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Medical Physics World

Bulletin of the International Organization for Medical Physics

38 Adhering National Organizations 1989

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President's Message

It's the end of the year and the end of the decade. This is a time for looking back and remembering and looking ahead and resolving. The decade has been busy, it was our third one of existence, for the IOMP was established in 1962.

It might be useful, at this time of reflection, to review the aims and functions of the organization and see how our record of this decade rates. Overall, of course, it is our aim to contribute to the advancement of medical physics in all of its aspects and this must include both scientific and professional contexts. As part of this we try to promote communication between all branches of medical physics and applied subjects. It is one of our main functions to encourage the formation of national organizations of medical physics and to induce them to join the IOMP. In this we have been reasonably successful. In this decade at least eleven new organizations were admitted; Australia, Colombia, Cyprus, Hong Kong, Malaysia, New Zealand, Nigeria, Peoples Republic of China, Republic of the Philippines, Sri Lanka and Turkey. That's eleven out of a total of thirty-eight and it's not bad for a third decade. It is also one of our general aims to promote international co-operation in medical physics in any way we can. One of these is the sponsorship of regional meetings and training courses and a number of these were held. We have affiliations with the European Federation of Organizations for Medical Physics and the Association Latinoamericane de Fisica Medica. We also have a small number of committees that promote specific concerns, such as medical physics education. Perhaps our greatest function is the promotion and organization of the International Conferences. There were three of these in this decade. They were in Hamburg, Germany, Espoo, Finland and San Antonio, USA. Although three is our most common number of meetings in a decade, these were all combined with the International Federation for Medical and Biological Engineering and were therefore large ones.

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Communication between medical physicists has also been improved considerably in the past few years with the advent of our official bulletin, **Medical Physics World,** which is sent free-of-charge to physicists in over 50 countries.

We also revised our Statutes at our last meeting in an effort to bring them more into line with membership and function requirements as they have evolved over the time of our existence.

It is not possible to look ahead for a decade. We have two meetings planned and that is as far ahead as these are currently arranged. They are to be in Kyoto, Japan in 1991 and in Rio de Janeiro, Brazil in 1994. It is still hoped that the planned regional meeting in China will go ahead this coming spring. With the rapidity of change that has been occurring in Eastern Europe, just the latter part of this year, it would be fairly safe to predict an increase of our activities and assistance to our medical physics colleagues in that part of the world. In many ways the next decade promises to be an interesting one.

J. R. Cunningham
President
IOMP

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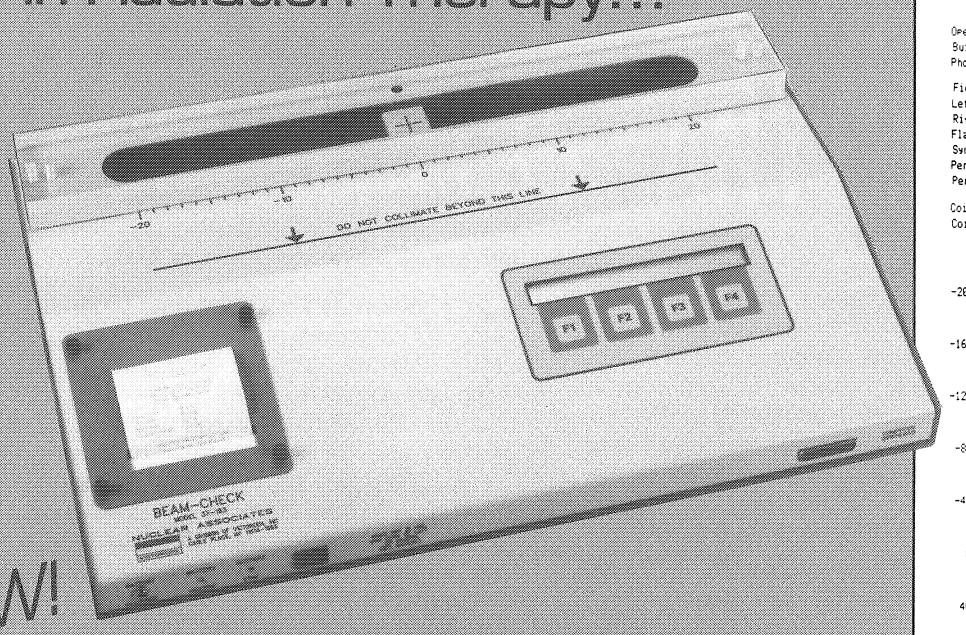

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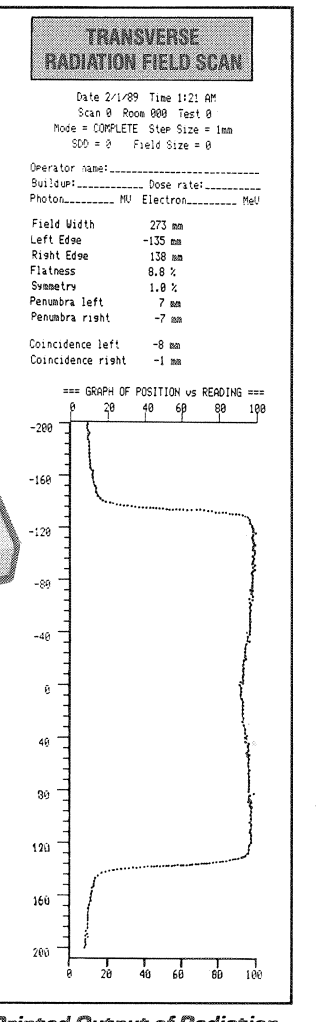

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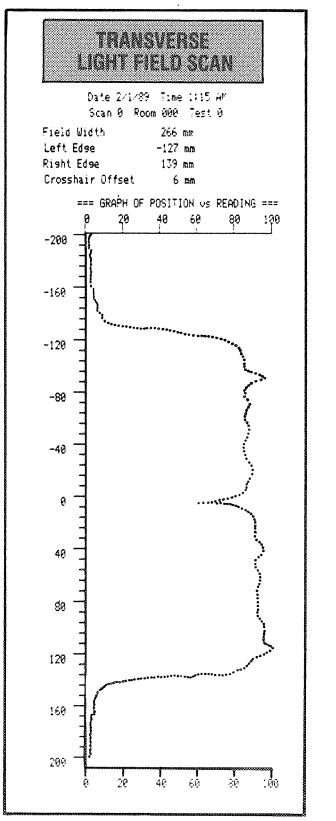

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Secretary-General's Report

New Members

Let me first welcome our two new members, the **Cyprus Association of Medical Physics and Bio-Medical Engineering**, and the **Medical Physics Association of Turkey**. This brings our membership up to 38 national organizations, with several applications pending.

Quality Assurance Articles

This issue of **Medical Physics World** contains the first two of the series of quality assurance articles developed by our Education and Training Committee (pages 6-12 and 16-20). This series of articles (see MPW Vol. 5, No. 1, page 8) will be published in successive issues of **Medical Physics World**. We also plan to publish all these articles together in book form, using the same printing company as **Medical Physics World**, thus avoiding any additional typesetting costs and keeping the price of the book to a minimum. I will be announcing the availability of this, our first official IOMP book, sometime within the next year. Proceeds from sales of this and future books are planned to go towards our developing countries activities.

Support for Developing Countries

As you will see from Prof. Xie's letter elsewhere in this issue (page 26), our Developing Countries Committee is planning an extensive program of support for the future. Of special interest is an agreement from the Officers for the IOMP to provide a $5,000 US budget for 1990 to initiate this Libraries program. In response to my last Secretary-General's Report (MPW Vol. 5, No. 1, page 6), requests have been received to establish libraries in several developing countries, utilizing books and periodicals primarily donated by members. The $5,000 US will be used to pay costs of transportation, etc. Due to the demand, we do not have enough publications to fulfill the needs of all our developing countries, so **I urge anyone who is able to donate books or sets of journals to this worthy cause, to contact me immediately.** I intend to provide a plaque to each of the libraries to indicate the principal donors, so your generosity will not go unrecognized.

In addition to this libraries program, the IOMP is planning extensive support for medical physicists from developing countries to attend the 1991 International Congress in Kyoto. This support will derive primarily through our Corporate Members dues program, and already one of our Corporate Members (Nucletron Trading BV) has provided additional funding for such travel grants. **Any member who needs financial support to attend the 1991 Congress (or other appropriate meeting) should write to me now for an application form.** These grants are clearly limited and will be awarded by the Developing Countries Committee on a competitive basis. The deadline for submission of a formal application is October 1, 1990.

With best wishes.

Colin G. Orton, Ph.D.

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Quality Assurance of Linear Accelerators

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I. Introduction

The role of quality assurance in radiation oncology is rightfully receiving increasing attention as it is realized that the consistent accuracy of dose delivery in radiation therapy is highly important. Sources of error in radiation therapy may derive from deficiencies in tumor localization, patient immobilization, field placement, daily patient set-up and dose calculation as well as from equipment-related problems.

Many of the equipment and calculation errors can be minimized through a program of periodic checks. Obviously, a comprehensive quality assurance (QA) program in radiation therapy has both clinical and physical components but, because this article deals with linear accelerators, only the physical aspects will be addressed here.

Quality assurance in radiation oncology may be defined as those procedures that ensure a consistent and safe fulfillment of the dose prescription to the target volume, with minimal dose to normal tissues and minimal exposure to personnel.[1] Because good quality assurance is not an independent program within a radiation oncology department, its relationship to other areas that affect dose accuracy will be discussed first. Indeed, no clear line exists between these programs and quality assurance and where the individual institutions choose to separate them will depend upon the local circumstances. Fortunately, many excellent guidelines exist for establishing QA programs, including: (1) the American College of Medical Physics (ACMP) Report No. 2 on Radiation Control and Quality Assurance in Radiation Oncology: A Suggested Protocol,[2] and (2) the American Association of Physicists in Medicine (AAPM) Report No. 13 in Physical Aspects of Quality Assurance in Radiation Therapy.[1] Additional reading suggestions that can be of help will be listed at the end of the article.

II. Overall Accuracy Consideration in Radiation Oncology

Because of the steepness of the dose response curve both for cure and complication, ICRU 24[3] recommends that the accuracy in delivery of dose to the target volume should be 5% for photon therapy. By analyzing more recent data, Johansson[4] arrived at the same conclusion for electron as well as photon therapy.

Listed below, in the chronological order in which the related activities are performed, are the three main areas for sources in inaccuracy in dose delivery:

1) Physical dosimetry, i.e., the commissioning and calibration of the treatment machine.
2) Clinical dosimetry, i.e., the delineation of the target volume and acquisition of patient specific factors.
3) Daily patient treatment, i.e., the setup of the patient and the recording of the treatment.

Once the acceptance tests, commissioning measurements and calibrations of a linear accelerator have been completed, a QA program must commence to insure that the accuracy of radiation treatments is maintained.

III. Quality Assurance Program for Linear Accelerators

The most significant factors affecting the ability to deliver the correct tumor dose include: exact dose calibration, accurately determined depth dose, off-axis dose characteristics, wedge and block factors, etc., that will be obtained during commissioning of a linear accelerator. In addition, certain other data will be obtained during acceptance test for such machines, including measurements of the mechanical, radiation-beam and radiation protection specifications. A good QA program will, therefore, monitor each of these parameters in order to ensure that the machine is performing within specifications and that the dose is being accurately delivered. The protocol for these QA tests should recommend the equipment to be used, the frequency of measurement, the techniques to be followed, and suggested performance criteria. Obviously the equipment and techniques should be as simple as possible in order to reduce the time, effort and cost of such tests. The frequency is chosen depending upon the likelihood of a change and the effect upon treatment if a change should unexpectedly occur. Finally, action and notification levels must be established.

One of the best QA programs is described in the Handbook of Radiation Therapy Physics by John L. Horton.[5] A compilation of the daily, weekly, monthly and annual QA checks recommended by Horton, the ACMP and AAPM, is given in Table I. Some of these checks are explained below. It should be pointed out that some flexibility should be applied to this table. For example, Horton recommends that most of the tests, listed in the table as annual checks, be done quarterly (i.e., every 3 months). A policy for the precise frequency at which each test is done should be developed at each institution. This table should be considered, therefore, only as a recommendation of a reasonable QA program.

A. Daily Tests

It is advisable to do a number of tests daily, including checking various gauges as specified by the manufacturer, the accuracy of the optical distance

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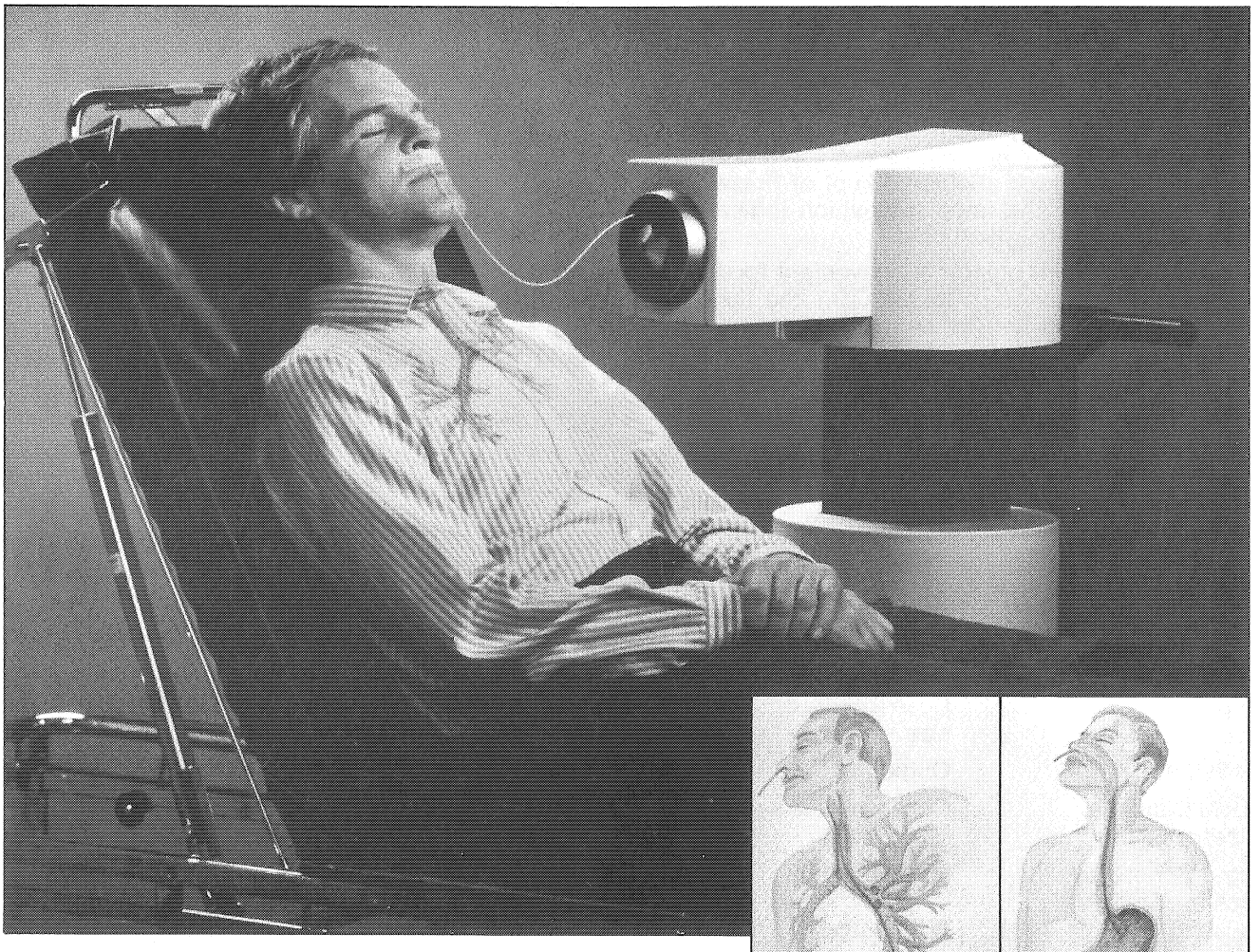
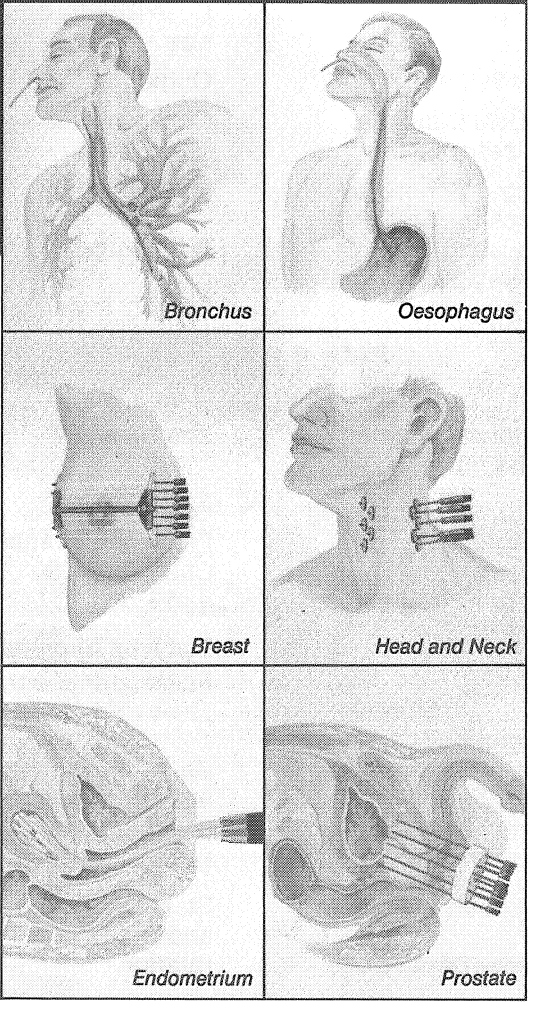
OUTPATIENT BRACHYTHERAPY TREATMENT





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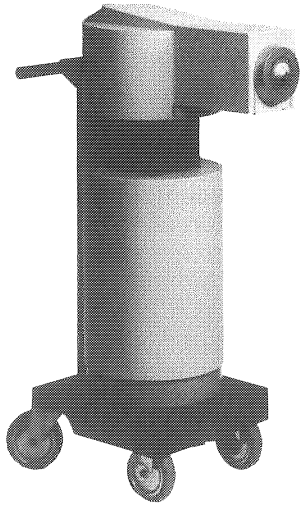

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indicator, the alignment of the sidelights and the radiation output. All but the output check can be done during the initial warm-up period. The output check should only take an additional 10 to 15 minutes.

The operator's manual will list the gauges that should be read daily. If the readings fall outside the ranges specified, it may indicate problems with the accelerator. A log-book should be kept of these daily readings, including the lamp test which indicates if all indicator lights are operational.

A mechanical front pointer is convenient for checking the optical distance indicator (ODI) and the sidelights. The table-top can be raised to the isocenter, determined by this pointer, and the ODI read on a piece of white paper, placed on the table. If there are laser sidelights aligned with the isocenter the light beams will be intercepted by the table-top. All measurements should line up to within 2mm; if they are off more than 5mm, adjustments should be made immediately. The vertical line of the sidelights, if present, should pass through the central axis of the beam. If a small white card is held in the beam at 45° to the central axis, the vertical laser line should coinside with the image of the cross hair. A similar test can be used for a sagittal laser.

TABLE I
DAILY, WEEKLY, MONTHLY AND ANNUAL QUALITY ASSURANCE CHECKS

Daily	Annually
Gauges	**Calibration at one gantry angle**
Interlocks	% Depth-dose for several field sizes
Lamp Tests	Dose-rate for one field size
Sidelights	Output factors
Optical Distance Indicator (ODI)	Check inverse square law
Output Constancy check for fixed beam and arc where applicable	Wedge factors
	Tray factors
	Monitor linearity and end effects
Weekly	Flatness/symmetry in water for several field sizes and with film
Flatness/Symmetry with Film	
Light-Radiation Field Congruence	Output check and Flatness/Symmetry Check at 0°, 90°, 180° and 270°
Cross-Hair Alignment	**Machine Alignment**
	Focal spot position
Monthly	Jaw symmetry
Emergency Off Switches and Interlocks	Definition of isocenter by intersection of axes of collimator, gantry and couch
Gantry and Collimator Angle Indicators	Stability of gantry arm and bearing under rotation
Field Size Indicators	Couch rotation and table top sag
Energy/Depth-Dose	
Mechanical Distance Indicator	

Output is best checked using a simple cubic plastic phantom, 15 cm on each side with a hole 5 cm from one surface that can accommodate the ion chamber to be used for the test. A Victoreen R-Meter ion chamber is quite suitable but other types of ion chambers can be used. With the front face of the block at isocenter and a 10 x 10 cm field, an exposure is made to yield a reading of approximately mid-scale. The reading should be corrected for temperature and pressure and compared to the value established at the time of the last complete calibration. The output should be within 3% of the reference value. If arc rotation is used, a similar test can be designed to check the output during rotation.

B. Weekly Tests

Flatness and symmetry, and light-radiation field congruence should be tested weekly. Flatness and symmetry can be verified with a film in a plastic phantom, at dmax for electrons and 5 cm for photons. The film is perpendicular to the beam central axis for a 30 cm x 30 cm field. Flatness and symmetry measurements can be compared to the values obtained at the last full calibration. Film is also used to test the congruence of the radiation and light field. The film is placed perpendicular to the beam at the isocenter with the localizer light on. Before the film is exposed, the corners of the light field are marked with pin pricks. A marker such as a pin prick on the right-hand side of the center of the field, outside the light field, can also be made to help with orientation. The difference between the edges of the light and radiation fields can be checked on this film.

The alignment of the intersection of the cross-hairs with the center of the radiation field can also be made at this time. Set the film at the isocenter perpendicular to the beam, mark the intersection of the cross-hairs with a pin-prick. As the collimator is rotated, the relative motion of the cross-hairs around the pin-prick should be observed to ensure that it is within specifications. After the film is exposured and developed, the center of the radiation field can be determined and compared to the position of the pin-prick.

C. Monthly Test

All interlocks and emergency switches should be checked at least monthly, as well as collimator gantry angle and field size indicators, energy or depth dose, and the mechanical distance indicator. The gantry

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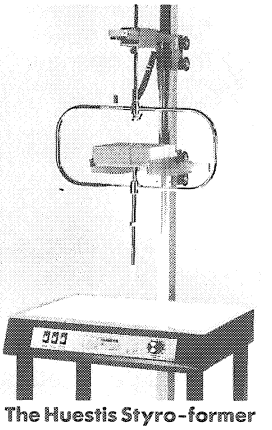

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TABLE II

PARAMETER	REASONS FOR MAKING THE OBSERVATION	SUGGESTED PERFORMANCE CRITERIA
External Beam Machines		
1. Dosimetry		
a) Central axis dose calibrations (A)	Calibration of the radiation beam using the local standard beam.	The stated accuracy is ± 3.4% for beams other than Co-60, ± 2.5% for Co-60 (6)
2. Photon Only Electrical Machines		
a) Constancy checks for mega-voltage machine dose per monitor unit along the central axis (D)	Checks for the possibility of change in calibration due to some change in the electronics of the unit.	± 3% of calibrated dose (1)
b) Constancy checks for conventional machine dose per unit time (W)	Checks for the possibility of change in calibration due to some change in the electronics of the unit.	± 3% of calibrated dose (1)
c) Depth dose (M)	Checks for change in the beam characteristics.	± 2% of calibrated values (1)
d) Beam uniformity (W)	Checks for changes in the beam characteristics.	± 3% of calibrated values (1)
3. Electron Beam Equipment		
a) Dose Calibration (A)	Calibration of the electron beam using the local standard system.	± 4% (1)
b) Beam uniformity (W)	Check for changes in the beam.	± 5% (1)
c) Depth dose (M)	Check for changes in the beam.	± 3 mm at 80% (1)
d) Dose per monitor unit constancy check (D)	Check for changes in the linac or beam.	± 3% (1)
e) Dosimetry reproducibility and linearity (A)	Check for changes.	Document
4. Geometry		
a) Field positioning aids		
1) Light beam and radiation field (W)	Check for coincidence.	Within 3 mm (1)
2) Mechanical distance indicator, lasers, SSD lights (M)	Change in alignment aids affects dose to patient.	± 2 mm variation from correct distance (1)
3) Scale readouts (M)	Check for any change in readouts.	± 1 unit (1)
b) Machine Alignment		
1) Focal spot position (A)	Check for any change.	Document
2) Jaw symmetry (A)	Check for any change.	Document
3) Definition of isocenter by interaction of axes of collimator, gantry and couch (A)	Check for any change.	± 2 mm (1)
4) Stability of gantry arm and bearing under rotation (A)	Check for any change.	± 2 mm (1)
5) Couch rotation and table top sag (A)	Check for any changes.	Document
5. Treatment Accessories		
a) Wedges and compensators (A)	Check basic parameters.	Document
b) Field shaping blocks (A)	Check basic parameters.	Document
6. Emergency Off System (M)	Check basic parameters.	Document

(1) AAPM Report No. 13
(6) SCRAD Report

(A) Annually (M) Monthly (W) Weekly (D) Daily

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angle indicators can be checked with a spirit level as the gantry is rotated. The collimator angle indicators at the four principal angles, and the field size indicators at 5 cm x 5 cm, 15 cm x 15 cm and 30 cm x 30 cm should also be checked.

The energy can be verified by measuring the output in a plastic phantom at a number of depths. For photons, two depths are usually sufficient, and depending upon the energy, 5 cm and 10 cm or 15 cm are convenient depths. For electrons, a minimum of three depths should be chosen in the region of linear decrease of dose.

D. Annual Test

A full calibration should be performed annually. It should include a determination and adjustment of the dose per monitor unit and measurements of flatness and symmetry at all four principal angles. Although a plastic phantom can be used for many of these tests, the measurements at 0° gantry angle should be done in a water phantom with an ionization chamber. Included in the field calibration will be verification of the inverse square law, output factors, cental axis depth dose for a number of fields, monitor linearity and end effects, and all wedge and tray factors. In addition, various mechanical specifications and alignments must be checked annually.

The determination of the mechanical isocenter would most accurately be carried out with a mechanical jig. If this aid is not available, other methods can be used with satisfactory accuracy. A white card with a dot on it is placed at the approximate position of the isocenter. As the gantry is rotated to different positions, the card is adjusted so that the cross hairs of the light field intersect the dot regardless of the gantry angle. With repeated attempts it is possible to locate the isocenter within the manufacturer's specification. When the isocenter has been located, the gantry should be rotated several times while the relative motion of the cross hairs around the point is observed. If the variation exceeds the allowable limits, there is a serious problem.

The accuracy of the collimator rotation can be determined by turning the collimator and observing the movement of the image of the cross hair. All couch movements and table top sag under load should be observed.

IV. Summary

Table II (adopted from the ACMP) summarizes these tests. This table not only includes the parameter under investigation but also the main reason for making the test and the suggested performance criteria. If the measurements fall outside the criteria, the parameter should be adjusted so as to come into compliance. If the paramter is significantly outside the criteria and/or is impossible to adjust to the required value, it will be necessary to call the authorized manufacturers' service to make the required adjustments, unless in-house expertise is available.

This in-house expertise will generally consist of the medical physicist and/or hospital engineer. With a good preventive maintenance program in which the parameters are measured and adjusted on a regular basis as outlined here, linear accelerators can be kept running in good operating condition. These tests and adjustments are generally simple to learn and easy to implement. When such a program is neglected and problems are not fixed as they arise, the machines can deteriorate, and authorized manufacturers' service will be required, which is often difficult to obtain.

REFERENCES

1. Physical Aspects of Quality Assurance in Radiation Therapy AAPM Report No. 13, Task Group 24, (New York, N.Y.: American Association of Physicists in Medicine, 1984).
2. Report No. 2 Radiation Control and Quality Assurance in Radiation Oncology: A Suggested Protocol. The American College of Medical Physics 1986.
3. International Commission on Radiation Units and Measurements: Determination of absorbed dose in a patient irradiated by beams of x- or gamma-rays in radiotherpy procedures. ICRU Report 24, 1976.
4. K. A. Johansson, "Studies of Different Methods of Absorbed Dose Determination and a Dosimetric Intercomparison at the Nordic Radiotherpy Centers," Thesis, University of Gothenburg, Sweden, 1982.
5. John L. Horton, "Handbook of Radiation Therapy Physics" 1987. Prentice Hall Inc., New Jersey.
6. Subcommittee on Radiation Dosimetry, AAPM, Phys. Med., Biol. 11, 505 1966.

Announcement

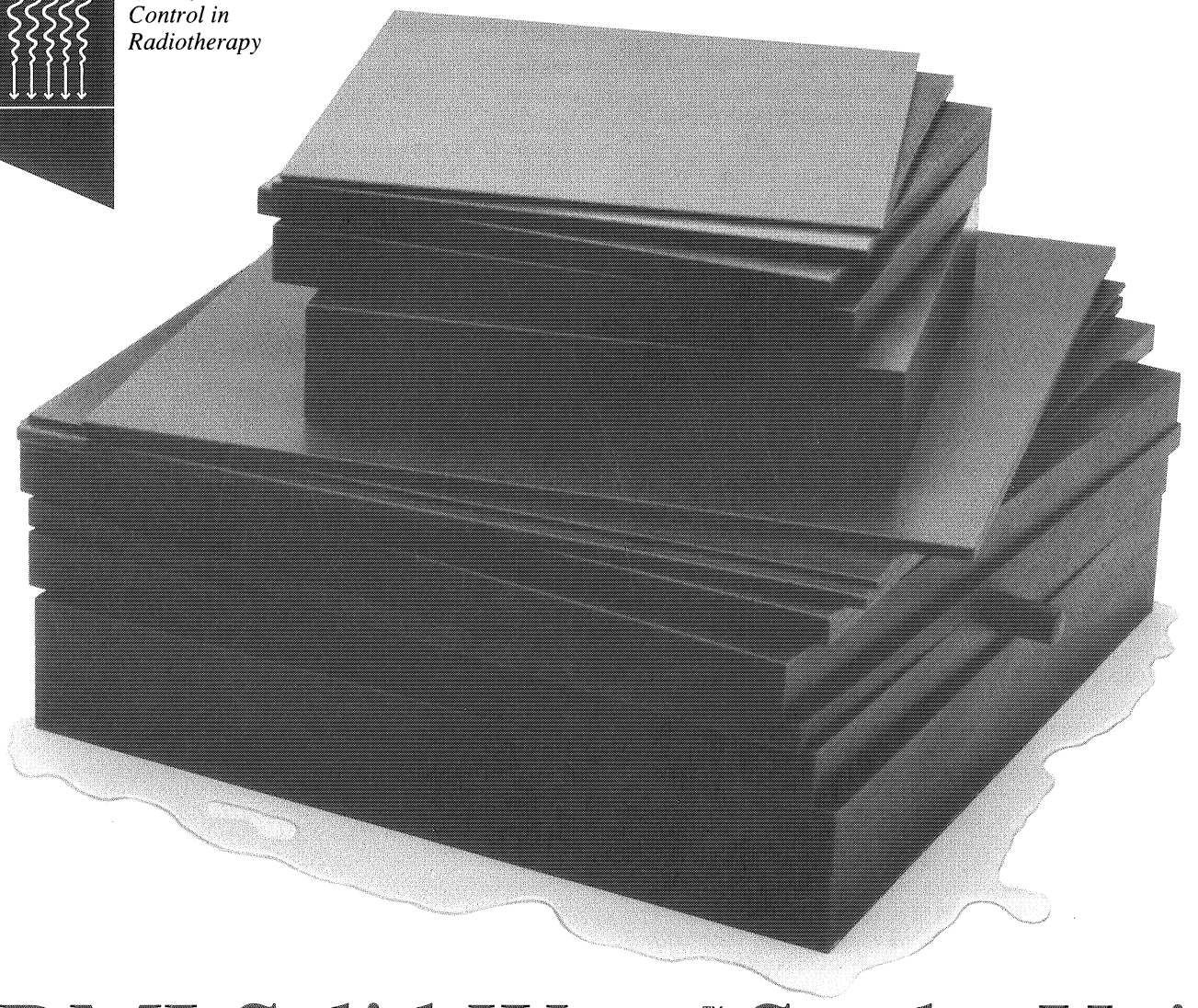
Beijing International Congress on Medical Radiation Physics Postponed Until May 27-30, 1990

After consideration of the active responses and the suggestions from most of the participants abroad, the Organizing Committee have made a decision to postpone the Beijing International Congress on Medical Radiation Physics to the later date of May 27-30, 1990. The schedules for the congress including the tour to other parts of China and Hong Kong after the congress have also been postponed.

For those participants who had already registered, their abstracts of papers, application forms, registration and other fees will be kept valid by the Organizing Committee during the interval. For future potential participants full details together with the relevant mailing addresses are given in the calendar which appears elsewhere in this issue.

The Organizing Committee regrets very much any inconvenience that this change of date may have caused to participants. We hope that the forthcoming Congress will be more successful and fruitful, and that it will be attended by more scholars and scientists from all over the world.

Quality Control in Radiotherapy



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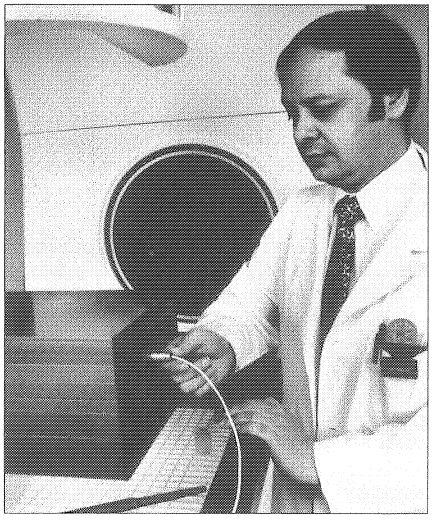

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CALENDAR OF EVENTS

Geoffrey S. Ibbott, Editor

1990

May 7 - 11

Munich, F.R. Germany, International Symposium on Radiation Protection Infrastructure, (Conference Service Section, IAEA, P.O. Box 100, A-1400 Vienna, Austria).

May 13 - 18

90th Annual Meeting of the American Roentgen Ray Society, Washington, D.C., U.S.A. (American Roentgen Ray Society, 1981 Preston White Drive, Reston, Virginia 22901, U.S.A. [703-648-8900]).

May 21 - 26

International Conference of the European Association of Nuclear Medicine, Amsterdam, Netherlands (QLT Convention Service, Ms. P. W. Wittebol, Keizersgracht 782, 2517 EC Amsterdam, Netherlands).

May 27 - 30

Beijing International Conference on Medical Radiation Physics, Beijing, China (Dr. Raymond K. Wu, Division of Physics, Department of Radiation Oncology, Eastern Virginia Medical School, 600 Gresham Drive, Norfolk, Virginia 23507, U.S.A. [Fax: 804-446-5172]; Dr. Jan Van Dam, Chief Physicist, Department of Radiotherapy, University Hospital, St. Rafael, Leuven, Belgium; Yimin Hu, Chief Physicist, Department of Radiation Oncology, Cancer Institute Hospital, Chinese Academy of Medical Sciences, Beijing, China 10021 [Tel: (01) 781-331, Ext. 381, Fax: (01) 771-3648]).

June 3 - 7

30th Annual Conference of the Canadian Nuclear Association and 11th Annual Conference of the Canadian Nuclear Society, Toronto, Ontario, Canada (Canadian Nuclear Association, 111 Elizabeth Street, Toronto, Ontario M5G 1P7, Canada).

June 4 - 8

ESTRO Teaching Course: Radiation Physics for Clinical Radiotherapy, Irish Institute for European Affairs, Leuven, Belgium (ESTRO Secretariat, University Hospital St. Rafael, Department of Radiotherapy, Capucijnenvoer 35, 3000 Leuven, Belgium).

June 6 - 7

NMR Imaging: Recent Developments and Future Prospects, London, United Kingdom (The Scientific Meetings Secretary, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG [01-839-5561 ext. 278]).

June 7 - 9

French Society of Hospital Physicists, Lille, France (tentative).

June 7 - 9

Canadian Organization of Medical Physicists Annual Meeting with Canadian College of Physicists in Medicine, (Dr. Chris Thompson, Rm. 723, 3801 University St., Montreal, PQ H3A 2B4 Canada, [514-398-8505, FAX 514-398-8540, ENA: CHRIS%RCLVAX@MEDCOR. MCGILL.CA]).

June 7 - 10

7th Annual Meeting of the American College of Medical Physics, Lakeway Resort and Conference Center, Austin, Texas, U.S.A. (Laura Fleming Jones, ACMP, 1891 Preston White Drive, Reston, Virginia 20091, U.S.A. [703-648-8966]).

June 10 - 15

Annual Meeting of the American Nuclear Society, Nashville, Tennessee, U.S.A. (Meetings Department, American Nuclear Society, 555 North Kensington Avenue, LaGrange Park, Illinois 60525, U.S.A.).

June 11 - 13

Radiology '90, 48th Annual Congress of the British Institute of Radiology and Annual Conference of the College of Radiographers, Harrogate, Yorkshire, United Kingdom (Programme Office, The British Institute of Radiology, 36 Portland Place, London W1N 3DG, United Kingdom [01 580 4085]).

June 14 - 16

43rd Annual Conference of the College of Radiographers, Harrogate, UK (The College of Radiographers, 14 Upper Wimpole Street, London W1M 8BN [01-935-5726]).

June 24 - 28

Health Physics Society, 35th Annual Meeting, Albuquerque, New Mexico, U.S.A. (Mr. R. J. Burk, Health Physics Society, 8000 Westpark Drive, Suite 400, McLean, Virginia 22101, U.S.A. [703-790-1745]).

June 25 - 27

2nd Conference on Osteoporosis and Bone Mineral Measurement, Sponsored by The Royal National Hospital for Rheumatic Diseases, Bath, and the National Osteoporosis Society, The Guildhall, Bath, UK (E. F. J. Ring, Department of Clinical Measurement, Royal National Hospital for Rheumatic Diseases, Bath, UK [Tel. (0) 225-65941]).

June 25 - 29

Seminar on the Application of Nuclear Techniques in the Early Diagnosis of Cancer in Developing Countries, Vienna, Austria (Conference Service Station, IAEA, P.O. Box 100, A-1400 Vienna, Austria).

July 9 - 13

8th International Symposium on Nuclear Chemistry, Radiochemistry and Radiation Chemistry, (Ms. M.T. Olguin, Instituto Nacional de Investigaciones Nucleares, Depto. de Quimica Nuclear, Apdo. Postal 18-1027, Colonia Escandon, C.P. 11801 Mexico, D.F., Mexico).

July 22 - 26

American Association of Physicists in Medicine, 32nd Annual Meeting, St. Louis, Missouri, U.S.A. (AAPM Executive Officer, 335 East 45th Street, New York, New York 10017, U.S.A.).

July 29 - August 3

10th International Biophysics Congress, Vancouver, British Columbia, Canada (Mr. L. Forget, Congress Manager, 10th International Biophysics Congress, National Research Council Canada, Ottawa, Ontario, Canada K1A 0R6 [Tel: 613-993-9009, Fax: 613-952-7928, Telex: 053-3145]).

August 12 - 16

8th International Congress and 25th Anniversary of International Society for Electrophysiology and Kinesiology, (Sheraton Inner Harbor Hotel, Baltimore, Maryland, U.S.A.).

August 26 - 29

World Congress on Health Technology Standards, Dublin, Ireland (The Electro-Technical Council of Ireland, 1 Fitzwilliam Place, Dublin 2, Ireland, [Tel: 353-1-612591, FAX: 353-1-61170/682595]).

August 26 - 31

5th World Congress of the World Federation of Nuclear Medicine and Biology, Montreal, Quebec, Canada (WFNMB Congress Secretariat, GEMS Conference Services, P.O. Box 997, Snowdon Station, Montreal, Quebec, Canada H3X 3Y1).

September

Inter-regional Seminar on Radiotherapy Dosimetry, Leuven, Belgium (Conference Service Station, IAEA, P.O. Box 100, A-1400 Vienna, Austria).

September 5 - 7

6th International Selection Users' Meeting, Montecatini, Italy (Rosemarie Warshowsky, Marketing Manager, Nucletron Corporation, 9160 Red Branch Road, Columbia, Maryland 21045, [Tel: 301-964-2249, FAX: 301-964-0912]).

September 10 - 13

9th Annual Meeting of the European Society for Therapeutic Radiology and Oncology, Including Sessions on Biology and Quality Assurance, Centro Congressi, Montecatini, Italy (ESTRO Secretariat, University Hospital St. Rafael, Department of Radiotherapy, Capucijnenvoer 35, 3000 Leuven, Austria).

September 12 - 15

4th Congress of the South African Society of Nuclear Medicine, Kruger National Park, South Africa (Jan Esser, Department of Nuclear Medicine, Area 559, Johannesburg Hospital, P.O. Box 39, Johannesburg, 2000, South Africa).

September 12 - 16

Institute of Physical Sciences in Medicine Annual Conference, Oxford, England (Institute of Physical Sciences in Medicine, 2 Low Ousegate, York YO1 1QU, United Kingdom).

September 13 - 17

6th Regional Conference of Asia and Australia of the International Society of Radiographers and Radiological Technicians, Christchurch, New Zealand (Miss V. Crown, 38 High Ashton, Kingston Hill, Kingston, Surrey KT2 7QL, United Kingdom).

September 14 - 19

Asian Oceanian Congress of Radiology, New Delhi, India (Dr. Sudarshan K. Aggarwall, Indian Radiological and Imatging Association, Dr. Dewan Chand Aggarwal X-ray Clinic, 10-B, Kasturba Gandhi Marg., New Delhi 110 001, India).

September 19 - 22

Annual Meeting of the Royal College of Radiologists, Edinburgh, Scotland, United Kingdom (The Conference Officer, The Royal College of Radiologists, 38 Portland Place, London W1N 3DG, United Kingdom).

September 23 - 28

23rd Annual Meeting of the European Society for Radiation Biology, Trinity College, Dublin, Ireland (ESRB Secretariat, Nuclear Energy Board, Clonskeagh Square, Dublin 14, Ireland [353-1-697766]).

September 24 - 28

Joint Annual Conference of the Australian Radiation Protection Society and the Australasian College of Physical Scientists and Engineers in Medicine, Adelaide, Australia (Dr. A. H. Beddoe, Conference Secretariat, SAPMEA, GPO Box 4-98, Adelaide, South Australia 5001 [Tel: 61-8-232-0918]).

September 30 - October 3

4th International Evoked Potentials Symposium, Toronto, Ontario, Canada (Colin Barber, Ph.D., Symposium Co-Director, Medical Physics Department, Queen's Medical Centre, Nottingham NG7 2UH, England [44 602 421421 Ext. 3531]).

November 4 - 7

14th Symposium on Computer Applications in Medical Care, Sheraton Washington Hotel, Washington, D.C., U.S.A. (The George Washington University Medical Center, Office of Continuing Education, 2300 K Street, N.W., Washington, D.C. 20037, U.S.A.).

November 11 - 14

10th International Conference on the Use of Computers in Radiotherapy, Sanjay Gandhi Post-Graduate Institute of Medical Sciences, Lucknow, India (Scientific Programme Contact Dr. P. S. Iyer, Head, MPSC, Division of Radiological Protection, Bhabha Atomic Research Centre, Bombay 400 085, India [Tel. 022-5514910, Ext. 2623]).

November 11 - 16

Winter Meeting of the American Nuclear Society, Washington, D.C., U.S.A. (Meetings Department, American Nuclear Society, 555 North Kensington Avenue, LaGrange Park, Illinois 60525, U.S.A.).

November 12 - 15

3rd International Symposium on Intraoperative Radiation Therapy, Kyoto, Japan (Mitsujuki Abe, M.D., Professor and Chairman, Department of Radiology, Faculty of Medicine, Kyoto University, Shogoin-kawaharacho, Sakyo-ku, Kyoto 606, Japan).

November 25 - 30

Joint Meeting of AAPM with the Radiological Society of North America, Chicago, Illinois, U.S.A. (AAPM Executive Officer, 335 East 45th Street, New York, New York 10017, U.S.A. [212-661-9404]).

1991

Vienna, Austria

International Symposium on Health Effects of Ionizing Radiations: Radiation Protection Implications, (Conference Service Station, IAEA, P.O. Box 100, A-1400 Vienna, Austria).

Goettingen, F.R. Germany

Joint Congress on Radiation Protection in Medicine, (Mr. H. Brunner, Abt. SU, EIR, CH-5503, Wurenlingen, Switzerland).

April 11 - 13

ART 91 — International Symposium on Treatment Planning and Tumor Response Monitoring, Munich, Federal Republic of Germany (Peter Kneschaurek, Ph.D., or Andreas Heuck, M.D., Institut fur Radiologische Onkologie, Technische Universitat Munchen, Ismaninger Str. 15, D-8000 Munchen, Fed. Rep. of Germany. [Tel: 49-89-41-40-43-04 or 49-89-41-40-43-01, Fax: 49-89-41-40-43-96]).

May 2 - 4

Radiology 91, 49th Annual Congress of the British Institute of Radiology, Brighton, United Kingdom (Programme Office, The British Institute of Radiology, 36 Portland Place, London W1N 4AT, United Kingdom [01-580-4805]).

June 2- 6

Annual Meeting of the American Nuclear Society, Orlando, Florida, U.S.A. (Meetings Department, American Nuclear Society, 555 North Kensington Avenue, LaGrange Park, Illinois 60525, U.S.A.).

June 17 - 20

Canadian Organization of Medical Physicists Annual Meeting with Canadian College of Physicists in Medicine and Canadian Radiation Protection Association, (Dr. Walter Huda, Medical Physic, 100 Olivia St., Winnipeg, Manitoba R3E 0V9, Canada [204-787-4191, FAX: 204-783-6875, ENA: WHUDA@UPFMCC]).

July 5 - 6

2nd International Symposium on Biophysical Aspects of Auger Processes, University of Massachusetts, Amherst, Massachusetts, U.S.A. (Dandamudi V. Rao, Ph.D., Professor of Radiology, University of Medicine and Dentistry of New Jersey, 185 South Orange Avenue, Newark, New Jersey 07103-2757, U.S.A.).

July 7 - 12

9th International Congress of Radiation Research, Sheraton Center, Toronto, Ontario, Canada (Ms. Meg Keiser, Radiation Research Society, 1101 Market Street, 14th Floor, Philadelphia, Pennsylvania 19107, U.S.A. [215-574-3153]).

July 7 - 12

9th International Congress of Medical Physics and 16th International Conference on Medical and Biological Engineering, (Dr. Hiroshi Abe, President 9th International Congress of Medical Physics, C/O Japan Convention Services, Inc., Kansai Branch, Sumitomo Seimei Midosuji Blgd., 4-14-3 Nishitemma, Kita-ku, Osaka 530, Japan).

July 28 - August 1

American Association of Physicists in Medicine, 33rd Annual Meeting, San Francisco, California, U.S.A. (AAPM Executive Officer, 335 East 45th Street, New York, New York 10017, U.S.A.).

September 2 - 5

5th Breast Cancer Working Conference, EORTC Breast Cancer Cooperative Group, Pauscollege Leuven, Belgium (Department of Radiotherapy, University Hospital St. Rafael, Capucijnenvoer 33, 3000 Leuven, Belgium, [32-16-21-22-11]).

September 2 - 6

6th Meeting World Federation for Ultrasound in Medicine and Biology, Copenhagen, Denmark (Soren Hanke, Ultralydlaboratoriet, Kobenhavns Amts Sygehus, Gentofte, DK-2900 Hellerup, Denmark).

September 2 - 6

Leuven, Belgium, Inter-Regional Seminar on Radiotherapy Dosimetry, (Conference Service Station, IAEA, P.O. Box 100, A-1400 Vienna, Austria).

September 8 - 14

International Conference on Magnetism, United Kingdom (The Meetings Officer, The Institute of Physics, 47 Belgrave Square, London SW1X 8QX, United Kingdom [01 235 6111]).

September 15 - 20

ECR '91; 7th European Congress of Radiology, Austria Center, Vienna, Austria (Mrs. Sylvia Altermann, Vienna Medical Academy, Alser Strasse 4, 1090 Vienna, Austria [Tel. 43-222 421383, Telex: 134743 medak a]).

September 18 - 21

Annual Meeting of the Royal College of Radiologists, Warwick, United Kingdom (The Conference Officer, The Royal College of Radiologists, 38 Portland Place, London W1N 3DG, United Kingdom).

November 10 - 15

Winter Meeting of the American Nuclear Society, San Francisco, California, U.S.A. (Meetings Department, American Nuclear Society, 555 Kensington Avenue, LaGrange Park, Illinois 60525, U.S.A.).

November 17 - 20

15th Symposium on Computer Applications in Medical Care, Sheraton Washington Hotel, Washington, D.C., U.S.A. (The George Washington University Medical Center, Office of Continuing Education, 2300 K Street, N.W., Washington, D.C. 22037, U.S.A.).

December 1 - 6

Joint Meeting of AAPM with the Radiological Society of North America, Chicago, Illinois, U.S.A. (AAPM, 335 East 45th Street, New York, New York 10017, U.S.A. [212-661-9404]).

1994

July - August

10th International Congress of Medical Physics, Rio de Janeiro, Brazil.

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*Readers are invited to send to the **Calendar of Events** Editor, Geoffrey S. Ibbott, M.S. (address on page 2), information on any events not listed in this issue of MPW and also additions or corrections to the items that are listed. Officers of national societies are especially encouraged to submit information on their future national meetings.*

Acceptance Test and Quality Assurance For Magnetic Resonance Imaging Equipment

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I. Introduction

The goal of an acceptance testing protocol is to measure quantifiable system parameters with system-independent instruments, to establish a baseline of system performance, and to verify that system performance meets the manufacturer's parameter specifications and perhaps compare the specifications with those of other vendors. The objective of a quality assurance (QA) program, on the other hand, is to establish a set of tests that, when performed on a regular basis, determine whether the imaging system is functioning in a reproducible and predictable manner.

In general, manufacturers have specific procedures for testing their systems' optimal performance before and after installation; a battery of QA tests, in conjunction with regular preventive maintenance, allows the vendors to evaluate their systems' efficiency. Although those customary vendor-specific tests are too complex to be used as independent QA test procedures by a customer, it is recommended that the clinical physicist work with the installers and review their test results. The user should request as part of purchase negotiations the manufacturer's specifications and clinical samples of images from routine studies that were obtained using such specifications. Also, the customer and vendor should identify and agree on, prior to the purchase, the test phantom(s) and evaluation criteria to be employed.

This report provides possible guidelines for an acceptance testing and QA program for an Magnetic Resonance Imaging facility that may be implemented by a physicist or any other technical personnel using only the test equipment normally supplied by the vendor. Also, we discuss the relevant clinical issues and provide a partial list of important publications on these topics.[1-5]

II. Acceptance Testing and QA Criteria For Non-Imaging Parameters

Non-imaging aspects for consideration in the initial acceptance tests include damage that may occur during transportation and improper installation. After installation, the equipment should be visually inspected for any damage, and a safety test of the mechanical parts, such as the movable patient table, needs to be performed.

A. Safety Procedures

Because of the presence of high magnetic fields in the magnet room, it is essential for patients and hospital personnel that proper safety procedures be implemented. Warning signs should be displayed in prominent places, and the security of the magnet room should be thoroughly assessed. The magnet area in which fields are greater than 1.5 mT should be secured against unauthorized entry, and the introduction of large ferromagnetic objects such as wheelchairs, IV poles, oxygen tanks, or floor polishers should be prohibited. The area in which magnetic fields are between 1.5 mT and 0.5 mT should have controlled access, and patients or personnel with cardiac pacemakers, cerebral aneurysm clips, implanted electrodes, loose ferrous objects, credit cards, and watches should be excluded from entering this area. Areas in which fields are smaller than 0.5 mT do not need to be controlled.

The presence in the scanner room of liquid cryogenics introduces liabilities and potential risks related to the emission of inert gases and subsequent dangerous reduction of the oxygen concentration. Thus, after the scanner installation, it is recommended that the optimal function of the room oxygen monitor be verified, the efficiency of the smoke detector be tested, and the intercom or any other device used by the patient to communicate with the technologist in case of an emergency be thoroughly inspected. The emergency shut down procedures — abortion of measurements, table release, and transfer of the patient to a safe area — should be evaluated, and the emergency procedures for ramping down the magnet to eliminate the magnetic field and remove ferromagnetic objects that cling to the bore or to release a patient becoming impaled or trapped in the magnet should be evaluated. The staff radiologist, technologist, assistants, security personnel, and custodial personnel should be educated on the procedures to carry out in the event of such emergencies.

B. Magnetic Field

As soon as the magnetic field is established and the rest of the electronics are being installed, it is common to test major system parameters such as main magnetic field stability, drift over time, magnetic fringe field, screen room integrity, cryogenic boil-off rate, and air-conditioning capacity. Because of the highly specialized equipment needed, the cooperation of the vendor's technical personnel should be sought to verify the accuracy of isoplets (i.e., fringe field values) and to evaluate attenuation of external radio frequency (rf) interference.

B1. Resonance Frequency

All systems have software procedures to determine the resonance frequency and the corresponding field strength using the vendor supplied phantoms.[6-8]

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Continued from page 16

B2. Homogeneity Over the Imaging Volume

Homogeneity of the magnetic field over the imaging volume is affected by the ferromagnetic environment of the magnet, like the magnetic shielding of the scanner room, nearby parking lots, elevators, and ferromagnetic objects within the building, and by the rf shielding, which should be of the order of 100 dB in the frequency range of 5-100 MHz. If the vendor did not provide a pulse sequence for field mapping and the generation of such a sequence requires in-depth knowledge of the system software, the standardized gaussmeter measurement or an equivalent procedure is recommended. These procedures should be performed at installation during the shimming of the magnet. Typically, for standard body imaging procedures, homogeneity within a 50 cm radius sphere should be 25 ppm, when the magnetic field distortion is measured within the sphere and compared with the isoplets at the isocenter. The homogeneity of the magnetic field can vary with time depending on the stability of the shim coil currents and changes in coil geometry due to temperature variations during operation.

B3. Long-Term and Short-Term Stability

The magnetic field drift in ppm per hour or per minute can be evaluated by monitoring the resonance frequency using the vendor's software. Magnetic field and rf stability determine the suitableness of the raw data. Field stability better tnan 0.1 ppm per hour is achieved with today's technology.

B4. Cryogen Boil-Off Rate For a Superconductive Magnet

The cryogen boil-off rate may be a useful indicator of damage to the magnet and its surrounding chambers that occurred during transportation or assembly of the system. It is the responsibility of the vendor to provide the necessary equipment and testing methods with the system. Typical cryogen boil-off rates are 0.5 liters/h for liquid helium and 1.5 liters/h for liquid nitrogen during gradient coil operation.

III. Imaging-Related Quality Acceptance Testing and QA Criteria

Measurements of image quality parameters are needed to assure proper system performance and represent a valuable source of quantitative data for routine quality control testing. These tests include measurements of signal-to-noise ratios, resolution, image uniformity, geometrical distortions, and slice characteristics including thickness, profile, and offsets from the magnet's isocenter. A number of MRI phantoms are available, each with appropriate QA tests that can be easily incorporated into a satisfactory QA program. Phantoms are necessary to test the basic imaging functions of the system and should include a uniform water phantom (signal-to-noise ratio phantom) and a resolution phantom with built in structures (e.g., parallel bars, star design bars, hot and cold holes, and edge response objects) for verification of spatial resolution. Appropriate phantoms may be easily built; however, they are usually provided by the vendors. MRI phantoms[1] are made with materials such as plastics that are nonmagnetic and have low proton concentrations. The phantom dimensions are primarily determined by the size of the head coil used; a phantom usually consists of a 23 cm diameter plexiglass cylinder container. The nuclear magnetic resonance signal-producing chemical solution can be any paramagnetic doped water solution and should have T1 and T2 values in the range of 500-1000 seconds, such as a water solution of 0.1 mM manganese chloride or polyvinyl alcohol gel with 60%-90% water content mixed with various concentrations of manganese chloride, copper sulfate, or graphite.

A. Slice Position

During the installation procedures, light markers or any other visual aids of the system are checked to ensure that they point to a specific location that matches the system's zero position. The accuracy of the isocenter position may be verified by placing a small structure (e.g., hot holes insert) in the resolution plantom at the assumed center and acquiring an image as shown in Figure 1.

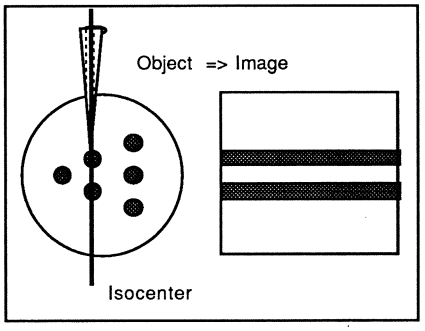

Figure 1. *Sagittal imaging along definite structures that do not emit signal can be used to verify the correct slice position. If there is a discrepancy between light marker pointer and actual excitation, the acquired image will not present the selected structure. The acutal positibn can be identified by varying the slice position slightly, to search for the center of the selected structure.*

The same method can be used to check the positioning accuracy at other locations by measuring the distance between the structures in the phantom and setting the selective excitation gradients at that distance (see Figure 2).

The accuracy of system positioning is a function of field strength, gradient, and transmitter linearity.[9-14]

A1. Spatial Linearity

Spatial linearity describes the capability of the system to reproduce an object's spatial features without geometrical distortions. Current gradient coils provide a linear gradient field only at the isocenter. The field becomes extremely nonlinear outside the specified imaging volume; therefore, to a certain degree, geometrical distortions at the edge of the imaging volume are unavoidable. The system's spatial linearity can be tested by measuring the sizes and distances between objects in the images acquired when the reso-

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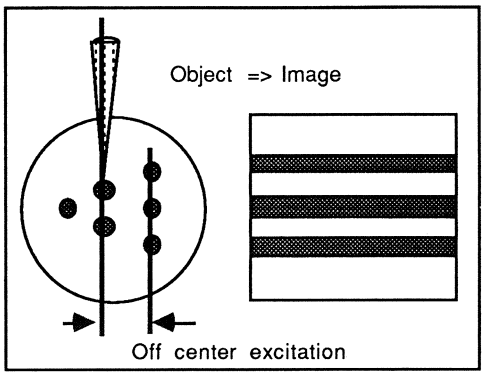

Figure 2. *Sagittal imaging along definite structures that do not emit signal can be used to verify the correct slice position in case of an off-axis excitation. Gradients are used to establsih the resonance frequency which is a function of location. If the frequency range covered with the selective pulse is not at the presumed location, the acquired image will not present the selected structure. The actual position can be identified by varying the slice position slightly, to search for the center of the selected structure.*

lution phantom is placed at the isocenter and by repeating this procedure with the phantom shifted toward the edge of the imaging volume (see Figure 3).

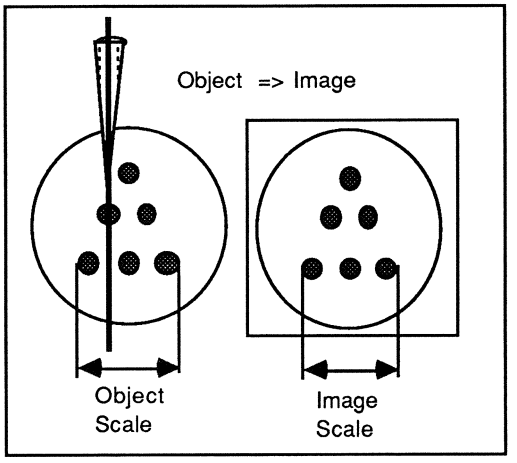

Figure 3. *Comparing the actual size with measurements taken from the image will allow the assessment of the actual gradient geometry. Gradients are used to establish spatial encoding. Insufficient linearity will establish itself as geometric distortion.*

Obvious, intolerable geometrical distortion may indicate shipping damage, poor alignment of the gradient coil, or insufficient eddy current compensation (active or passive). It may also indicate an inhomogeneity of the main field (insufficient active or passive shimming).

A2. High-Contrast Spatial Resolution

High constrast spatial resolution reflects the capability of the system to resolve small structures in an object. It is an extremely important factor in the evaluation of joints (i.e., searching for tears). To evaluate this capacity, the resolution phantom is used to measure a profile of the signal intensity at the location of the small structures and their surroundings (see Figure 4).

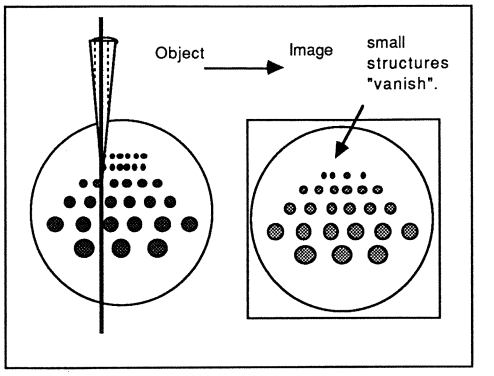

Figure 4. *The "loss" of small structures in the image can be used as a criterion to assess the capability of the system to resolve small structures.*

Spatial resolution is a function of the selected matrix size and field of view. Insufficient high-contrast spatial resolution may indicate poor gradient stability (inadequate current compensation) as shown in Figure 5.

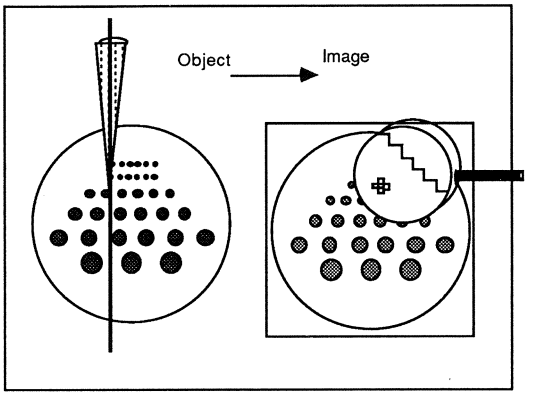

Figure 5. *Spatial resolution is predetermined by selecting a specific matrix size and a certain field of view. The invisibility of small structures may be the result not of system insufficiency, but rather of selective imaging parameters dictating the spatial resolution.*

A3. Low-Contrast Spatial Resolution

The capability of the system to resolve low-contrast objects is clinically important. An example is the imaging of pituitary microadenoma. In the absence of a low-contrast phantom, this system capability can be evaluated by imaging the contrast between the internal capsule, putamen, and caudate nucleus as the low ventricular level in an axial slice.

A4. Slice Profile and Slice Crosstalk

Some vendors provide a specific projection sequence to visualize directly the slice profile of a water phantom. If no such sequence is available, the profile can be estimated by stepping through a known phantom structure insert and measuring the convolution between slice profile and object size; this procedure is schematized in Figure 6.

The slice profile can also be evaluated by measuring the signal intensity in a given slice and comparing it with slice separation in a multislice measurement, as diagrammed in Figure 7.

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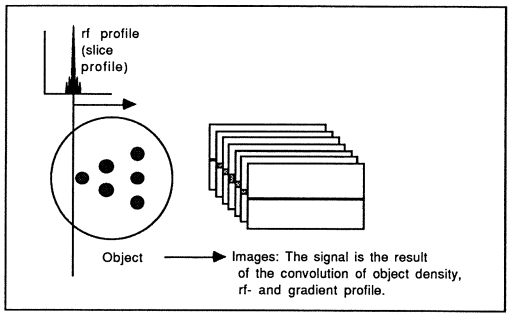

Figure 6. *Images acquired by selecting a certain rf bandwidth and shifting the center frequency through a region with known structures allow the evaluation of the rf profile. The intensity within the image is a convolution of object density, rf and gradient profile.*

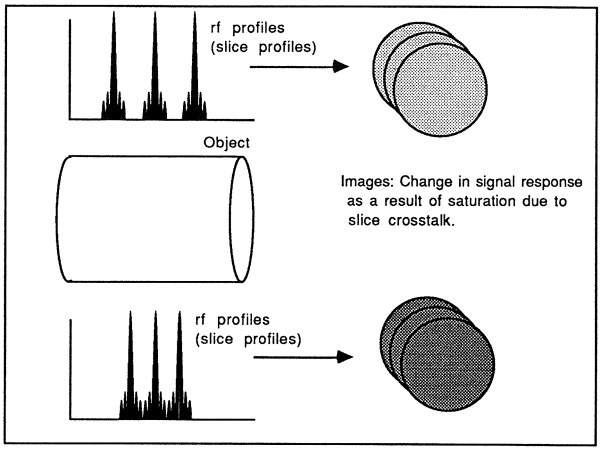

Figure 7. *The signal intensity in a uniform water phantom depends on rf profile and distance between selected slices. The rf envelopes leading to poor slice profiles will cause excitation and saturation outside of the selected region. Moving these regions closer together will cause a decrease in signal intensity due to this saturation or so-called slice crosstalk.*

This measurement will provide data on the range of slice crosstalk. The slice profile and its location may be a function of the phantom structure location within the excited plane.[15-16]

A5. Signal Intensity Uniformity

Uniformity of the signal is estimated in terms of the deviation from the mean signal intensity. The water phantom used to evaluate uniformity must be large enough to sample the usable field of view for the coil being tested. Signal intensity uniformity depends on the load to the gradient coils, which is associated with the resulting rf distribution and homogeneity and the image uniformity depends on the slice profile, if this profile is a function of location.

A6. Signal-To-Noise Ratio

The signal-to-noise ratio (SNR) is an important determinant of the system's ability to detect low-contrast objects and small lesions. Also, it is an excellent but nonspecific indicator of general problems of the system (e.g., system calibration, rf coil tuning, rf shielding, or other critical hardware parameters.) Image SNR, slice thickness, geometrical distortion, and image uniformity can be used as reliable indexes of system image quality performance. The National Electrical Manufacturers Association has designed a non-invasive SNR test that can be performed on all current magnetic resonance imagers, under clinical conditions.[17-19] The SNR is evaluated on an image of a phantom that looks to the system like a 75 kg person and produces a large signal in the scanning volume. Two images are generated using a standard clinical scan and reconstruction sequence and analyzed using the system's software for proton imaging. The signal is defined as the mean pixel value in a region of interest covering 75% of the first image; the second image is then subtracted, and the mean pixel value of the same 75% region is measured. The standard deviation of the pixel values divided by the square root of 2 is the estimated noise in the image.

Results of this calculation should be within 10% of the stated specification. The SNR measurement depends on the design and composition of the phantom used, the imaging parameters selected, machine integrity, radio frequency integrity, degradation, and improper coil tuning. The SNR should be used to monitor system performance regularly.

B. System-Specific and Inherent Imaging Method Artifacts

Artifacts are very common in clinical magnetic resonance images. They correspond to signal intensities that do not originate in the true spatial distribution of tissues in the volume being imaged. Artifacts may originate from many sources and degrade the images to varying degrees, compromising clinical diagnosis. There are three main sources of artifacts: those which are system specific (static magnetic field inhomogeneity and temporal instability, rf magnetic field inhomogeneity, gradient magnetic field non-linearity, and eddy currents), those that depend on the sequences that are used to obtain the images, and those internal to the patient (motion and ferromagnetic materials). In the context of acceptance testing and quality control, it is important to recognize and understand artifacts and their sources not only to minimize or eliminate them but to distinguish the ones normal to the equipment from those due to malfunctioning. Some artifacts can be resolved only by the manufacturer's service representative; however, most can be identified and eliminated by a proficient technician.[20-23]

B1. Ghosts

Ghosts in the image may arise from the excitation of an area outside the selected slice, a quadrature imbalance in the receiver channel, or a regular malfunction of the phase-encoding gradient. Ghosts appear as a smearing or distinct image in the direction of the phase encoding gradient. To evaluate the presence of ghosts, place the phantom out of the isocenter, not necessarily within the imaging volume. Insufficient radio frequency modulation can be traced by placing the phantom with its edge in the isocenter extending to one side and selecting a multislice excitation tech-

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nique at the opposite side, outside any object inserted in the phantom. Ghosts can be resolved by adjusting the receiver or rephasing all higher order echoes or integer amplitude phase gradients.

B2. Edge Ringing

Truncation of the image caused by finite image acquisition time causes discontinuity at the boundary of the Fourier space and results in edge ringing or syrinx-line stripes within the reconstructed image. If truncation artifacts are visible in the test images and in those obtained from the vendor prior to purchase, it is assumed that these artifacts are inherent to the system; they can be reduced by computer filtering, although spatial resolution will be compromised.

C. Reproducibility of the Relaxation Times and Spin Density Parameters

Magnetic resonance imagers are in general designed to reproduce optimally the contrast between tissues with slightly different densities or relaxation times. Most imagers have software capabilities to measure and calculate the tissue-specific parameters of proton density, T_1 and T_2 for distinct imaging sequences. To test the reliability of these measurements, a special phantom is required. However, the reproducibility of these measurements is not essential for routine clinical performance. A discussion of the test procedures and necessary phantoms is beyond the scope of this paper. Some pertinent references on this topic are included.[24-31]

IV. Conclusions

An acceptance testing and quality control program has been proposed that can be implemented by a physicist or any other technical person involved in MRI. The test equipment required can be obtained from the vendors or easily built by the users. The procedures proposed cover all points and can be easily understood. The technical personnel of an installation are largely responsible for choosing test procedures that meet their needs, determining the optimal frequency at which test are performed, and maintaining records of test results and periodically reviewing the trends; they should also have adequate factory support when service is needed. Some parameter specifications may change with progress in MR imaging technology. It is important, therefore, that the technicians involved in acceptance testing and quality control keep abreast of advances.

Acknowledgements

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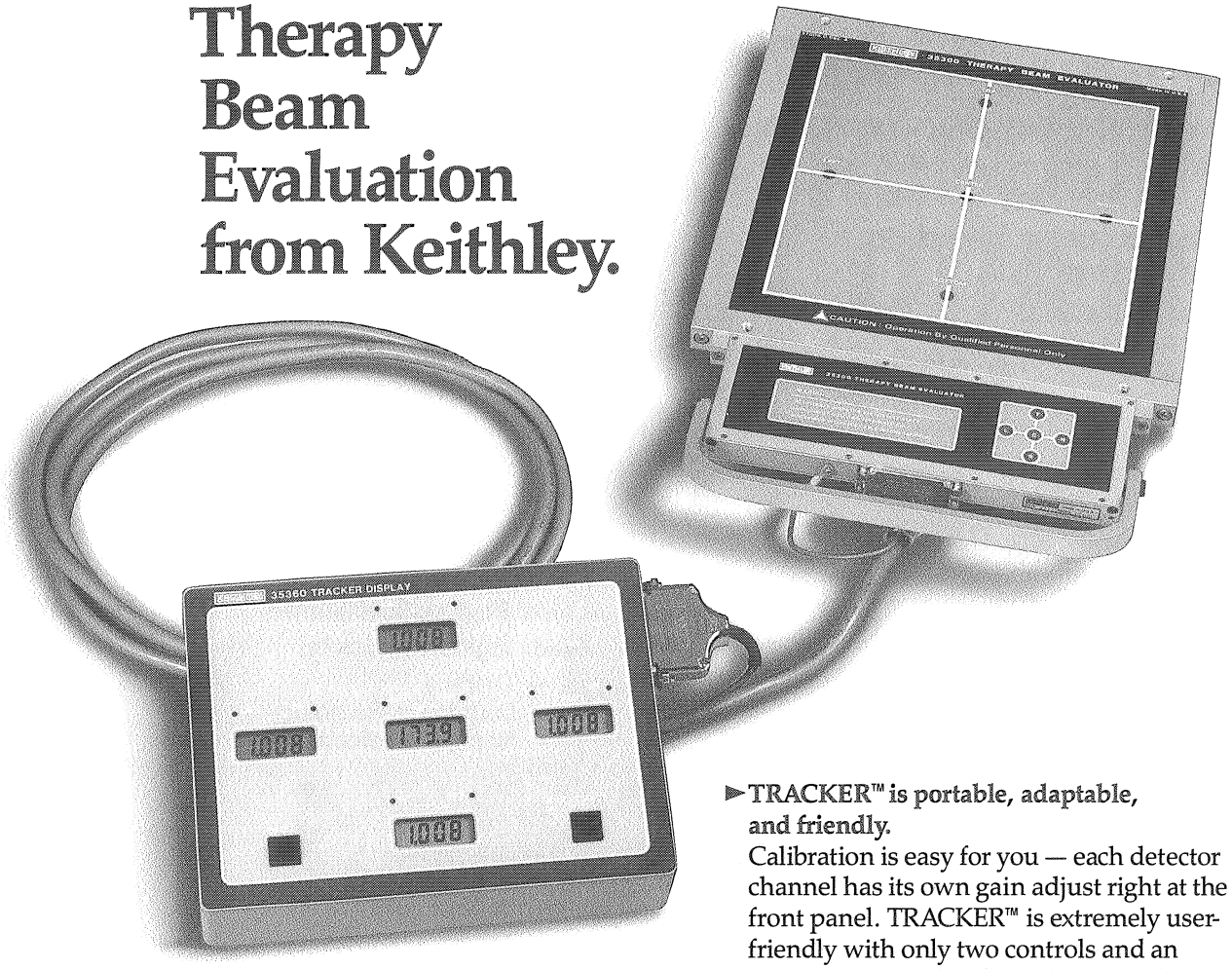

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The Role of the Physicist in Clinical Medicine: *A Malaysian Perspective*

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Introduction

Malaysia, in its move toward greater industrialisation and inevitable urbanisation has experienced widespread introduction of technologically advanced facilities, both within and surrounding its medical services; with these developments have appeared physicists whose efforts are seen to be directly or indirectly related to accommodating the advancing needs arising from the growth of modern medicine. We attempt in this article, to provide the case for greater national representation for medical physicists and further propose the establishment of a Malaysian medical physics centre, structured along the lines of a unit within an institutionalised academic establishment (a University Hospital, Medical Faculty or Medical Research Establishment would seem most appropriate). We draw parallels with such developments in more infrastructurally developed countries. No attempt is made here to establish economic arguments; R & D in Malaysia is highly topical and much discussion has been held elsewhere in terms of expenditure, GNP and per capita income. Similarly one may look elsewhere for general arguments supporting the benefits of developing a strong science and technology base.

We open the discussion by attempting the construction of an overview (albeit much simplified) of medical physics. Brief comment is made of its past whilst fuller account, in general tems, is made of the present international status in order to establish credible arguments for the development of a Malaysian medical physics base. We then turn to the more specific Malaysian case study.

Medical Physics: Evolution, Present Extent and Requirements

Contemporary medical physics continues to be most strongly associated with developments and applications to medicine of radiations resulting in ionisation of media. Historically however it might be argued that the earliest tangible associations of physics with medicine could best be traced to the Renaissance whilst yet others might care to identify a much earlier relationship centered on the Middle Eastern Civilizations and studies of, for instance, Ibn Sina (Avicenna). The association of physics and its applications to the monitoring of well-being, as well as in the diagnosis, treatment and prevention of human malady, has indeed a much earlier heritage than the year 1895 and the discovery, by Roentgen, of X-rays. Yet there have been a number of reasons, beyond the effective application and control of the hazards of radiation in medicine, why in the past few decades there has been an increasing demand for direct contact between the clinician and physical scientist. Not least among these reasons has been the rapid growth of science and technology during the twentieth century.

Table 1, an adaptation from Kaul,[1] provides a broad classification of those areas of medicine in which physics is seen to be able to play a significant role. Within this classification modification has been made to include explicit representation of non-ionising therapeutic and diagnostic measurement and imaging techniques to reflect the increasing interest in their possible applications in the many areas of medicine.

TABLE 1

Medical Physics Specialities:

Radiological Physics In:
- — Therapy
- — Diagnostic Radiology
- — Nuclear Medicine

Non-Ionising Techniques In:
- — Therapy
- — Diagnosis

Physiological Measurements In:
- — Cardiology
- — Opthalmology
- — Neurology
- — Audiology

Each Of These Subspecialities Contain:
- — Applied Electronics
- — Data Processing
- — Instrumentation

At the operative level clinician and physicist are seen to work in close cooperation, usually through the indispensable mediation of technical staff who are not only located within the various clinics and medical laboratories, as for instance, radiographers and medical laboratory technologists, but also within the physics department where they justifiably constitute a somewhat larger percentage of the establishment.

It has been within this atmosphere of an interdisciplinary scientific approach that advances have been seen to be made in providing a firmer quanitative approach towards the treatment of trauma and the management of ill-health. A very important further role has been identified to lie in aspects of education and training, fulfilling the needs of physicist, clinician, nursing staff, technical staff and also members of the public (we recall for instance the 'vital' role played by U.K. medical physicists in providing public information throughout Britain in the aftermath of Chernobyl). The modern medical physics department, it would appear,

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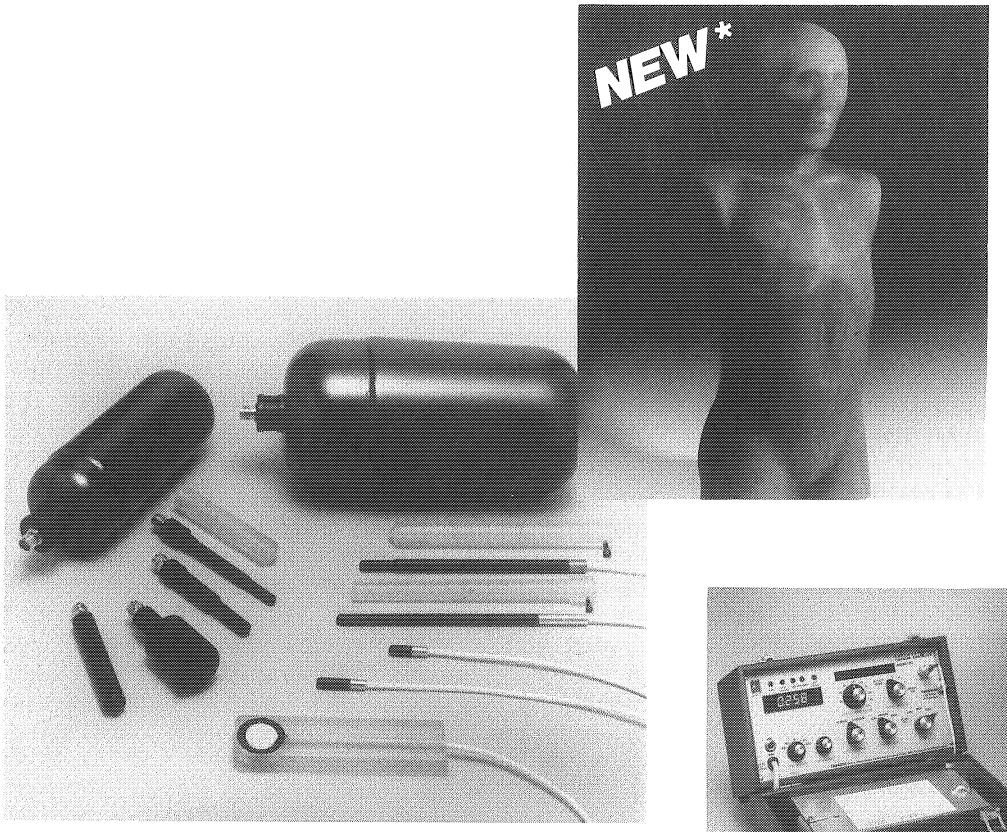

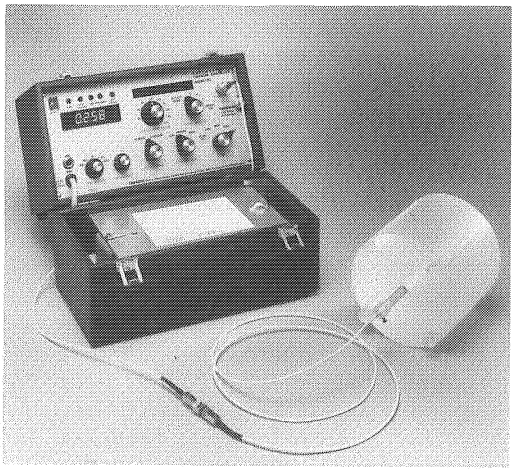

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has developed into one with established commitments towards the development and implementation of new techniques and procedures, the provision of quality assurance and safety services and one with a distinct liason and educational role.

The International Status of Medical Physics

Perhaps the extent to which the physicist is involved in medicine can be judged from the number of national and international bodies that presently represent those interests. Among the larger of these organizations are the U.K. Hospital Physicists Association formed in 1943, its sister organization the Institute of Physical Science in Medicine (IPSM) established in 1982, and the American Association of Physicists in Medicine (AAPM) established in 1958. These Associations are involved, together with something like 36 other national organizations, in the International Organization for Medical Physics (IOMP), itself established in 1963, manifesting in an overall represented membership of in excess of 7000 individuals.

In a mid-1975 survey[2] it was estimated that for every one million inhabitants of the U.K. 9 experienced hospital physicists were employed (the most recent figures would suggest rather more than this since membership of the HPA now stands at a level of in excess of 1360). In the Western Pacific Region the corresponding figures for New Zealand, Singapore and Malaysia, were 5..5, 2.4 and 0.3 respectively. The figures are presented here not to serve as criticism for any lack of development in Malaysia, indeed important infrastructural developments have taken place, as in for instance the establishment of University Biophysics groups, an IAEA approved Secondary Standards Dosimetry Laboratory (SSDL) and an Atomic Energy Licensing Board. The data is important however in establishing the extent to which medical physics has been allowed to flourish in perhaps more infrastructurally developed countries.

Developments in Malaysian Medical Physics

Clearly on an international level medical physicists have established themselves as an indispensable component of the medical services. Within the Asian continent and the Pacific Basin region, national affiliates to the IOMP are now numerous including representation of Australia, Hong Kong, the People's Republic of China, India, Japan, New Zealand, Republic of Philippines, Taiwan and Thailand. In Malaysia an initial step towards meeting a long-term wish to consolidate efforts in the area of physics applied to medicine and the biological sciences, has been met in the formation of an Institute Fizik Malaysia sub-group bearing the name of radiation physics, biophysics and medical physics; we acknowledge that numbers are as yet insufficient to allow separate viability. Formation of the group is somewhat reminiscent of the establishment of the Canadian Association of Physicists Division of Medical and Biological Physics (DMBP) in the mid 1950's.[3] It can also be mentioned that although to date there exists representation of medical physics in some of the larger Malaysian medical institutions, this representation has not yet been formalized in the establishment of a medical physics department. The formation of a medical physics unit/department would perhaps, beyond the already established role, also allow for the creation of central facilities that would otherwise almost certainly be ruled-out in a normal hospital budget; the U.K. experience is that expensive equipment such as a 3-D isodose plotter can be purchased on the basis of central facilities and be loaned out on a strict rotational routine. Consultancy could also be allowed for; it is clear from the Malaysian experience that this could form a strongly viable component as many smaller hospitals and clinics require the assistance of physicists but find themselves unable to justify the employment of such a person on a full-time basis. That a physics unit/department does not as yet exist in Malaysia is understandable; priorities in the development of hospital medicine would almost certainly have not provided for such a move in the early years of the Malaysian Federation. If, however, a medical physics unit/department is not established within the coming few years (we note the 1995 centennial of Roentgen's discovery of X-rays) then it will largely have resulted from the inability of Malaysian physicists to have made sufficient case for its creation. Growth and the demands for teaching (at least one Medical Faculty presently supports a Masters programme in Radiology) could also properly be met by an established medical physics unit/department.

In examining established departmental structures (in the U.K. there are presently in excess of 120 departments and 15 professorial chairs in what we might loosely and collectively term medical physics) it might be suggested that a model medical physics department of moderately large size would comprise of several sub-sections perhaps predominantly involved in aiding in diagnosis and therapy and in physiological monitoring. The department would in addition support research the theme of which would focus on the demands placed upon each of the sub-groups, reflecting the interests of medical needs within the particular hospital.

Over the past several years medical-physics-research-related efforts within Malaysia have taken place but these have been somewhat fragmentary and isolated; cases in point include the development of a cancer registry, vitally (sic) important in examining the efficacy of radiotherapy/chemotherapy treatment regimes as in for instance the therapy of nasopharyngeal carinoma (NPC), the local incidence of which far exceeds that in certain other ethnic make-ups (predominating white populations being one example). Yet another example has been seen in efforts to develop precision attenuation techniques for determining the extent of osteoporosis, with again importance for epidemiological study of the Malaysian populace (significant differences in stress- fracture incidence are known to exist between the predominating Malay, Chinese and Indian races). Presently developments are

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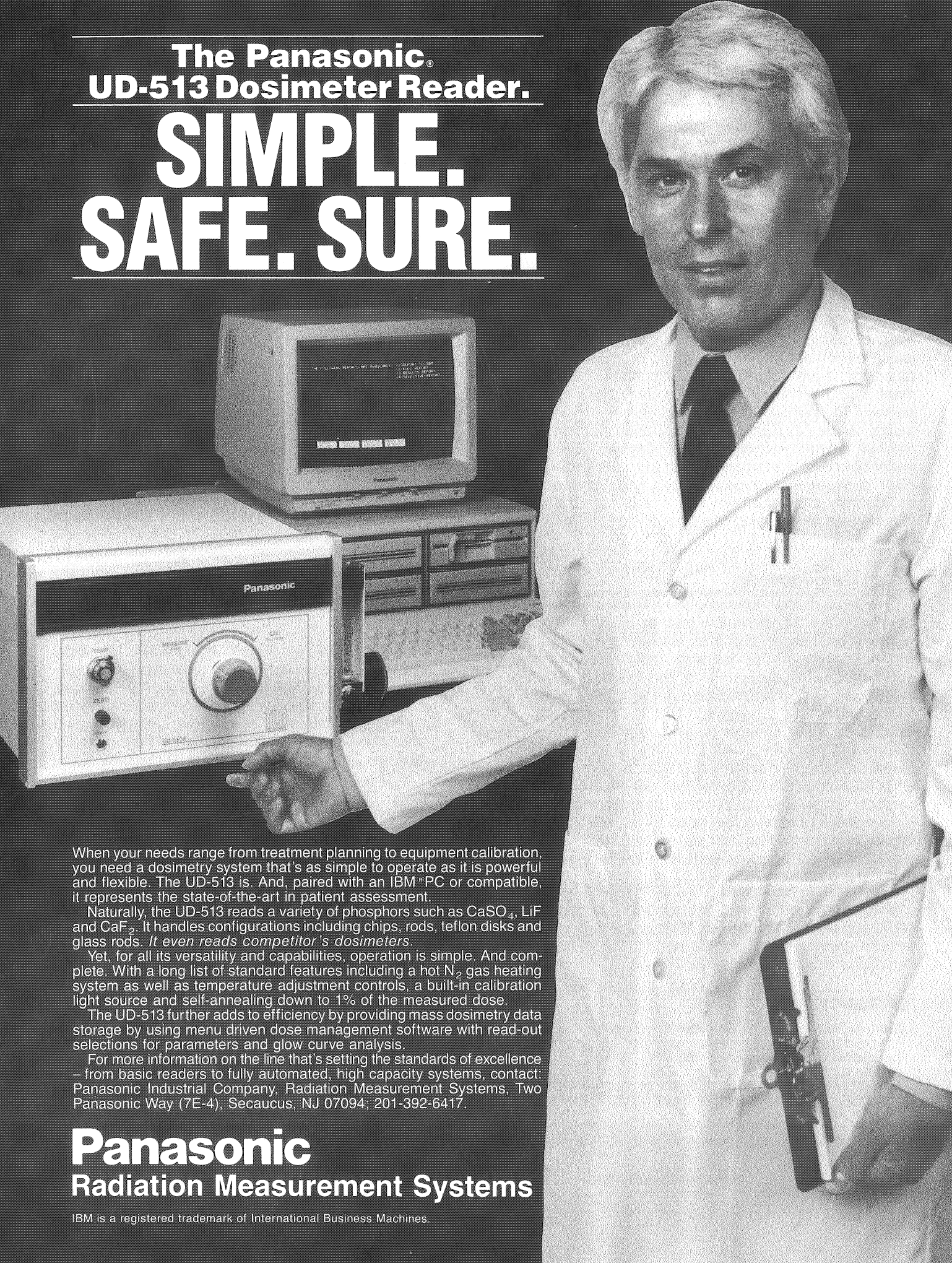

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also being seen in quality control of radiotherapy and diagnostic radiology procedures. The absence of Malaysian participation in the IAEA/WHO Postal Dose Intercomparison in Radiotherapy for the period 1969-1980 (Malaysian participation only has a much more recent history) had actually led to specific mention of the fact in a 1980 survey of the results of the Programme.[4]

There are also other areas of interest wherein benefit could be perceived from greater interaction and focusing of efforts; Becker[5] for instance has reviewed radiation protection monitoring in tropical, developing countries citing factors of concern in instrumental management such as high ambient temperatures, high relative humidities, voltage fluctuations and maintenance of perhaps overly sophisticated apparatus where otherwise more- robust and less sophisticated equipment would serve the purpose equally well. It is also relevant to mention here that, government establishments aside, a significant component of the total medical physics effort within Malaysia takes place under honorary consultancy; long term dependence on such a system of goodwill does not provide for a satisfactory state-of-affairs and this is especially true in situations where rapid response to specific problems occur.

Concluding Remarks

It is evident that contemporary Malaysian medical physics plays an essential role in existing medical services with prime activities remaining substantially within the realms of ionising radiations and their applications. The centennial of the first use of X-rays in Malaysia is now only some eight years distant (there is one claim to the first use of an X-ray apparatus in Taiping in 1897); though present facilities extend to mammographic units, CAT facilities, X-ray simulators, seven radiotherapy centres and two nuclear medicine units there appears to be no such advancement in the creation of a medical physics unit/department. We believe there to exist a real need for at least one such facility which would be best served by formal establishment within a University with location in a teaching/ medical environment.

The recent formation of a medical-physics-oriented sub-group of the Institut Fizik Malaysia will, it is hoped, provide greater forum for furthering the interests of medical physicists in Malaysia.

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Correspondence

Developing Countries Committee

I feel greatly honored to be chosen as Chairman of the Developing Countries Committee. Please allow me to express my thanks to the IOMP membership.

As members of this Committee, we are obligated to try our best to plan a program which is beneficial to medical physicists in the developing countries both at the professional and personal levels. I hope that all members of the committee will spare no effort to offer good ideas in order that we may plan our three-year-term program. I suggest that we carry out works as follows:

1. Continuation of the unfinished program that had been started by the last committee. This program included the encouragement of our colleagues in developed countries to donate spare materials, equipment and medical physics journals to satisfy the needs of those in the developing countries where shortages may exist. To continue to seek financial support from international organizations such as IAEA and WHO, etc.

2. Preparation of an Asian and Pacific Regional Medical Physics Conference to be held in Guangzhou, People's Republic of China in November, 1990. This meeting will provide an opportunity for medical physicists to share their technology and their experiences particularly in the field of Medical Imaging, including NMR Imaging and Spectroscopy. It is hoped that the meeting would be good for the further development of medical imaging techniques in the developing countries.

3. To seek the financial support of the medical instrumentation manufacturers to enable medical physicists from the developing countries to attend International Conferences and special training courses.

4. The establishment of travelling libraries in some of the major developing countries.

Would you please tell me your opinions about the above suggestions and your proposals?

With best wishes,

Sincerely yours,

Professor Nan-Zhu Xie
Chairman
IOMP Developing Countries Committee
Gangzhou Medical College
Dongfengxi Road
Guangzhou, People's Republic of China

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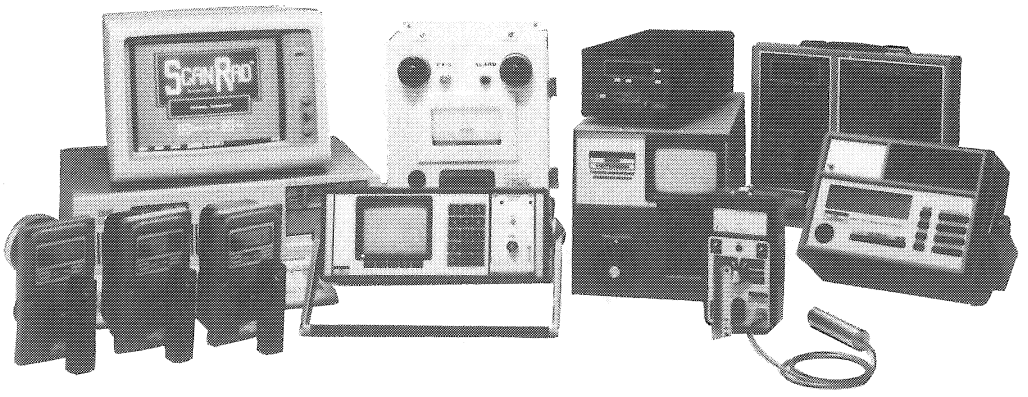

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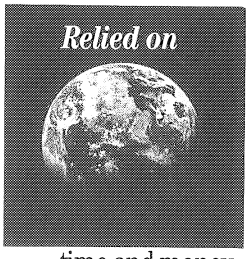

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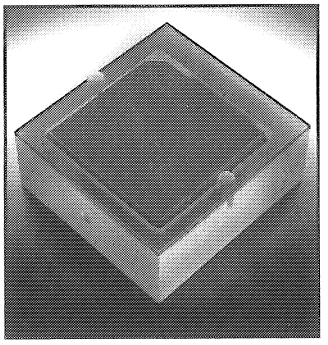

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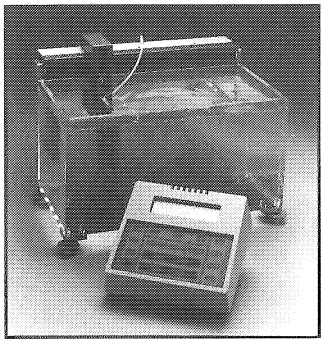

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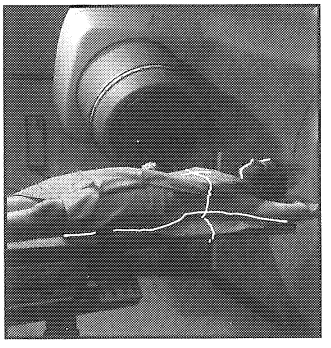

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