors. The basic method for the last of these was the Rutherford backscattering.

For a new ion implanter having 350 keV energy and a high dose rate, an ion source has been designed with 1-2 mA heavy ion current and a few hundred hours of cathode life time. In *Fig. 9* the schema of the source can be seen and the emittances measured in the xz and yz planes are shown in *Fig. 10*.

To improve our previous implanter (type ILU-3a) which had a relatively poor homogeneity, a rotating target assembly was constructed (see *Fig. 11*). The holders move the samples in the y direction while the ion beam is swept in the x direction with 50 cycles. The resulting homogeneity on the surface of a 2" sample is better than 97.5%. The construction enables the use of post-accelerating voltages up to 50 kV.

The incorporation of oxygen into Si_3N_4 layers was investigated and also the oxidation of the Si_3N_4 itself. Together with co-workers of the Institute for Technical Physics, Budapest, the formation of native oxide layers on GaP Schottky structures was investigated. In co-operation with the California Institute of Technology, Pasadena, Calif., USA, the radiation damage produced by high-dose implantation was examined. It was shown that an oxidation step following a high-dose phosphorus implantation causes a misfit dislocation network.

Polysilicon implanted with Sb as a diffusion source for the doping of silicon was investigated together with the Institut für Fest-
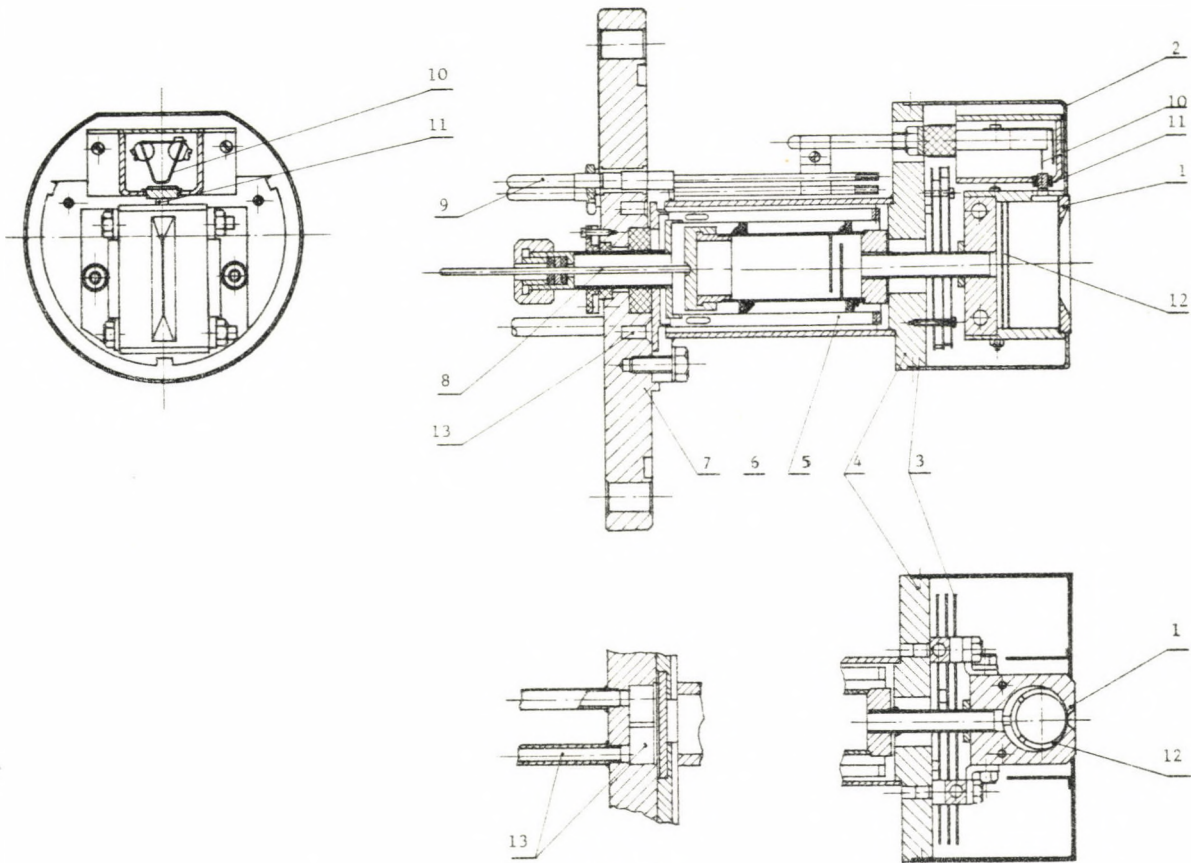
Fig. 9

Construction of the ion source

1 - Discharge chamber, 2 - High voltage covering, 3 - Heat shielding, 4 - Support, 5 - Oven,
6 - Crucible, 7 - Base plate, 8 - Thermocouple tube, 9 - Feed throughs, 10 - Filament,
11 - Cathode, 12 - Ta chamber, 13 - Water cooling

"Y" plane

mrad

Area = 114 mm mrad

Total current : 1.7 mA

Analysed current : 340 μA

"X" plane

mrad

Area = 12.8 mm mrad
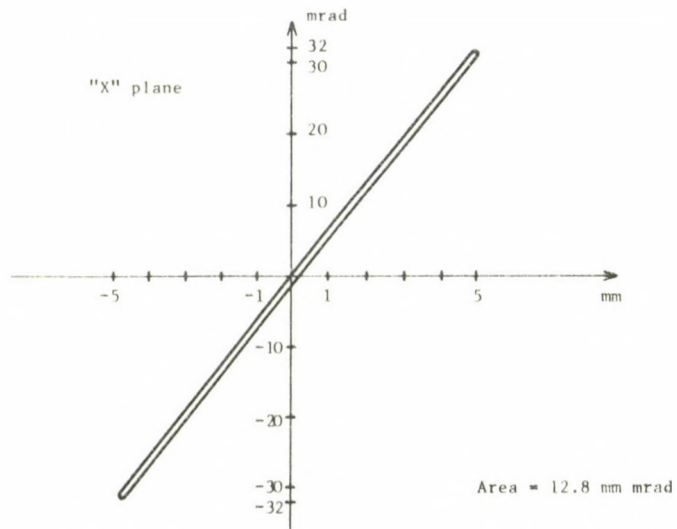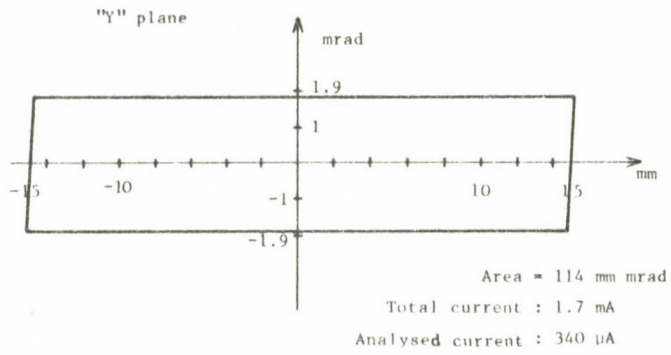
Fig. 10

Emittances of the ion source in the xz and yz planes
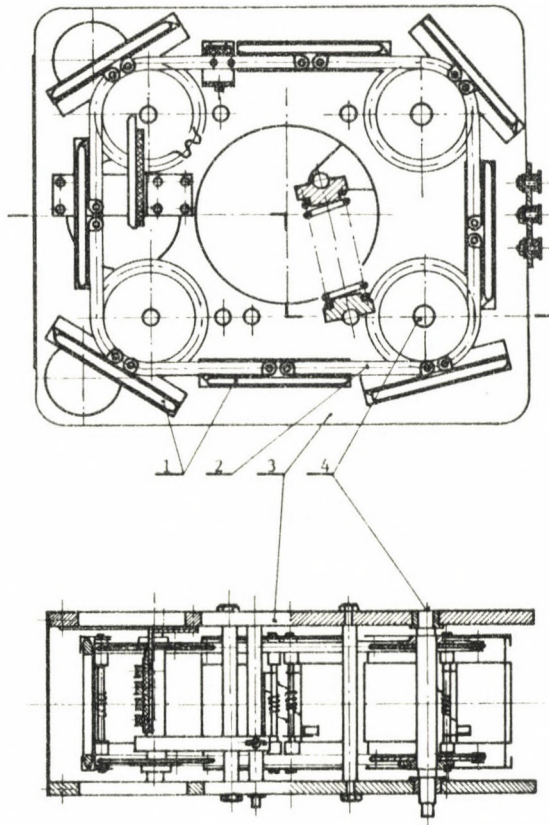
Fig. 11

Rotating target assembly for the ILU-3 implanter
1 - Sample holder plates, 2 - Chain, 3 - Assembling plates, 4 - Driving axis
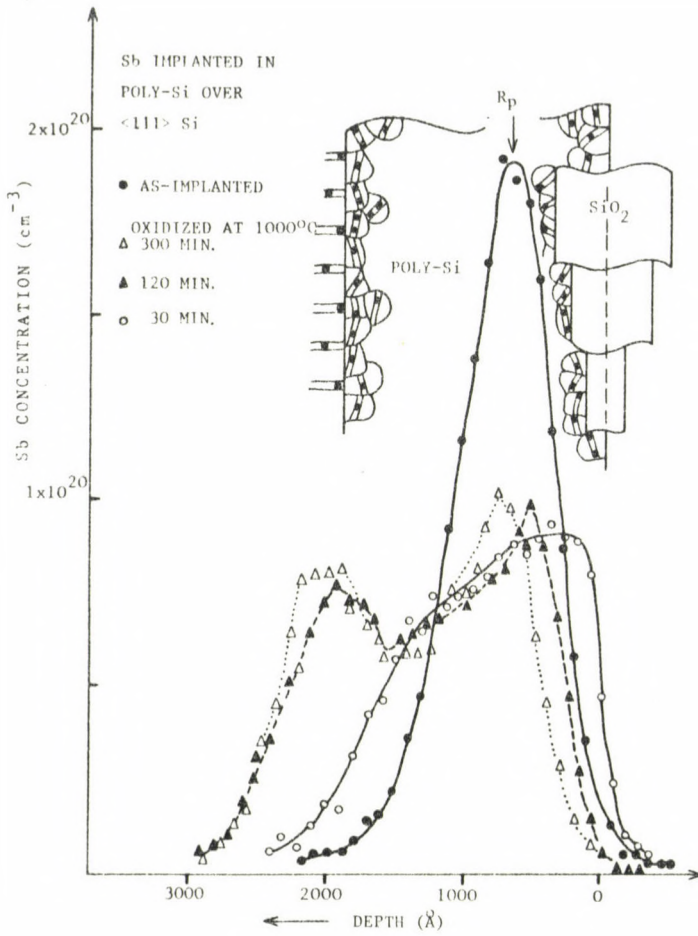
Fig. 12

*Sb concentration dependence on depth in Sb implanted poly-Si
as-implanted and after heat treatments (Rp: projected range)*
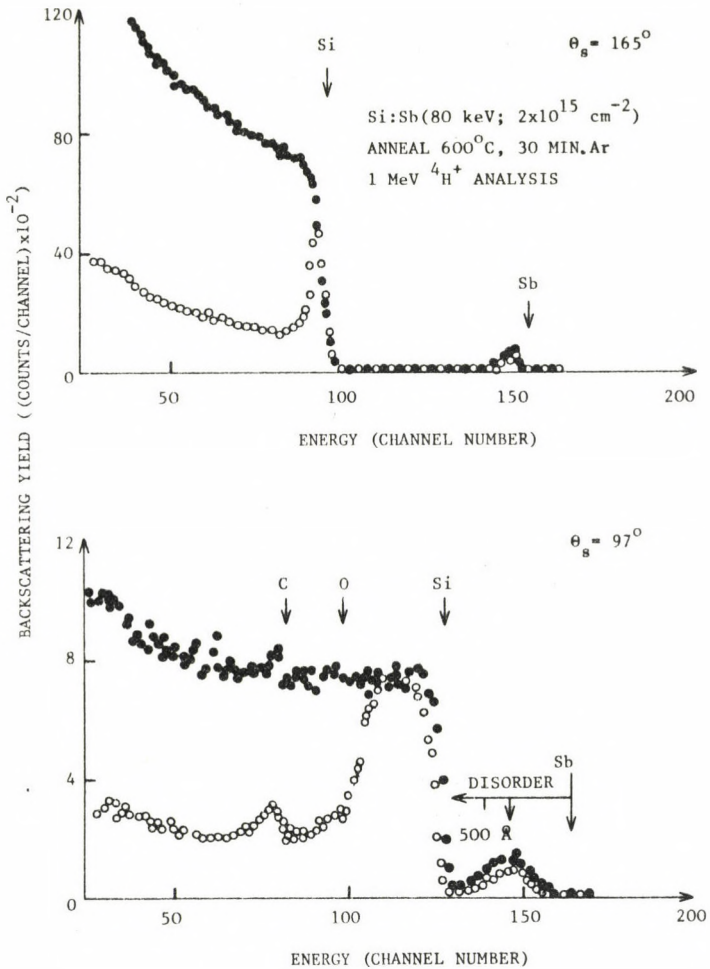
Fig. 13

Comparison of the "regular" backscattering spectrum ($Q_S = 165°$) with that made by the tilted detector geometry ($Q_S = 97°$)

körpertechnologie, Munich, FRG. Figure 12 displays one of the results when the drive-in was made in an oxidizing ambient (wet oxidation).

As a methodological result, we used a tilted detector geometry in backscattering which results in a 30 $\overset{o}{A}$ depth resolution and still provides the possibility of finding channels. Figure 13 provides a comparison between "regular" backscattering and the tilted detector geometry.

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AMORPHOUS SEMICONDUCTOR RESEARCH

P. Fazekas, Mária Füstöss-Wégner, J. Gazsó, J. Hajtó , T. Kemény, M. Koós
I. Kósa Somogyi, L. Matus, L. Tóth, Gy. Zentai

Some of the chalcogenide semiconducting alloys are distinguished by their ability to undergo reversible phase changes induced by intense light irradiation.

Amorphous thin films of compositions $Te_x(AsSe)_{1-x}$ (x=0.7; 0.62; 0.50) were prepared by vacuum evaporation on glass substrates. An Ar-ion laser of 700 mW output power served to induce phase transitions by photo-crystallization, and a low power (5 mW) He-Ne laser beam was used simultaneously for detection of the degree of transformation. The radial distribution of the laser beam intensities being of Gaussian form, the kinetic rate constants were deduced by the help of derived analytic formulae. By working in the reduced intensity regime where temperature rise was negligible, we were able to establish the primary role of the light irradiation.

Comparison of photoluminescence spectra of amorphous semiconductors with the crystalline counterparts yields information on the corresponding band structures. The measurement of the photoluminescence spectra of amor- phous and crystalline $GeSe_2$ at 77 K provided broad bands of Gaussian distribution. The half-width of the bands was greater, the Stokes shift was smaller for the amorphous state. The results confirm the usefulness of the Mott-Davis-Street model.

Under laser irradiation without focusing, amorphous thin films of AsSe and $GeSe_2$ first exhibit permanent photodarkening which is then followed by photobleaching. Further irradiation induces reversible trans- mission decrease $(T-T_\infty) \sim 1/t$ in time; when the light is switched off the relaxation is exponential. (Characteristic time constants are of a few seconds.) In addition, in $GeSe_2$ films of 5-10 micron thicknesses under focused He-Ne laser irradiation, another new phenomenon sets in, viz. pe- riodic pulsation (3-50 Hz) *(Fig. 14)*. All these observations seem to con- firm the existence of at least two different atomic configurations in the semiconductors mentioned above.

As a continuation of earlier studies electrically induced switch- ing in metal free phthalocyanine has been studied, too.
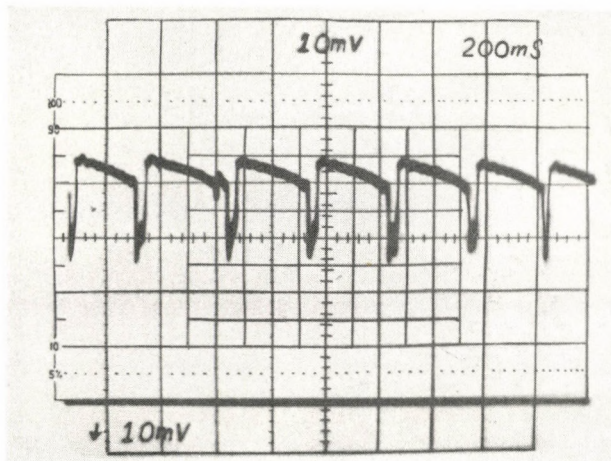
Fig. 14

Autochopping effect in the transmittivity of amorphous $GeSe_2$ film under focused, continuous He-Ne laser beam

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ORGANIC CONDUCTORS AND SEMICONDUCTORS

Mária Erő-Gécs, G. Grüner, K. Holczer, A. Jánossy, Katalin Kamarás, G. Mihály, Katalin Pintér, Katalin Ritvay-Emandity

The temperature dependence of transport properties (dc conductivity, 9.1 GHz conductivity and dielectric constant, thermoelectric power)

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** Eötvös Loránd University, Budapest

of single crystals of a series of well conducting complex charge transfer salts of the form $D(TCNQ)_2$ was studied. In all cases except one, the donors were found to be asymmetric and we calculated the corresponding dipole moments by a molecular orbital method. We demonstrated that donors with large dipole moments are arranged regularly thereby leading to a charge ordered state with low conductivity and a large energy gap. Smaller donor dipoles are stacked randomly. When intra- and interchain Coulomb forces are much larger than the random donor-acceptor interactions the material is a band semiconductor with a small but well defined energy gap. For large random site energies, random localization is important and the transport properties may be described by the variable range hopping model. The localization length for materials of this type is estimated from the low temperature dielectric constant, and it is found that it is determined both by disorder and correlation effects.

We have investigated the magnetic properties of the charge transfer salts $Qn(TCNQ)_2$, $Cs_2(TCNQ)_3$ and TTF-TCNQ in the form of single crystals, and after strong compression or grinding to a fine powder; the effect of these is to introduce lattice defects and increase the surface area. It has been found that for the first two compounds compression or grinding leads to a non-linear, saturating component in the magnetization field curves, whereas the effect is absent for TTF-TCNQ. It has been suggested that this behaviour could arise from strongly coupled localized spins at the surface, i.e. surface magnetism in these materials.

DC conductivity and thermoelectric power measurements were carried out on the organic charge transfer salt $TTT-I_{1.6}$. It has been argued that the metallic low temperature behaviour arises from the joint influence of a finite interchain bandwidth and weak disorder.

Electronic spectra of $TTT-I_n$ both in solution and in the solid state were measured between 8000 and 40,000 cm^{-1}. The highly conducting phase $TTT-I_{1.5}$ is assigned as $(TTT^{\circ}TTT^{+})$ $(I_3)^{-}$. A phase $TTT-I_{2.7}$ is obtained and its possible electronic structure discussed. Conductivity results on both phases were obtained.

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* University of California, Los Angeles, Calif., USA

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LIQUID CRYSTAL RESEARCH

L. Bata, Ágnes Buka, I. Jánossy, I. Pócsik, J. Szabon

This year the investigations which were formerly used to study nematics, have been extended to other liquid crystal phases, such as smectics and cholesterics.

Calorimetric, dielectric, optical measurements and the study of elastic properties have been carried out on two materials: on octyl-cyano biphenyl (OCB), synthesized in the institute and on nitrophenyl-octiloxy benzoate (NPOOB), which was obtained from the Martin Luther University, Halle, GDR. The common feature of the two materials is that both of them

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possess nematic and smectic-A phases. The different investigations have shown unambiguously that the nematic-smectic-A transition is of first order, although the transition enthalpy is small compared with other phase transitions (for OCB 30 cal/mol, for NPOOB 8 cal/mol). In the case of OCB the static dielectric constants, the frequency of the dielectric relaxation, and the refractive indices vary nearly continuously at the phase transition; in the case of NPOOB these quantitites have much larger discontinuities. On OCB, strong pretransitional effects have been observed in the elastic properties. According to the measurements near the nematic-smectic-A phase transition the bend elastic constant is proportional to $(T-T_c)^{-1}$.

The results described above were reported at the Second Liquid Crystal Conference of Socialist Countries, held in Bulgaria. At the same conference L. Bata presented, as an invited lecture, a summary of his investigations on molecular dynamics in nematics.

A paper has been published on the optical investigations of flow induced instabilities in nematics. This work was carried out in cooperation with the Orsay Liquid Crystal group, Orsay, France.

During this year electro-optical and hydrodynamical investigations of nematic-cholesteric mixtures were commenced.

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RESEARCH ON METAL PHYSICS

*I. Bakonyi, Éva Császár-Gilicze, C. Hargitai, Katalin Jámbor, Klaudia
Karlik-Scserbak, T. Kemény, Éva Kisdi-Koszó, G. Konczos, K. Lázár, A. Lovas,
G. Mészáros, I. Nagy, L. Pogány, A. Sütő, Erzsébet Sváb, J. Takács, L. Takács,
T. Tarnóczi, K. Tompa, Enikő Tóth-Kádár, J. Tóth, P. Tóth, B. Vasvári,
I. Vincze, Katalin Zámbó-Balla*

In the field of metal physics we have continued our research on glassy metallic alloys and the investigation of metal-gas reactions in alloys of industrial interest.

The $Fe_{100-x}B_x$ binary alloys have been splat cooled in continuous ribbon form on a rapidly rotating brass disk. The as-cast ribbons were checked by X-ray diffraction scans made in transmission mode with a Philips XDC-700 Guinier camera using CrK_α radiation and were chemically analysed by a Varian atomic absorption spectrophotometer. The data on the coercive force and the X-ray diffraction have clearly shown that at cooling rates of $\sim 10^6$ K/s estimated from high speed motion film, the glassy state is formed in splat cooling when the boron concentration is higher than 12.5 atomic per cent. The thermal stability of the glassy $Fe_{100-x}B_x$ ($12.5 \leq x \leq 20$) alloys has been investigated by thermomagnetic and differential scanning calorimetric (DSC) measurements. In the hypo-eutectic concentration range ($x<16.5$), two-stage crystallization processes have been revealed. An empirical correlation between the soft magnetic and the structural properties of the as-cast iron-boron has been found. Its origin lies in the two-phase nature of both the hypo- and the hyper-eutectic binary iron-boron glasses *(Fig. 15)*.

The crystallization of several metallic glasses has been investigated by DSC. The temperature of crystallization and the heat of transformation were measured. The presence of intermediate transformation stages can be related to the thermodynamic properties of the al-
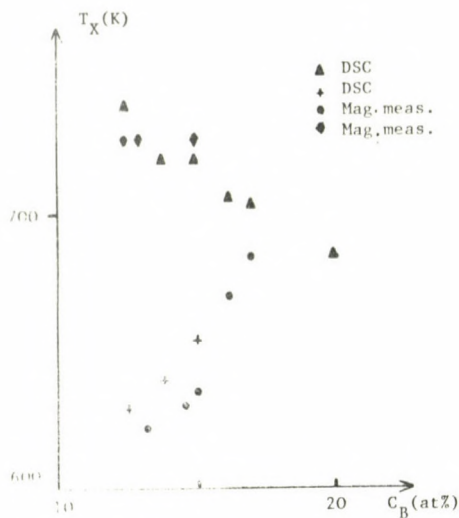
Fig. 15

Crystallization temperatures determined by DSC and thermomagnetic measurements in glassy Fe-B alloys

loy system. The thermal activation energy has been determined from the
heating rate dependence of crystallization process; the frequency factor
and the exponent of time dependence estimated by fitting the reaction rate
to the formula characteristic to nucleation and growth mechanism.

The various processes of crystallization in amorphous Fe-B al-
loys of different composition have been followed by magnetic measurements.
Samples with low boron content exhibit two-step crystallization. Curie
points in amorphous state, crystallization temperatures and activation
energies for crystallization processes are evaluated. The data support
the earlier suggestion that a metastable Fe_3B phase appears.

To investigate transformation kinetics of crystallization pro-
cesses in splat cooled metallic glasses the changes in electrical resis-
tivity during the high temperature isothermal heat treatment have been
measured on $Fe_{83.8}B_{16.2}$, $Fe_{80}B_{20}$ (Metglas 2605) and $Fe_{78}Mo_2B_{20}$ (Metglas
2605A) alloys. The activation energies obtained in this way agree well
with those determined from DSC measurements.

The electrical resistivity of amorphous iron-boron alloys has
been studied as a function of temperature from 4.2 to 60 K in high mag-
netic fields (H_{max} = 5 T). The results confirmed the earlier findings
that the general shape of the $\rho(T)$-T curve is unaltered by the magnetic
field. The composition of the splat cooled samples was around the eutectic
composition. The very small magnetic resistance was found to be definitely
negative for all samples.

The electronic structure of Fe-B, Fe-Co-B and Fe-Ni-B metallic
glasses has been investigated using Mössbauer effect. Comparing them with
the properties of crystalline Fe-Co and Fe-Ni alloys and T_2B, TB inter-
metallic compounds we calculated that the electronic structure can be well
described in terms of the donor model. The localization of the electronic
states is basically determined by the metalloid concentration. The elec-
tronic structure does not depend strongly on whether the alloy is amor-
phous or crystalline.

A new experimental method has been proposed for simplifying the
complex Mössbauer spectra often obtained in ferromagnetic materials. It
has been applied for amorphous $Fe_{80}B_{20}$ (Metglas 2605) and for a crystal-
line disordered $(Fe_{0.65}Co_{0.35})B$ alloy. In these cases the hyperfine field
distributions have been determined. The effects of isomer and quadrupole
shift distributions have also been discussed.

Neutron diffraction measurements have been carried out on splat
cooled Cu-Zr and $Nb_{39}Ni_{61}$ metallic glasses. The reduced pair distribution
function has been determined *(Fig. 16)*.
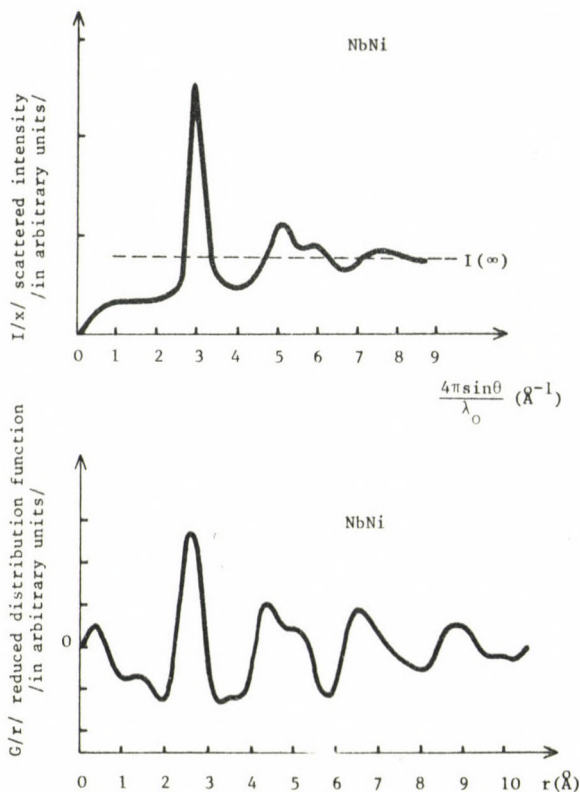
<u>Fig. 16</u>

*The interference function of $Nb_{39}Ni_{61}$ metallic glass by
neutron diffraction. The reduced distribution function
G(r) of $Nb_{39}Ni_{61}$ metallic glass*

We have reviewed results of NMR investigations on metallic glas-
ses. [31]P nuclear magnetic resonance signals have been detected by cw and
pulse NMR methods in electrodeposited amorphous Ni-P alloys. The charac-
teristic parameters of the ^{31}P signal and the relaxation times have been
determined. The ^{31}P NMR signal is inhomogeneously broadened due to the
distribution of Ni moments. The temperature dependence of the spin-lattice
relaxation time, T_1 indicates that the largest contribution to the relaxa-
tion mechanism is due to the conduction electrons *(Fig. 17)*.
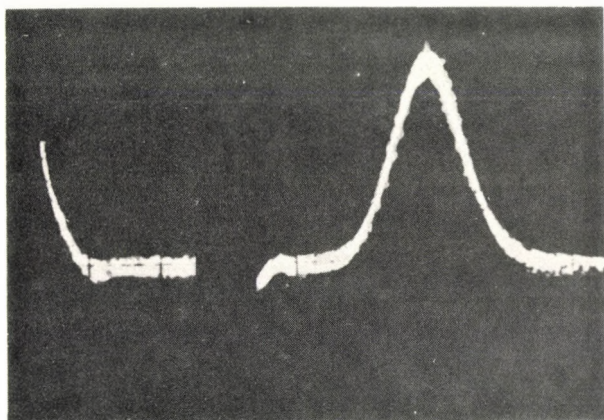
Fig. 17

^{31}P *nuclear spin echo detected on electrodeposited amorphous Ni-P alloy*

The investigations on carburization and decarburization of iron and its alloys and on internal oxidation of dilute copper based alloy have also been continued this year.

In the first topic, investigations on the iron-nickel alloys have begun. Measurements were performed on alloys containing 50 and 75 per cent nickel and on pure nickel at the beginning. The increase in the nickel content was found to accelerate the carburization and decarburization processes significantly. On pure nickel the two processes are more than one order of magnitude faster than on pure iron. The observations are to be continued in an attempt to clarify the details. The determination of the diffusion coefficient of carbon during the carburization and decarburization by measuring the thermopower also belongs to this topic.

The investigations on internal oxidation are related to the problems of the mechanism of the solution of oxygen. The so called sampling method developed by Chipman has been used to determine the saturation concentration of oxygen in high purity copper and in dilute solid solutions of copper-gold. After determining the saturation concentration the interaction parameter was calculated. It has its extremum between 900-1000 ^{o}C at 8-10 atomic ppm content of gold. If the change in the interaction parameter is compared with that in the residual resistance it may be concluded that the dissolved gold decreases the activity coefficient of oxygen and hinders the processes of internal oxidation.

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   metallic glasses. ibid. (in press)

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        CSSR

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TECHNICAL DEVELOPMENT

ELECTRONIC MEASURING EQUIPMENT

O. Bakos, I. Eördögh, L. Farkas, P. Horváth, K. Kertész, B. Lévay, Gy. Pájer, I. Pálmai, F. Tóth

The digital storage transient recorder *(Fig. 18)* is capable of processing single or repetitive fast analogue signals (max. 5 MHz). It utilizes a high speed parallel type analogue-to-digital converter which converts the input signal to 8 bit words. The sample rate and the dwell time are determined by the dual time-base generator (max. 10 MHz). The

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[+] Bánki Donáth Technical High School, Budapest
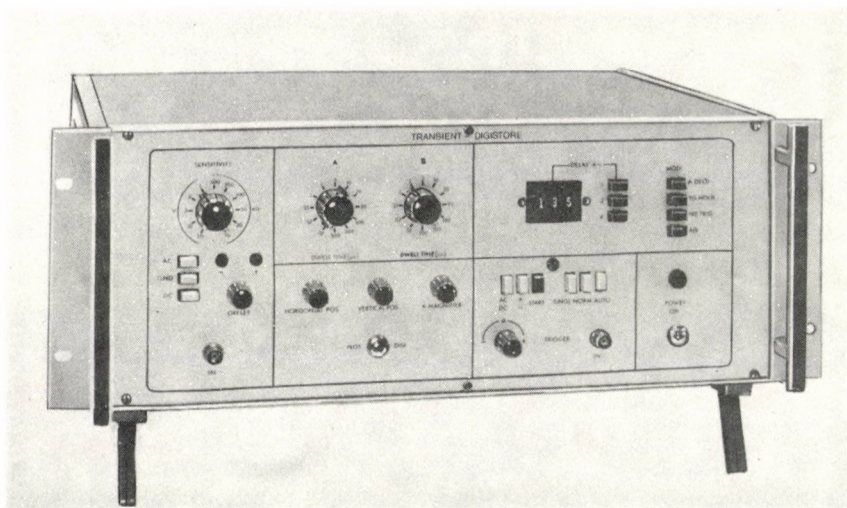
Fig. 18

Digital storage transient recorder

8 bit words are stored in an 8 bit x 1024 word fast memory. After a record-
ing cycle, the content of the memory is added word by word to the content
of a 20 bit x 1024 word memory. In the single store operating mode the
error is about 0.4 % in amplitude resolution. In accumulation operation
mode, the signal-to-noise factor is improved significantly (theoretically
by 2^6).

The stored data may be displayed on the screen of a conven-
tional oscilloscope or TV monitor by means of the output 12 bit digital/
analogue converter. The binary data are present at the same time on the
14 line TTL compatible output.

A time program generator for the automatic production of magnetic
garnet films by the liquid phase epitaxy method has been developed. In
accordance with the predetermined course of the technology, the equipment
controls the speed regulators of the lifting and rotary motors. The
main parameters of the technology may be preset with high precision in
a wide range, thus it is usable both during the development stage and
in standardized production.

A further 40 measuring instruments have been developed of which
the following are the more significant ones:

- resistivity change recorder for testing metal-gas systems,
- box-car integrators,
- various power supplies for lasers,
- automatization for producing multi-layer optical mirror,
- Fabry-Perot interferometer stabilizer,
- device for compensating optical vibration,
- pneumatic system controller,
- single and two phase lock-in amplifiers,
- cryo-temperature controllers for the temperature range
  1 K - 800 K,
- various peripheral interface units,
- digital time program generator.

LOW TEMPERATURE MEASUREMENT TECHNIQUES

J. Balla, A. Pintér, I. Szakáll

For Mössbauer effect measurements a new type of He cryostat has been developed. In the cryostat the temperature of both the specimen and the source may be decreased to the temperature of liquid He. The specimen can be changed in a few minutes without disturbing the thermal insulator vacuum system. Continuous measuring time is 40 hours at 4.2 K.

Also developed was a new variant of our gas-flow gauge for measuring the Mössbauer effect. The temperature of both the specimen and the source may be set from 4.2 to 300 K, and the preset value may be maintained over a long period. In order to maintain the pressure of He gas leaving the gauge at a value less than atmospheric pressure, a pneumatic suction pressure controller of high sensitivity has been produced.

For optical measurements a new type of He cryostat and a gas-flow gauge have been developed. The measuring range of the cryostat extends from 2 to 300 K and that of the gauge from 4.5 to 300 K. During the period of measurement the specimen can be turned around an axis which is perpendicular to the beam. Change of specimen may be performed in a few minutes without opening the vacuum system.

This year a total of 5,500 litres of liquid He and 175,000 litres of liquid N_2 has been condensed in our plant.

FOREIGN RELATIONS

Lectures by visiting scientists

B. Györffy   (H.H. Wills Laboratory, University of Bristol,
                    Bristol, England)
                    Band structure of disordered alloys

A. Bjelis   (Institute for Physics, University of Zagreb,
                    Zagreb, Yugoslavia)
                    Ginzburg-Landau theory of Peierls transition

P. Noziéres   (Laue-Langevin Institute, Grenoble, France)
                    Orbital effects on Kondo impurities

G. Lehmann   (Zentralinstitut für Festkörperphysik und Werkstof-
                    forschung, Dresden, GDR)
                    Electronic structure of A-15 compounds

Yu. Kagan   (Kurchatov Institute, Moscow, USSR)
                    Quantum oscillations of the superconducting
                    transition temperature

I.M. Halatnikov   (Landau Institute for Theoretical Physics,
                    Chernogolovka, USSR)
                    Nonlinear acoustic phenomena in superfluids and
                    the parametric creation of sound

                    Orbit and spin hydrodynamics in anisotropic
                    superfluid ^{3}He

A. Migdal   (Landau Institute for Theoretical Physics,
                    Chernogolovka, Moscow, USSR)
                    Quantum chromodynamics

                    Real space renormalization applied to critical
                    phenomena

W. Javorski   (Institute of Molecular Physics, Poznan, Poland)
                    Role of spin-orbit coupling in the itinerant
                    model of ferromagnetism

S. Olszewski   (Institute of Physical Chemistry, Warsaw, Poland)
                    Research in the Institute of Physical Chemistry
                    in Warsaw

E. Brezin   (CEN de Saclay, Gif-sur-Yvette, France)
Non-linear sigma model in $2+\varepsilon$ dimension

F.B. Humphrey   (California Institute of Technology, Pasadena, Calif., USA)
Creep and overshoot in bubble translation

E.Th. O'Dell   (Imperial College, London, England)
Bubble research in the United Kingdom

Yu. Starostin   (Complex Computer Control Institute, Moscow, USSR)
Bubble memory research in INEUM

R.W. Hoffman   (Case Western University Cleveland, Ohio, USA)
Mechanical properties of thin films

C.A. Evans   (University of Illinois, Urbana, Ill., USA)
SIMS and Auger in semiconductor physics

V.G. Litovchenko   (Institute of Physics, Ukranian Academy of Sciences, Kiev, USSR)
Influence of irradiation on MOS structures

L.C. Feldman   (Bell Laboratories, Murray Hill,, New Jersey, USA)
New methods in surface science

W.L. Brown   (Bell Laboratories, Murray Hill, New Jersey, USA)
New results in sputtering

S.T. Picraux   (Sandia, Albuquerque, New Mexico, USA)
Profiling of light elements

J. Sworakowski   (Technological Institute, Wroclaw, Poland)
Study of traps for charge carriers in organic solids

A. de Vries   (Ohio State University, Kent, Ohio, USA)
X-ray investigation of smectic C phase

Staff members on study tours

P. Fazekas   International Centre for Theoretical
Physics, Trieste, Italy   6 weeks

P. Szépfalusy	University of Geneva, Geneva, Switzerland	3 months
A. Zawadowski	Laue-Langevin Institute, Grenoble, France	2 months
E. Praveczki	Joint Institute for Nuclear Research, Dubna, USSR	2 years
Maria Füstöss-Wegner	Zentralinstitut für Elektronenphysik, Berlin, GDR	1 month
J. Gazsó	Institute of Solid State Physics, Prague, CSSR	1 month
G. Grüner	University of Groningen, Groningen, The Netherlands	2 months
A. Sütő	H.H. Wills Laboratory, University of Bristol, Bristol, England	5 months
T. Tarnóczi	Sendai, Osaka, Tokyo, Japan	1 month
L. Tóth	A.F. Ioffe Physico-Technical Institute, Leningrad, USSR	1 month
G. Zentai	Zentralinstitut für Elektronenphysik, Berlin, GDR	1 month
Gy. Zimmer	California Institute of Technology, Pasadena, Calif., USA	1 month
L. Gál	California Institute of Technology, Pasadena, Calif., USA	6 months
I. Pintér	Complex Computer Control Institute, Moscow, USSR	2 months
L. Gál	Complex Computer Control Institute, Moscow, USSR	2 months
P. Révész	California Institute of Technology, Pasadena, Calif., USA	1 year

J. Gyulai	California Institute of Technology, Pasadena, Calif., USA	2 months
T. Lohner	Institute for Physics of Semiconductors, Novosibirsk, USSR	2 months
Ágnes Buka	University College of Wales, Alberystwyth, Wales	1 year

Guest scientists and fellows

A. Migdal	Landau Institute for Theoretical Physics, Chernogolovka, USSR	1 month
A. Kazantsev	Landau Institute for Theoretical Physics, Chernogolovka, USSR	1 month
E.Th. O'Dell	Imperial College, London, England	1 month
Yu.G. Starostin	Complex Computer Control Institute, Moscow, USSR	2 months
V.B. Sevastianov	Complex Computer Control Institute, Moscow, USSR	2 months
G.N. Orlov	Complex Computer Control Institute, Moscow, USSR	2 months
P.L. Potapov	Complex Computer Control Institute, Moscow, USSR	2 months
E. Della Tore	McMaster University, Hamilton, Canada	1 month
F.B. Humphrey	California Institute of Technology, Pasadena, Calif., USA	1 month
G.I. Kohanchik	Solid State Research Institute, Chernogolovka, USSR	1 month
A.V. Vlasov	Institute of High Temperatures, Moscow, USSR	1 month
A.Y. Kishmiri	Baghdad University, Baghdad, Iraq	4 years

G. Lehman	Technische Universität, Dresden, GDR	4 months
J. Möller	Technical University, Lyngby, Denmark	4 months
P. Rennert	Martin Luther University, Halle, GDR	1 month
M.A. Tagirdzhanov	A.F. Ioffe Physico-Technical Institute, Leningrad, USSR	1 month
V.A. Vassilev	A.F. Ioffe Physico-Technical Institute, Leningrad, USSR	1 month

THESES

J. Kollár   Cohesive and elastic properties of transition and noble metals. (For the academic degree of Candidate of Physical Sciences)

F. Woynarovich   Charge ordering in quasi one-dimensional systems. (For Ph. D. degree)

G. Mihály   DC conductivity and thermopower measurements on organic charge transfer salts and their interpretations. (For Ph. D. degree)

K. Holczer   Measurements on the conductivities and dielectric permittivities of organic quasi-one-dimensional substances at microwave frequencies. (For Ph. D. degree)

L. Takács   Studies on the structural and the electronic structural properties of some metallic glasses. (For Ph. D. degree)

Gy. Zentai   Amorphous semiconductors. (For Ph. D. degree)

PATENT

I. Pintér   Chemical etchant for photolithographical etching of iron or nickel base thin films (MA-2858)

OPTICS

RESULTS

INTERACTION OF ULTRASHORT LASER PULSES WITH ELECTRONS

Gy. Farkas, Z.Gy. Horváth

The investigations of the interaction of free and quasifree electrons with ultrashort laser pulses as well as the X-ray radiation of the laser plasma were continued in 1977.
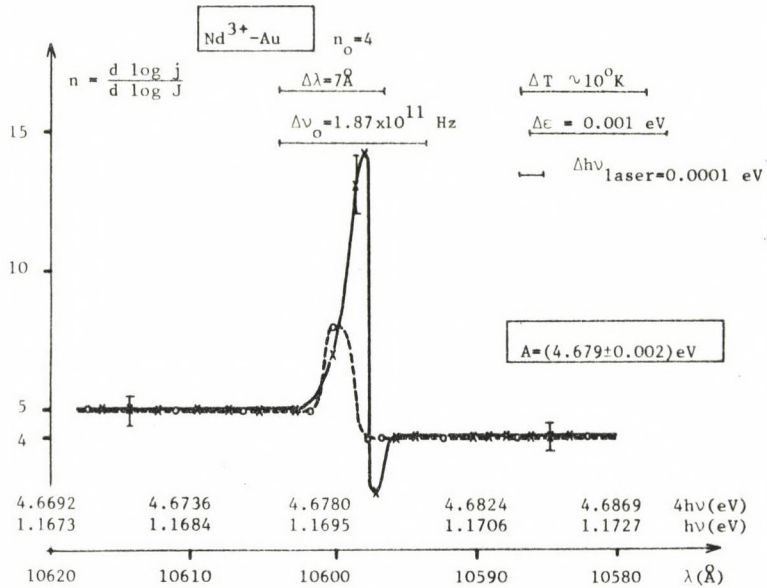
<u>Fig. 1</u>

Dependence of the order of nonlinearity (n) on the photon energy. The two curves relate to two different treatments of the cathode. Quantity A is the work function of gold determined from these resonance curves

The importance of the present year's work is that due to the international cooperations (Lebedev Physical Institute, Moscow, USSR; Landau Institute for Theoretical Physics, Chernogolovka, USSR; C.E.N. de Saclay, Gif-sur-Yvette, France), we obtained new quantitative results which are very precise compared with those of former years.

In the course of the investigations of the multiphoton photo-effect of gold we have found the resonance like behaviour shown in *Fig. 1.* Besides the theoretical importance of the value of the resonance wavelength and the sharp half width of the resonance curve, it seems to be convenient for the work function determination of metals with a precision of 0.002 eV. Meanwhile theoretical works have been published to explain this effect but the extremely sharp half width of the resonance curve remained un-explained. The resonance behaviour furnished the explanation of the un-expectedly strong light intensity dependence of the multiphoton photo-effect observed by us in the case of irregular non bandwidth limited ultrashort laser pulses. For the control of the existence of this re-sonance like phenomenon we pointed out that in the case of nickel no resonance occurs in our tuning range of the laser wavelengths correspond-ing to the theoretical expectations.
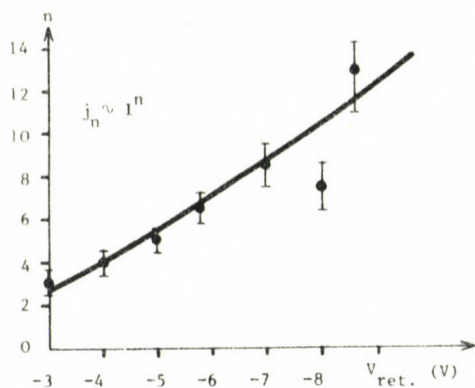
Fig. 2

Experimentally measured n values as a function of retarding potential (V_{ret}) for photon - free electron interac-tion

In other experiments we demonstrated that in a high intensity laser beam quasifree electrons may absorb $1, 2, 3, \ldots, n$ photons as opposed to what might be expected from basic considerations. In these experiments a mesh kept at a negative retarding potential V_{ret} of several volts was situated in front of a cathode emitting thermal (~ 20 meV) electrons, which evidently could not penetrate the mesh. If, however, this electron cloud was shot by intense laser pulses consisting of photons of $h\nu = 1.17$ eV, those electrons having $n\, h\nu \geq eV_{ret}$, i.e. electrons which have absorbed n photons, did penetrate the mesh. The partial electron current j_n originating from the absorption of photons flowing through the mesh depended on the laser intensity I in the form $j_n \sim I^n$. Figure 2 shows the dependence of the experimentally measured n values on the mesh potential V_{ret}.

In the course of former years we showed that the X-ray yield of the laser plasma provoked by picosecond laser pulse was enhanced in a strong external electrostatic field. It was questionable, however, to what extent this external static field influences the very dense laser plasmas. We have already demonstrated that a 10^4 V/cm static field increases by several orders of magnitude the X-ray yield of a laser plasma created by 10^{12} W/cm^2 laser intensity. We repeated the experiment in the Lebedev Physical Institute, Moscow, USSR, using a laser of 10^{15} W/cm^2. The results showed that by applying 2.5×10^4 V/cm field, the increase of the X-ray yield was 100 % up to 10^{14} W/cm^2. With 10^{15} W/cm^2 no essential further increase was observed at the mentioned external static field. The study of the general behaviour of this phenomenon will be performed in Soviet cooperation in 1978.

PUBLICATIONS

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4. S.I. ANISIMOV***, V.A. BENDERSKII***, Gy. FARKAS: Nelineinyi fotoelektricheskii effekt v metallakh pod deistviem lazernogo izlucheniya. Usp. Fiz. Nauk 122, 185 (1977)

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INVESTIGATIONS ON HIGH VOLTAGE HOLLOW CATHODE LASERS

J. Bergou, L. Csillag, M. Jánossy, K. Rózsa

Recently a discharge, the so-called hollow anode-cathode (HAC) discharge was developed in order to choose voltage, tube diameter, discharge current and gas pressure independently of each other. The principle

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*** Landau Institute for Theoretical Physics, Chernogolovka, USSR
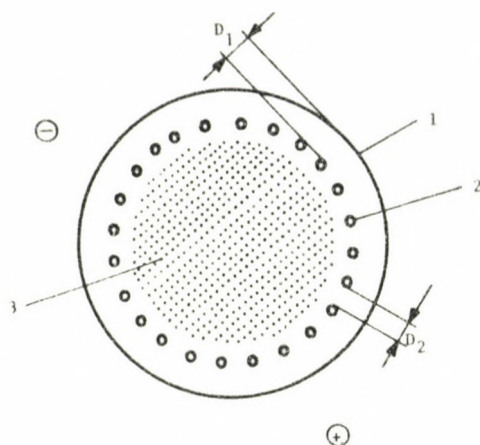
Fig. 3

Scheme of the hollow anode-cathode
discharge. 1 - cathode, 2 - anodes,
3 - bright part of the discharge

He-Kr 4694 Å

HAC

LASER POWER (mW)

	P_{Kr}	P_{He}
	mTorr	Torr
HAC	75	11
HCD	80	10

0.5
0.4
0.3
0.2
0.1

HCD

0   2   4   6   8   Amp.

INSTANTANEOUS DISCHARGE CURRENT
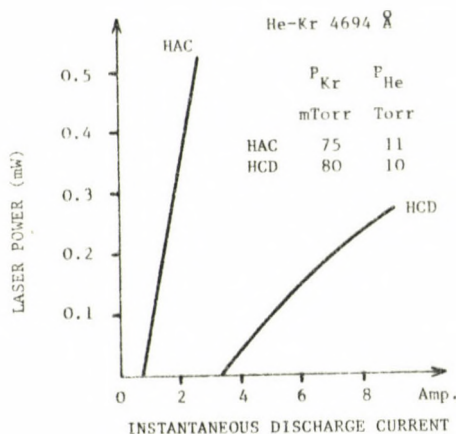
Fig. 4

Dependence of He-Kr ion laser output
power on instantaneous discharge cur-
rent in HAC and in hollow cathode
lasers

of this discharge scheme is shown in Fig. 3. The anode system (2) is placed symmetrically inside a cylindrical cathode (1). The bright part of the discharge is formed in the middle of the tube (3). The tube voltage at given pressure, current, and diameter is determined by the distances D_1 and D_2. The increase in the tube voltage in this way results in more high energy electrons in the discharge, this being expected to improve the parameters of lasers. Investigations were performed on various hollow anode-cathode lasers, where, due to the high voltage, low threshold currents and increased output power were observed. Figure 4 shows the dependence of laser output power on discharge current for the 4694 Å He-Kr ion laser in the case of conventional hollow cathode and HAC discharges. It can be seen from the figure that in the HAC laser, the current threshold for oscillation is much lower, and higher output power is obtained at such a discharge current where the HCD laser does not even operate. The tube voltage of the HAC laser was 880V, that of the HCD laser 350 V.

Similar results were obtained in the case of the recently discovered cw 4765 Å He-Ar transition. In this HAC laser cw laser oscillation was observed for the first time at the 5314 Å and 4863 Å transitions of the Xe ion in a He-Ne-Xe gas mixture. Endeavours to obtain cw laser operation were unsuccessful for many years.

It was demonstrated that a HAC laser can oscillate simply by sputtering the cathode material and using this as the active medium for

the laser. This was done using an Al cathode and low threshold laser opera-
tion was observed on three near infrared Al ion transitons; the tube volt-
age in these experiments being in the region of 2000 V.

Operation of the infrared Cu ion laser was also improved in an
HAC laser; 30 mW output power was obtained from a 19 cm long discharge
tube. The discharge parameters were 2.5 A, 1600 V.

Thus the experiments carried out on noble gas mixture and metal
vapour lasers have shown that the high voltage HAC discharge is indeed
efficient in improving laser output parameters.

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4. K. RÓZSA, M. JÁNOSSY, L. CSILLAG, J. BERGOU: cw Cu II laser in a hollow
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   and output parameters of a hollow cathode He-Kr laser. 3rd Int. Conf. on
   Lasers and their Applications, Dresden, GDR, 1977. Abstracts p. 59

AUTOMATIZED INSTRUMENTS FOR ANALYTICAL SPECTROSCOPY

F. Engard, I. Horváth, E. Láng, J. Szőke

The CERES-1 computer organized instrumental laboratory has been
developed for the agroanalytical work of the State Farm of Pécs.

Most of the instruments use the spectroscopic principle. They
are perfectly discrete and completely or semi automatized instruments.
They can be used on-line or off-line, or in parallel. Every mode is com-
puter-compatible. The general scheme of the instruments can be seen in
Fig. 5.

The samples are arranged in the magazines of the sample changers.
The control signals are generated by the electronic part of the sample
changer or an external source (e.g. small computer). All the instruments
are suitable for the direct driving of standard peripherals. The automatiz-
ed instruments give simultaneous analogue and digital output signals to
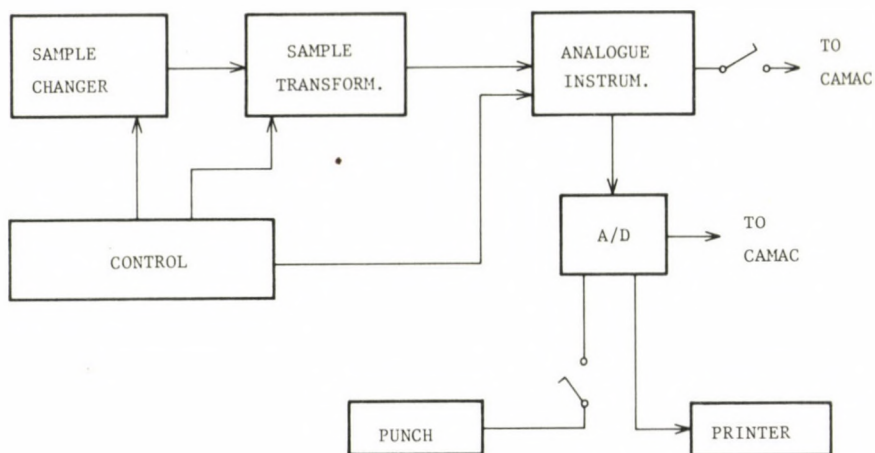
Fig. 5

General principles of the automatized instruments
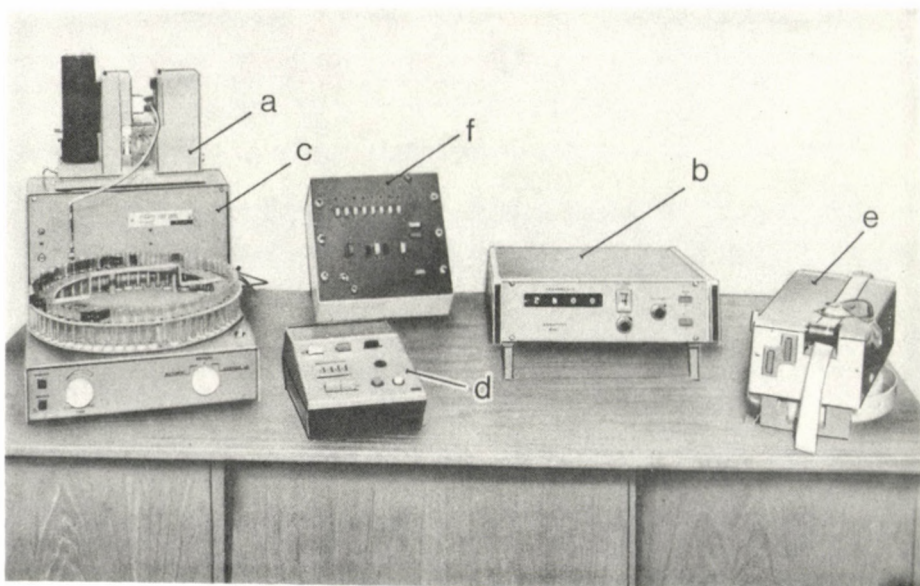
Fig. 6

AGROPHOT automatized analytical photometer
a) photometer optomechanical part; b) photometer electronic measuring in-
strument; c) automatic sample changer; d) remote control unit; e) paper
tape punch; f) driver of PTP

the computer (through the CAMAC interface system), and results are printed by a mosaic printer and, optionally, are synchronously punched by a paper tape punch.

The instruments detailed below have been developed.

AGROPHOT analytical photometer *(Fig. 6)*. Both the digital (absorbance) and the analogue (transmittance) outputs are computer-compatible. The AGROPHOT is used for the determination of humus (in concentrated sulphuric acid and potassium bichromate solution) in soils, and for other photometric tasks where the time of reaction and the incubation temperature are not important. Such tests are: nitrite, nitrate, chloride, sulphate, magnesium in soils; carotene, vitamins, total nitrogen in plants and fodders; total protein, albumin, glucose, cholesterol, copper, haemoglobin in blood. The AGROPHOT can perform 240 analyses per hour.

FLAME PHOTOMETERs are used in two versions. Both types were developed from the FLAPHO-4 (Zeiss-Jena). In the simple version, one of the two channels is used as a Li reference channel; the other channel is for the measurement of sodium, potassium and calcium in soils, fertilizers and fodders.
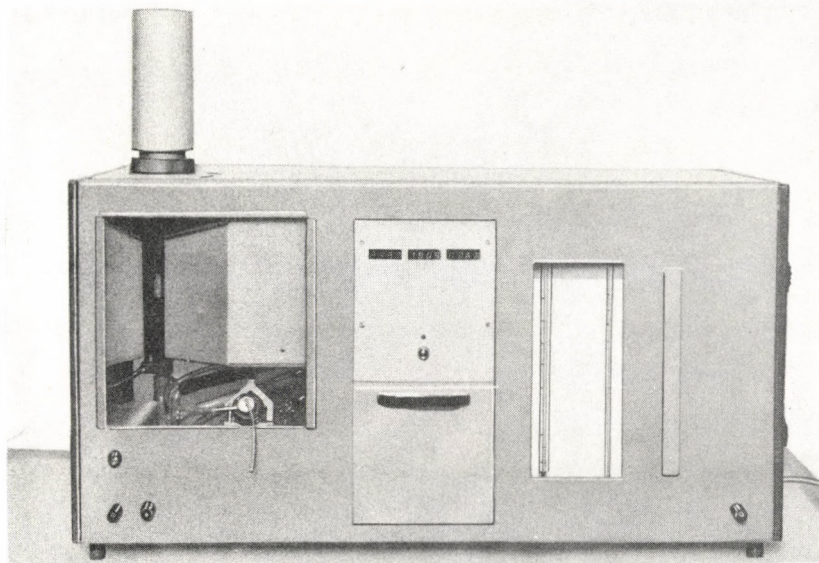
Fig. 7

FLADIPHOT-3, the 3÷1 channel flame photometer. Units c - e of Fig. 6 combine to complete an automatized system

The more advanced flame photometer is completely digital (FLADIPHOT-3). The original detectors, filters and the complete electronics have been changed. As we can see in *Fig. 7* the instrument has no pushbuttons. The main application field of this instrument is the simultaneous analysis of sodium, potassium and calcium in serum.

The respective performances for the two versions of the instruments are 120 and 360 analyses per hour.

ATOMIC ABSORPTION SPECTROPHOTOMETER. The Model AAS-1 (Zeiss-Jena) is used as a basic instrument with the analogue output signal being converted by a DIGITIZER and TAPE CONTROL also developed in our laboratory *(Fig. 8)*. The application field is the determination of biological trace elements such as copper, manganese, and magnesium in soils, fodders, plants, blood and hair. This spectrophotometer can perform 120 analyses per hour.
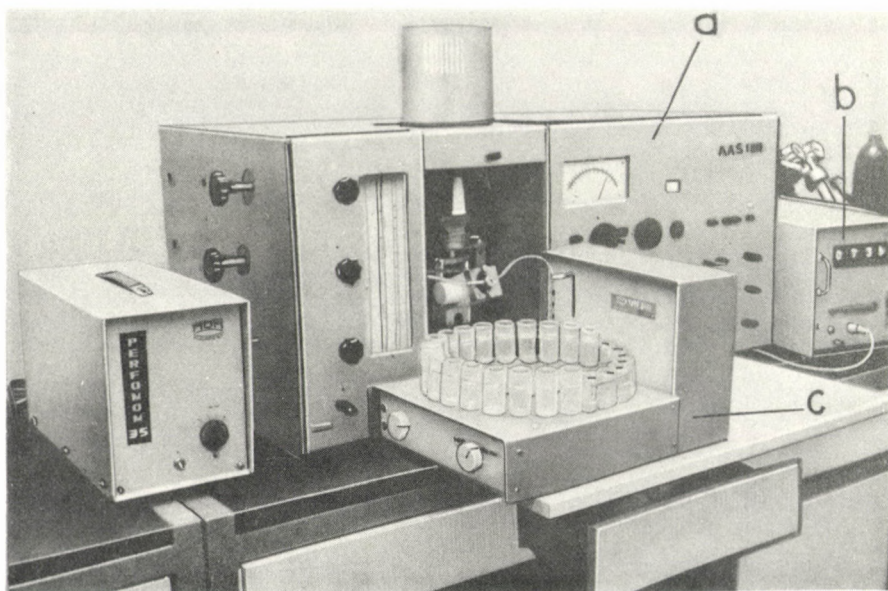
Fig. 8

Automatized atomic absorption spectrophotometer a) Zeiss (Jena) Model AAS-1;
b) DIGITIZER TAPE CONTROL; c) automatic sample changer

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MOMENTUM TRANSFER

Fig. 9

Neutron groups at different momentum transfer values in nematic PAA. + and ● measured at different collimation conditions. Q corresponds to the momentum transfer, the q̂ values are reduced to the first Brillouin zone

NEUTRON SPECTROSCOPY

N. Kroó, L. Mihály, L. Rosta, Erzsébet Sváb, I. Vizi

Investigation of the dynamic properties of liquid crystals has been continued by thermal neutron scattering. A fully deuterated p-azoxyanisole (PAA) sample was studied on the triple-axis spectrometer at the WWR-M reactor of the Institute.

Based on the results of structure investigations (see Yearbook '76') a reciprocal lattice space was introduced for the magnetic field oriented nematic phase corresponding to the periodicity observed parallel as well as perpendicular to the long axis of the molecules. The inelastic neutron scattering measurements were carried out by the method used for single crystals, and they resulted in relatively sharp resonances in a wide range of the momentum-energy space.

As a result of detailed measurements in the direction perpendicular to the nematic director we succeeded in demonstrating that the resonances measured at different values of the momentum transfer can be grouped into translatory invariant momentum transfer intervals, in agreement with the introduced reciprocal lattice space *(Fig. 9)*. This means that the observed resonances can be reduced into the first Brillouin zone and they are the origin of collective excitation, i.e. phonons. The neutron resonances reduced into the first Brillouin zone give the dispersion curves of the collective motions - as can be seen in *Fig. 10*.

Dispersion curves of collective excitations in nematic phase.
Vertical lines indicate the half-widths of the measured reso-
nances. < optical spectroscopy data

Taking into account these results on collective properties as
well as the structure data one can conclude that certain long range order
takes place in the nematic state. From this point of view a model of the
nematics can be suggested demonstrating the crystal-like behaviour of this
liquid crystal state. It means that the nematic phase consists of domains
of molecules with crystal-like ordering but these domains are disoriented
according to the fluid state, resulting in a smaller average order para-
meter for the bulk of the material.

As a next step of the liquid crystal programme a fully deuterated
p-azoxyphenetole sample was studied in the solid phase. The structure of

the solid single crystal specimen was registered, and inelastic scattering measurements were done to observe phonon branches at room temperature. Acoustic modes were determined parallel as well as perpendicular to the long axis of the molecules.

New results have been obtained by investigating the phonon dispersion curves of solid solutions of disordered Cu-Ge and Cu-Ga alloys by inelastic neutron scattering on the triple axis spectrometer. The analysis of experimental data shows that the dispersion curves of different alloys with the same valency electron concentration per atom, are the same. The empirical dependence of phonon frequencies on the concentration of impurity atoms was formulated, and the results have been interpreted in terms of the Born-von Kármán model as well as in terms of a phenomenological electron-shell model. The model calculations and experimental points are compared in *Fig. 11.*
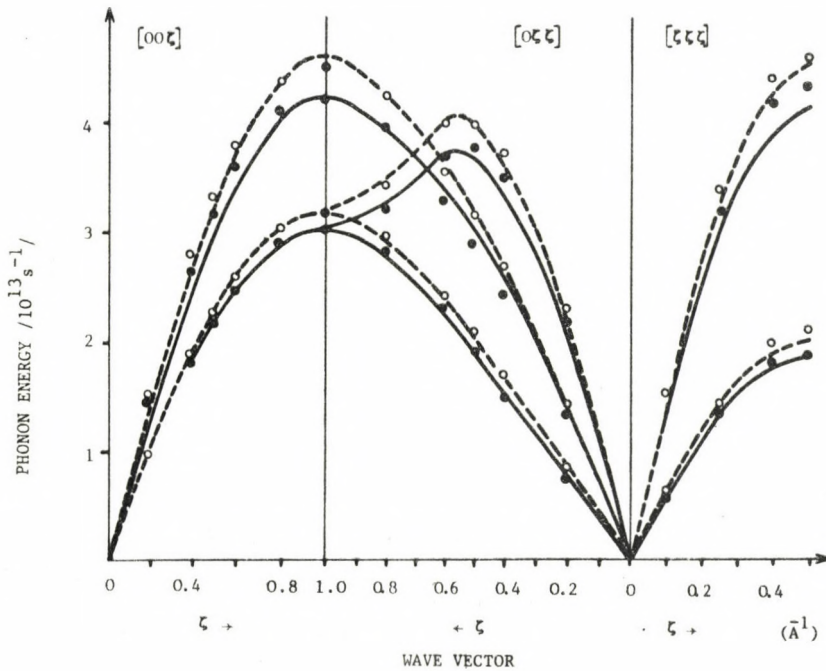
Fig. 11

Comparison of experimental data with calculated dispersion curves for copper and its alloys with Zn, Ga and Ge, at certain electron concentration
--- calculation by the electron shell model for Cu;
—— calculation by the electron shell model for the alloys;
- o Cu; ● average frequency values of alloys (experimental)

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4. V.L. BROUDE**, N. KROÓ, G. PÉPY***, L. ROSTA: Long-range-order effects in nematic p-azoxyanisole by neutron scattering. Third Conf. of the Condensed Matter Division of EPS, Leeds, England 1977. Europhysics Conference Abstracts, Vol. 2D, p. 9

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6. V.L. BROUDE**, N. KROÓ, L. ROSTA, I. VIZI: Structure investigations of different phases of p-azoxyanisole by neutron diffraction. ibid. p. 162

LASER LENGTH MEASUREMENT

P. Jani, Á. Kiss

The work of our group involves the development of a laser length measurement system for use on industrial machine tools.

In the first period of this work approximate calculations were made to define the ranges and accuracies, the tolerances of optical elements in an interferometric measurement of length, angle, straightness of travel and the deviation from a theoretical flat.

The optical block scheme of the length measurement device constructed, based on a Michelson-type interferometer, is shown in *Fig. 12*. It is possible to mount the interferometric units in the vicinity of the object to be measured thus augmenting the absolute accuracy of measurement and eliminating the disturbing vicinity of laser due to heat transfer. The mechanical construction provides easy and versatile mounting capabilities.

* Lebedev Physical Institute, Moscow, USSR
** Solid State Research Institute, Chernogolovka, USSR
*** Laboratoire Léon Brillouin, Saclay, France

CUBE CORNER 1

MEASURING HEAD

LIGHT SOURCE

DETECTOR

BEAM SPLITTER

CUBE CORNER 2
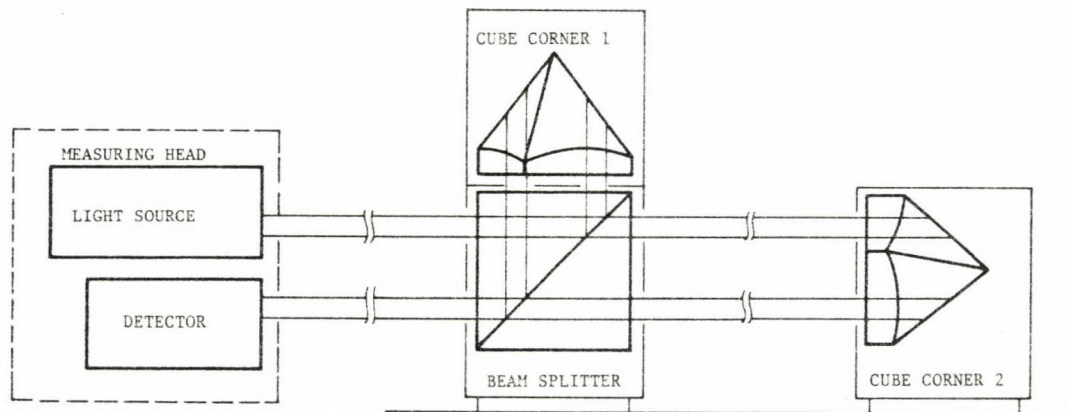
Fig. 12

Length measurement

The electronic unit coupled to the detector head determines the sense of motion, it counts and displays the number of interference fringes (one count every λ/8 of motion), and it sets an error flag in the case of excessive slew rate or loss of light power.

At present, due to the unstabilized multimode laser used, the range of measurement is R=0-20 cm. In this range the absolute accuracy is ± λ/8 ≈ 0.1 µm.

The device is suitable for gauging the precision mounting elements designed and constructed in our institute. An example is shown in *Fig. 13* where the deviation of the nominal from the true position of a mounting table is plotted against the nominal position.
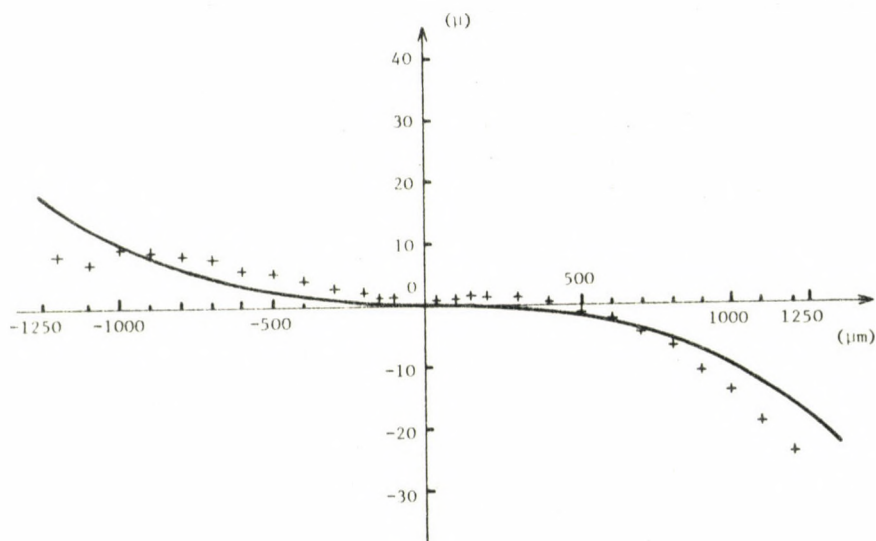
Fig. 13

Test of a mounting table (Solid line is the theoretically expected value of deviation)

LASER PROCESSING AND DEVELOPMENT OF cw Nd:YAG LASERS

I. Czigány, I. Kertész

Visiting research worker: *J. Jung*

The aim of our team is to establish, with the support of the State Committee for Technical Development (OMFB), a laser processing centre armed with lasers and positioning equipment. It is planned that this project be fulfilled by 1980 and in 1977 laser processing experiments were carried out at the request of many Hungarian firms and institutes. On the other hand the efficiency (and power) of our institute's Nd:YAG laser was increased and the intracavity frequency doubling of the infrared laser was realized by the thermal control of $0.1^{\circ}C$ accuracy of a Soviet $Ba_2NaNb_5O_{15}$ (banan) crystal. From the cutting, drilling, welding and scribing experiments on heat resisting materials, glasses, metals, ceramics, wood-fibre, plastics, semiconductors, etc., three applications only are stressed:

- development of economic ceramic substrate scribing and drilling technology and (small) serial ceramic substrate scribing of good quality for the Industrial Research Institute for Communication (HIKI),
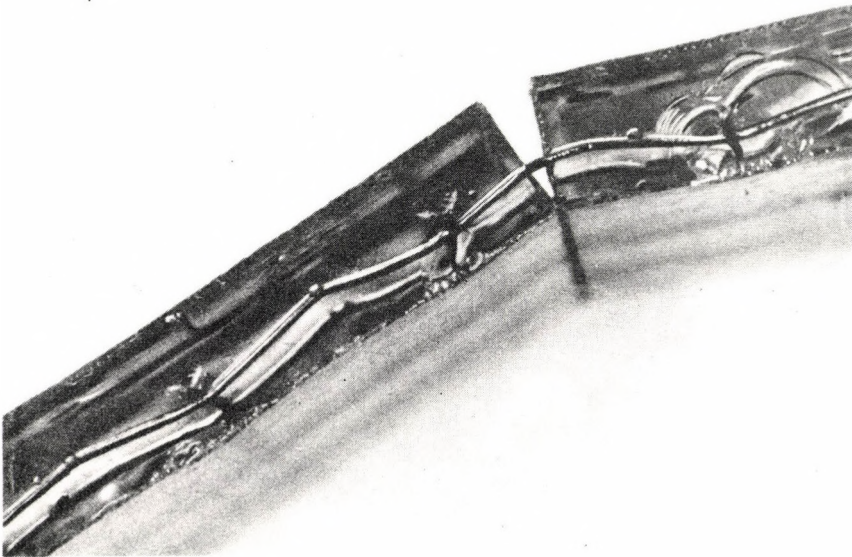
Fig. 14

Broken wire glass after CO_2 laser scribing

- experiments for splinter-free cutting of glass tubes and ampoules for the pharmaceutical industry,

- scribing (at a rate of some metres per minute) of aesthetic enamelled wire glasses for very resistant building coatings. The force needed for controlled breaking *(Fig. 14)* dropped - due to the laser scribing - from 35 kgf (diamand scribing) to 20 kgf.

We were commissioned by the REMIX radio-component firm to design and build a Nd:YAG laser head of 150 % higher efficiency (above 2 %) than that of the English original for use in the firm's high productivity trimming system.

LIGHT SCATTERING OF DIELECTRIC FILMS

K. Ferencz, A. Lutter

The elastic light scattering was measured of UV thin film components and mirrors consisting of $\lambda/4$-layers, to measure the intensity run out of the coherent direction. Figure 15 shows the experimental set-up. The scattering losses of the different systems consisting of CeF_3/MgF_2,
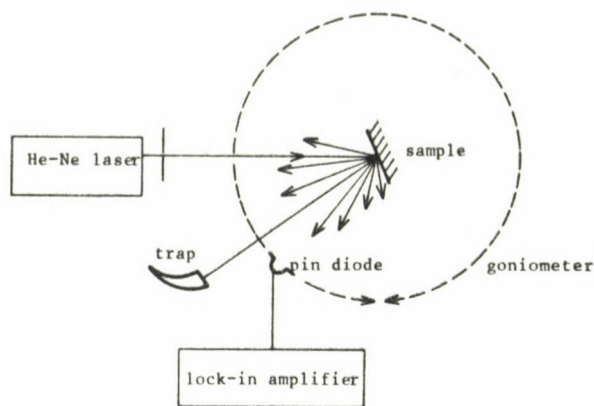
Fig. 15

Experimental arrangement of the light scattering measurements

PbF_2/Na_3AlF_6, components are sufficiently high for the absorption losses to be negligible in the near UV. Only the ZrO_2/SiO_2 systems show extremely low scattering losses. The scattering losses of the different systems consisting of 15 $\lambda/4$ layers show the following values:

film system	losses (in arbitrary units)
CeF_3/MgF_2	61.6
PbF_2/Na_3AlF_6	14.1
TiO_2/SiO_2	2.0
ZrO_2/SiO_2	1

FOREIGN RELATIONS

Lectures by visiting scientists

G.J. Collins   (Colorado State University, Fort Collins, Colorado, USA)
Metal vapour lasers

S.I. Anisimov   (Landau Institute for Theoretical Physics,
Chernogolovka, USSR)
Inertial confinement of high density plasma for
controlled nuclear fusion

Guest scientists and fellows

S.I. Anisimov	Landau Institute for Theoretical Physics, Chernogolovka, USSR	1 month
B.H. Dolganov	Solid State Research Institute, Chernogolovka, USSR	1 month
V.B. Belanin	Spectroscopic Institute, Moscow, USSR	1 month
Yu.M. Kagan	Kurchatov Institute, Moscow, USSR	1 month
A.P. Kazantsen	Landau Institute for Theoretical Physics, Chernogolovka, USSR	1 month

| S. Stenholm | Helsinki University of Technology, Helsinki, Finland | 1 month |

| A. Zisu | Institute of Physics, Bucharest, Romania | 1 month |

Staff members on study tours

| F. Mezei | Laue-Langevin Institute, Grenoble, France | 3 years |

| Z.Gy. Horváth | Lebedev Physical Institute, Moscow, USSR | 1 month |

| Gy. Farkas | Lebedev Physical Institute, Moscow, USSR | 1 month |

| K. Rózsa | Lebedev Physical Institute, Moscow, USSR | 4 months |

| Gy. Rubin | Joint Institute for Nuclear Research, Dubna, USSR | 3 years |

| Gy. Zsigmond | Joint Institute for Nuclear Research, Dubna, USSR | 1 1/2 years |

| L. Cser | Joint Institute for Nuclear Research, Dubna, USSR | 6 years |

THESES

| J. Jung | Investigation of the regimes and efficiency of Nd:YAG lasers. (For Ph. D. degree) |

| P. Molnár | Ceramic scribing with laser. (For Ph.D. degree) |

CHEMISTRY

RESULTS

ANALYSIS FOR SOLID STATE RESEARCH

L. Bakos, J. Bogáncs, Gabriella Csada-Némethy, Mária Csajka, A. Elek, P. Gróz,
L. Hodány, Erzsébet Kelen-Füzessy, F. Molnár, Á.Z. Nagy, Z. Pokó, Ibolya
Sziklai-László, Éva Szirmai-Kulus
Visiting research workers: Mária Lőrincz, H. Rausch, A. Salamon

The analysis of alloys for solid state research has been continu-
ed. The main components of Pb-In and Al-Mn alloys of different composi-
tions were determined by means of titration with ethylenediamine tetra-
acetic acid and by atomic absorption.

A further improvement of the oxygen determination in aluminium
by neutron generator activation analysis has been achieved using chemical
etching of the sample surface after irradiation. This technique, together
with some other relevant modifications (4π geometry for detection, in-
creased neutron yield, etc.), made it possible to lower the oxygen detec-
tion limit to below 2 ppm.

In cooperation with the Research and Planning Institute for the
Aluminium Industry anhydrous aluminium chloride samples of a few grams
have been investigated in order to determine the oxygen content. The
amount of oxygen was found to be proportional to the moisture content
of the sample, if the other oxygen-containing species can be ignored.

Using ammonium phosphorous molybdenates of varying composition,
the optimum conditions for determining phosphorus by neutron generator
activation analysis were studied. The results seem to be as accurate as
those obtained by wet chemical procedures. The technique elaborated was
applied in the analysis of Ni-P alloys.

In cooperation with the Joint Institute for Nuclear Research,
Dubna, USSR, the determinations of the dose, the range and the profile

of boron atoms in ion-implanted silicon, based on the measurement of the energy loss of α-particles from $^{10}B(n,\alpha)^{7}Li$ nuclear reaction, were continued. The results obtained for the 10-80 keV energy region at 6×10^{14} - 1.2×10^{16} atom cm^{-2} were compared with those of other experiments and utilized in implantation technology.

The α-spectra for a typical ion-implanted boron profile before and after heat treatment of the silicon sample are shown in *Fig. 1*. A program system DECONV-II has been developed for calculating the dose
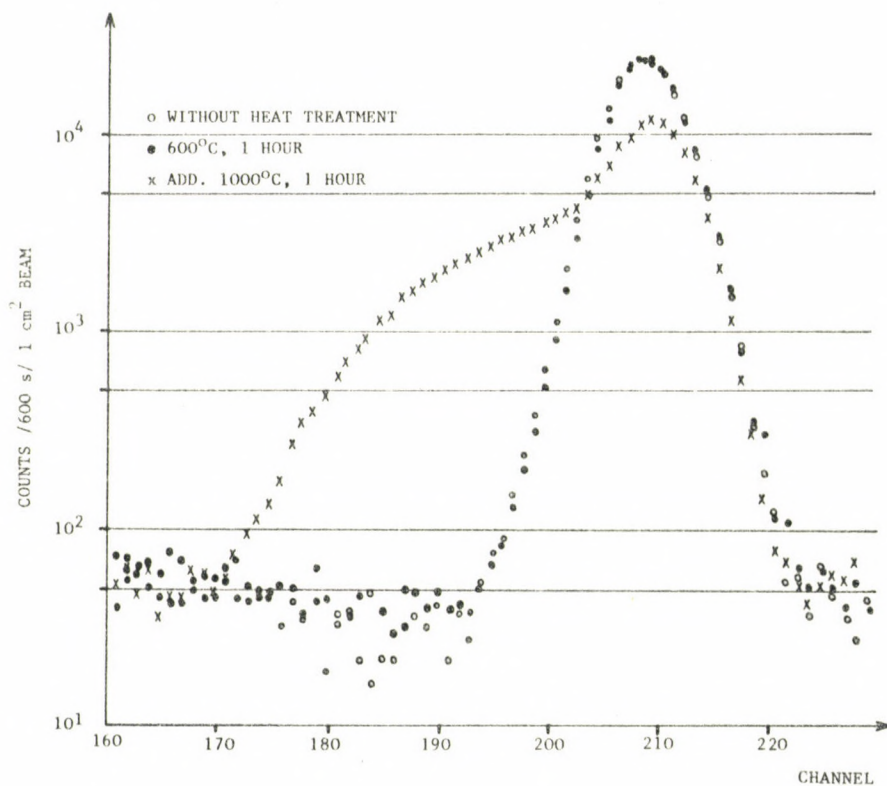
Fig. 1

α-spectrum from ^{10}B implanted into a silicon wafer at 40 keV, with a dose of 6.2×10^{15} atom cm^{-2}, before and after the heat treatment (FWHM = 1100 Å in the source layer before drive-in)

and range distribution of boron from a single measurement. The same analytical method was applied to a series of experiments on diffused boron layers and to glassy metals containing boron with a boron concentration higher than that usually to be found in implanted samples.

Reactor activation analysis was employed to determine trace impurities in high purity water samples used for electronic research. Beyond the previously studied Cu and Na, trace amounts of Au were determined. These analyses were also used as a means of checking the water purifiers.

The investigation of trace element abundances (Cu, Au, Mo, Na, W) in SiO_2 layers to a sensitivity of 10^{-4}-10^{-6} w% has been continued in cooperation with the Research Institute for Telecommunication. The analysis of the representative samples can be utilized in following the different stages of the oxide layer growth technology. The oxide layer was removed from the surface of the silicon slice by chemical etching and the subsequent measurement of the traces was performed by reactor activation analysis. These investigations were completed by establishing the Na distribution using autoradiography.

The layer removal technique combined with reactor activation analysis has also made it possible to determine the depth concentration distribution of P in ion-implanted silicon samples.

The mechanism of inclusion formation in the course of metallurgical processes was investigated by the inactive tracer technique. In cooperation with the Institute for Technical Physics a sensitive reactor activation method applying La_2O_3 and Eu_2O_3 as inactive tracers has been used, mainly for controlling the steel ingot casting process. The concentration of tracers added previously to the casting powder was found to be two orders of magnitude higher on the surface (i.e. 5 mm depth) than inside the ingot. It has been established that the wall of the ingot mould also contributes to the inclusion formation.

The determination of iodine in 40-50 µg samples of tetrathiotetracene iodide crystals has been performed for quasi one-dimensional organic conductor research, using the isotope dilution method.

Separation of phosphoric and phosphorous acids by means of ion exchange technique and micro measurements has been developed in order to give analytical information for electrolytic glassy metal technology.

In order to produce thin layer depositions the preparation and investigation of metal β-diketonate chelates - especially those of cobalt

derivatives – has been continued. According to the thermoanalytical and
infrared measurements the products obtained consist of the mixture of
volatile cobalt hexafluoro acetylacetonate $(Co(HFA)_2)$ and hexafluoro
acetylacetone dihydrate $(HFA \cdot 2H_2O)$, as is shown in *Fig. 2*. The com-
ponents were separated by fractional sublimation and their thermal
decomposition in the vapour phase has been studied. It was established
that in a nitrogen atmosphere both compounds decomposed in the same
temperature range; the layer contains metal and carbon too. The magnetic
properties of the thin layers formed from the pure $Co(HFA)_2$ are better
than of those produced from the mixtures.
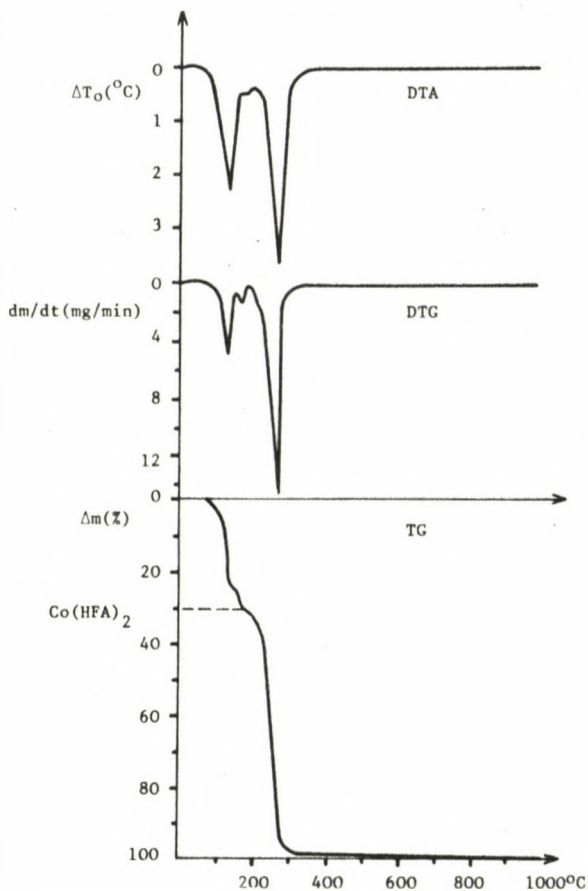
Fig. 2

Thermoanalytical curves of a Co chelate product

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   A. SZABÓ*, YU. YAZVITSKY*: Determination of boron range distribution
   in ion-implanted silicon by $^{10}B(n,\alpha)^7Li$ reaction. J. Radioanal. Chem.
   38, 19 (1977)

2. J. BOGÁNCS, J. GYULAI, Á.Z. NAGY, V. NAZAROV*, Z. SERES: Ispolzovanie
   reakcii $^{10}(n,\alpha)^7Li$ dlya opredeleniya raspredeleniya atomov bora v
   kremnii. Preprint JINR, P3-10777, Dubna (1977)

3. G. LIPTAY, (Ed.): Atlas of thermoanalytical curves V.
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   and Son Ltd., London, 1976

4. G. LIPTAY, (Ed.): Atlas of thermosnalytical curves; Cumulative index
   (Vol. I-V). Contributors: M. Fodor, Z. Pokó: Akadémiai Kiadó, Budapest,
   1977

AGRO- AND BIOANALYSIS

L. András, A. Csőke, A. Fehér, L. Mihály, Mária Ördögh, Éva Zemplén-Papp

The development of new methods of seed selection for plant
breeding purposes has been continued. An in-beam analytical method was
elaborated and an automatic measuring system was installed for de-
termining the protein content of single seeds.

In cooperation with the Laue - Langevin Institute, Grenoble,
France, the determination of the raw protein content of a single seed
in 60-150 s, with an experimental error of 5-7% (expressed in relative
protein content), has been achieved, based on the $^{14}N(n,\gamma)^{15}N$ nuclear
reaction.

Non-destructive neutron activation analysis was applied to
establish the amounts of Mn, Mg, Cl, Na, K and V in biological samples.
The method was modelled using Bowen's kale sample as a standard reference
material for a great number of elements, according to the international
comparative investigations for more than 10 years.

The samples were irradiated for 1 min in the WWR-SM reactor
using a pneumatic tube system built into a vertical channel with a neutron
flux of 2×10^{13} n cm^{-2} s^{-1}. The measurements were carried out 3 min after
the termination of the irradiation by means of a high resolution Ge/Li
detector coupled to an ICA-70 4096 channel analyser. The γ-spectrum of

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Joint Institute for Nuclear Research, Dubna, USSR
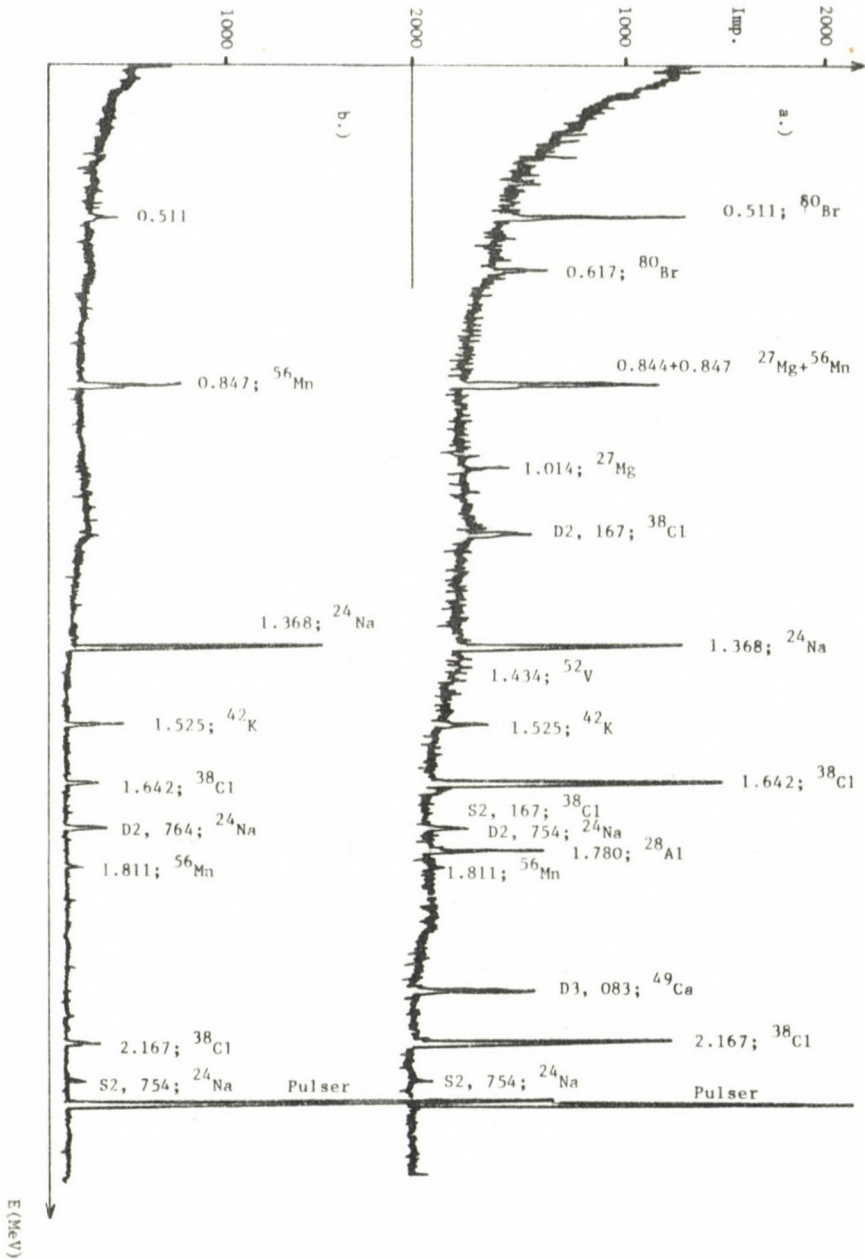
Fig. 3

γ-spectra of a kale sample irradiated for 1 min: a) 3 min after termination of irradiation, b) ∿2 hours after termination of irradiation

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an irradiated kale sample is shown in *Fig. 3*. As the main photopeaks of ^{27}Mg and ^{56}Mn cannot be separated, the γ-spectrum was again taken after the decay of ^{27}Mg isotopes (about 2 hours).

For the determination of Cu in biological samples chemical separation after irradiation had to be applied. The sample was completely broken down in a cc H_2SO_4-HNO_3 mixture and after dilution with water precipitated in the form of CuSCN. A separation factor of about 10^5 and high radiochemical purity was achieved.

From the results obtained, as shown in Table I in comparison

TABLE I

VALUES GIVEN IN ppm FOR ELEMENTS DETERMINED BY NEUTRON ACTIVA-
TION ANALYSIS IN BOWEN'S KALE AS COMPARED WITH BOWEN'S "GRAND
MEAN"

Element	Bowen's "grand mean"	Present work	Deviation from the "grand mean" %
Mn	14.58 ± 1.26	14.0 ± 0.96	-4.0
Mg	1514 ± 88	1333 ± 112	+12
Cl	3711 ± 368	3750 ± 101	+1.1
Na	2257 ± 258	2260 ± 112	+0.1
K	24248 ± 1390	24031 ± 2602	-0.9
	20976 ± 3701*(INAA)		
V	0.366 ± 0.03	0.45 ± 0.085	+23
Cu	4.679 ± 0.644	4.56 ± 0.21	-2.5

*Instrumental neutron activation analysis - value

with Bowen's "grand mean" contributed in 1975, it can be concluded that
for Mn, Cl, Na and Cu the accuracy and reproducibility of the method
are excellent. For K the accuracy of the determination is satisfactory
but the reproducibility is poor. In the case of Mg and V the method can
be used for fast survey analyses only.

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1. L. ANDRÁS, L. BAKOS, A. CSŐKE: In-beam activation analysis for de-
   termining the nitrogen content of agricultural protein carriers.
   KFKI Report 77-94 (1977)

DEVELOPMENT OF ANALYTICAL METHODS

Mária Csajka, A. Elek, Mária Ördögh, G. Pernecki, A. Simonits
Visiting research worker: *A. Salamon*

The elaboration of simple and fast radiochemical separation
techniques as well as of standardization methods for non-destructive
multi-element activation analysis have been continued.

The apparatus developed earlier for simultaneous separation
of elements or groups of elements and for the handling of several
samples *(Fig. 4)* was utilized recently for determining the alkali
earth and rare earth content of rocks. The optimum experimental condi-
tions were investigated. The accuracy of the method was checked by the
analysis of USGS BCR 1 basalt.

In cooperation with the Institute for Nuclear Sciences,
Rijksuniversiteit, Ghent, Belgium, $k_{o,Au}$ factor measurements – specific
activity ratios for gold – have been extended to further elements.
Accurate $k_{o,Au}$-values for 35 isotopes, i.e. 70 k_o-values for analytically
important gamma lines, have been established. In addition, new I_o/σ_o
ratios (thermal to epithermal cross-sections) were measured for 15 iso-
topes and also evaluated at the Rijksuniversiteit, Ghent, where large
discrepancies have been found in the literature.

In some cases, accurate k_o-values can be used for selecting
"best values" of literature gamma intensities and neutron cross sections
– as was demonstrated for ^{56}Mn, ^{65}Zn, ^{95}Zr and ^{97}Zr(^{97m}Nb) isotopes. The
set of k_o factors established will provide a basis for a computerized
nuclear data library thereby facilitating easy access and use for reactor
neutron activation analysis.
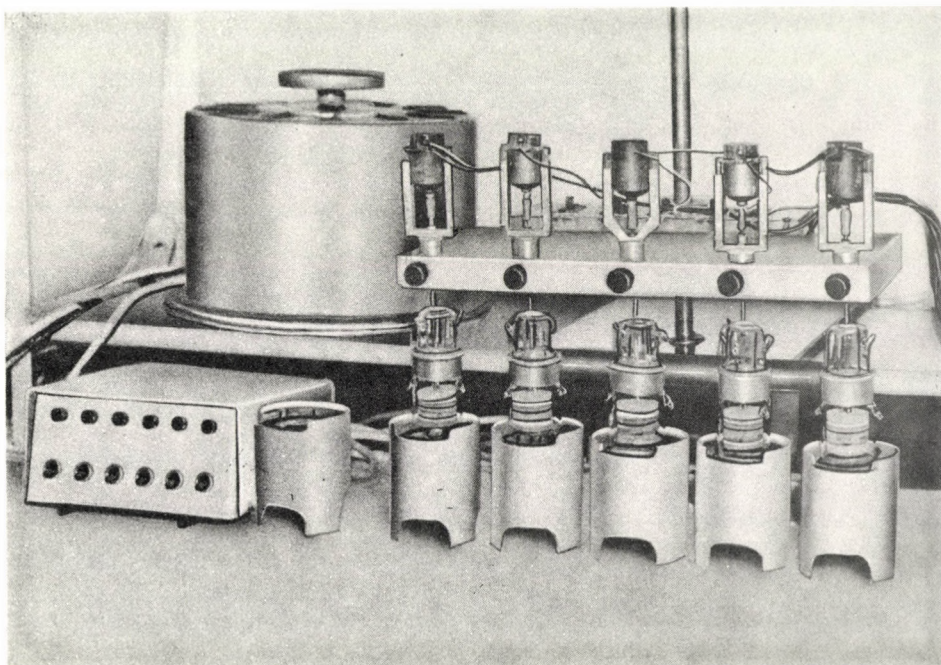
Fig. 4

Apparatus for simultaneous radiochemical separations.
(The construction shown is for handling 5 samples)

The applicability of the matrix comparator method was investigated and substantiated by the determination of La and Eu in a great number of steel samples. In this case, instead of using a standard or a separate comparator, the matrix itself serves as the comparator, and the concentration of contaminations is obtained from the ratio of matrix/contamination activities. The main advantages of the comparator present in the sample are:

a/ the probability of non-systematic errors is decreased due to the identical irradiation and measuring geometry as well as dead-time and pile-up losses;

b/ lower costs because of smaller number of irradiations and measurements required;

c/ simpler sample administration.

PUBLICATION

1. G. PERNECKI: Program for automatic evaluation of single full energy peaks in gamma-spectra. KFKI Report 77-113 (1977)

MASS SPECTROSCOPY

J. Frecska, L. Matus, I. Nyári, I. Opauszky
Visiting research worker: *E. Keszei*

   The determination of trace impurities in different matrices by
means of the AEI-702/R spark source mass spectrometer has been contin-
ued. More than 300 analyses have been carried out. Most of them were used for
industrial purposes, such as development in refining processes of high
quality Al, Ga and Cu. The other part of the measurements was related
to solid state research investigations, e.g. the determination of the
chemical composition of thin films and of some Fe and Cu dilute alloys.

   Both photographic and electric ion detection techniques were
used in the spark source mass spectrometry (SSMS). For the analyses of
unknown samples the photographic method, using Ilford Q-2 plates, was
preferred due to its high mass resolution. The quantitative evaluation
of different isotopic lines by the microdensitometric method is, however,
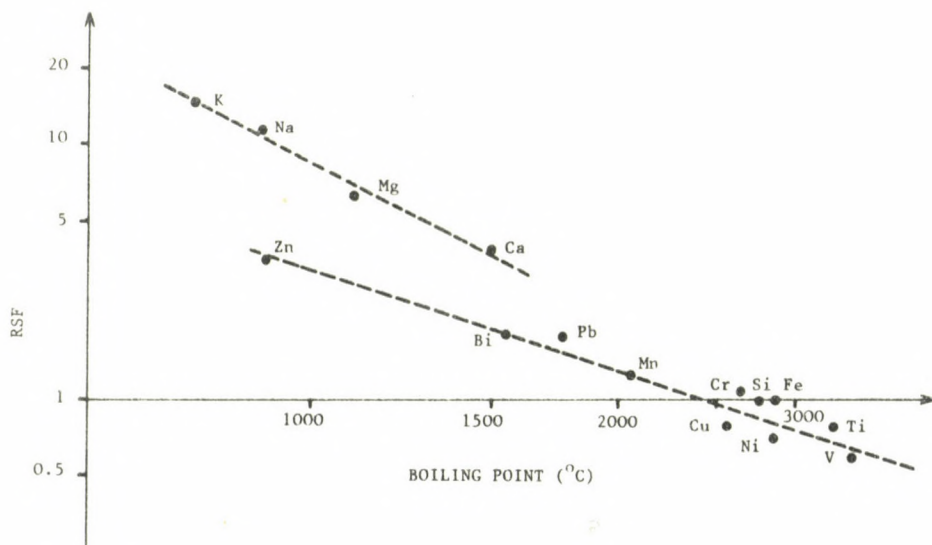
Fig. 5

*Relative sensitivity factors (RSF) in aluminium (ALCAN) $RSF_{Fe}=1$;
relative standard deviation of the values is about $\pm 20\%$*

very time consuming. Therefore, a microdensitometric measuring system
is being developed for the automatic quantitative evaluation of the
blackenings.

The semi-quantitative character of most of the SSMS data is
caused mainly by the lack of relative sensitivity factors (RSF). A
linear relationship between the boiling points of impurities and their
logarithmic RSF values has been found experimentally in Al standards,
as is shown in *Fig. 5*. This empirical relationship permits us to ascertain
the values of RSF for any impurities in Al samples with an acceptable
accuracy ($\sim \pm 30$ %).

The thermodynamic behaviour of semi-metals has been studied by
high temperature mass spectrometry using a Knudsen cell. Investigations
carried out with As-Se alloys showed 8 different species in the vapour
phase, with compositions Se_5 and $As_n Se_m$, where n=1-5 and m=1-3. The
evaporation ratio for As/Se is 1.1/1.0 in the case of AsSe. Due to the
further modifications to the equipment the background was reduced con-
siderably and thus the sensitivity was raised by an order of magnitude.

PUBLICATION

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   XXth Coll. Spectr. Intern., Prague, 1977. Abstracts No. 276

ISOTOPE EFFECTS
Borbála Gellai, Hédy Illy-Vajda, Gy. Jákli, G. Jancsó

Theoretical analysis of the experimentally observed vapour pres-
sure isotope effects (VPIE) in the series of deuterobenzenes, solutions
of isotopic isomers of benzene and cyclohexane and mixtures of benzene
and cyclohexane has been carried out in cooperation with A. Van Hook and
his co-workers at the Chemistry Department, University of Tennessee,
Knoxville, Tenn., USA. The calculations were performed within the frame-
work of the statistical theory of isotope effects in condensed systems
using a cell model in the quasi-harmonic approximation. The results show
that the largest contribution to the VPIEs arises from the shift in the
CH stretching force constant on condensation. The adequate description of
the temperature dependence of the VPIE forced us to introduce temperature

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dependent CH stretching force constants. It can be seen in *Fig. 6* that the temperature dependence is nearly linear between 5.5 and 80 $^{\circ}$C but falls off markedly at higher temperatures probably indicating a failure of the quasi-harmonic approximation. The validity of this approach is supported by the data available in the literature on the volume dependence of internal force constants of benzene. In order to obtain agreement between calculated and experimental VPIEs of all intermediate isotopic isomers (C_6H_5D, o-$C_6H_4D_2$, m-$C_6H_4D_2$, p-$C_6H_4D_2$) it was necessary to introduce force constants which couple the CH out-of-plane bending modes and the translational motion with the rotational motion of the benzene molecule.

'Fig. 6

Temperature dependence of the CH stretching force constant (mdyn/Å) in liquid benzene ($\Delta f_{CH} = f_{CH}/5.5^{\circ}C) - -f_{CH}/t\ ^{\circ}C/$)

The deviation of the equimolar isotopic solution of protio- and deuterobenzene from the ideal behaviour could be interpreted in a fashion consistent with that employed for the VPIEs of the pure substances. It was demonstrated that consideration of the contribution of internal degrees of freedom is essential and the dependence of the internal part of the partition function on the overall system volume must be given due consideration. On the other hand for solutions of H_2 in D_2 the effect is dominated by the compressibility which is principally determined by the intermolecular potential.

The data on benzene - deuterobenzene VPIE were also used to estimate the change to be expected in anharmonic constants on condensation from vapour to liquid. The detailed analyis showed that the changes in these constants should be of the same order of magnitude or smaller than the relative changes in harmonic force constants. This conclusion is consistent but considerably more precise than the conclusions drawn from what little spectroscopic information is available on this subject.

Experimental data on $^{13}C/^{12}C$ and $^{34}S/^{32}S$ VPIE of CS_2 have been analysed in the context of the theory of condensed phase isotope effects and the available spectroscopic information. The agreement between the calculated and experimental results is satisfactory *(Fig. 7)*. The analysis indicates that the principal contribution to the ^{13}C isotope effect is
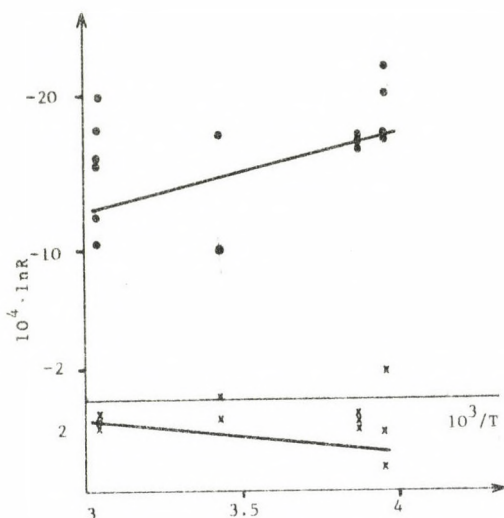
Fig. 7

VPIE of CS_2. Upper line
$R = (P_{12_C32_{S_2}} / P_{13_C32_{S_2}})$, calculated.

Lower line $R = (P_{12_C32_{S_2}} / P_{34_S12_C32_S})$,
calculated. The data points are
from Can. J. Chem. 54, 3007 (1976)

due to the shift in condensation of the very intense asymmetric stretching absorption and quantitatively corroborates the theoretical conclusion reached earlier by spectroscopists of the magnitude of the "dielectric correction" for this band. This correction is associated with the difference in the effective field of the light wave acting on the molecule in a condensed medium and the average field in that medium. In favourable cases like this the observed VPIEs can be employed to give an independent evaluation of the contributions of the intrinsic effect due to the action of the intermolecular forces and the dielectric correction to the observed shift of IR absorption bands on condensation.

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4. P. BOPP**, K. HEINZINGER**, G. JANCSÓ: A molecular dynamics study of aqueous solutions VI. Remarks on the hydration numbers of alkali and halide ions. Z. Naturforsch. A 32, 620 (1977)

5. G. JANCSÓ, W.A. Van HOOK***: The effect of intermolecular interaction on the asymmetric stretching vibrations of CS_2. Chem. Phys. Lett. 48, 481 (1977)

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HOT ATOM CHEMISTRY
Klára Berei, L. Matus, Ágnes G. Nagy-Csató, L. Vasáros

Phase effects on the replacement reactions of energetic halogens have been investigated by nuclear methods along with mass spectroscopic studies of ion-molecule reactions. Some new information about the structure of bridged ferrocene derivatives has been obtained by Mössbauer spectroscopy.

Halogen and hydrogen replacement of (n,γ)-produced ^{38}Cl in liquid and solid 1,1-dichloroethane(1,1-DCE) and in its mixtures with ethyl alcohol and hexafluorobenzene have been studied. In crystalline systems chlorine replacement was found to occur partly *via* isomerization resulting in the formation of ^{38}Cl labelled 1,2-DCE. This fact can be considered as evidence for thermal radical recombination contributing to the hot replacement processes. In the liquid and in the glassy phase, however, no radioactive isomerization products could be detected. The results have shown that the absence of isomerization in the liquid phase cannot be explained either by the competing hydrogen abstraction of thermalized ^{38}Cl atoms, or by the escape of these atoms from the liquid cage. The structure of crystalline 1,1-DCE is assumed to play an important role favouring a fast 1-2 H-shift against the radical recombination, thereby resulting in isomerization. The excitation decomposition of the primarily formed replacement products as a function of the phase and composition of the irradiated systems has also been investigated.

In cooperation with the Joint Institute for Nuclear Research, Dubna, USSR, the investigations concerning the replacement reactions of (EC)-produced ^{211}At were extended to the solid and gaseous benzene and halobenzenes. Comparison of the results obtained for different phases enabled conclusions to be drawn concerning the importance of radical recombination and the mechanism of hot reactions. A linear dependence of the halogen replacement yields on the bond strength of the halogen to be replaced has been obtained both for liquid and gas phase halobenzenes, as is shown in *Fig. 8*. The isomer distribution of hydrogen replacement products has been found to be nearly statistical in all the halobenzene systems and also in liquid and solid aniline (used for comparison). From these results the conclusion has been drawn that the halogen and hydrogen replacement reactions of (EC)-produced ^{211}At are hot homolytic processes in the systems studied.

The study of the ion-molecule reactions in chlorobenzene, with special emphasis on the charge transfer processes, and determination of their rate constants, has been continued.
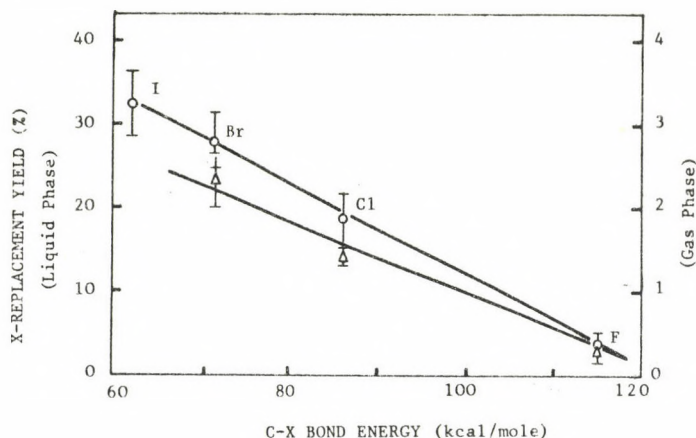
Fig. 8

Bond strength dependence of the ^{211}*At*
for halogen replacement yields in
gaseous (Δ) and liquid (O)
C_6H_5X *(X=F, Cl, Br, I) systems*

In the course of investigating the radiation damage of ferrocene
derivatives a correlation was observed between the Mössbauer parameters
of the trimethylene bridged ferrocenes as a function of the number and
the position of the bridges. The quadrupole splittings (QS) of these
compounds are given in *Fig. 9* (solid lines). For the interpretation of
this correlation, structural changes caused by the short trimethylene
bridges were presumed, namely the change in the tilt, the planarities
of the cyclopentadienyl rings and the distance of iron to the ring carbons.
These assumptions were confirmed by Mössbauer spectroscopical investiga-
tion of the tetramethylene bridged ferrocene derivatives (QMF, 13QMF) in
which the preferred inter-ring separation of ferrocene could be spanned
by the chain of four carbon atoms without any deformation. The QS values
of QMF and 13BQMF (dashed line) were found to be much larger than the ap-
propriate values of TMF and 13BTMF and nearly the same as the QS value
of ferrocene.
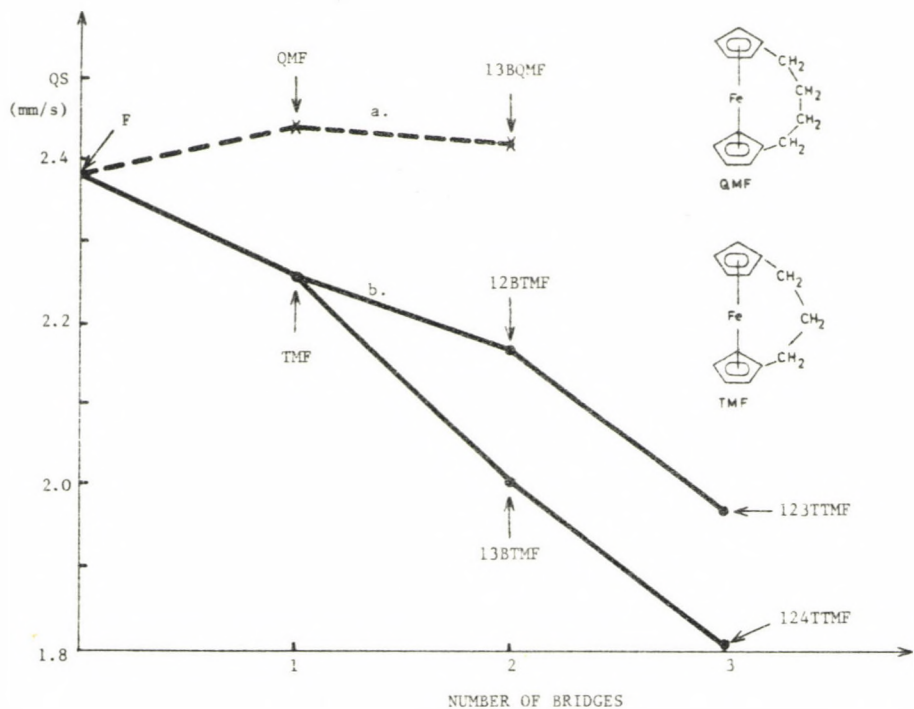
Fig. 9

*Values of quadrupole splittings (QS) in the Mössbauer spectra of poly-bridged tri-
and tetramethylene-ferrocenes as a function of the number and the position of the
bridges.*

*F: ferrocene; TMF: 1,1'-trimethyleneferrocene; 12BTMF: 1,1'2,2'-bistrimethylene-
ferrocene; 13BTMF: 1,1'3,3'-bistrimethyleneferrocene;
123TTMF: 1,1'2,2' 3,3'-tristrimethyleneferrocene; 124TTMF:
1,1'2,2' 4,4'-tristrimethyleneferrocene; QMF: 1,1'-tetramethyleneferrocene;
13BQMF: 1,1' 3,3'-bistetramethyleneferrocene*

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3. E. VIETZKE[**], J. HEUSCHKEL[**], L. MATUS, G. STÖCKLIN[**]: Crossed beam
   kinetics: Abstraction and substitution in the reactions of Br with CH_3I.
   ibid. p. 23

4. J. HEUSCHKEL[**], L. MATUS, G. STÖCKLIN[**], E. VIETZKE[**]: Crossed beam
   kinetics: Angular product distribution of the reaction of Br with CH_3I.
   VIth Int. Symp. on Molecular Beams, Noordwijkerhout, The Netherlands,
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   ferrocene derivatives. KFKI Report 77-105 (1977)

6. G.Á. NAGY, I. DÉZSI, M. HILLMAN[***]: Electronic structure of trimethylene
   bridged ferrocene derivatives J. Phys. (Paris) C6-471 (1976)

7. I. DÉZSI, G.Á. NAGY, D.L. NAGY: After-effects observed in ^{57}Co-HEDTA
   complexes. J. Phys. (Paris) C6-909 (1976)

RADIATION AND ELECTRON CHEMISTRY
Gy. Hutiray, L. Nyikos, Magdolna Roder, R. Schiller, Sz. Vass, Erika Zádor
Visiting scientist: *Yu.A. Berlin[****]*

The two main fields investigated previously, i.e. the behaviour
of excess electrons in liquids and the radiation chemistry of liquid
crystalline materials, obtained a somewhat wider scope this year by
introducing photoelectrochemical methods and dealing with certain theo-
retical problems of reaction kinetics.

Excess electron mobilities were studied theoretically in terms
of a previously developed two-state model. Motion in the localized state
was described as that of a microscopic bubble finding both mobility and
its energy of activation in reasonable agreement with our earlier ex-
perimental data. The transport of the quasi-free electrons was regarded
as the propagation of a plane-wave scattered by density fluctuations of

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the liquid. By introducing the mean free path calculated by this model
into the mobility equation of Cohen and Lekner, an adequate description
of our experimental data was found (Table II).

EXPERIMENTAL AND THEORETICAL MOBILITIES OF THE QUASI-FREE
ELECTRONS IN DIFFERENT LIQUIDS

Substance	μ_F(exp) $cm^2 \ V^{-1} \ s^{-1}$	μ_F(calc) $cm^2 \ V^{-1} \ s^{-1}$
n-hexane	27	34
n-pentane	43	41
c-hexane	42	52
2,2-dimethyl-butane	440	>157
2,2,4,4,-tetra- methylpentane	630	>200
isooctane	145	104
neopentane	440	>435

Photo-induced hole injection on the interface polycrystalline
CdS and aqueous solutions was investigated by standard electrochemical
methods. The effect of organic thin layers and the regeneration of the
solid surfaces with a view to stability and efficiency were studied.

Two further liquid crystalline substances, para-n-hexadecyl-
oxycinnamic acid (smectic) and para-phenylene-di-para-n-heptyloxybenzoate
(smectic and nematic) were analysed regarding their radiation chemical
behaviour (Fig. 10). A phase effect on radiation stability similar to
that observed earlier was found. The C-C bond scission turned out to
be the predominant process in polymer formation in the case of the
cinnamic acid derivative.

The chemical reaction of the type A+B $\rightleftharpoons$ AB was treated in terms
of an encounter model. The time dependence of the expectation value and
the dispersion of the number of molecules formed along with the informa-
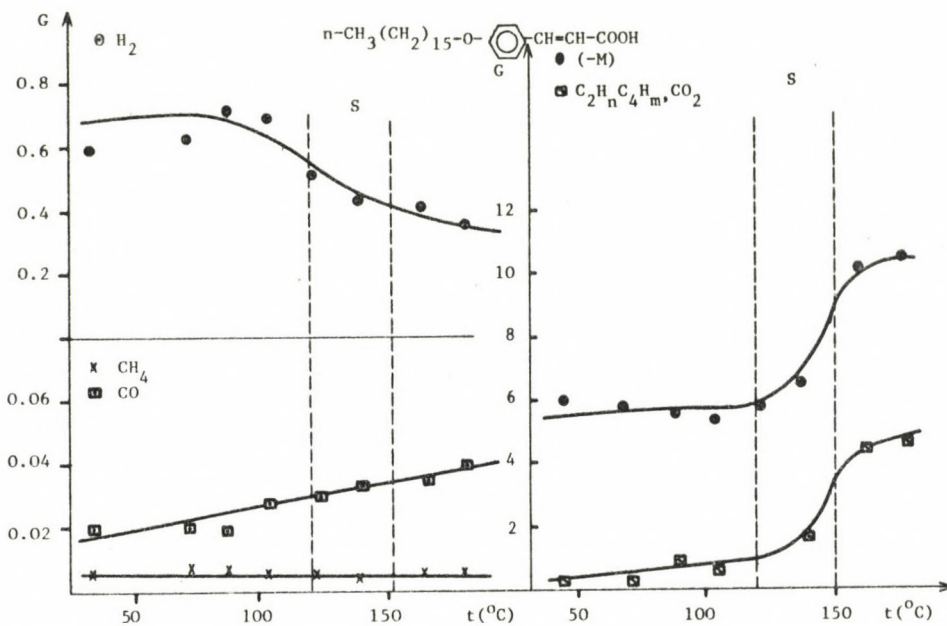
Fig. 10

Radiation chemical yields of para-n-hexadecyloxycinnamic
acid as a function of temperature. S=smectic phase

tion theoretical entropy defined by the possible number of products were
calculated. The results indicate both dispersion and entropy to exhibit
an extremum in the transient region of the reaction.

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   mobility in liquid hydrocarbons. ibid. p. 179

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   liquid crystals. ibid. p. 1027

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4. I. KISS, SZ. VASS: Random walk model of isotope enrichment in cascades. J. Chem. Phys. __66__, 3750 (1977)

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12. SZ. VASS: Transformation of tridiagonal coefficient matrices of first order linear systems with uniform time-dependence in the subdiagonals into matrices having constant eigenvalues. KFKI Report 77-100 (1977)

FOREIGN RELATIONS

Lectures by visiting scientists

Yu.A. Berlin (Institute of Chemical Physics, Academy of Sciences of the USSR, Moscow, USSR)
Some problems of electron-transfer reactions

H.J. Dietze (Zentralinstitut für Isotopen- und Strahlungsforschung, Leipzig, GDR)
Anwendungen von Lasern in Massenspektroskopie

M. Grätzel (University of Lausanne, Lausanne, Switzerland)
Light energy conversion processes *via* light-driven redox reactions in homogeneous and micellar systems

F. De Corte (Institute for Nuclear Sciences, Rijksuniversiteit, Ghent, Belgium)
Recent activation analytical programs at the Institute for Nuclear Sciences, Ghent, Belgium

L. Moens   (Institute for Nuclear Sciences, Rijksuniversiteit, Ghent, Belgium)
The k_o-method in reactor neutron activation analysis: A new standardization technique and a tool for the evaluation of activation and decay parameters

W.A. Van Hook   (University of Tennessee, Knoxville, Tennessee, USA)
Vapor pressure isotope effects in benzene-cyclohexane systems

M. Mishikawa   (University of Tokyo, Tokyo, Japan)
Electron transport in liquid hydrocarbons

Staff members on study tours

J. Bogáncs	Joint Institute for Nuclear Research, Dubna, USSR	6 years
A. Fehér	Laue - Langevin Institute, Grenoble, France	5 months
G. Jancsó	University of Tennessee, Knoxville, Tennessee, USA	1 year
L. Mihály	Laue - Langevin Institute, Grenoble, France	5 months
L. Nyikos	Interuniversitair Reactor Instituut, Delft, The Netherlands	1 year
E. Szabó	International Atomic Energy Agency Vienna, Austria	6 years
L. Vasáros	Joint Institute for Nuclear Research, Dubna, USSR	4 years

Guest scientists and fellows

Yu.A. Berlin	Institute of Chemical Physics, Academy of Sciences of the USSR, Moscow, USSR	2 1/2 months

INSTITUTE FOR
ATOMIC ENERGY
RESEARCH

NUCLEAR ENERGY RESEARCH

RESULTS

REACTOR PHYSICS

F. Adorján, L. Bod, T. Czibók, J. Gadó, Z. Gyimesi, A. Kereszturi, A. Kondor, Gy. Kosály, K. Krinizs, I. Lux, L. Meskó, I. Pázsit, G. Pór, F. Szabó, Z. Szatmáry, L. Turi, J. Valkó, P. Vértes, O. Vidovszky, J. Zsoldos

The experiments on the critical assembly ZR-6, within the framework of the Temporary International Research Collective, were completed this year. These experiments related to room temperature and atmospheric pressure. Throughout the year, the study of perturbed systems continued with the main emphasis being placed on the investigation of the effect of europium control rods. The europium absorbers are potentially important control rods of the WWER-1000 type reactors. The parameters studied cover critical mass and macroflux distributions, and in some configurations, spectral indices and epithermal parameters too.

In the field of nuclear reactor calculations, efforts were devoted mainly to the fuel burn-up studies, the lattice heterogeneity calculations and the investigations concerning nuclear data libraries.

For testing the previously elaborated BETTY pin cell burn-up code, the experimental data obtained at the YANKEE power reactor were used. The comparison of calculated and experimental results *(Fig. 1)* illustrates the applicability of the BETTY code for burn-up calculations. Lattice cell parameters – as used in the Soviet BIPR code for WWER-type power reactors – were reproduced by the BETTY code and found to be in good agreement with the Soviet data.

ZR-6 lattices perturbed with absorber rods and cassette wall imitators were investigated by calculations and the results were compared with measured data. The most noteworthy results of these investigations were a significant improvement in the interpretation of microflux and cell parameter measurements and the elaboration of a theoretically correct de-
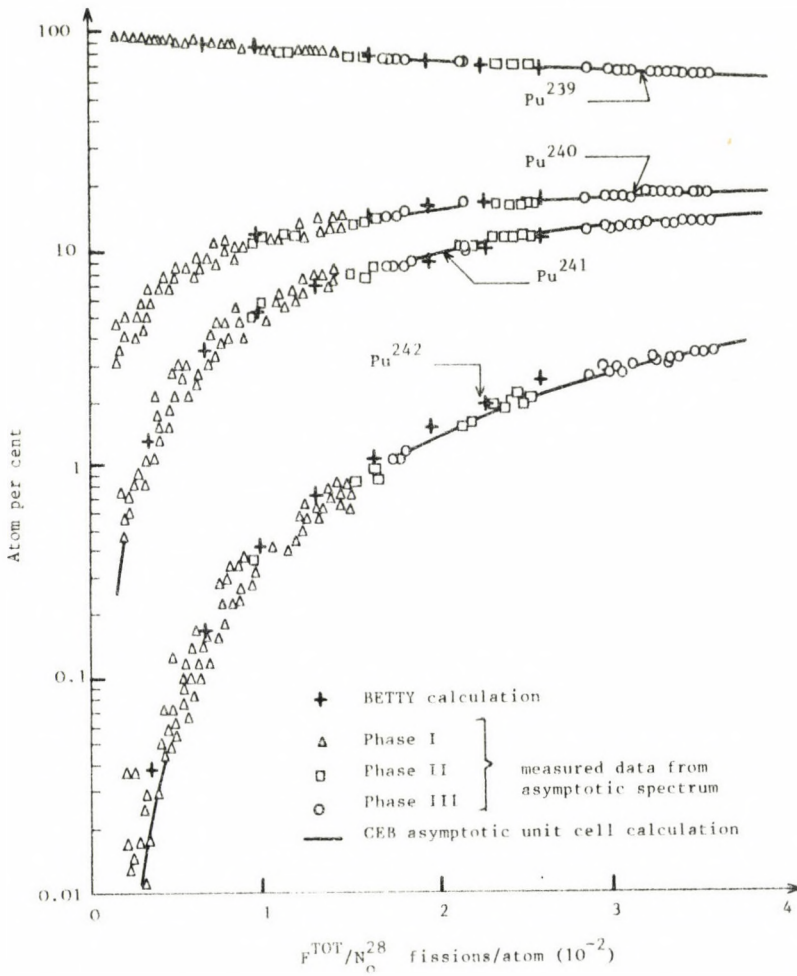
<u>Fig. 1</u>

Plutonium isotopic abundance vs total fissions

finition of few-group constants in the neighbourhood of lattice hetero-geneities.

The calculational tools for nuclear data analysis and adjustment were elaborated in 1977. They are based on calculations of lattice cell parameter sensitivities to nuclear data. The MAGGIE code was written for checking the moments of the neutron slowing down kernel and some interest-
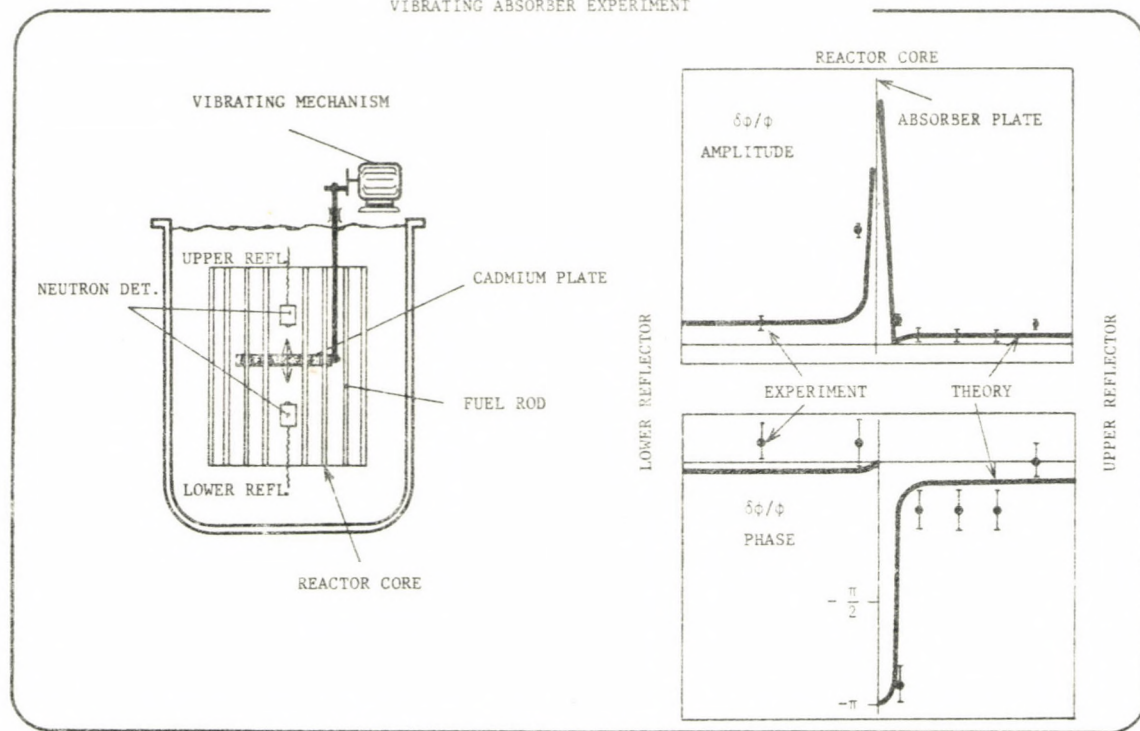
Fig. 2

Theoretical and experimental determination of space-dependent neutron flux fluctua-
tion amplitude and phase around a vibrating absorber plate in a nuclear reactor

ing results emerged from the first applications of this code. The comparison of resonance integral calculation results with experimental data was successfully closed.

In the field of reactor dynamics, the investigation of the effects of perturbations travelling with the coolant has been continued by theoretical and numerical methods. A new theory has been formulated for the description of the neutron flux fluctuation caused by vibrating absorbers and vibration experiments performed in the ZR-6 zero power reactor to give a consistent verification of the theoretical results. The experimental arrangement and the amplitude and phase behaviour of the neutron fluctuation are to be seen in *Fig. 2*. This research is aimed at localizing the vibrating control rods and may have practical significance in reactor diagnostics. An important contribution was made in the initiation of a reactor Diagnostic System to be installed at the WWER-440 power station at Paks. At the ZR-6 system measurements of β_{eff} and $\frac{\partial \rho}{\partial H}$ have been performed.

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2. I. PÁZSIT: Investigation of the space-dependent noise induced by a vibrating absorber. Atomkernenergie 30, 29 (1977)

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4. G. KOSÁLY, L. MESKÓ, I. PÁZSIT: Investigation of the possibility of using static calculations (adiabatic approximation) in the theory of neutron noise. Ann. Nucl. Energy 4, 79 (1977)

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6. J. GADÓ, A. KERESZTURI: Moments of the Fourier-transformed neutron slowing-down kernel. KFKI Report 77-44 (1977)

7. P. VÉRTES: TIBSO: A program system for the calculation of the production transfer, life cycle and radiation of radionucleides in a compound nuclear reactor system. KFKI Report 77-83 (1977)

*   Zentralinstitut für Kernforschung, Rossendorf, GDR
**   Institute for Nuclear Technology, Bucharest, Romania
***   Swiss Federal Institute for Reactor Research, Würenlingen, Switzerland

8. J. VALKÓ, L. MESKÓ: Experimental and numerical investigation of the local and global components of boiling noise. Proc. Second Specialists Meeting on Reactor Noise, Gatlinburg, Tennessee, USA, 19-23 September 1977, M.M.R. Williams, Ed., Pergamon Press, 1977, p. 205

9. G. KOSÁLY, Lj. KOSTIC*, L. MITEFF*, G. VARADI*, K. BEHRINGER*: Investigation of the local component of the neutron noise in a BWR and its application to the study of two-phase flow. ibid. p. 99

THERMOHYDRAULICS

T. Beszeda, Gy. Egeli, Gy. Ézsöl, Gy. Gyenes, T. Katona, E. Maetz, L. Maróti, L. Perneczky, L. Szabados, I. Tóth, I. Trosztel, J. Vigassy

In the experimental field first of all critical heat flux measurements have been carried out. Starting from the nominal parameters of the WWER-440 reactor critical power was measured on a 7-rod bundle in loss-of-flow type accident conditions: loss of flow was simulated by closing a valve at the test section inlet. The first tests have been run in the PERF test series, the aim of these being the evaluation of critical heat flux values in the fuel assembly of the WWER-1000 reactor with perforated shrouds. (These tests are carried out in cooperation with the Kurchatov Institute, Moscow, USSR). The aim of this year's experiments was to test section design and the measurement method: these have been accomplished with good results.

Boiling crisis during power transients (power changing in step-wise manner) was investigated in another test-series using tube geometry. The time until crisis as a function of the intitial steady state power and the power step applied was measured under the following conditions: $p = 125$ bar, $G = 2700$ kg/m^{2}s and inlet subcooling 55 $^{\circ}$C. The range of initial power was zero to 80% of steady state critical power, that of the power steps 150 to 750 kW. A precise evaluation of the experimental data was carried out; power to coolant during the transient was calculated by the BIOT code and the method of defining the real time of crisis onset was elaborated. The experimental results were compared with calculations by the HOTRAN code and it was found that a transient fluid calculation coupled with a steady state CHF correlation adequately describes the process *(Fig. 3)*.

In cooperation with scientists from the Zentralinstitut für Kernforschung, Rossendorf, GDR, acoustic and temperature noise experiments have been carried out in single and two-phase flow. It was found

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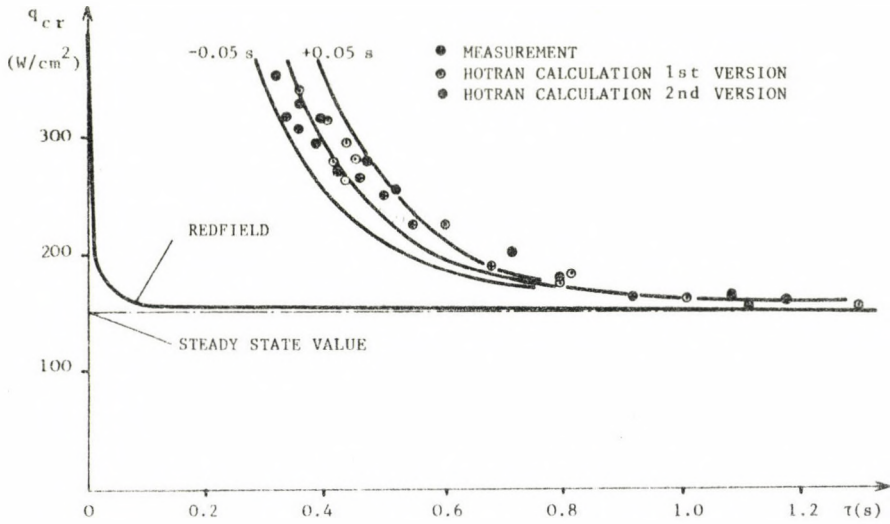
<u>Fig. 3</u>

Comparison of calculated and measured critical heat flux values (q_{cr})
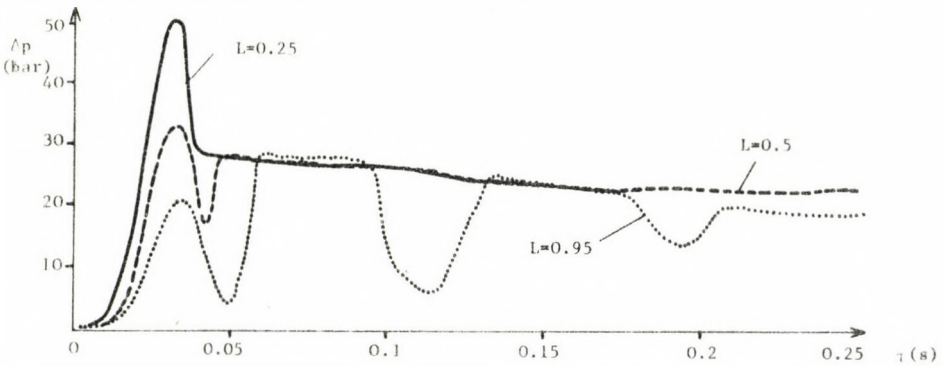
<u>Fig. 4</u>

Pressure difference in time between steam generator outlet and inlet
for cold leg break in function of breach position (L)

that from the acoustic noise level and spectra the onset of boiling and crisis can be detected and even predicted.

On the NVH-E test facility velocity profiles in the subchannels of a 19-rod bundle were measured. According to the experimental data the theoretical models based on an infinite bundle give results that are only valid for the central channel. The Ibragimov model was modified so that it describes side channel velocity profiles as well.

In the field of computer code development the module describing the behaviour of the pressurizer for the primary circuit dynamical program has been coded. The COBRA-3C and the BRUCH-D-03 codes have been adapted to our computer, the latter was used to calculate the processes following the break in the primary circuit of a WWER-440 reactor *(Fig. 4)*. Using the blowdown code that we ourselves developed preliminary investigations have been carried out to include flow reversal; the existing versions of the code were tested. A model was developed for the description of thermo-dynamic non-equilibrium phenomena during vessel blowdown. Several improvements have been made in the HOTRAN code, e.g. new correlations have been added for calculating the critical heat flux and metric units can be used in the input/output.
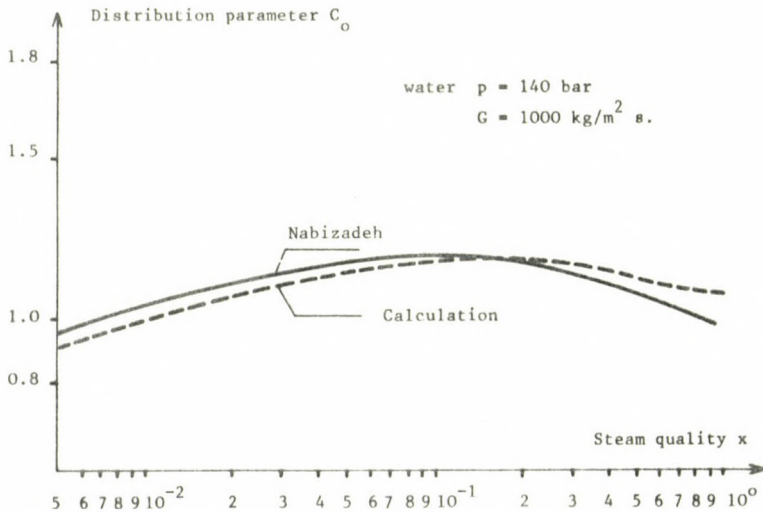
Fig. 5

Comparison of calculated values of C_o with the distribution parameter measurements by Nabizadeh

A new approach was developed for determining the void fraction in two-phase flows. The average void fraction is related to the "total" relative velocity between the phases, this "total" relative velocity being the result of buoyancy forces and the radial void distribution. The "total" relative velocity was determined from the amount of dissipation caused by relative motion; using a known relationship for buoyancy effects the Zuber-Findlay distribution parameter could be evaluated. The comparison of this latter with measurements shows good agreement *(Fig. 5)*.

One of our colleagues took part in the safety calculations of the institute's WWR-SM research reactor that is due to be reconstructed to provide higher power.

PUBLICATIONS

1. L. MARÓTI: Axial distribution of void fraction in subcooled boiling. Nucl. Technol. <u>34</u>, 8 (1977)

2. L. PERNECZKY, L. SZABADOS, L.M. KOVÁCS: HOTRAN-2 – A code for coolant flow transient calculations of watercooled reactor cores. KFKI Report 77-16 (1977)

3. L. MARÓTI: A new approach for the determination of void fraction. KFKI Report 77-29 (1977)

4. J. VIGASSY, L.M. KOVÁCS* COBRA-3C/KFKI a digital computer program for steady state and transient thermal-hydraulic analysis of rod bundle nuclear fuel elements. KFKI Report 77-97 (1977)

COMPUTERIZED REACTOR CONTROL

Laura Bürger-Pátkai, A. Gossányi, J.S. Jánosy, K. Nyéky, J. Péter, G. Sándor, G. Szabó, Á. Szentgáli, E. Végh, E. Zobor

The main activity in this field, as also in the preceding few years, was concentrated on two areas, namely:

- the establishment of a computer based experimental control system for the WWR-SM research reactor of the institute,

- the investigation of synthesis procedures for and the applicability of hierarchical systems to controlling nuclear reactors.

The first project was supported by the State Office for Technical Development of Hungary, the investigations falling within the second area were carried out in the framework of a Research Contract (N^{O} 1194/R2/RB) with the IAEA.

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* Institute for Machine Technology, Budapest

In the autumn of 1976 the first phase, i.e. an open-loop data
acquisition and information system, of the computer control system, based
on an R-10 computer with 64 K byte core memory supported by an 800 K byte
disc was completed using a control program package designed for a CPU
with an 8K core memory. During 1977 the throughput of the computer control
system was analysed and - exploiting the possibilities offered primarily
by the high core capacity - a more efficient new control program package
called PROCESS-24K was developed with the following main characteristics:

- it can handle up to 2300 variables with a throughput of 120
  analogue measurements/s processing rate,

- it provides frameworks for the on-line alarm analysis and
  control program reorganization.

With the PROCESS-24K system the first phase of the reactor con-
trol system was reproduced and the efficiency of the system was determined.
The present tasks of the computer (i.e. measurement and processing of
90 analogue and 120 digital variables divided into groups with 1, 4, 16 s
cycle times; preparation of alarm-, event- and hourly operational log on
two typewriters; yielding information to the operator on two alphanumeric-
al displays) need less than 10% of the CPU time.

In order to realize the second phase of the project when the
computer performs closed-loop control of the reactor, measuring channels
of the Instrument System for Nuclear Industry were installed and the data
acquisition system was completed with the handling of these channels and
measurements. As far as the actuating elements are concerned an additional
control rod drive mechanism was installed and the modifications necessary
for adapting a valve in the primary circuit so that it is able to slightly
influence the coolant flow were carried out.

The work done in connection with the hierarchical control systems
has been motivated by the aim that the theoretical and experimental re-
sults be applied in the realization of the closed-loop control system of
the WWR-SM research reactor. The circumstance that many of the industrial
processes - as e.g. a nuclear reactor - can be decomposed into subsystems
having time constants covering several orders of magnitude allows such a
control strategy to be followed in which the slower subsystems are measur-
ed and controlled with a smaller rate than the fast ones. During the year
the hierarchical control system approach was extended in this direction
and the formulae for coordinating such control subsystems were derived.
Using the PROHYS digital simulation program, developed earlier in the
framework of this same project, adaptation methods were investigated to

fit the parameters of simplified mathematical models so that they yield good agreement with the actual time response of the reactor.

PUBLICATION

1. J.S. JÁNOSY: A simple method for digital simulation of stiff systems. Proc. Int. Symp. Simulation '77, Montreux, Switzerland 1977. (in press)

REACTOR DIAGNOSTICS

T. Hargitai, S. Horányi, D. Pallagi, S. Tőzsér

Analysis of information obtainable from the temperature noise of the reactor coolant was continued. The early perceptibility of the blockage of a LMFBR core was investigated on an electrically heated 37-pin bundle under various power and flow rates. On the basis of the results, the minimum blockage depends on the normal heat gradient in the core, the response time of the thermocouples and the measuring time. The detection of an RMS value seems to be the most favourable method for the indication of a blockage. Curves "a" and "b" in *Fig. 6* show the RMS value of temperature noise measured by thermocouples as the function of normal heat gradient; curves "c" and "d" show the increase of this value caused by the blockage of a central cooling channel.

Fig. 6

Temperature noise vs heating

The in-core flow-rate measurements based on the analysis of temperature noise were continued, too. Development of a multichannel system intended to match the local flow-rate of the core of an RBKM type reactor was started with the efficient help of our Soviet partners. A four channel instrument which can be considered as the simplified version of the planned system was made and given over for long-term testing. The studies aimed at deciding on the usefulness of the NZ-664 Correlation Flow Rate Meter in nuclear power plants were finished. After two years operation in the AES

plant in Obninsk the instrument was recommended for application in nuclear power stations. A further ten NZ-664 Flow Rate Meters were made to supply our domestic customers.

Experiments were begun with the help of the Ultrasonics Dept. of the Hungarian State Railways in order to examine the correlation flow-rate measuring method using ultrasonic transducers as sensors.

PUBLICATION

1. V.M. SELIVANOV*, D. PALLAGI, S. HORÁNYI, T. HARGITAI, S. TŐZSÉR: Izmerenie raskhoda metodom korrelyatsii sluchainykh signalov termopar v konturakh s estestvennoi tsirkulyatsiei teplonositelya. At. Energ. 42, 1 (1977)

TECHNICAL DEVELOPMENT

MEASUREMENT TECHNIQUE FOR STOCHASTIC PROCESSES

P. Pellionisz, A. Péter, L. Zeke
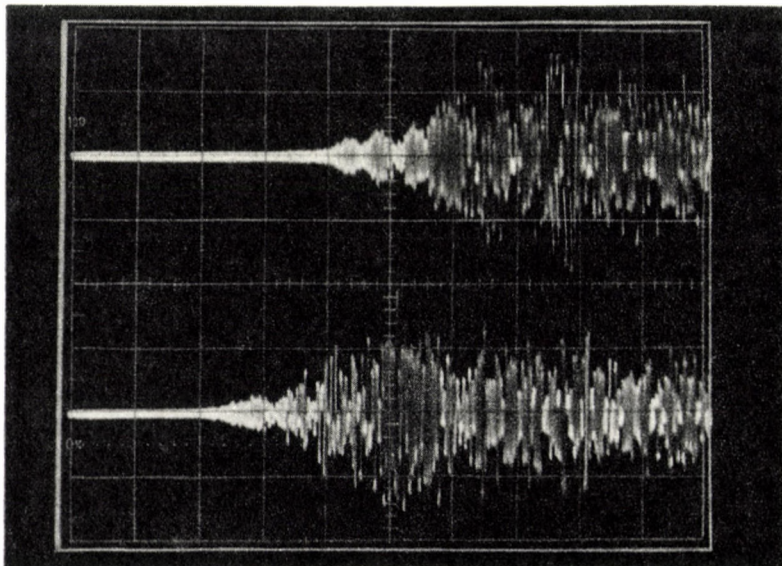
Fig. 7

Acoustic emission signals measured by two detectors at:different distances from the material failure

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* Physical-Energetical Institute, Obninsk, USSR

The Stochastic Analyser developed in the past years has been successfully utilized in our own institute in reactor-physical, thermo-hydraulic experiments and at the Physical-Energetical Institute, Obninsk, USSR for various measurements.

The production licence of the Stochastic Analyser instrument family has been taken over by the Hungarian Works for Electronic Measuring Gear (EMG). In the course of this activity the first products have been cross-checked and the documentation of the additional modules (Fourier Transformer NE-640, CRT Monitor NE-641, Digital Interface NZ-675) is now completed.

In connection with acoustic emission measurements, we studied the behaviour of acoustic emission waves in different materials, the linear localization of material flaws, and the process of stress corrosion cracking (Fig. 7). Some special instruments were developed for these measurements.

INTERCOSMOS PROGRAM
I. Apáthy, I. Szemerey

Three scientific measuring apparatuses developed and manufactured by us were on board "Intercosmos" crafts launched in 1977:

- On the satellite Intercosmos-17 a detector for measuring the energy, dispersion and erosion effect of micrometeorites has been orbiting since September 1977;

- On the geophysical rocket "Vertical-6" launched in October 1977, two instruments measured characteristics of the ionosphere.

The construction of a unit surveying some special features of the solar wind has also been continued.

INSTRUMENTATION FOR REACTOR PHYSICS AND TECHNIQUES
A. Baranyai, P. Pellionisz, L. Várhalmi

In 1977 the installation of four safety channels for the Computerized Reactor Control Centre of the WWR-SM reactor was finished. The electronic part of this system was built up from the units of the Instrument System for Nuclear Industry family developed by us (Fig. 8). Further nuclear safety systems for two research reactors are under manufacture.

154
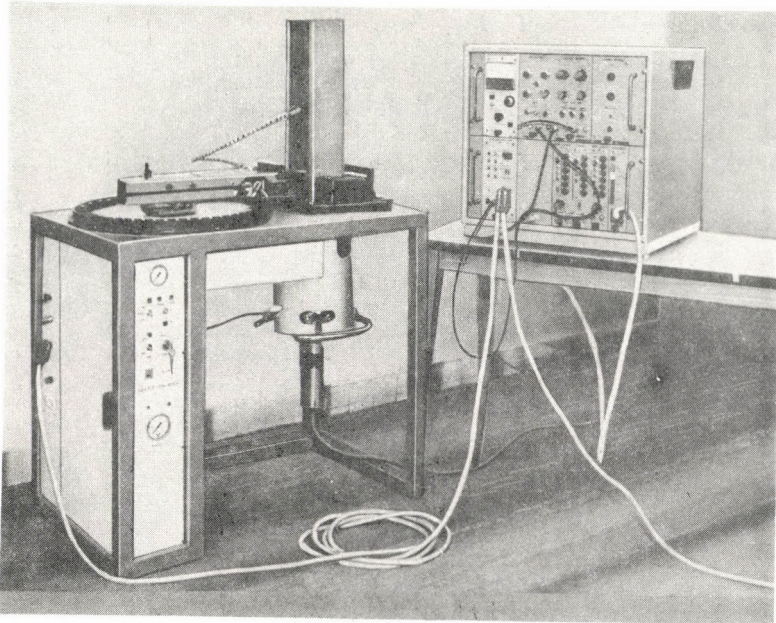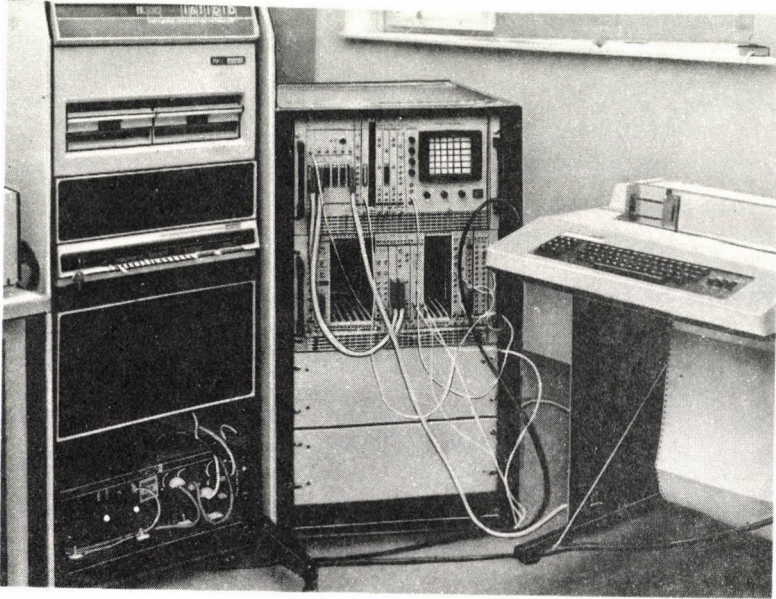
Fig. 9

Computerized, automatic measuring system for reactor statics

For the automatized neutron flux distribution measurement of zero reactors by the method of the measurement of irradiated samples we designed different modules to provide interfaces with the system's components.

The complex measuring, data collecting and evaluating system is based on a PDP-11 minicomputer which is coupled via CAMAC channels to pneumatic sample changers *(Fig. 9)*.

WWR-SM RESEARCH REACTOR

J. Balogh, S. Balogh, L. Frankl, L. Goda, Z. Honti, Gy. Lugosi, Vera Mátis, Gy. Mucskai, M. Tóth, L. Várkonyi, G. Vizdos

In 1977, the WWR-SM reactor worked according to schedule and was operating for 3059 hours thereby ensuring facilities for research work in the fields of solid state physics, nuclear physics, activation analysis and biology and also for the production of radioactive isotopes.

The heat power of the reactor varied between 4.0 and 4.9 MW, resulting in a mean value of 4.5 MW, in 1977. At these power levels, by different core-configurations, the following average values of the maxima of the thermal neutron fluxes were obtained: in the vertical irradiation channels 4.5×10^{13} n cm^{-2}s^{-1} and in the neutron traps $8.7-9.1 \times 10^{13}$ n cm^{-2}s^{-1}.

The main parameters of the reactor for 1977 were:

Operating time (hours)	3059
Interruptions due to breakdown (hours)	
- from internal faults (hours)	0.25
- from external faults (hours)	1.0
Thermal energy produced (MWd)	580.5
Burn-up of ^{235}U (g)	754
Working time of horizontal channels (hours)	10380
Number of irradiations in the pneumatic irradiation system	420
Number of irradiated tubes	855
Tube-hours	164600

In 1977, two core configurations were used, one consisting of 165 and the other of 143 (single) fuel assemblies. In addition, the principle was preserved so as to maintain the useful flux level at a constant value while keeping the heat output for the given configuration to a minimum value. During the operation of the reactor every effort was made to maintain the burn-up level of the fuel assemblies at the maximum possible value making use of core rearrangements and by the adoption of an appropriate fuel policy. In 1977, 19 (single) fuel assemblies were taken out of the core the burn-up level of which was as high as 50.3% on average.

In addition to the necessary summer maintenance work the active core was, together with the beryllium displacers and the control rods, taken out. The aim of this was firstly to take measurements from certain "hot" places of the core in advance of the reconstruction of the reactor and, secondly, to gain information about the welded seams of the reactor vessel, of the shield vessel and of the primary cooling system, by visual inspection and by X-ray and penetration investigations (these latter investigations were carried out together with a foreign firm). The evaluation of the results of the investigations is still in progress.

The modernization of the secondary cooling system was continued this year too, and as a result of this the loading of the heat exchangers of the reactor became more uniform. The outgasser was disconnected and this decreased by 50% the concentration of the radioactive gases emerging from the stack of the reactor, this also resulted in a decrease in the pressures of the primary and secondary systems too.

In addition to providing accident-free operation of the reactor, the group took an active part in the establishment of the closed loop cycle of computerized reactor control.

In the first half of the year a delegation from the Kurchatov Institute, Moscow, USSR, headed by V.V. Goncharov, was received in connection with the reconstruction of the WWR-SM reactor. At the end of the year the plan of cooperation between the two institutes for the years 1978-79 concerning the reconstruction of the reactor was elaborated.

FOREIGN RELATIONS

Lectures by visiting scientists

J.J. Schmidt   (IAEA Nuclear Data Section)
                          Problems of evaluated data files

M. Cumo   (Centro di Studi Nucleari della Casaccia,
                               Casaccia, Italy)
                               Thermohydraulic research work at Casaccia

Staff members on study tours

I. Lux   Technical Research Center, Helsinki,
                               Finland   13 months

Gy. Kosály   Swiss Federal Institute for Reactor
                               Research, Würenlingen, Switzerland   14 months

Guest scientists and fellows

I. Sabotinov   Institute for Nuclear Physics and
                               Nuclear Energy, Sofia, Bulgaria   6 months

THESIS

A. Baranyai   Hardware system with programmable CPU for the
                               automatic measurement of logic networks.
                               (For Ph.D. degree)

PATENTS

1. A. Baranyai   Method for expanding the output voltage range
   S. Cseri   of isolated high voltage parallel stabilizers.
   P. Szintai   (MA-15423)
   F. Városi

2. F. Baranyi   Procedure and equipment for the stabilization of
   Gy. Dóra   the mechanical zero position of the Mössbauer
   E. Serf   transducer. (MA-2682)
   L. Várhalmi

HEALTH PHYSICS

RESULTS

INTERNAL CONTAMINATION STUDIES BY WHOLE BODY COUNTING

A. Andrási, Éva Beleznay, Gy. Kötél, R. Strommer
Visiting research worker: B.J. Vaidya[*]

A simple and fast method has been developed for the calibration of our whole body counter using a point source instead of a uniformly distributed source. The calibration method was tested and utilized for several isotopes and counting geometries.
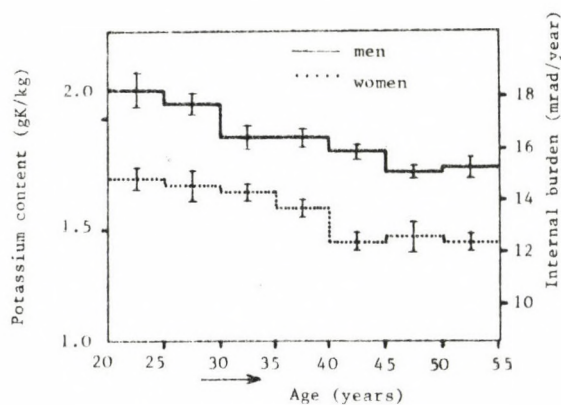
Fig. 1

Whole body average potassium mass concentration and yearly absorbed dose due to ^{40}K in different age groups

[*] BHABHA Atomic Research Centre, Bombay, India

A set of computer codes was developed by means of which the characteristic parameters of the isotope transport processes in the human organism and the different organ doses can be estimated.

An autonomic CAMAC system was designed and partly realized for controlling different whole body scanning methods.

The natural potassium content of the human organism and the whole body dose due to ^{40}K isotope were investigated on the basis of age and sex (Fig. 1).

DOSIMETRY STUDIES

L. Koblinger, S. Makra, J. Pálfalvi, B. Szabó, P.P. Szabó

The accident dosimetry system for a mixed neutron-gamma field, introduced earlier in order to gain experience, was improved. To measure the thermal and the intermediate neutron doses we adopted a new activa-

KFKI accident dosimeter

plastic bag

S pellet
12 mm diam.
4 mm thick

Cd, 0.9 mm thick

Au, 100 mg/cm^2

^{7}LiF powder

Au, 200 mg/cm^2

window

Track detector
Macrofol E 7 mm diam.

Th^{232} 5 mm diam.

inner box
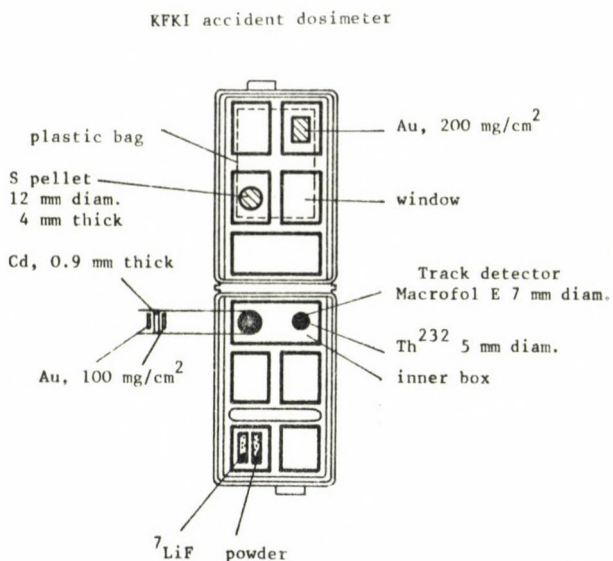
Fig. 2

View of nuclear accident dosimeter used in the institute

tion foil method using two gold foils. To obtain even more accurate gamma dose values, instead of ^{7}LiF teflon discs incorporated in the experimental dosimeter, we used detectors of ^{7}LiF powder located in small plastic tubes. Accident dosimeters are evaluated once a year and the results are compared with those from the measurements of personal dosimeters evaluated monthly. An Instruction Manual was compiled on how to handle and evaluate the accident dosimeters.

For the Biological Irradiation Facility (BIF) at the WWR-SM reactor a device was designed and manufactured to facilitate the irradiation of different personal and accident dosimeters for the purpose of calibration. Our improved accident dosimeters *(Fig. 2)* were utilized during an international dosimeter intercomparison arranged by us at the BIF this year. Very good agreement was found for the dose data measured by the different institutes.

The accuracy of the environmental monitoring measurements was increased by using $CaSO_4$:Dy powder instead of $CaSO_4$:Dy teflon discs. We participated in the IIIrd international Environmental Monitoring Intercomparison, held in USA, using the powder dosimeter.

PUBLICATIONS

1. P.P. SZABÓ: Low exposure rate dependence of $CaSO_4$Dy TLD-s. Nucl. Instrum. Methods <u>147</u>, 451 (1977)

2. B. SZABÓ, P.P. SZABÓ, S. MAKRA, J. VÁGVÖLGYI, J. SOÓS: The TLD-04B thermoluminescent reader for research and routine dosimetry applications. KFKI Report 77-33 (1977).

3. B. SZABÓ, P.P. SZABÓ, S. MAKRA, J. VÁGVÖLGYI, J. SOÓS: TLD-04B - universalnyi pribor dlya izmereniya termoluminestsentnykh materialov. KFKI Report 77-34 (1977).

4. S. MAKRA, P.P. SZABÓ, L. BENKŐ[*], T. BIRÓ[*] Opyt primeneniya individual'nykh dozimetrov, ocnovyvayushchikhsya na plenochnykh i termolyuminestsentnykh dozimetrakh. KFKI Report 77-36 (1977).

ENVIRONMENTAL MONITORING AROUND NUCLEAR POWER PLANTS

A. Andrási, S. Deme, I. Erdélyvári, I. Fehér, M. Rövid, P. Zombori

The operational plans for the environmental monitoring system of the Paks Nuclear Power Plant have been completed. This system is formed from the instruments measuring the amount of radioactivity released; a 120 m high meteorological tower; measuring and sampling stations; a laboratory for sample measurements; a mobile laboratory set up in a van.

[*] Institute of Isotopes of the Hungarian Academy of Sciences, Budapest
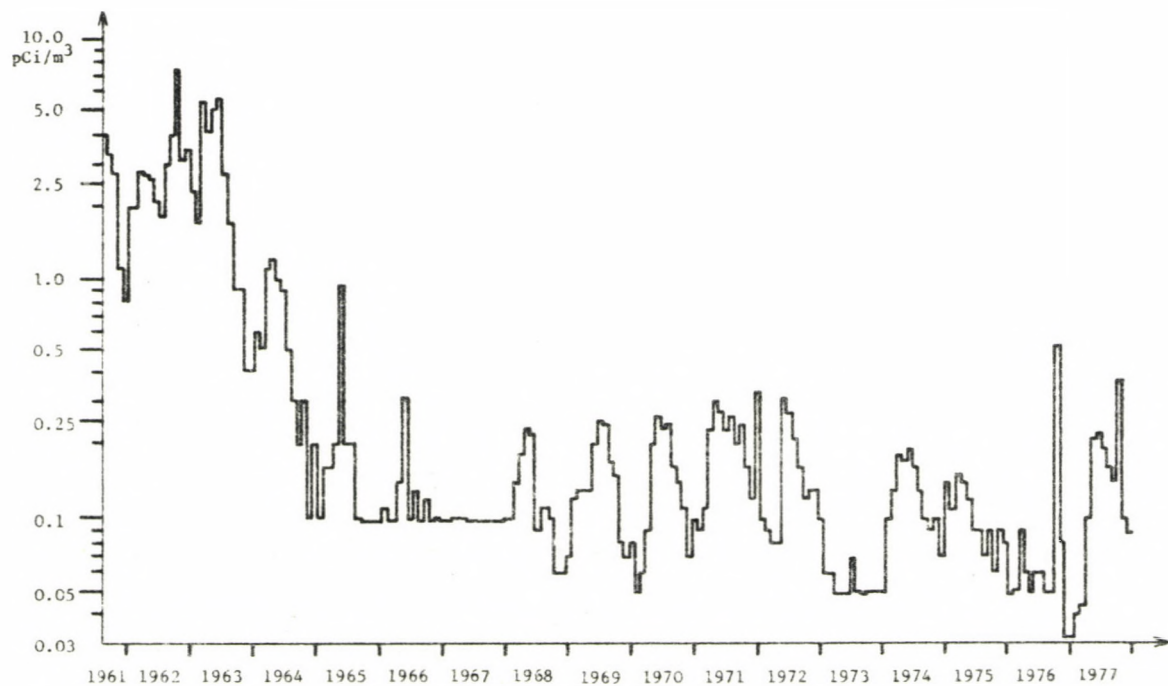
Fig. 3

*Beta activity concentration of aerosol in the grounds of
the Central Research Institute for Physics*

We have investigated the characteristics of the detectors which can be used at measuring stations. Scintillation γ-spectrometric methods have been elaborated for the purpose of environmental background radiation measurements carried out by the mobile laboratory. The origin of environmental background radiation and the amount can be determined by these methods quickly, sensitively and selectively.

RADIATION PROTECTION SERVICE

A. Andrási, Éva Beleznay, J. Biró, S. Deme, I. Erdélyvári, I. Fehér, J. Molnár, Éva Pados-Farkas, M. Rövid, P.P. Szabó

The personnel, the working places and the whole area of the Research Centre were routinely controlled, the tasks in connection with isotope handling and with the central records concerning radiation were duly performed by the Radiation Protection Service in order to safeguard the workers from health hazards, and to protect materials and goods from radiocontamination.

The dose received by the majority of personnel ($\geq$ 98%) working in places exposed to radiation in our institute does not exceed from year to year 10 % of the maximum permissible dose. Figure 3 shows the radioaerosol concentration values measured within the grounds of the Research Centre over the years 1961-1977. According to our investigations the observed radioactivity of the atmosphere was due in 1977, similarly to that observed in the preceding years, mainly to worldwide contamination. The increased radioaerosol concentration observed in October 1977 (similarly to that observed in October-November 1976) can be attributed unequivocally to the nuclear weapon tests in China.

In addition to our local monitoring service, we took part in the development of sampling and measuring techniques to be utilized at the Nuclear Power Plant being built at Paks.

PUBLICATION

1. I. BOJTOR, I. ERDÉLYVÁRI, L. BOROS, S. DEME: Individual'nyi dozimetricheskii kontrol' v Vengrii. KFKI Report 77-35 (1977)

FOREIGN RELATIONS

Guest scientists and fellows

B.J. Vaidya	BHABHA Atomic Research Centre, Bombay, India	9 months

THESES

P. Zombori   γ-Spectrometric Methods for the Determination of the
                    Environmental Background Radiation. (For Ph.D degree)

L. Koblinger   Monte Carlo Calculations for Health Physics. (Thesis
                    for the academic degree of Candidate of Physical
                    Sciences)

RESEARCH INSTITUTE
FOR MEASUREMENT
AND COMPUTING
TECHNIQUES

COMPUTING TECHNIQUES

RESULTS

COMPUTING FACILITIES

K. Bánáti, T. Benkő, Magda Bodnár, L. Diósi, Zs. Dobolyi, Andrea Dömölki-Nagy, T. Gaál, Katalin Kulcsár, Livia Major, A. Nagyházi, G. Sásdi, Magda Zimányi

This year our computing centre was extended by the installation of ES 1040 and TPA 1140 computers.

The computing centre of the Institute now operates the following computers:

- ES 1040 computer equipped with 1 Mbyte core memory, 12 exchangeable disk units, 8 magnetic tape decks and slow peripheral units;

- ES 1020 computer equipped with 128 Kbyte core memory, 4 exchangeable disk units, 4 magnetic tape decks and slow peripheral units;

- ICL 1905 computer equipped with 32 K words core memory, 6 magnetic tape decks and slow peripheral units;

- TPA 70 computer equipped with 16K words core memory, CDC cartridge disk and slow peripheral units;

- TPA 1140 computer equipped with 32K words memory, MOM disk and slow peripheral units.

With regard to the installation of the ES 1040, all operators of the computer were given special training. In order to inform users about the characteristic features of the operating system OS-ES a series of lectures and seminars was held and a set of lecture notes and manuals

was published. An advisory service has been organized to provide continuous help for users. To meet user demands a system procedure library has been created which is constantly extended.

PUBLICATION

1. M. ZIMÁNYI: Some experiments in converting FORTRAN programs to other computers. KFKI Report 77-12 (1977)

THEORETICAL COMPUTER SCIENCE

J. Bagyinszki, Borbála Gellai, G. Németh, J. Szlankó, L. Varga

The VDL (Vienna Definition Language) was designed for the formal definition of the semantics of programming languages, but recently it has also been used as a general technique for defining data structures and algorithms.

VDL is a definition system. It consists of objects, a machine operating on these objects, and a programming language.

The VDL objects are abstract data structures. We have developed a formal system of VDL objects in which the basic properties of the operators are taken as axioms and their further properties are then proved. This is the basis for the formal verification of VDL programs.

The Hoare deductive method was extended to the verification of VDL-like programs. A VDL-like program is a hierarchically structured program in which the order of execution of its statements is partially non-deterministic (i.e. some statements are taken as collateral). Loops are organized by means of recursive calls.

Using the above techniques a method was developed for programs of verified design.

In cooperation with the Laboratory for Computing and Automation of the Joint Institute for Nuclear Research, Dubna, USSR, we have worked out a set of algorithms and programs for the solution of some problems in physics. Among others the following subjects were dealt with: generation of random numbers; finding the eigenvalues of the quantum-mechanical two-centre problem; numerical rational approximations of some functions.

We have studied the problem of linear function classes in prime-valued logics. The lattice of linear function classes in prime-valued

logics, furthermore the complete structure of certain classes of symmetric languages, were worked out and a proof was given that the languages in question are regular.

One of us (J.B.) took part in the work of the Stefan Banach International Mathematical Center, Warsaw, Poland, as an invited lecturer.

The increasing tendency to use mini- and microcomputers in small scale data measuring and logging applications raises the need for the definition of an easy-to-learn standardized real-time BASIC. Supported by experience gained in the use of several CAMAC BASIC, we play an active part in the standardization work of the BASIC committee of the Purdue workshop.

PUBLICATIONS

1. J. BAGYINSZKI, J. DEMETROVICS[*]: The structure of the class of symmetric languages invariant for inner linear transformations. Proc. Second Hungarian Computer Science Conf., Budapest, 1977. p. 100

2. L. VARGA: The verification of VDL-like programs. ibid. p. 895

3. J. FEKETE[**], L. VARGA: On the formal definition of VDL-objects. Acta Cybernetica $\underline{3}$, 239 (1977)

4. B. GELLAI: Generalized inverse method for computation of the molecular force field. J. Mol. Struct. $\underline{42}$, 181 (1977)

5. B. GELLAI, C. LANCZOS[***]: Fourier analyses of random sequences. KFKI Report 77-12 (1977)

6. G. NÉMETH: A relative rational approximation to the exponential function. Matematicheskie Zametki $\underline{21}$, 581 (1977)

7. G. NÉMETH, CZO LONG NAM[****]: Computer approximations to Ladenburg function. KFKI Report 77-12 (1977)

8. G. NÉMETH: Rational approximations to some special functions. KFKI Report 77-12 (1977)

9. J. SZLANKÓ: Real-time programming systems in the KFKI. Proc. of Workshop on Process Control Computing. University of Karlsruhe, Karlsruhe, FRG, 1977. p. 107

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[*]   Computer and Automation Institute of the Hungarian Academy of Sciences, Budapest
[**]   Eötvös Loránd University, Budapest
[***]   Dublin Institute for Advanced Studies, Dublin, Ireland
[****] Research Institute for Mathematics and Physics, Pyongyang, DPRK

SYSTEM SOFTWARE

A. Arató, Z. Gálfi, Mária Ivanyos, K. Kovács, Mariann Kővári, Erika Lovas,
Gy. Lőcs, I. Mező, M. Nagy, M. Salamon, I. Sarkadi-Nagy, G. Takács, F. Telbisz,
J. Telek, J. Tibor, Erzsébet Vass

In order to improve the efficiency of the ES 1040 computer, we wish to use the system OREMUS (On-line Remote Editor and Minicomputer User's Support),which services interactive display terminals and small computers (intelligent terminals).

In 1977 the channel - channel adapter which can be used to connect the TPA 70 to the multiplexor or selector channel of ES computers was completed. The stand-alone testing of the adapter as well as the on-line testing with the ES 1020 computer have been performed. The small computer part of the text editor, running in the front-end processor (TPA 70), was finished. A preliminary version of the host computer part was developed under the operating system DOS. The adaptation of the interactive text editor for the operating system OS is in progress.

The software development for the minicomputer TPA 1140 has been continued. The processor of the TPA 1140 developed in the institute is program compatible with the SM-4 model of the Unified Minicomputer System of the COMECON countries. We played a successful part in the international approbation of the Paper Tape System in Moscow using an SM-3 processor. International approbation of the FOBOS disk operating system is scheduled. The FOBOS system includes powerful assembly level programming support and offers high level languages such as FORTRAN IV, BASIC and an interactive multi-user version of BASIC. The FOBOS system has been successfully implemented and tested on our configuration containing a TPA 1140 central processor and a DISCMOM disk unit.

The development of a DOS/RV real-time operating system for the TPA 1140 was started too.

The work relating to the development of the TPA 70 disk operating system (MINOR/D) has been completed. The fixed-head disk oriented version of the MINOR/D has been tested and made ready for installation.

The following extensions were completed this year:

- program-chaining facility in the MINOR/D supervisor,
- new version of the File Handling Package,
- Plotter Subroutine Package implementation and testing,
- Scientific Subroutines Package implementation,
- some important modifications of the BASIC system to support the

CAMAC handling and other real-time applications of the BASIC conversational system.

The real-time system MINOR/RT for the TPA 70 has been completed. To provide a wider range of application the system MINOR/RT has been extended with the following facilities

- CAMAC peripherals handling,
- magnetic tape and disk handling tasks,
- ICA 70 analyser handling task.

PUBLICATION

1. MARIA IVANYOS, G. TAKÁCS, J. TELEK: MINOR/D system generation and initialization: User's manual. KFKI, Budapest, 1977

APPLICATION PACKAGES

M. Bak, K. Balajthy, L. Buday, L. Diósi, M. Horvai, A. Horváth, I. Horváth*, L. Ivanyos, J. Kiss, Katalin Kulcsár, Erika Lovas, Z. Padányi, M. Pap, B. Papp, Mária Rigó, P. Soós, Z. Szemereki, J. Szlankó, S. Trencséni, Judit Vámos, Magda Zimányi

Our main activity in the period dealt with here has been oriented towards the completion of the in-house testing phase of those large application programs which were designed and coded in the previous year. Besides this, a considerable amount of design and programming work has been done on two new application projects for the oil industry. These are:

- a control system for automated storage vessels at the filling station of the Tisza Oil Refinery, Leninváros, Hungary,

- an on-line production control system for the Szeged-Algyő (Hungary) Oilfield.

In both cases CAMAC peripherals are used as elements in the interface system between the process and computers. The machines are KFKI-manufactured TPA/i-s running under the control of RTS/i real-time executive.

In order to make programming easier a set of new system programs has been developed for the TPA/i. The OPAL (Operating System and Language), an improved version of INDAC, has been successfully implemented and certified in practice. RTS/i has been extended to handle disk-resident tasks.

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* Deceased 10th October, 1977

As a move toward distributed process control several device handlers and communication tasks have been written for the intelligent CAMAC crate (ICC).

The demand for non-numeric applications of computers is ever increasing especially in theoretical physics (relativity theory, field theory, nuclear physics). In order to facilitate such applications, the well known languages LISP and the REDUCE2 have been implemented on the ES 1040 computer. REDUCE2 is a language designed for general algebraic computations. The most important facilities of REDUCE2 are the following:

- expansion of polynomials,
- symbolic differentiation,
- substitutions and pattern matching,
- simplification,
- calculations with symbolic matrices.

In order to replace the spectrum-analysing system SIRIUS having been written in ALGOL and still working on the ICT computer, a FORTRAN version of this program system was developed to be used on the ES 1040 computer.

PUBLICATIONS

1. A. ARATÓ, I. SARKADI-NAGY, F. TELBISZ: A local network for the support of software development. Proc. COMNET '77 Symposium Budapest, 1977. p. 227

2. L. DIÓSI: Generalized path integrals. KFKI Report 77-9 (1977)

3. L. DIÓSI: A simple method for measuring the moments of the gamma particle multiplicity distribution. Nucl. Inst., Meth. **140**, 533 (1977)

FOREIGN RELATIONS

Staff members on study tours

T. Benkő	VEB Kombinat ROBOTRON, Leipzig, GDR	7 months
K. Bánáti	VEB Kombinat ROBOTRON, Leipzig, GDR	3 months
Irina Gladkih	Joint Institute for Nuclear Research, Dubna, USSR	7 years
Borbála Gellai	University of Tennessee, Knoxville, Tennessee, USA	1 year

Cs. Hegedüs	MacMaster University, Hamilton, Ontario, Canada	18 months
A. Nagyházi	VEB Kombinat ROBOTRON, Leipzig, GDR	6 months
M. Zsenei	Joint Institute for Nuclear Research, Dubna, USSR	5 years

THESIS

L. Varga — The VDL-graph with applications: verified design of programming systems.
(For the academic degree of Doctor of Mathematical Sciences)

ELECTRONICS

RESULTS

DEVELOPMENT OF CAMAC MODULES AND SYSTEMS

L. Almási, J. Biri, M. Blasovszky, P. Bördén, N. Buchmüller, P. Giese,
P. Görög, Gy. Kertész, Gy. Messing, I. Mohos, T. Nemes, J. Reho, Gy. Révész,
I. Sarkadi, L. Somlai, Katalin Somlay, Gy. Stanchich, Zs. Zárándi, K. Ziegelmann

During the past year we developed further our CAMAC system devices. In the course of this period we significantly increased the number of types of our CAMAC units; these now number over one hundred. As new members of our biomedical functional module family, amplitude and shape discriminators have been prepared. In addition, many other general purpose units are now available, viz.: alphanumeric-graphic display driver for a conventional TV set, digital multiplexer basic module, crate controller, programmable burst generator, symmetrical eight-channel analogue multiplexer, status register.

The intelligent system based on the INTEL 8080 microprocessor elaborated during the previous years has been expanded with an autonomous driver. This system is suitable for serving a minimum of four CAMAC modules (it allows a bidirectional transfer of 1-3 bytes between the served CAMAC module and the memory for every instruction).

In order to increase the application possibilities of our complete systems, more special purpose units have been produced. One of them, the Crate Controller CAM 1.22, contains seven programmable registers and in the CAMAC crate it is plugged into the position of the crate controller. This method has made it possible to build multicrate systems. The data transfer can be programmed or interrupted. Each CAMAC module may have a separate interrupt vector. The crate controller provides an access to the individual lines; only one of the controller type modules can use the DATAWAY at a time and it can be interfaced to the TPA 1140 bus-system.

Besides the development of hardware units, advances have also been made in CAMAC operating software. Satisfying software requirements
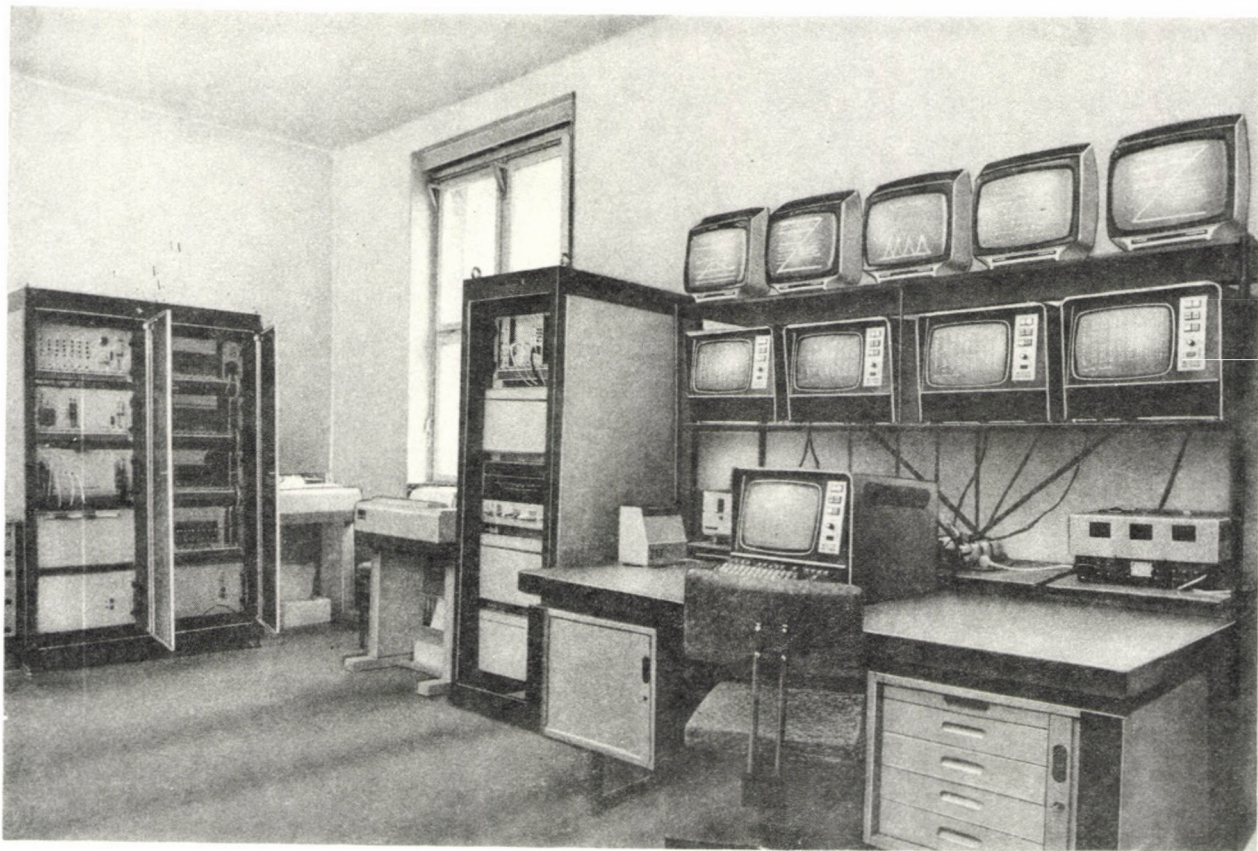
Fig. 1

Data logging system for the cryogen unit of the T-7 Tokamak

of the microprocessor system needed special care. A new BASIC interpreter was prepared, suitable for executing CAMAC instructions; in addition, a very effective text-editor has been elaborated. We have developed floating point packages for solving problems of measurement and data-collection. One of these can be used with the BASIC interpreter and the other one -- which is less accurate - seems to be very useful for measuring and processing large amounts of data.

The test programs of the recently developed CAMAC modules needed a considerable amount of programmer's time. This field requires very close coordination and cooperation in hardware and software developments.

Last year several highly complex measuring systems were installed. For the Belka Institute, Pushchino, USSR, a system for the control and evaluation of collected data of a liquid chromatograph was finished. Two systems have been installed at the Kurchatov Institute Moscow, USSR: a measurement automatization system of the three-axes neutron spectrometer and a computerized data collecting system for the superconducting magnets of the T-7 Tokamak. This latter contains a TPA/i with 24K words operative memory and three intelligent CAMAC systems and measures and evaluates 100 fast and 400 slow analogue signals *(Fig. 1)*.

PUBLICATIONS

1. Gy. MESSING: A distributing LAM grader unit - a way to distribute intelligence in the CAMAC crate. KFKI Report 77-18 (1977)

2. T. BEUCHEL*, J. LINGERTAT*, Gy. MESSING, A. STAREPRAVO*: Basic design considerations for a multicontroller configuration in a CAMAC crate. Akademie der Wissenschaften der DDR Zentralinstitut für Elektronenphysik, Preprint 77-8 (1977)

3. J. LUKÁCS: Real-time applications at KFKI. Proc. of a Workshop on Process Control Computing, Budapest, 1977; Universität Karlsruhe Bericht 63, p. 100

4. L. ALMÁSI, J. BIRI, P. GÖRÖG, J. LUKÁCS, I. MOHOS, J. REHÓ, J. SARKADI: On the data-collecting and measuring systems based on distributed intelligence. Symp. on Nuclear Electronics Varna, Bulgaria, 1977; Publ. Joint Institute for Nuclear Research Dubna, p. 153

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Zentralinstitut für Elektronenphysik, Berlin, GDR

INDUSTRIAL APPLICATION OF SMALL COMPUTERS

K. Balajthy, L. Buday, J. Cser, P. Görög, J. Kenessei, L. Kerényi, J. Kiss,
T. Nagy, M. Pap, Z. Szemereki, Z. Szetei, J. Szlankó, L. Szőnyi, Gy. Vashegyi

After previous successes in this field the design, realization and installation of industrial control systems have been continued.

Among the systems applied in different fields of industry we present two reports of applications concerning the most significant results of the last year.

In the field of power plants, computerized process control systems have been set up for the four blocks of the Tisza Power Plant. These systems are planned on the basis of the operating experiences obtained in the Danube Heat Power Station, where six systems are already operating serving similar purposes, and our latest systems show significant advances over the earlier systems.

The most significant improvements are:

- application of the most up-to-date measuring and computing devices (CAMAC modules, industrial analogue measuring system, floppy-disk, microprocessor controlled pseudographical display),

- introduction of new system-technical concepts aiming at safe system operation,

- application of new scientific methods for verification of user program-systems.

During the year a great deal of work concerning process control systems for the transportation and storage of natural gas, oil and oil products has been done.

The supervisory and control system of a pipeline for the Mineral Oil Trading Company (ÁFOR) and the supervisory system for the tank farm of the Tisza Oil Refinery have been installed. We have also been concerned with the computer-aided verification of the supervisor and control programs of systems completed during this year.

The storage and mixing of the raw materials of the oil industry and of semi-finished and finished products also represent a fundamental task of the tank-farm technology created at the Tisza Oil Refinery. Various materials to and from the store are transported by train or pipeline. The most important problems of the tank farm's technology are: the high speed of the arriving materials, the variety of the stored goods, the necessity for direct contact with the processing plants.

With these factors in mind, the computer system provides the control of the technology and helps the system-control by advice based on the measured data.

DEVELOPMENT OF SMALL COMPUTERS

Gy. Balatoni, F. Báti, Margit Benkő, B. Biró, T. Bozsó, A. Csákány, J. Harangozó, A. Jávor, Judit Kántor, Róza Kertes, Gy. Komlós, I. Kővári, G. Lőrincze, M. Marton, Z. Nyitrai, P. Patóh, J. Sulyán, P. Szabó, Gy. Tamás, Katalin Tarnay, T. Török, Klára Varga

In recent years one of the most important achievements has been the development of the TPA 1140 small computer *(Fig. 2)* and certain of
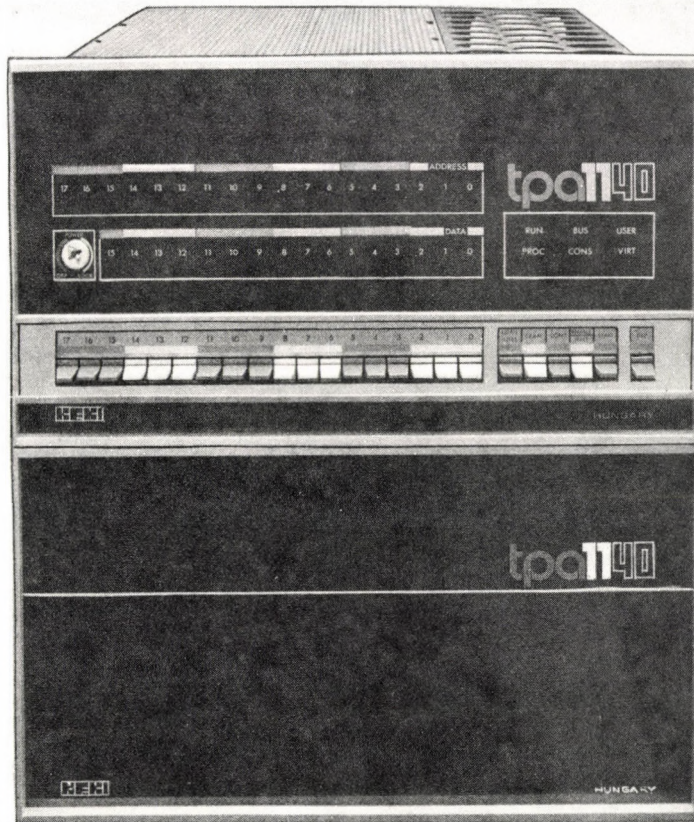
Fig. 2

Minicomputer TPA 1140

its options. (The processor is a Hungarian version of one of the elements of the Socialist countries' Mini Computer System, MCS).

The planned applications of the computer can be divided into two groups:

- technical-scientific calculations, interactive and batched data processing;
- data collection, process control, automation of technological processes.

The software system requirements for these two groups are different: the operating system of the first group is called FOBOS, a single user foreground/background operation system running programs written in high level languages; the other group requires a real time multiprogramm- able operating system.

The hardware systems developed on the basis of the software requirements reflect these differences. The following configuration is typical of the FOBOS operating system:

- TPA 1140 processor, 16-28K words operative memory, extended and floating point instruction set, cartridge disk, console display, line printer.

A typical configuration of the real time system:

- TPA 1140 processor, memory management, 32-64K words operative memory, fixed head disk, console display, line printer, CAMAC peripherals.

The typical configurations can be extended with the following: magnetic tape unit, floppy disk, paper tape peripheral devices, synchronous/ asynchronous interface, asynchronous 16-channel multiplexer. The peripheral devices are either Hungarian products, or products of the Socialist coun- tries, all of which are used according to the MCS recommendations. For this reason our programs developed for testing these devices are of great importance, apart from this they also help the work of the manufacturer.

Our systems based on the TPA 1140 processor were presented last year at several national and international forums. The exhibition held on the occasion of the Moscow meeting of the presidents of the national science academies of the Socialist countries was the most important. Another event was a technical show for the chief designers of MCS. The mutual development project - an agreement between our institute, and

the Complex Computer Control Institute, Moscow, USSR (leading institute of MCS) - can be considered as a recognition of our results.

The importance of the investigation for the potential application of new computer elements urged us to develop a complex testing device for the magnetic bubble memory project of the institute. Our testing device checks the operation, the selection, and the investigation of the marginal bounds. For this purpose, a rotating field generator with a wide frequency range has been completed. (The maximal amplitudes of the sine and cosine currents are of 2.5 A, the frequency can be continuously regulated from 1 Hz to 10 KHz, furthermore 20, 50,100 kHz fixed operation frequencies can be selected, the number of rotating field periods and the number of rotating field spaces are independently adjustable, the system is start-stop operated and free of transients).

The selection process is performed on slices containing 25-100 chips, by means of a multi-pin automatic wafer tester at 10 kHz frequency. For this purpose different flexible current generators are necessary, and a bias jump generator for the determination of the bias margin. The very complex test programs can be selected or modified by means of a program selection matrix. The design of a test system mode of CAMAC modules is in progress.

Last year we started an investigation concerning the possible use of small computers in education. An educational system (TEASYS) has been produced, which is suitable for the simultaneous serving of 8 terminals of a TPA/i small computer in BASIC language. During the year several configurations were operated in secondary schools and in colleges in order to determine the requirements of the special application environment. Apart from physics and mathematics, history, grammar, and conventional subjects, other - non-conventional - applications were considered such as the support of the education of the blind and the teaching of the handicapped have been studied. Judging by our experiences the computer motivates students and presents a challenge regardless of the age of the students. Thus, their activities and abilities increase. A program library of significant volume has been elaborated ranging from computer games to basic curricula of the different subjects.

Activities in the field of circuit simulation programs (LOBSTER) have been continued in order to improve the time mapping algorithm of large numbers of elements. The transfer of the program to a faster and larger computer is now being carried out. Elaboration of testing methods for computer networks is also going on revealing the applicational possibilities of small computers in this field. Theoretical questions of computer

networks were also a current topic with particular regard to the problems
of the description of network protocols with formal languages.

PUBLICATIONS

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   a formal language. Proc. Fifth Data Communication Symp., Snowbird, Utah,
   USA, 1977. p. 37

2. J. HARANGOZÓ: A method to describe data link level protocol of computer
   networks with a formal language. Proc. Second Hungarian Computer
   Science Conf., Budapest, 1977. p. 434

3. J. HARANGOZÓ: Formal approaches to describing protocols. Proc. Computer
   Networks and Teleprocessing Symp., Budapest, 1977. p. 195

4. K. TARNAY: The measurement of computer networks. ibid. p. 213

5. M. BENKŐ, A, JÁVOR, P. KERESZTES: LSI system simulation: an interdiscipli-
   nary approach. Proc. JUREMA, Zagreb, Yugoslavia, 1977. Paper G-1

6. A. JÁVOR; An adaptive time advancement algorithm for discrete simulation.
   Information Processing Letters $\underline{6}$, 83 (1977)

7. A. CSÁKÁNY, F. VAJDA: The impact of computer availability on engineering
   education in Hungary. IEEE Trans. on Education $\underline{20}$, 2 (1977)

8. A. CSÁKÁNY, L. HOLTZER, K. TARNAY, F. VAJDA: Education by minicomputers
   KFKI Report 77-78 (1977)

APPLICATION OF MICROPROCESSORS

*R. Alpár, Gy. Ambrózy, S. Ebergényi, I. Erényi, L. Godeny, L. Leveleki,
J. Miskolczi, I. Rényi, L. Sándor, M. Szalay, M. Szoják, F. Vajda*

      The development of the technology of electronic circuits sup-
plying the latest LSI components made it necessary to renew the tradi-
tional methods of hardware/software design and application. On the basis
of the experiences gained earlier by the application of a small com-
puter based development system for microprocessor hardware/software and
of the MMPS (Multi Micro Processor System), new modules of the devel-
opment system were created. Besides the printed cards enabling one to
program the newest type PROM and REPROM elements, the programming of
the FPLA circuits (Field Programmable Logic Array) -which are needed for
developing modern logical systems and for instruction decoding - was
realized. The principles of a new microcessor-based universal development
system were also elaborated. In this dual-processor system the software
programs to be developed are able to run by means of a Z80 type "master"
central processing unit. An "in-circuit emulator" changeable according
to the microprocessor of the system to be developed, a programmable event-
condition module, and a real-time event-memory are connected to the
"master" central processing unit.

For the development of microprograms of microcontrolled systems a control-memory simulator was constructed which can be used as an intelligent ROM-simulator.

As a new member of the family of microprocessor-controlled display terminals interfacing between man and industrial processes (or rather the computers controlling the processes) a coloured symbol-handling display was developed. Significant ergonomical improvements resulted from the application of colours; because of the symbol-handling principle this could be obtained without any increase in memory size. The first display terminals are due to be installed in the Research Institute for Electric Energy (VEIKI) for process control in the energy industry, and in our own institute for reactor control.
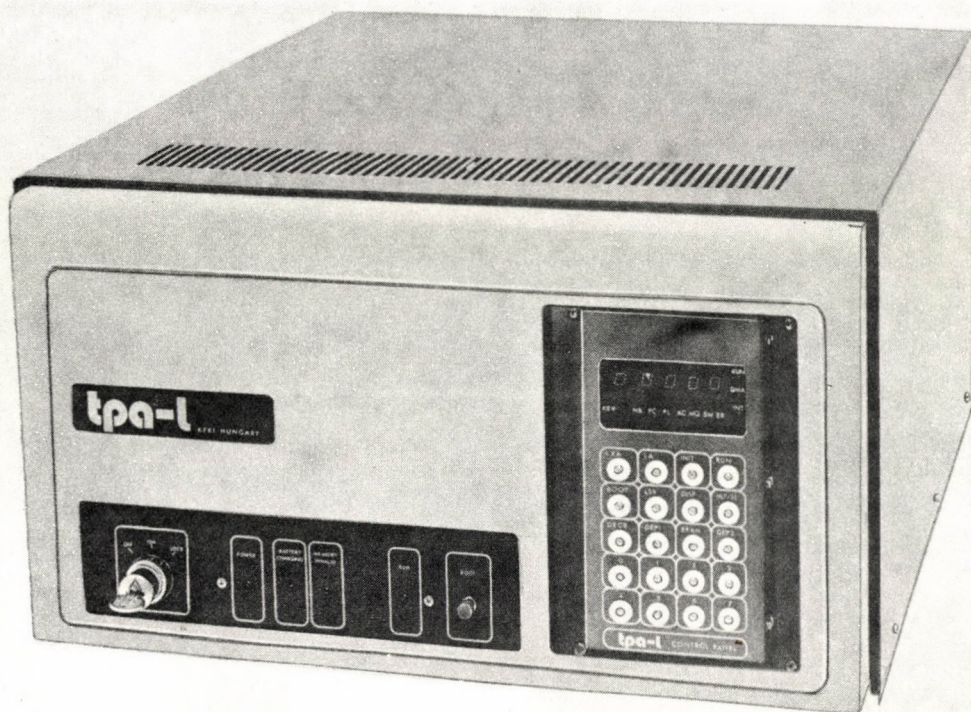
Fig. 3

Small computer TPA-L

During this year the first LSI-based member of the TPA computer
family - the TPA/i compatible TPA-L computer - came into being *(Fig. 3)*.
This machine of modern technology is able to apply the system- and user-
programs and peripheral controllers of the small computers produced in
significant numbers in the previous years.

Compatibility means the validity of the most important principles
listed below.

- Instruction and program-level compatibility with the TPA/i

- full compatibility with the internal bus of the TPA/i machines

- a mechanical system which is the same as the system of the
  TPA/i small computers (identical characteristics of the printed
  cards, racks, connectors, etc.).

Two versions of the TPA-L were elaborated and prepared for produc-
tion. The first version can handle an operative memory of a maximum of 32K
words, in the second one the operative memory can be up to 128K words.This
latter has a few other advantages besides its larger memory, e.g. reloca-
tion of user programs by hardware, memory places bigger than 4K words in
user mode, etc. An inexpensive audio-casette and tape-recorder memory
were also developed for the system; these units can be programmed as paper-
tape peripherals.

A great deal or experience of software and hardware compatibility
has verified that the TPA-L - because of its up-to-date technology and
its excellent peripheral and software support - can be applied very ef-
fectively in laboratory and industrial measurement-data acquisition-
control systems, for business and automation tasks, technological and
scientific calculations, in education and communication systems, and in
a number of other applications; this small computer also means a new
category concerning its low price - this having been made possible by
the application of modern components.

This year has witnessed the successful completion of the emulation
experiences with the Intel 3000 microprocessor family begun last year.
The test programs we have already run prove the instruction-level compatibi-
lity of the EM-11 emulator with the TPA 1140 computer.

PUBLICATION

1. Gy. AMBRÓZY, F. VAJDA, I. RÉNYI: Principi postroenia i oblasti primeneniya
   intelligentnogo displeinogo terminala s mikroprocessornim upravleniem.
   KFKI Report 77-27 (1977)

TECHNOLOGICAL RESEARCH

Gy. Binder, B. Forgách, E. Gaál, L. Honti, A. Karacs, Vera Szabó, Zs. Szabó, Nina Törő, J. Zsembery

During the past year the preparations for setting up the computer-aided design of printed circuits have been continued. The study and the adaptability tests of the designing and drawing programs of the ADMAP drawing machine to be utilized in the future have been brought to a successful conclusion.

The laboratory experiments relating to roller-coating technology have been completed. The problems of the liquid photoresist and the roller compatibility as well as the relationship between the viscosity and the rolling parameters have been solved.

In printed circuit technology the introduction of the single step activation has now become feasible by the development of an activator which makes the technological line suitable for processing copper clad sheets with 5 μm copper thickness.

Using an adhesive procedure the technology of the printed circuits with a maximum of four conducting layers has been worked out at laboratory level. The adhesives utilized are compatible with the chemical baths of the technological line. The standard qualifying procedures have been satisfactorily completed. These production procedures will be introduced next year.

FOREIGN RELATIONS

Lectures by visiting scientists

F. Meijer   (University of Amsterdam, Amsterdam, The Netherlands)
                             Microprocessor based minicomputers

Yu. Safroshkin   (Belka Institute, Pushchino, USSR)
                             Analysis of peptides and proteins with the help of
                             a chromatograph controlled by small computer

Staff members on study tours

M. Zsenei   Joint Institute for Nuclear Research,
                             Dubna, USSR   6 years

G. Kalmár	Joint Institute for Nuclear Research, Dubna, USSR	4 years
L. Miller	Joint Institute for Nuclear Research, Dubna, USSR	4 years
T. Keresztfalvi	Joint Institute for Nuclear Research, Dubna, USSR	3 years
F. Poysl	Joint Institute for Nuclear Research, Dubna, USSR	3 years
J. Harangozó	Joint Institute for Nuclear Research, Dubna, USSR	3 years
E. Serf	Joint Institute for Nuclear Research, Dubna, USSR	2 years
T. Nemes	Joint Institute for Nuclear Research, Dubna, USSR	2 years
E. Kindzierszky	Interatominstruments, Warsaw, Poland	4 years
G. Lőrincze	Technical University, Delft, The Netherlands	3 months

Guest scientists and fellows

F. Meijer	University of Amsterdam, Amsterdam, The Netherlands	1 month
N.V. Mohindra	V.E.C. Project Bhabha Atomic Research Centre, Calcutta, India	1 year
F.V. Sintenon	University of Helsinki, Helsinki, Finland	1 month

DEVELOPMENT ENGINEERING

INSTRUMENTATION DEPARTMENT

RESULTS

DEVELOPMENT OF COMPUTER-AIDED SURFACE MAPPING METHODS IN CARDIOLOGY

S. Békési, Gy. Kozmann, I. Préda*, V.V. Shakin**, F. Szlávik

The aim of surface mapping type measurements in cardiology is to provide a detailed picture of the electrical and mechanical events of the
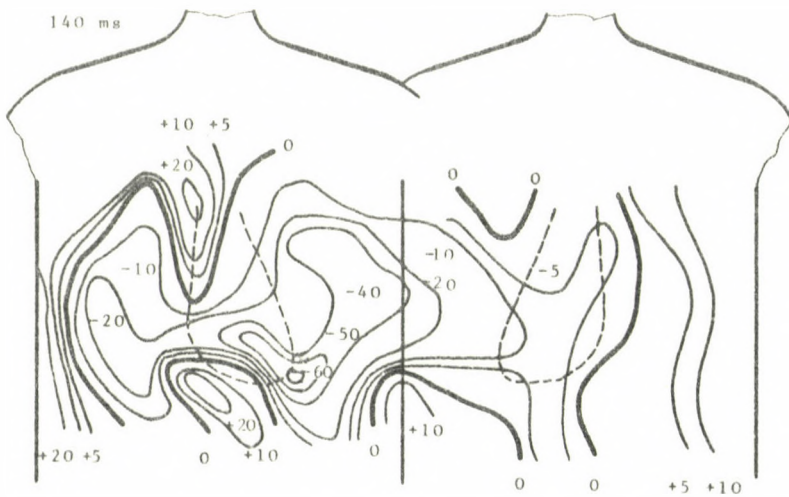
Fig. 1

Surface acceleration map in the period of rapid ejection (amplitudes in cm s^{-2} units, time instant 140 ms from ECG Q-wave onset)

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** Institute for Information Transmission Problems, Moscow, USSR

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heart as a function of space and time coordinates. The measurement technique
fundamentally requires the simultaneous multitransducer measurement of the
electrical and mechanical field data on the chest surface. By means of a
series of isopotential or iso-acceleration contour maps produced by the
computer the cardiac electro-mechanical events can be followed "visually"
(Fig. 1).

The provision of a reasonable medical interpretation of the
cardiac events revealed by the body surface maps is often considerably
easier using the corresponding heart surface (epicardial) field data.

To perform the epicardial map estimations further experimental
data (geometrical coordinates of the body and heart surface) are required
as well as the knowledge of certain electrical and mechanical tissue pro-
perties. In 1977, we were able to work out a provisional measuring and
a TPA/i small computer aided data processing system suitable for all the
measurements mentioned above.

For the quantitative investigation of the heart generated mechanic-
al (acoustical) vibrations, a mathematical model was elaborated.

Pioneering work was done to characterize the different types of
left bundle branch blocks (LBBB) by the method of body surface potential
mapping. The results gained offer new possibilities in clinical practice
for the diagnosis of certain LBBB and myocardial infarction combinations
unidentifiable by the classical, e.g. 12 lead ECG, methods.

The tedious epicardial field computations were performed in co-
operation with scientists of the Institute for Information Transmission
Problems, Moscow, USSR and the Research Institute for Telecommunication,
Budapest.

PUBLICATIONS

1. Gy. KOZMANN, J. PRÉDA*, V.V. SHAKIN**, F. SZLÁVIK, S. BÉKÉSI: Computer-
   aided measuring system for complex heart activity investigations at body
   surface and epicardial level. Proc. 4th Int. Congr. Electrocardiology,
   Balatonfüred, Hungary, 1977, Excerpta Medica, Amsterdam (in press)

2. I. PRÉDA*, J. BUKOSZA*, Gy. KOZMANN, V.V. SHAKIN**, Á. SZÉKELY*, Z. ANTALÓCZY*:
   Distribution of heart potentials on the human thoracic surface in the
   cases of left bundle branch blocks. ibid. (in press)

DIGITAL TEMPERATURE
CONTROLLER
NZ-663/1

HEKI

HEATG ON   SPH UP

DPLY
SELECT   SPH

0 7 8 1.8 °C

OFF

DIRECT
HEATG

ON

LOAD
SPH

SETPOINT [SPS]

0 7 8 1 6 °C

CORR
RATE

X

RATE FACTOR   °C/h

SPH
CORR

OFF

6 2   0 8

DLY
OFF

MON O/P

ALARM
BAND

CORR
BAND

TO

GATE O/P

PWR UNIT

1 5   6 °C

SAMPLE

TC INPUTS

HEATER

CJC

ALARM   IN BAND
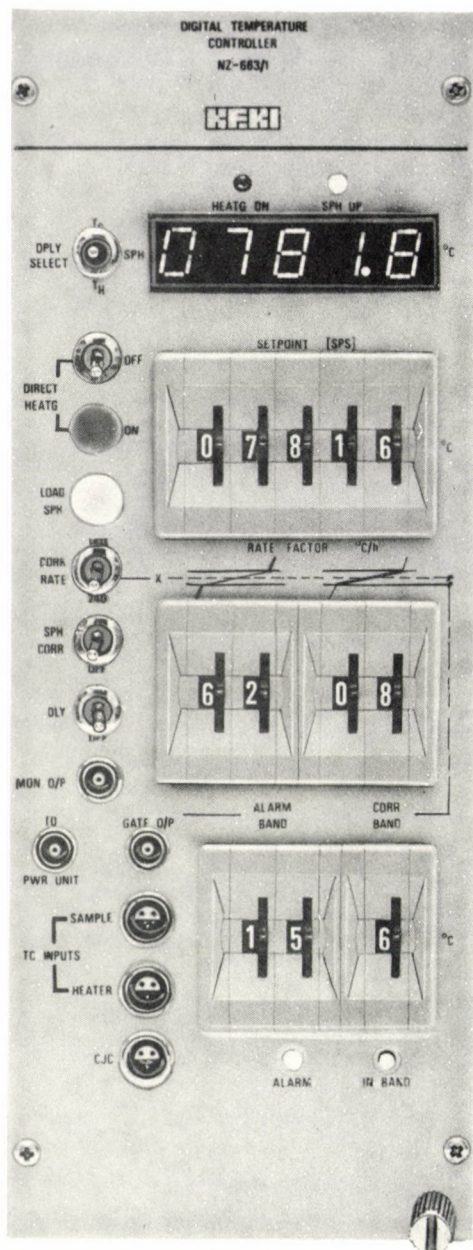
3. V.V. SHAKIN*, Cs. CSAPODI,
   Gy. KOZMANN, I. PRÉDA**: In-
   verse problems for a mathemat-
   ical model of the cardio electro-
   mechanical field. ibid. (in press)

4. Gy. KOZMANN: An acoustic model
   of the heart. In: Medical Com-
   puting. Taylor and Francis, Lon-
   don, 1977. p. 254

5. Gy. KOZMANN: Computerized method
   for quantitative characterization
   of heart vibrations by a multipo-
   lar model. In: Computers in Cardi-
   ology, IEEE Computer Society,
   USA, 1977, (in press)

DIGITAL TEMPERATURE CONTROL

L. Tankó

Based on our previous re-
sults on high resolution digital
thermometry, last year we complet-
ed the design and put into produc-
tion a temperature controller, type
NZ-663/1, by means of which the
range -200 °C to +1300 °C can be
covered with 0.1 °C resolution.

Digital signal processing
used overwhelmingly in the new
double-loop cascade controller al-
lowed new features and provisions
together with high stability and
noise rejection capability to be
realized at an acceptable cost.

Fig. 2

*The NZ-663/1 digital temperature
controller*

*   Institute for Information Transmission Problems, Moscow, USSR
**   Postgraduate Medical School, Budapest

Although during the development we were principally concerned
with the requirements of the Mössbauer instrumentation developed in and
produced by the Institute, the NZ-663/1 also has extensive applications
as an autonomous peripheral of automatic computerized measuring systems
too.

The new device has been constructed in the form of manually or
dataway-controlled CAMAC modules as well as a mechanically stand alone
unit *(Fig. 2)*.

FOREIGN RELATIONS

Staff member on study tour

J. Németh   Joint Institute for Nuclear Research, Dubna,
                  USSR   2 years

PATENT

L. Tankó   Digital temperature controller, especially for ovens
A. Ribényi   used in spectrometry. (MA-2895)

MECHANICAL ENGINEERING DEPARTMENT

RESULTS

AUTOMATIC CHEMICAL ANALYSER

B. Bak, I. Bartucz, F. Engard, B. Egri, T. Juhász

The 3A Automatic Absorption-Photometric Analyser, type NK-230, is a newly developed, versatile and reliable instrument. On the basis of experience gained during recent years at the laboratories of the Hungarian Public Health Institutions from the working of the KFKI-produced programmable single channel automatic chemical analysers (previously named: "SATELLITE"), considerable development of the instrument has recently taken place leading to the updated version. First of all, view-points of handling, reliability, versatility and data processing were considered during development *(Fig. 1)*.
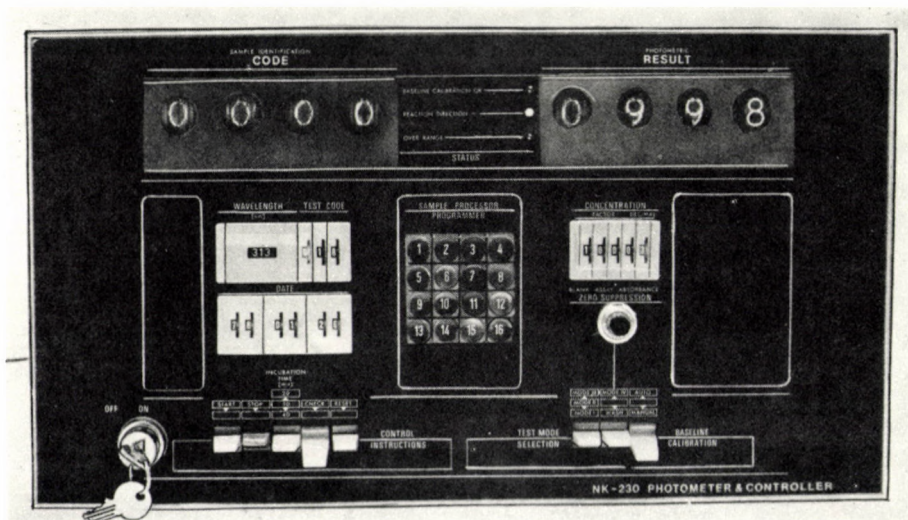
Fig. 1

Front panel of the measuring-control unit of the NK-230 automatic absorption-photometric analyser

The new, self-calibrating photometer unit of the instrument consists of a mercury-lamp, interference filters, a flow-through cell with reference lightpath, and a photomultiplier tube detector.

The instrument is suitable for any type of equilibrium, zero-order and first order reactions.

The modes of operation are as follows:

- Measurement in equilibrium state or zero order reactions with reagent blank;

- Parallel measurement as above;

- Measurement of any type of reaction with complete sample and reagent blank.

The printed paper tape containing date, test codes, sample iden-tification codes and results can be used directly in preparing medical reports.

HIGH-SPEED DRILLING MACHINE
B. Egri, Gy. Szeli

This machine - which is admirably suited to the semiautomatic drilling of printed circuit boards - is the direct result of an essen-tial improvement to an earlier type *(Fig. 2)*.

The work-pieces (from 1 to 3 printed circuit boards) fastened to the baseplate, are positioned with the help of a fixed pin. This pin can be substituted by a screen with the help of which the drilling of single pieces or the production of templates can be accomplished. This efficient high-speed drilling machine is pneumatically controlled.

The surface finish meets the requirements of hole galvaniza-tion.

Main technical data:

Hole diameter	$\emptyset$ 0.3 to 3 mm
Performance	max. 50 holes/min
Spindle speed	adjustable from 0 to 40 000 rpm
Printed board size	max. 400x500 mm
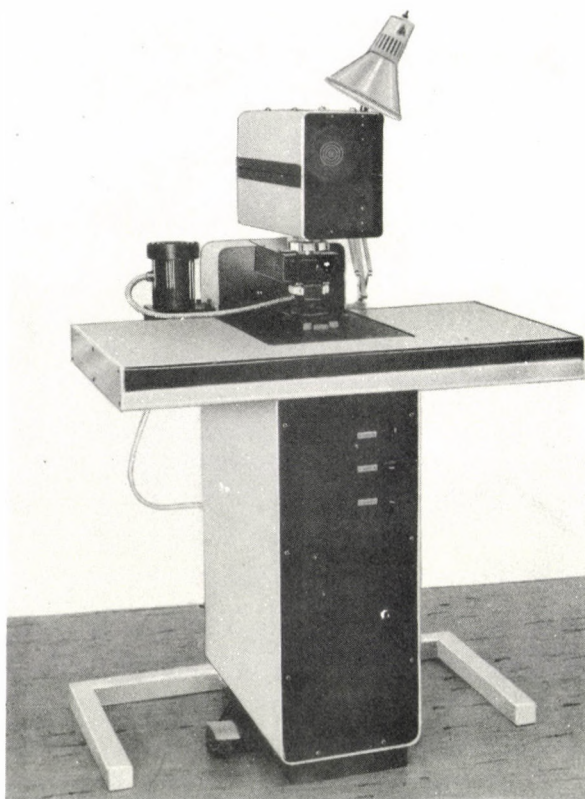
Fig. 2

High-speed drilling machine

PUBLICATION

1. M.F. RÁNKY, B. EGRI: Subjective fingerprints in digital motion analysis.
   Proc. XXXIst AICS-ISFIA Congress, Venice, Italy, Sept. 1977, p. 8

FOREIGN RELATIONS

Staff members on study tours

| M. Szalók | Joint Institute for Nuclear Research, Dubna, USSR | 3 years |
| E. Kiss | Joint Institute for Nuclear Research, Dubna, USSR | 1 year |

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TO MEMBERS OF THE SCIENTIFIC STAFF

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*Ch: Chart of Organization