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Letter from the President

During the period since the last issue of E.M.P. News the Federation has been engaged in many scientific activities. Some colleagues will remember the EFOMP/ENMR Workshop, held in London in March and described more fully in this issue. At the 6th Annual Meeting of the European Society for Therapeutic Radiology and Oncology (ESTRO), in Lisbon, the session on Quality Assurance was a collaboration between EFOMP and ESTRO. To a somewhat greater extent EFOMP was involved in the European Congress of Radiology. This was also held in Lisbon and followed the ESTRO meeting. The sessions on 'the Role of the Physicist in Imaging Modalities' and on 'the Radiation Protection of the Patient' were organised and co-ordinated by EFOMP.

The meeting of the Austrian and German Societies of Medical Physics, in Innsbruck in September, was the first meeting of National Organisations with a full day of EFOMP contributions included in the Scientific Programme. Austria, especially Innsbruck, proved to be a very attractive meeting place. Besides the more usual scientific matters the impact of the Chernobyl accident was discussed in one of the sessions. This is a topic of great interest to us all and many member societies reported upon the involvement of medical physicists in the assessment of the consequences of the accident.

The EFOMP Council Meeting for 1987 was also held in Innsbruck. I enjoyed meeting the delegates from our member organisations for detailed and wide ranging discussion on the future activities of EFOMP. Some news from the Innsbruck meeting is included in this issue of E.M.P. News. There will be further details in the next issue.

H.-K. Leetz

News Items

Welcome to Poland
At the 1987 EFOMP Council meeting, held in Innsbruck, the Polish Society of Medical Physics was formally accepted as a member of EFOMP. General information about the Society was included in the last issue of E.M.P. News.

Radiation Measurements, Inc. (RMI)
RMI was founded in 1968 by Dr. John R. Cameron. The company specialises in the field of quality assurance for radiographic and ultrasonic procedures. The Board of RMI recently approved the purchase of its assets by Physics Associates, Ltd. (PAL). The chief executive officer of PAL is Mr. Charles Lescranier, who is also head of Gammex, Inc. It is intended that the established aims of RMI will be continued and developed, under the new structural arrangements.

The new arrangements have also triggered the formation of Wisconsin Innovarium, Ltd. This organisation will promote and encourage the study of innovations relating to medical diagnostic and therapeutic equipment. Initially it will support two graduate fellowships in the Department of Medical Physics at the University of Wisconsin-Madison, U.S.A., in each of the next five years. It will also provide a research grant to that department. Dr. Cameron is the former Chairman of the department.

World Congress on Medical Physics and Biomedical Engineering
The congress, which includes the 8th International Conference on Medical Physics, will be held in San Antonio, Texas, USA, in August 1988. The contact address is included in the list of meetings elsewhere in this issue. Dr. Kopp can supply author kits, exhibitor kits and general information.

EFOMP Calendar
Officers' Meeting. London. Early in 1988.
5th Symposium on Clinical Radiation Physics with International Participation and with EFOMP. Neubrandenberg, GDR. 25–28th April 1988.
2nd European Congress of NMR in Medicine and Biology. Berlin, FRG. 23–25th June 1988.
Council meeting. Milan. In late summer or autumn 1988.
Council meeting. Paris. In July 1989 at the time of the International Congress of Radiology.

Quality Assurance in Magnetic Resonance Imaging.
In 1984, the EEC concerted research project on 'The Identification and Characterisation of Biological Tissues by Magnetic Resonance' was initiated by Dr. F. Podo, of Rome. One of the products of the multinational group activity has been the development of five test objects, with associated protocols. The work drew upon the experience of several centres and particularly the University of London, Royal Postgraduate Medical School, where an assessment programme was already being funded by the United Kingdom Department of Health and Social Security.

The test system is now being produced commercially and is called the Eurospin Test System. The following parameters can be assessed: Uniformity of the image signal, uniformity of image signal to noise ratio, image signal to noise ratio, geometric distortion, slice profile, slice width, slice position, slice warp, spatial resolution, image contrast to noise ratio, T1 and T2 precision and accuracy. Further details can be obtained from Diagnostic Sonar Ltd., Kirkton Campus, Livingstone, EH54 7BX, SCOTLAND.

Some dates from the ESTRO Diary
Teaching courses in 1988:
Radiation Physics for Clinical Radiotherapy. Leuven. 6–10th June.
Quality Assurance of Equipment for External Beam Therapy. Den-Haag. 2–4th September.

The 7th annual meeting of ESTRO will be held in Den-Haag on 4–8th September 1988. There will be a full physics programme.

Details from the ESTRO Secretariat, University Hospital St. Rafaël, Department of Radiotherapy, Capucijnenvoer 35, B–3000 Leuven, Belgium. Telephone (32) 16 222213.

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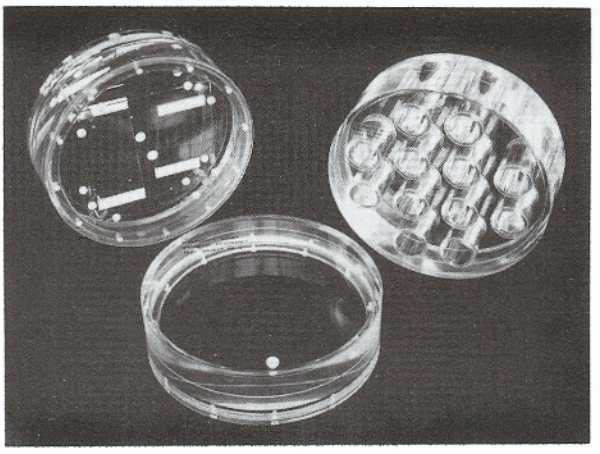
THE EUROSPIN TEST SYSTEM

QUALITY ASSURANCE IN MAGNETIC RESONANCE IMAGING

In 1984, the EEC concerted research project on "**The Identification and Characterisation of Biological Tissues by Magnetic Resonance**" was initiated under the leadership of Dr F Podo of Rome.



This multinational group was able to draw upon the experience of a large number of research centres, particularly that of Dr R A Lerski of the University of London Royal Postgraduate Medical School who was already engaged in an assessment program of magnetic resonance imaging equipment funded by the DHSS of the United Kingdom.

The concerted action has resulted in the development of a set of five Test Objects and Associated Protocols for their use. These have now been extensively tested at sites throughout Europe on equipment from all the major manufacturers. The system is known as **The Eurospin Test System**.

Implementation of this evaluation system allows the following parameters to be measured:

Test Object 1	**Uniformity**	Uniformity of image signal. Uniformity of image signal-to-noise ratio. Image signal-to-noise ratio.
Test Object 2	**Slice**	Geometric distortion. Slice profile. Slice width.
Test Object 3	**Slice Position**	Slice position (single and multi slice). Slice warp.
Test Object 4	**Resolution**	Spatial Resolution.
Test Object 5	**Contrast**	Image contrast-to-noise ratio T1 and T2 precision and accuracy.

DIAGNOSTIC SONAR

All Test Objects can be used in transverse, sagittal or coronal scan planes.

A particular feature of Test Object 5 is that it contains 12 calibrated gel test substances, with a range of T1 and T2 relaxation times appropriate to tissue. Such substances are essential to quantitative studies in magnetic resonance aimed at tissue characterisation.

Details of cost and availability can be obtained from:

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Kirkton Campus, Livingston EH54 7BX, Scotland
Tel: 0506 411877. Telex: 72591 DSONAR G. Fax Tel: 0506 412410

1987 European Workshop: Magnetic Resonance in Medicine — Spectroscopy and Imaging

Organised by: European Federation of Organisations for Medical Physics
European Workshops on Nuclear Magnetic Resonance in Medicine
European Society for Magnetic Resonance in Medicine and Biology

The considerable growth of Magnetic Resonance (MR) in medicine, as witnessed by the interest in MR conferences over the past five years, has surprised even those committed to its development. MR imaging has been the focus of attention at most clinically orientated meetings. This stress on imaging, in the rush to discover immediate clinical applications, has perhaps left other aspects of MR, in particular spectroscopy, in the background. Spectroscopy is time-consuming, requires expensive hardware and software and the interpretation of *in-vivo* spectra seems fraught with difficulties. Imaging seems straightforward by comparison. However, attempts to obtain quantitative indices of pathology based on relaxation times calculated from MR images have yielded disappointing results. Probably MR images represent an over-simplification of the data obtainable from an MR scan. The contributions of intra-voxel tissue inhomogeneity, variable water to fat ratios, bound-unbound water etc. cannot easily be separated out by single frequency band detection. The key to unravelling this data and defining clinically useful indices of pathology may come from MR spectroscopy, not from more exhaustive analysis of MR imaging.

The 1987 European Workshop on Magnetic Resonance in Medicine was held in the Department of Chemistry at University College, London, from 27–29 March. Poster and manufacturers' exhibitions were held in the more classical surroundings of the South cloisters of the main UCL building. 277 delegates and invited speakers attended the workshop which was organised so that the centre of attention would be Magnetic Resonance Spectroscopy (MRS) rather than imaging. The hard realities, not only of the limitations of *in-vivo* spectroscopy, but also of the cost of MRS provision, were brought home to everyone. The principal sessions, on spectroscopy, are detailed in this article. There were parallel sessions on clinical imaging and other techniques such as flow, diffusion and the use of contrast agents. The subsequent publication of the MRS papers presented should provide a realistic assessment of the future of MRS and its funding, particularly within the scope of public health-care.

Mr. John Clifton, Head of the Department of Medical Physics and Bioengineering at UCH, opened the workshop and outlined the main objectives. Fundamental questions concerning MRS were immediately addressed by Drs. D. G. Gadian (UK) and D. I. Hoult (USA), with little concession to optimism. The major obstacles encountered in MRS were identified, namely low sensitivity, low metabolite concentrations, poor spectral and spatial resolution *in-vivo*, high noise levels, long data collection times, uncertainties and inaccuracies in localisation, excessive power deposition in tissues, magnetic susceptibility inhomogeneity, lack of standard calibration procedures and, of course, high equipment cost. Ample theoretical and empirical data was presented to illustrate the scale of each problem.

The next two sessions helped to restore the balance by focusing on studies where MRS already has the potential to offer assistance in clinical diagnosis. Prof. G. K. Radda (UK) gave an extensive presentation on ^{31}P spectroscopy centered on the work of his group on muscle, brain and heart function *in-vivo*. Precisely because of the complexity of MRS data, there is much to be said for an empirical approach where the physiological changes under investigation are expected to produce gross alterations of the MR spectra. Experimental design is critical if systematic errors are to be eliminated. Work on muscle energetics in the diagnosis of peripheral vascular disease and subsequent post-operative recovery provided a good example. In skeletal muscle, the PCr to Pi ratio and the chemical shift of the Pi resonance (which indicates pH) undergo considerable changes under conditions of ischaemia and provide a limited clinical utility despite the lack of a rigorous understanding of the relationship between the physiological conditions and the resulting MR spectra. Case studies were presented in which ambiguous or negative diagnoses were resolved after *in-vivo* MRS results had led to non-routine tests being applied e.g. in the case of defective phosphate transport caused by mitochondrial defects. Although MRS is not yet acceptable as a stand-alone diagnostic technique, it can be used to suggest other specific measurements.

Prof. R. G. Schulman (USA) considered the potential of ^{1}H and ^{13}C MRS. Available magnets have sufficiently high field strengths and homogeneities to make *in-vivo* observation of these nuclei worthwhile, at least for clinical research. Water and lipid suppression, spectral editing and indirect detection methods were beginning to make feasable detection of particular metabolites on a time scale comparable with ^{31}P spectroscopy. Useful spectra could now be acquired in a matter of seconds to minutes, depending on concentration. The types of molecules accessable via ^{1}H and ^{13}C spectroscopy made this a worthwhile pursuit. Of particular interest were lactate for studies of hypoxic metabolism, pyruvate to study lactate dehydrogenase activity, glycogen metabolism as an indicator of phosphorylase-A activity, and saturated and unsaturated lipids and glucose for dietary studies. The development of doubly-tuned coils allowed simultaneous acquisition of ^{31}P and ^{1}H spectra which was of great value in studies of stressed metabolism. Most of the experimental work presented was based on perfused organs or small animals — however, practical work on both ^{1}H and ^{13}C spectroscopy in humans was already in progress as was demonstrated in papers later on in the workshop.

The afternoon sessions consisted of reports, outlining practical clinical experience of approximately 500 MRS studies, from four centres with hospital-based installations. The work presented by Prof. E. Reynolds (UK), Dr. O. Henriksen (Denmark), Prof. G. Gademann (W. Germany) and Dr. J. Bittoun (France) was primarily ^{31}P MRS although Dr. Bittoun's group has been experimenting with water-suppressed ^{1}H spectroscopy using the ISIS localisation method on a 2.0 Tesla system. The consensus with regard to protocols for clinical MRS can be summarised as:

(1) the need for proton images to confirm the precise location of the volume of interest (VOI) during spectroscopy;
(2) the need to shim the magnet on every patient — if switching from proton to phosphorous both time and patient discomfort can be reduced by shimming on a PCr phantom first;
(3) careful determination of the index (e.g. PCr/Pi, pH etc.) to be measured and, if possible, correlated with other clinical parameters;
(4) involvement of clinical staff to ensure good experimental design and proper follow-up of patients.

The first day ended with a symposium dinner, held in the upper refectory of University College. Dinner was followed by an informal talk by Mr. G. Higson, Head of the Science and Technical Branch of the UK Department of Health and Social Security. The ensuing lively discussion considered whether funding in the UK should be spread between more centres rather than be targetted at a small number of specialist ones. However, because of the expense involved, broad funding is not likely to be justifiable at the present time.

A speaker from the floor commented that, after several years in the market, no company had yet made a profit from the manufacture of medical MR systems because of the large amounts of investment necessary to maintain continuous development of the systems, as demanded by end users. In his view, some users were more concerned with extricating as much as possible from the manufacturers in terms of system specifications than with developing and applying the systems themselves. He felt that the full potential of the machines currently available had not been exploited and that manufacturers could not implement every latest development prior to delivery.

The issue of the control and management of research-orientated MR installations was raised. It was generally agreed that MR required a multidisciplinary approach with physics, biochemisty and physiology working together to provide a facility run on a service basis to research groups.

The second day opened with three papers on spectroscopy methods. Dr. R. Gordon (UK) presented a good overview of the plethora of different localisation methods available for achieving *in-vivo* spectroscopy. Eighteen techniques were listed, from TMR through selective excitation sequences such as DRESS, SPARS and ISIS to full 4DFT. This talk was particularly useful in highlighting the need to define optimum localisation methods for clinical MRS, which should be supplied as standard on future commercial systems. There are considerable variations in the quality of spectra obtained by different localisation methods. Some display considerable sensitivity to factors such as RF pulse shape and gradient switching rise times. Others require high RF powers which limit their applicability in patient studies. Methods relying on subtraction of Fourier Transforms are subject to statistical variations which could result in the production of artefacts.

Dr. J. den Hollander (Netherlands) showed the results of using the SPARS localisation method to produce spatially resolved, water-suppressed ^{1}H spectra in patients. Measurements of Phospho-Choline, Creatine, N-Acetyl-Aspartate and lactate could be made within clinically acceptable time scales. This method was also used to obtain spectroscopically resolved T1 and T2 measurements in normal and cancerous tissues in patients with brain tumours. Early analysis of the data seemed to indicate that the method was more accurate and gave

more information about the state of individual tissues than assessment of T1 and T2 from conventional proton images. It was hoped that the work would help to resolve the problem of relating relaxation times to tissue pathology.

The session ended with a contribution from Dr. W. Aue (Switzerland) on ^{31}P and ^{13}C localised spectroscopy and emphasising chemical shift displacement which creates particular problems when using localisation methods dependant on field gradients. Giving the case of a 2 Tesla system and a field gradient of 10mT per metre, the chemical shift values represented by the frequency ranges of ^{1}H, ^{31}P and ^{13}C spectra were compared. Whereas for protons and phosphorus the chemical shifts were relatively small, the 200ppm frequency range of carbon could result in a chemical shift of up to 40mm. It was suggested that proton decoupling be employed in order to remove major chemical shifts, allowing an increase in sensitivity of a factor of four. Alternatively, if only a particular resonance was of clinical interest, then the spectral width could be limited to a small enough range to make chemical shift negligible.

Dr. P. Sadler (UK) opened the second session with a contribution on highfield spectroscopy of body fluid samples. The sharp resonances and negligible noise levels of the 500MHz spectra that were shown accentuated the gulf between *in-vivo* and *in-vitro* MRS. Most body fluids require no preparation for NMR spectroscopy except for the addition of a small amount of ammonium chloride to achieve water suppression. Proton exchange with the water broadens the signal so much that it is possible to eliminate the water signal on the basis of relaxation time. For most major metabolites, a good quality spectrum could be acquired in around five minutes giving significant advantages over routine clinical chemistry. Currently, NMR spectra could only be used to direct diagnostic investigation towards a specific test. A wide range of applications had been developed: glucose, acetoacetate and ketone products could be assessed from a single spectrum to help identify insulin withdrawal; fetal stress could be monitored by comparing levels of lactate and triglycerides from maternal and umbilical chord plasma samples; creatine levels in urine samples could be measured directly to determine kidney function. Alongside natural abundance spectroscopy, labelling with ^{2}H, ^{13}C, ^{15}N or ^{19}F could be used in a wide variety of metabolic and pharmacokinetic studies.

Dr. Sadler also discussed promising developments in para-magnetic and stable free radical contrast agents. Standard metal chelators, such as DTPA, whilst being effective for overcoming the toxicity of paramagnetic ions, had the disadvantage of limiting the range of interaction with water molecules. Chemical stability also posed problems as it was often the case that metals displaying good relaxation properties had only poor stability. An alternative was the use of polysaccharides, such as dextrose, amylose or cellulose, coupled via amine linkers to multiple chelated metal ion groups. Dextran molecules labelled with 130 Ga-DTPA units displayed excellent relaxation properties (reducing T1 for water from 3000ms to only 90ms) and good clearance *in vivo* (98% in 2 hours). The next step was to couple nitroxide free radicals to polysaccharides but the chemistry was not so straightforward. A final possibility being explored by Dr. Sadler's group was related to attempts to find a method of spin-labelling monoclonal anti-bodies. Several workers had been using chelated metals but it was difficult to attach sufficient groups to each antibody. Attention had now been turned to magnetite particles which exert considerable local fields over distances comparable with typical antibody dimensions.

The morning's proceedings ended with two linked papers on the subject of *in-vivo* magnetic susceptibility mapping. Dr. I. Young (UK) presented the technical aspects of the method and Dr. G. Bydder (UK) illustrated the application to clinical MR Imaging. One major source of the degradation of *in-vivo* spectra, as compared with *in-vitro* NMR, is the local variations in susceptibility, particulary around lesions where breakdown of blood has led to the accumulation of iron. These variations were of too high a spatial frequency to be shimmed out and could lead to splitting of lines, errors in chemical shift if PCr and Pi are in different compartments, failure of suppression sequences to work predictably and uniformly across the region of interest and difficulties in shimming because of significant line broadening. Mapping of these susceptibility inhomogeneities is achieved by subtracting data taken immediately after excitation (e.g. 20–30msec) from data acquired after a long delay (100–200msec) thus allowing the spins to develop in their local fields. In the resulting image, large scale effects are seen due to main-field inhomogeneities as well as local variations caused by such things as haematoma, air/tissue and bone/tissue boundaries. Several images of brain lesions were shown where the susceptibility images helped to define the lesion boundaries more clearly than the conventional image. At this stage it is not known whether this information can be used to improve spectra directly but it does aid our understanding of the scale of inhomogeneity effects in MRS experiments.

At the conference dinner, held at the Royal Zoological Society's headquarters in Regents Park, Prof. George du Boulay CBE was the guest speaker. The award of the 1987 European Workshop on Magnetic Resonance in Medicine was presented to Prof. John Mallard of the Department of Bio-Medical Physics and Bio-Engineering at the University of Aberdeen, Scotland, in recognition of the pioneering work on medical MR carried out by his group over many years. Prof. Mallard thanked the president of the European Workshop and said that he accepted the award on behalf of the very hard-working team of scientists, engineers and clinicians at Aberdeen. Prof. du Boulay gave an entertaining talk on the applications that had been found for medical physics in veterinary care of rare and exotic animals.

The final day's presentations looked at a variety of new techniques in MR which were relevant to spectroscopy. Dr. T. Brady (USA) covered the latest approaches to chemical shift imaging including the Dixon Method, which can achieve CSI images at field strengths below 0.1 Tesla. The method used the difference between the in-phase image (the sum of the water and fat signals) and the out-of-phase image (the difference between the fat and water signals). He advocated that the "fat fraction", as displayed in the out-of-phase image, gave better diagnostic information than images simply based on relaxation times. Since the method relied upon phase differences rather than gradients it is not affected by chemical shift problems. He also demonstrated how GRASS imaging could be used to generate fast CSI images because the relative phases of the fat and water signals altered with TE. Typical imaging times using this method were around 10 seconds. Extending the concept further to echo-planar imaging permitted lower resolution, single-shot fat and water images to be acquired in around 40 milliseconds.

Dr. W. Muller (W. Germany) gave a paper on relaxometry and commented that his research seemed far removed from the spectroscopy and imaging that had been covered in the workshop so far. Nevertheless, the need for a thorough understanding of the factors affecting measurements of T1 and T2 were crucial if standard protocols for their measurement *in-vivo* are to be developed. Relaxation rates displayed a strong dependance on temperature, viscosity, pH and field strength. Furthermore, the presence of contrast agents, for example Ga-DTPA or serum iron, altered the form of the field and pH dependance of the relaxation rates of the surrounding tissues thus complicating the picture even more. This shed light on the difficulties of defining standard techniques for T1 and T2 assessment. Despite such complexities, this behaviour could be exploited in a positive way, e.g. to measure the level of oxygenation in fluorinated blood substitutes by monitoring the chemical shifts induced by the presence of free radicals.

Microscopic imaging is still in its infancy, but already use is being made of the newer techniques developed for macroscopic MR. Dr. R. Ordidge et al. (UK) have been applying chemical shift selective pulse sequences, such as SPEAD, CHESS and Dixon, to overcome the problems of chemical shift and minimise acquisition times. After covering the theoretical aspects of microscopic MR, in particular the limitations imposed by statistical fluctuations of spin populations and diffusions of spins between voxels, some state-of-the-art images were presented to illustrate the application of these methods. With imaging resolutions between 1 and 5 micron in-plane, chemical shift between fat and water could be so large that the fat image was shifted completely out of the water image. This could be overcome by using CSI pulse sequences where echoes from fat and water are collected separately and then combined to yield a chemical shift free image. The technique had been used to study embryonic development in the locust egg. Early segmentation and limb development could be followed by sequential imaging. Furthermore, ISIS localisation had been used to obtain proton spectra from different regions within the egg. Although the results of microscopic imaging and spectroscopy were still crude by comparison to macroscopic MR, it would appear that it was only a matter of time before it became sufficiently refined to be applied to major studies of microscopic biological systems.

High speed imaging methods are very relevant to *in-vivo* spectroscopy which, until very recently, has been restrained by prohibitively long acquisition times. Dr. A. Haase (W. Germany) presented a brief overview of current fast imaging techniques and pointed out that it was possible to use the same methods to acquire spectral data at the expense of spatial information. For example, 3-D acquisition sequences could be used to produce spectroscopically resolved 2-D images with moderate spectral resolution. The same principle could be applied to acquire high resolution spectra with only one spatial dimension (e.g. depth-resolved spectroscopy) or 2D shift-correlated spectra from a single VOI. Dr. Haase stressed that fast sequences relying on low flip angles or reduced repetition times could lead to poor slice profiles thereby leading to artefacts. However, these sequences can be modified to restore the slice profile without sacrifice of speed. Care needed to be taken as more exacting pulse sequences

became available which were prone to small errors in timing and limits on gradient rise times.

The closing session of the workshop raised again the issue of justification of MR on the basis of cost versus clinical utility compared to existing diagnostic services. With spectroscopy now starting to make inroads into the clinical environment, the debate over optimum field strength continues. With a prototype 4 Tesla whole-body magnet already beginning evaluation and a 10 Tesla system being considered, there was an urgent need to demonstrate that such high-technology ventures were justifiable. It would be easy for opponents to argue that investment in super-high-field magnets was premature since the exploration of spectroscopy on existing systems was still in its early stages. The impact of the recent discovery of high-temperature superconductors on the cost of MR systems could be considerable but the technology required to produce these materials industrially could take a long time to develop. As was made clear at the symposium dinner, the research required to develop the full potential of clinical MR spectroscopy would be limited principally by the availability of funding.

The workshop proved to be lively, informative and challenging. Moreover, it was realistic and honest and should do much to ensure that MR development is pursued efficiently and does not lose sight of its primary objectives, namely, to advance our understanding of human physiology and disease and to improve healthcare in our hospitals and communities.

J. Dykes.

Lisbon — VIth European Congress of Radiology, June 1987

Two sessions at the Congress were arranged by EFOMP, with technical and financial assistance from the Congress organisers. EFOMP was particularly helped by Dr. Gomez da Silva, who was in charge of the physics programme.

The Role of the Physicist in Imaging Modalities

This session was chaired by Professor P. W. Horton. Several speakers described the role of the physicist in different areas of clinical physics. The speakers were Dr. A. Bauml (Diagnostic Radiology), Professor P. W. Horton (Nuclear Medicine), Dr. K. McCarty (Ultrasound) and Dr. R. A. Lerski (Nuclear Magnetic Resonance).

The general principles described were common to all the modalities and so are summarised here without distinction. The physicist should bring a broad based background in science and technology and needs to acquire the ability 'to speak the language of his clinical partners'. He can then fulfil roles as an adviser in equipment selection and installation; a colleague in equipment utilisation and management, with particular reference to Quality Assurance and maintenance; a participant in staff training programmes and can also pursue research and development objectives.

Radiation Protection of the Patient

The second EFOMP session, on the Radiation Protection of the Patient, was held during the period when diagnostic radiology papers were programmed. Most radiologists elected to attend parallel clinical sessions, in spite of the relevance of the topic. Dr. J. C. Rosenwald opened the session with a paper prepared by an EFOMP working group. He summarised the principles defined in ICRP 26. Assuming that a patient exposure is justified, a matter of informed clinical judgement, then in terms of patient protection the discussion centres on considerations of dose optimisation. In diagnostic exposures it is important to minimise the dose per image and the number of images. Good administrative procedures are needed so that radiographs can be exchanged between hospitals. Practitioners need to be diligent in minimising variables such as the number of projections used in examinations. Quality Assurance programmes, particularly for film processors, can significantly reduce the number of retakes. Quality Assurance and good practice also have a part to play in reducing the dose per image. Considerations of equipment suitability and clinical practice apply similarly in defining radiation protection goals in the fields of Nuclear Medicine and Radiotherapy.

There is much relevant published material on aspects of radiation protection of the patient. Until recently there had been relatively little progress in adopting, in legislation, the basic measures which would lead to an improved practical situation. In Europe in 1984 a directive 'laying down basic measures for the radiation protection of persons undergoing medical examinations or treatment' was issued by the Commission of the European Communities (CEC). This directive required member states, by 1st January 1986, to take proper actions to ensure that patient doses are justified and optimised.

EFOMP has been collecting information from its own member organisations, so extending beyond the CEC territories. Enquiries were first made in 1985 and again in 1987. A number of broad conclusions can be drawn:

1 All countries require that a physician must prescribe the use of ionising radiation for medical purposes. However, specific training in Diagnostic Radiology, Radiotherapy or Nuclear Medicine is not always required.

2 All countries have defined competent authorities and established criteria of acceptability for diagnostic radiology installations; most have also done this for radiotherapy installations. Such arrangements often do not apply to nuclear medicine installations though they are required in the CEC directive.

3 'Quality control of the appliances' is generally recommended but is required in only 50% of the countries responding. The requirement is most commonly for radiotherapy installations. Some requirements, apparently introduced in response to the directive, were reported from FRG (for Diagnostic Radiology) and Denmark (for Nuclear Medicine).

4 The directive states that 'a qualified expert in radiophysics shall be available to sophisticated departments of radiotherapy and nuclear medicine'. In practice such a requirement frequently exists for Radiotherapy, but not for Nuclear Medicine.

EFOMP fully acknowledges the need for a qualified expert. As well as fulfilling the role of scientific support there are growing needs in the education and training of medical and paramedical staff and for the promotion of Quality Assurance. **The Federation is publishing a policy document on the Training of the Medical Physicist as a Qualified Expert in Radiophysics.**

The session continued with a contribution from Dr. L. Gonzales, describing work in Spain to evaluate the radiation build up due to population exposure to radiological examinations, particularly chest radiographs. Four hospitals, with different patient workloads, will be assessment centres, providing data on a large number of exposure conditions. Thermoluminescent LiFl dosemeters are being used.

The paper presented by Dr. A. Kiuru, discussed the significance of shielding in X-ray examinations, giving particular attention to the methods by which scattered radiation in tissue can be minimised by good shielding techniques.

Miss K. Fisher presented details of the legislation, in response to the directive, introduced in the United Kingdom. The 'Ionising Radiation Regulations, 1985' were first passed, by Act of Parliament. To assist in the interpretation of this law an 'Approved Code of Practice' has been published by the Government. Practical guidance on the implementation of the law, including aspects of patient protection, will be published shortly in 'Notes for Guidance'. There has been substantial consultation with the professional bodies in drafting the documents. Miss Fisher pointed out that the role of the 'qualified expert' required in the directive is discharged by the Radiation Protection Adviser, defined in the Regulations and usually a medical physicist. Secondly she pointed out that the law places responsibility on the employer for providing suitable equipment installations and investigating any incidents which involve patient exposure at levels beyond those intended.

In summary, in the United Kingdom, radiological and therapeutic equipment is checked at installation time. Under active consideration are matters such as a national equipment inventory and the standardisation of diagnostic radiology procedures. Perhaps the most problematic area is that of on-going quality assurance. Medical physicists have done much work in this area. However, quality assurance work in diagnostic radiology is not yet a formal requirement. The EFOMP member medical physics organisations in Europe might usefully agree on practical quality assurance criteria to apply in the various areas of clinical physics.

The full proceedings of the Congress will be published by Elsevier Science Publishers.

The American Association of Physicists in Medicine

The American Association of Physicists in Medicine (AAPM) has created a new membership category for people resident outside the United States. The category is called 'Corresponding Member' and it does not carry either the right to vote or to hold office in the Association. For a fee of $35 a Corresponding Member will receive AAPM mailings, which include the Newsletter and Scientific AAPM Reports. For a fee of $60 the Journal 'Medical Physics' will also be included with the mailed material.

Eligibility and acceptance conditions for Corresponding Membership are the same as for Full Membership. Application forms and further details may be obtained from:

Elaine P. Osterman,
Executive Officer, AAPM,
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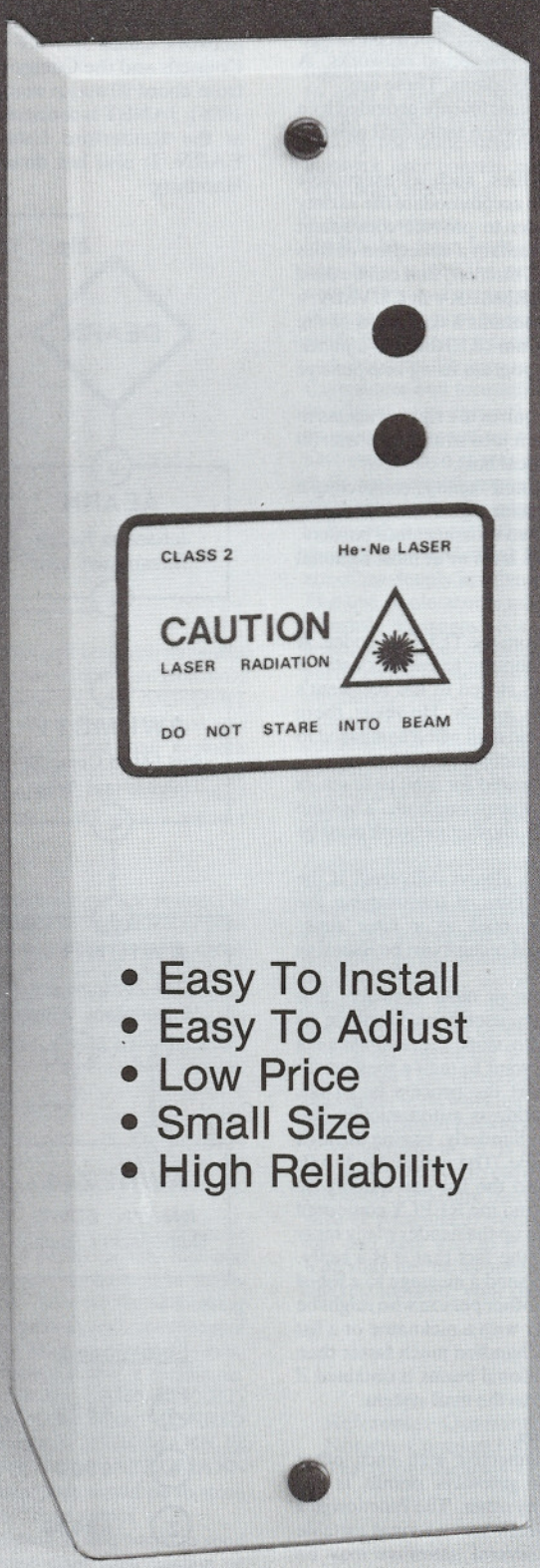

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Computer Networks and Electronic Mail

1. What is a computer network?

A computer network is a set of computers which are able to communicate with each other via common data transfer protocols. A variety of interconnection media are used including telephone lines, optical fibres, coaxial cables, and satellite links. The participating computers are the nodes of the network and can range in size from personal computers to supercomputers. Apart from hosting the individual users they connect physically to the other nodes of the network and, most importantly, run sophisticated communications software which makes electronic communication so easy to use. Local area networks (LANs) usually cover a distance of not more than several kilometres between the nodes. The major LANs usually, through gateways, give access to Wide Area Networks, which can span continents. Thus the potential for ready communication, in particular electronic mail, exists between all users of connected networks. A network provides several facilities to the participants. These are:

Electronic mail. Electronic Mail is the most basic feature provided by a network. It is used to exchange messages between individual users or groups of users.

File transfer. The transmission of binary files, such as executable programs, needs special transfer protocols to accommodate the variety of data formats in use. In addition, in order to provide convenient access, some hosts offer file servers which contain a collection of files (e.g. help files, data and programs of general interest) that can be used by all participants. A typical example is KERMSERV at CUVMA, a file server at Columbia University which contains a collection of the most recent versions of the KERMIT program (KERMIT is a public domain communications and file transfer program using inexpensive RS232 serial line connections).

Remote command execution. This facility requires the right of access to a remote host and is frequently used to submit jobs to a more powerful computer that are too big to be run on the local host.

Remote login. Although an easily implemented facility, connecting a user interactively to a remote host with similar rights as a local user raises legal and administrative problems when crossing state borders. Thus the facility is usually available only for local or at most national networks.

2. What is electronic mail?

In principle electronic mail does not differ from the TELEX service. A message is sent by a user of the local host computer to another user, at the same or a remote host. The message is stored in the recipient's computer waiting for retrieval and, possibly, a reply. However, there are several significant advantages of electronic mail when compared to the more conventional methods of communication:

— Electronic mail is very fast. The time required for mail to reach its recipient computer ranges from minutes to at most one hour. The time does not increase significantly if a gateway to another network must be used.

— In contrast to a telephone call the mail is always delivered. If the recipient's computer is not on line at the time of transmission the communication program will deliver the mail at a later time. Optionally in some networks a notification of receipt can be issued as soon as the mail is inspected.

— The mail programme (mailer) available in most networks is a sophisticated software package with a very user friendly mode of operation. Facilities are usually available to store the address of a person under a nickname. If for example I want to mail a message to Trevor C. in Canada the command to start the process is: MAIL TREVOR. This sets up the correct full address automatically and leaves me to type in the text of the message. Similarly, paging through new incoming mail is made very comfortable. The command MAIL displays a list of the new mail received and the list can quickly be inspected using cursor and function keys. I find the REPLY command particularly convenient. It automatically sets up the header of my reply to a letter, even indicating in my message the fact that it is a reply. Further useful features are the possibility to send a message to a list of people or to directly pass on a message to another person who might be interested, using simple commands together with a nickname or a list of nicknames. These aids enable mail to be handled much faster than with ordinary secretarial facilities. An additional bonus is obtained if the secretary's word-processor is connected to the mail system.

3. Existing major non-profit network facilities

All those networks named below are connected with each other via gateways. The minimum service the gateways permit is the transmission of mail from any network to any other. The function of a gateway is to transform data from one network into a format suitable for transmission in the other network. Several gateways may be required before the mail is delivered to the final destination.

The most important network connecting universities in continental Europe is EARN (European Academic Research Network). EARN makes use of the RSCS (Remote Spooling and Communication Subsystem) software package developed for IBM mainframes. Many computer systems from other companies, such as DIGITAL's VAXes, are included in the network. EARN is directly linked, i.e. without the need for a gateway, to BITNET in the United States, to NETNORTH in Canada and to ASIANET in Asia. These networks have different names for geo-political reasons but are essentially one network. BITNET is tree structured, with each country as a branch. In continental Europe, access to a country is made through the EARN country node (Fig. 1), which operates the NETSERV file server and performs administrative responsibilities such as updating country specific files. At present 25 countries with 1692 hosts are connected to the BITNET network family (Table 1). No estimates for the number of users are available but many of the hosts have of the order of 100 or more users. The UK, in the early 1970's, established a national network called JANET (Joint Academic Network of the Research Councils and the Computer Board). JANET connects some 400 hosts from about 90 major academic and research sites in the UK (as of May 1986). JANET is connected to the BITNET community, via a gateway at the Rutherford Laboratories, enabling exchange of mail with EARN. It also has direct links to CERN in Geneva and DESY in Hamburg.

Fig. 1. The EARN network in Austria.

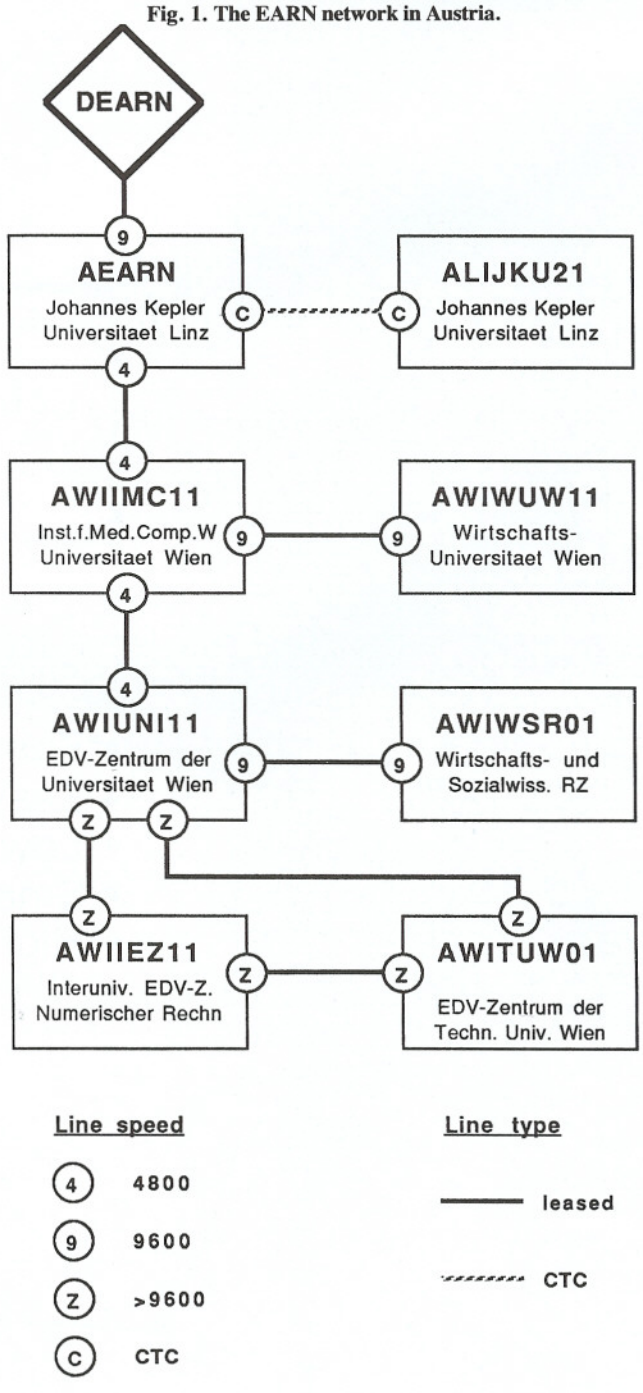

Table 1. BITNET Hosts as of January 12, 1987

Country	Abbreviation	Number of Hosts	Network
U.S.A.	USA	1059	BITNET
Mexico	MEX	1	
Canada	CAN	127	NETNORTH
North America total	3	1187	
Japan	JPN	15	ASIANET
Singapore	SGP	1	
Asia total	2	16	
Austria	A	8	EARN
Belgium	B	18	
Denmark	DK	16	
Finland	SF	9	
France	F	62	
Germany	D	156	
Greece	GR	2	
Iceland	IS	1	
Ireland	IRL	3	
Israel	IL	46	
Italy	I	42	
Luxembourg	L	1	
Netherlands	NL	51	
Norway	N	4	
Portugal	P	1	
Spain	E	11	
Sweden	S	17	
Switzerland	CH	32	
Turkey	TR	7	
United Kingdom	GB	2	
Europe total	20	489	
All hosts		1692	

ARPANET and CSNET are the most important research networks in the U.S.A. CSNET is dedicated to computer science and primarily supports mail. The design was based on experience with ARPANET which showed that the mailing facility of the network service was appreciated most highly. UUCP is an international mail network mainly for machines running the UNIX operating system. The number of connected hosts is estimated to be around 10,000. Many other research, company and commercial networks exist which are not mentioned here because of lack of space.

4. Using a network

The first step in getting into the electronic mail business is to connect to a network. Medical Physics departments usually are regarded as non-profit institutions and should therefore have no difficulty in obtaining permission to connect to a suitable host. The costs arising for network use can be divided between those for the connection to the local host and those made for using the network. Academic institutions usually connect to a university computer free of charge, the only costs possibly involved are those for the operation of the transmission line. Charges for the network use are made on the basis of the amount of data transferred and are typically of the order of the fees of ordinary mail. However, network charges are often taken care of by a central research funding authority and may not show up explicitly at the departmental level so that electronic mail may appear to be free for practical purposes.

The next stop is to actually establish contacts. The first exercises in electronic communication are supported by a wealth of help files and other information available from the different file servers at major nodes. As long as one stays within the "home" network the addressing scheme to contact another user is well standardised, well documented and easy to use. Full addresses are rarely used in practical work, repeatedly contacted persons are always stored under a nickname. Even a full address is simply structured. For the EARN-BITNET-NETNORTH network family it is composed of two fields: "USERID NODEID". My EARN-address, for example is BERGMANN @ AWIIMC11 or, equivalently recognized by the mailer, BERGMANN AT AWIIMC11. The initial task for a counterpart would be to store this address under a suitable nickname in his file of names.

Matters become slightly more difficult as soon as one wants to send mail to users in other networks. The address must then contain an identification field for the target network and may also have a format different from the addressing conventions in the home network. In general however the basic addressing scheme for any network is a structure consisting of "userid @ nodeid. networkid". Frequently the nodeid is also structured using the domain and subdomain principle. Since the naming habits of computer people are surprisingly predictable, e.g. the machine in a department of computer science invariably gets the nodeid "CS", some further distinction must be made. This is done by using geographical or otherwise unique domain names which are appended to the nodeid. The best ways to obtain the correct address of a person in another network are either to ask a knowledgeable friend or to consult the various help files specifically dealing with naming conventions in different networks.

The message must then be sent through a gateway. The mailer program is usually sophisticated enough to automatically route the message to the appropriate gateway and perform the necessary transformations of the data, particularly of the header and trailer of the message. If the mailer cannot handle the address, the user must put together header and trailer suitable for the target network manually. In such a situation some more test runs are required until the mail works, since it is difficult to find an expert who already has explored exactly the same situation. But again, the help files available to the network user contain much information about how to communicate with other networks.

5. Future aspects

EARN has been built up in Europe during the past few years. Most sites have joined the network within the past 2 years. It is a relatively new facility and many people may not yet be aware that a large number of people can now be accessed by electronic mail. Medical Physics can profit from the new facility in a variety of ways.

A Medical Physics unit is ideally suited to connect to a network. Computers and terminals are usually available in sufficient quantities and local area networks are already used in many places, enabling economic connections to a host computer. When our connection was first established it was not long before the mail service was used to exchange scientific papers or to discuss draft programmes for meetings with colleagues far away, even on the other side of the Atlantic. I believe that several other very fruitful applications can be found useful specifically in Medical Physics. For example medical physics people are often deeply involved in working with standardisation committees. The use of electronic mail, in particular the facility to simultaneously transmit messages to a group of people, could help speed up the lengthy process of finding agreements, familiar to anyone having participated in such work. Secondly, many tasks in Medical Physics are intimately connected with computing. The exchange of specialised programs, e.g. in therapy planning or nuclear medicine, by the conventional means of data transport using magnetic media has proved notoriously difficult. After the initial disappointment a series of phone calls or the shipment of missing program parts may require so much time that the program may never actually be made to run, leaving frustrated people on both sides of the exchange. Also, in Europe, state borders and customs regulations still present barriers for the shipment of magnetic media which obviously do not exist for electronic communication. Electronic mail may well set the stage for more rewarding and effective exchange of programs. This may lead to progress in the standardisation of applications software in fields of Medical Physics, as an important contribution to improving the homogeneity and thus the quality of our services. Incidentally, a European project dealing with "Standardisation and Quality Control of Nuclear Medicine Software" which is about to be accepted by the European Communities as a joint European project has, among the first items in its working programme, the task of establishing electronic communication between the collaborating institutions.

In conclusion, it is certainly worthwhile for all of us, not only computer freaks, to participate in electronic communication as soon as possible. There are many possibilities still to be explored. I agree fully with G. Maguire Jr's outlook on the future: "Using electronic mail is a fun and easy way to communicate with your friends and colleagues. You may not be as familiar with it yet as you are with your telephone, but rest assured, your children will be."

Reference: Quarterman J.S., Hoskins J.C:
Notable Computer Networks, Comm ACM 29 (1986) 932–971.
This paper includes 92 further references.

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Clinical Physics and Physiological Measurement

Enquiries about subscriptions to Clinical Physics and Physiological Measurement should be made to Mr. K. Carley, General Secretary, Institute of Physical Sciences in Medicine, 2 Low Ousegate, York, YO1 1QU, U.K.

Volume 8, Number 2, May 1987

Papers

A comparison of oto-acoustic emissions and brain stem electric response audiometry in the normal newborn and babies admitted to a special care baby unit *J C Stevens, H D Webb, M F Smith, J T Buffin and H Ruddy*

Radiographic image analysis in the study of bone morphology *M A Browne, P A Gaydecki, R F Gough, D M Grennan, S I Khalil and H Mamtora*

Continuous 24 hour ambulatory monitoring of intragastric pH in man *B K Kapur, P J Howlett, N G Kenyon, M J Lunt, J G Mills, R H Smallwood, A J Wilson and K D Bardhan*

The use of ground reaction measuring shoes in gait evaluation *M Kljajic and J Krajnik*

The effect of fat on bone mineral measurements in normal subjects with recommended values of bone, muscle and fat attenuation coefficients *C E Webber*

Critical analysis of the accuracy of a combined test (^{75}Se-HCAT and ^{58}Co-B_{12}) of ileal function using a whole-body counter *T Smith, I Bjarnason, and R Hesp*

A simple blood sample method for measuring oral zinc absorption in clinical practice *W S Watson, K G Mitchell, T D B Lyon, M I F Bethel and G P Cream*

Short communication

Laser Doppler assessment of skin blood flow in arteriopathic limbs *P I M Allen and M Goldman*

Book reviews

Physics in medical ultrasound. Quality assurance in medical imaging. Electrogastrography: methodology, validation and application. Physiology and the scientific method: the design of experiments in physiology. Cardiopulmonary bypass: principles and management. Radionuclide imaging in medicine: theory and practice.

Abstracts of proceedings: Radionuclide investigations of the lung.

Forthcoming events

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Review article

Physics and physiology in the hyperbaric environment *V Flook*

Papers

Comparison of laser Doppler and Doppler ultrasound in lower limb vascular diagnosis *T Cochrane, T Fail and S B Sherriff*

The pattern of distribution of blood flow in dog limb bones measured using microspheres *P Tothill, G Hooper, I D McCarthy and S P F Hughes*

Clinical comparison of one *in vitro* and three in-line blood gas Po_2 sensors during cardiopulmonary bypass *S J Poslad, D T Pearson and A Murray*

A simple and accurate automated system for continuous long-term metabolic studies during artificial ventilation *H Stam, B van den Berg, J M Bogaard and A Versprille*

Body Composition of fasting obese patients measured by *in vivo* neutron activation analysis and isotopic dilution *R A Siwek, J K Wales, R Swaminathan, L Burkinshaw and C B Oxby*

Letters to the Editor

Accuracy of bone blood flow measurement
Comment *P Tothill*
Reply *R Wootton*

Book reviews

Electronic speech recognition: techniques; technology and applications. Measurement in physical therapy. Echocardiographic diagnosis of cardiac malformations. Electrosurgery. Nuclear magnetic resonance spectroscopy.

Forthcoming events

Physics in Medicine and Biology

"PMB" first appeared in July 1956 as the official journal of the Hospital Physicists' Association. Over the succeeding 31 years it has been officially recognised not only by British hospital physicists but by other associations including German (DGMP), European (EFOMP) and indeed international (IOMP) organisations. Through EFOMP, PMB now has official status in 22 European countries. In fact, it is an international journal, both as regards readership and authorship. During 1986, the geographical distribution of first authors was as follows:-

United Kingdom	29%
West Germany	15%
Rest of Europe	14%
United States	21%
Canada	9%
Rest of World	12%
	100%

It is noteworthy that 58% of all published articles were written by Europeans, the number being equally divided between British and other European authors.

As regards its field of interest, PMB has consistently tried to represent the whole range of physics applied to medicine and biology under two main headings:

(a) study of the physical properties of living matter;
(b) actual or potential application of physical methods in medicine or in biological science.

No attempt has been made to define our scope more rigorously. Consequently, we have been able to respond positively to scientific advance. For example, the early emphasis was on radiation physics and physiological measurement techniques. Over the years the outstanding trend has been the dynamic growth of papers on all aspects of image science, which now includes a quarter of all published papers. Recent articles on body composition, electromagnetic properties of the tissues, hyperthermia, lasers and biomagnetism all represent other activities by physicists and their colleagues which were almost non-existent 30 years ago.

However, for many hospital physicists the safe, accurate and effective use of ionising radiation remains their chief raison d'etre. In radiotherapy, radiology and nuclear medicine physicists and engineers continue to build on firm physical foundations. The Editorial Board of PMB adheres to its policy of reflecting all these activities in the traditional branches of medical physics as well as in newer domains. Papers on radiation topics continue to be welcomed providing that the emphasis is on physical aspects, whether theoretical, experimental or instrumental. Articles which deal with matters of direct clinical application should be directed either to the sister journal, CPPM, or to one of the specialist clinical journals.

Sometimes, the work of a practising medical physicist may merit general dissemination and discussion, even though it may not amount to a well-rounded scientific project. For this purpose we welcome *Letters to the Editor* and *Preliminary Communications,* for which accelerated publication is usually possible. This possibility is especially valuable for the reporting of early results and for critical comment on other published work. Alternatively, short articles may take the form of *Technical, Instrumental* or *Scientific Notes*, which differ from full-length articles only in their concentration on one specific topic.

Most of the material published by PMB consists of original *Scientific Papers*, averaging about 10 pages in length. These are seen by two referees, who advise the Editor on their scientific and presentational standard and on their general suitability to the interests of PMB readers. Inevitably, the maintenance of high scientific quality demands somewhat longer publication times than for Letters and Preliminary Communications.

When writing up their work and submitting it for publication, authors should consider the various formats mentioned above (and listed inside the back cover of each issue of PMB). Attention is particularly drawn to the speed of publication offered by short letters and preliminary communications.

Readers will be aware of the concessionary subscription rates offered to members of organisations affiliated to EFOMP. Will they please also remember the scientific and economic advantages arising from wide availability of PMB in libraries.

M. J. Day, Honorary Editor, PMB

Forthcoming Meetings

International Symposium on the Technologies for Optoelectronics — (SPIE and ANRT).
16–20 November, 1987, Cannes, France.
ANRT, 16, Avenue Bugeaud, 75116 Paris, FRANCE.

Medical Imaging and Expert Systems Applied to Medicine.
10–12 March, 1988, Lyon, France.
Package; Les Entretiens de Lyon, 55, montée de Choulans, 69323 Lyon Cedex 05, FRANCE.

North Sea Conference — Biomedical Engineering: 'Advances in Rehabilitation Technology'. — (A Regional meeting of IFMBE).
12–15 April, 1988, Masstricht, The Netherlands.
Dr. Th. Gerritsen, Institute for Rehabilitation Research, Zandbergsweg 111, 6432 CC Hoensbroek, THE NETHERLANDS.

Osteoporosis and Bone Mineral Measurement — (IPSM).
18–19 April, 1988, Bath, United Kingdom.
F. J. Ring, Royal National Hospital for Rheumatic Diseases, Bath, BA1 1RL, UNITED KINGDOM.

Vth Symposium: 'Clinical Radiation Physics' with international participation and with EFOMP.
25–28 April, 1988, Neubrandenburg, GDR.
Sekretariat der Gesselschaft fur physikalishche und mathematische Biologie der DDR, Am Kupfergraben 7, Berlin, DDR-1080.

XXVII Congrès de la Société Française des Physiciens d'Hôpital.
9–11 June, 1988, Clermont-Ferrand, France.
Secrétariat du XXVII Congrès SFPH, Service de Radiothérapie, Centre Jean Perrin, B.P. 392, 63011 Clermont-Ferrand Cedex, FRANCE.

Second European Congress of NMR in Medicine and Biology.
23–25 June, 1988, Berlin, FRG.
Dr. C. D. Claussen, Radiologische Klinik und Poliklinik, Klinikum Charlottenburg, Freie Universität Berlin, Spandauer Damm, 130 D-1000 Berlin 19, FRG.

World Congress on Medical Physics and Biomedical Engineering.
6–12 August, 1988, San Antonio, USA.
Dr. David T. Kopp, Secretary General — WCMPBE, Department of Radiology, UTHSCSA, 7703 Floyd Curl Dr., San Antonio, Texas 78284, USA.

5th International Selectron Users' Meeting and Brachytherapy Working Conference.
1–3 September, 1988, The Hague, The Netherlands.
Dr. H. Bartelink, Radiotherapy Department, Netherlands Cancer Institute, Antoni van Leeuwenhoekhuis, Plesmanlaan 121, 1066 CX Amsterdam, THE NETHERLANDS.

Clinical Applications of Biomechanics — (BES).
7–9 Septembeu, 1988, Salford, United Kingdom.
The Secretary, Biological Engineering Society, Royal College of Surgeons, 35, Lincolns Inn Fields, London, WC2A 3PN, UNITED KINGDOM.

Recent Advances in Medical Imaging — (IPSM).
12–16 September, 1988, Bath, United Kingdom.
F. J. Ring, Royal National Hospital for Rheumatic Diseases, Bath, BA1 1RL, UNITED KINGDOM.

5th National Conference of Biomedical Physics and Engineering with International Participation.
15–17 October, 1988, Sofia, Bulgaria.
Assoc. Prof. M. Markov, Department of Biophysics, Biological Faculty, Sofia University, 8, Dragan Tzankov Blvd., Sofia 1000, BULGARIA.

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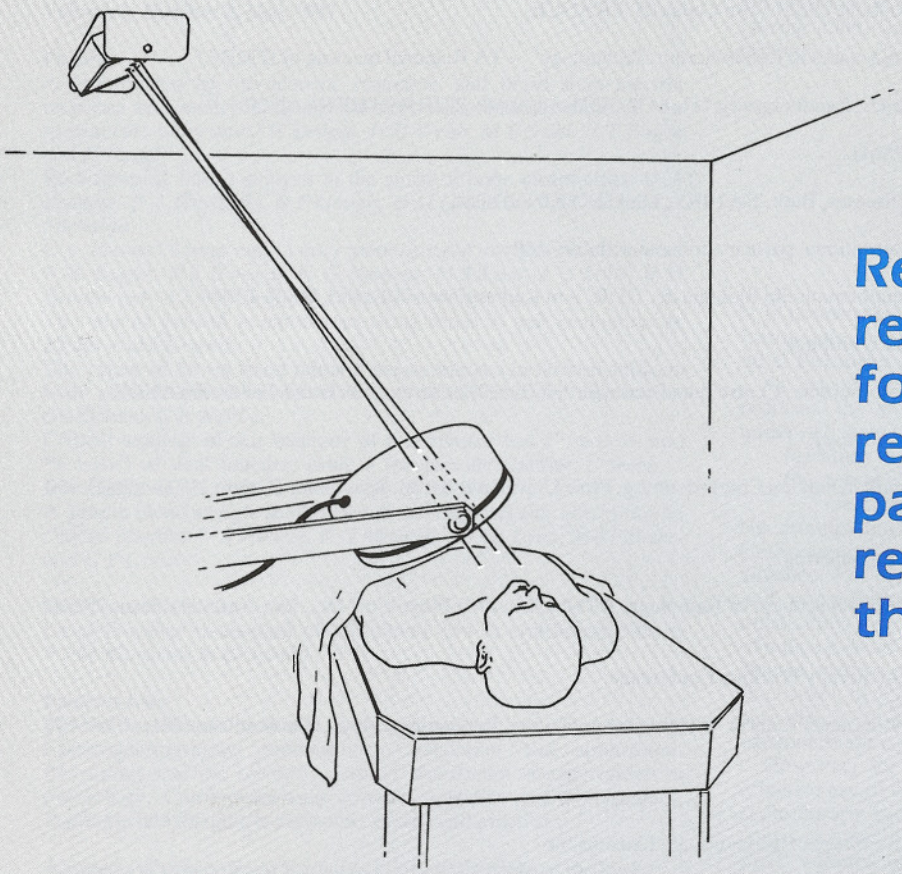

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