

***apdas***

***applied physics division analytical services***

***a division of Ansto***

## ***applied physics division analytical services***

APDAS (Applied Physics Division Analytical Services) is a service supplied by the Australian Nuclear Science and Technology Organisation, a government-funded body committed to building and maintaining strong links with industry by providing scientific and technical goods and services wherever possible.

Because of its background and achievements in high-tech research, APDAS can provide solutions to many of the problems that arise in Australian industries.

APDAS offers design, calibration and medical services which are not available elsewhere in Australia.

These include:

- a custom design service for the development of analogue electronic systems
- maintenance of absorbed dose standards
- a calibration service for ion chambers
- a fast and accurate method for measuring whole body protein. This medical service is important for studies of patients with wasting disease (e.g. cystic fibrosis and renal dysfunction). It also can be used for on-line measurement of foodstuffs, etc.

### DESIGN, CALIBRATION AND MEDICAL SERVICES PRESENTLY AVAILABLE

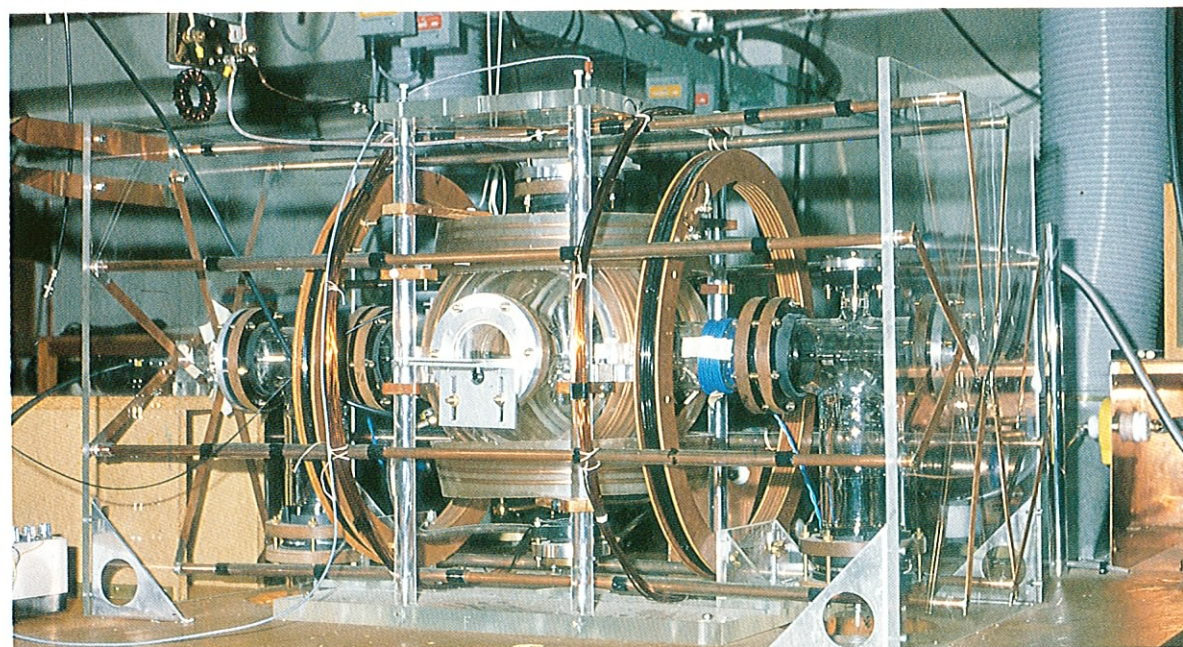
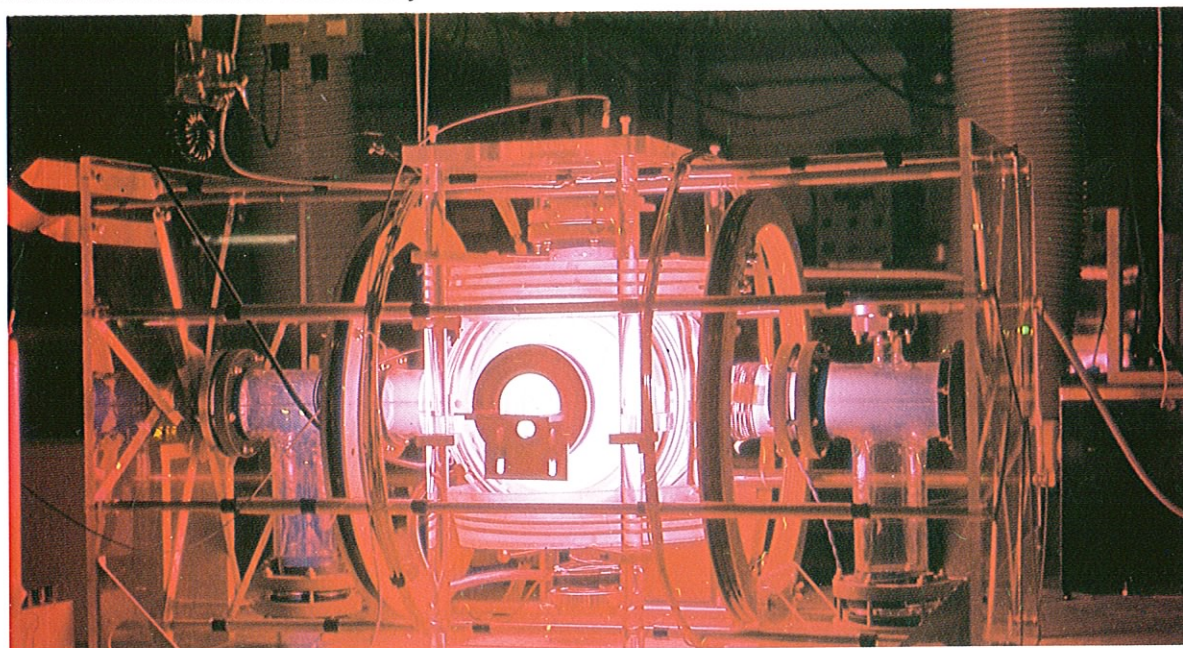
Special Electronics

Absorbed Dose Calibration

Thermoluminescence Dosimetry

Whole Body Protein

Measurement of Uranium and  
Plutonium Enrichment



ANSTO'S ROTAMAK PLASMA DEVICE (RA-1),  
WHICH IS USED FOR THE PRODUCTION OF PLASMA DISCHARGE

**DESIGN  
CALIBRATION &  
MEDICAL SERVICES**

## **GAS PHASE ENRICHMENT MONITOR**

APDAS has considerable experience in the development of a wide range of specialised nuclear instrumentation. These services can be utilised by Australian industry to solve appropriate problems.

### **INSTRUMENTATION FOR NUCLEAR SAFEGUARDS**

As a signatory of the Treaty for the Non-Proliferation of Nuclear Weapons (NPT), Australia is committed to the need to ensure that credible international safeguards are being applied. As part of a bilateral assistance package to the International Atomic Energy Agency (IAEA) APDAS, with support from the Department of Foreign Affairs, has been developing a number of special instruments which safeguards inspectors from the IAEA can use in their verification studies at nuclear installations. One of these instruments is the Gas Phase Enrichment Monitor (GPEM). See Fig. 1.

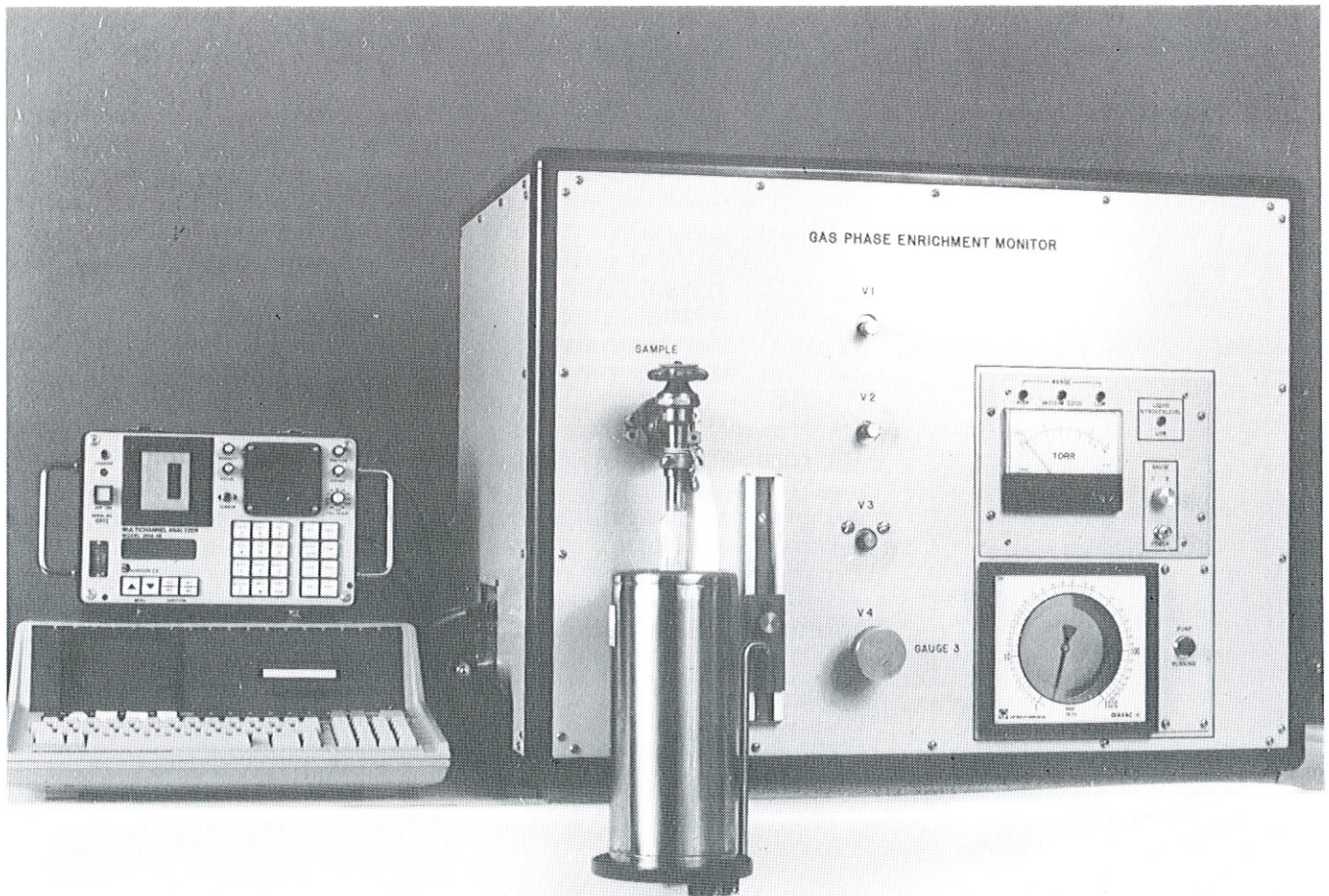


Fig. 1. Gas Phase Enrichment Monitor (GPEM).

## APPLICATION

The GPEM enables the inspector to determine the enrichment of uranium hexafluoride ( $\text{UF}_6$ ) gas samples taken from the product, feed and waste lines of gas centrifuge enrichment plants. The enrichment measured is the ratio of  $^{235}\text{U}$  to total uranium ( $^{235}\text{U} + ^{238}\text{U}$ ). The inspectors use the monitor to verify the enrichment values supplied by the operators of a plant.

## HISTORY

The GPEM was developed and extensively tested by APDAS over a number of years. It was first demonstrated at URENCO, Netherlands in 1983 and underwent long-term evaluation at Ningyo in Japan and at the Siebersdorf Analytical Laboratory in Austria.

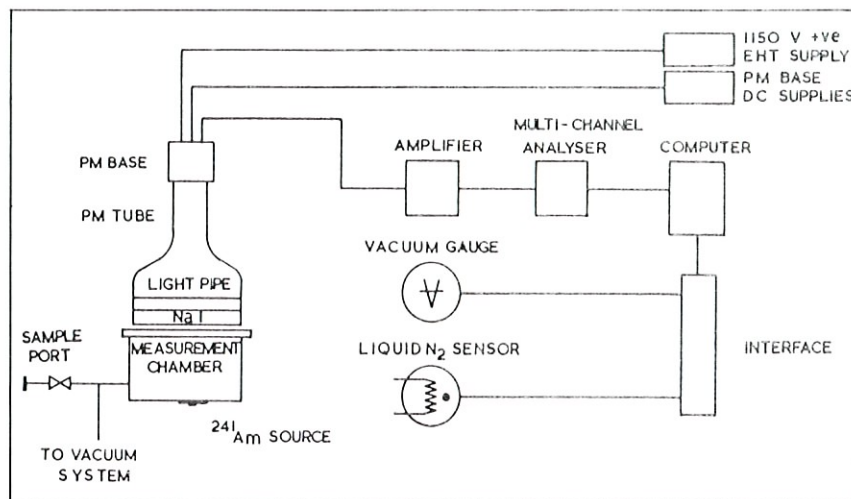


Fig. 2.

## PRINCIPLE OF OPERATION

A  $\text{UF}_6$  sample of approximately 3g is evaporated into a measurement chamber. See Fig. 2. Located above the chamber is a sodium iodide detector and directly beneath the chamber is an americium- $^{241}$  radioactive source. The total uranium content is calculated by measuring the attenuation of the 59.6 keV gamma ray emitted from the americium as it passes through the gas volume. The  $^{235}\text{U}$  content is calculated by counting the 185.7 keV gamma ray emission from the  $^{235}\text{U}$  sample. An enrichment is then calculated by comparing the two measurements.

The measurement also involves calibration of the instrument by the use of standards, as well as correction for radioactive deposition on the chamber walls.

The operation is supervised through an interactive program between the inspector and a desk top computer where each step of the operation relies on computer prompts and typed responses. This ensures simplicity of operation and guards against incorrect sequencing of manual operations.

## CONTACT

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## SPECIAL ELECTRONICS

The Electronic Design Group provides a custom design facility for the development of analogue electronic systems which are otherwise unobtainable. Areas of particular expertise are as follows:

### NUCLEONIC INSTRUMENTATION

Instrumentation for nucleonic measurements, e.g. –

- picoamp sensitivity current amplifiers (ion chambers, electrometers);
- low-noise charge amplifiers (radiation detectors, capacitive transducers); and
- battery-powered scalars, counters, amplifiers and ratemeters for field use.

### HIGH-ISOLATION SYSTEMS

Several systems have been designed to preserve the integrity of measured signals during their transfer through electrically noisy environments or across large potential differences. Inexpensive fibre-optic cables are used. Two typical systems are described below.

#### ACCELERATOR TELEMETRY SYSTEM

A system for telemetering measurements of various diagnostic voltages, for example those within a 3 million volt Van de Graaff accelerator, can be provided. Highly reliable measurements are made on the high-voltage terminal (at 2-3 MV potential) in the presence of high pressures, terminal discharges and radiofrequency (RF) interference.

Special circuitry includes versatile and ruggedised voltage-frequency converters for measuring EHT potentials (10-30 kV) (see Fig. 1) and an analogue optical link with feedback stabilisation to maintain calibration against optical parameter variations.

The measurements are transferred to ground-referenced display equipment by fibre-optic cables providing an isolation of over three million volts d.c.

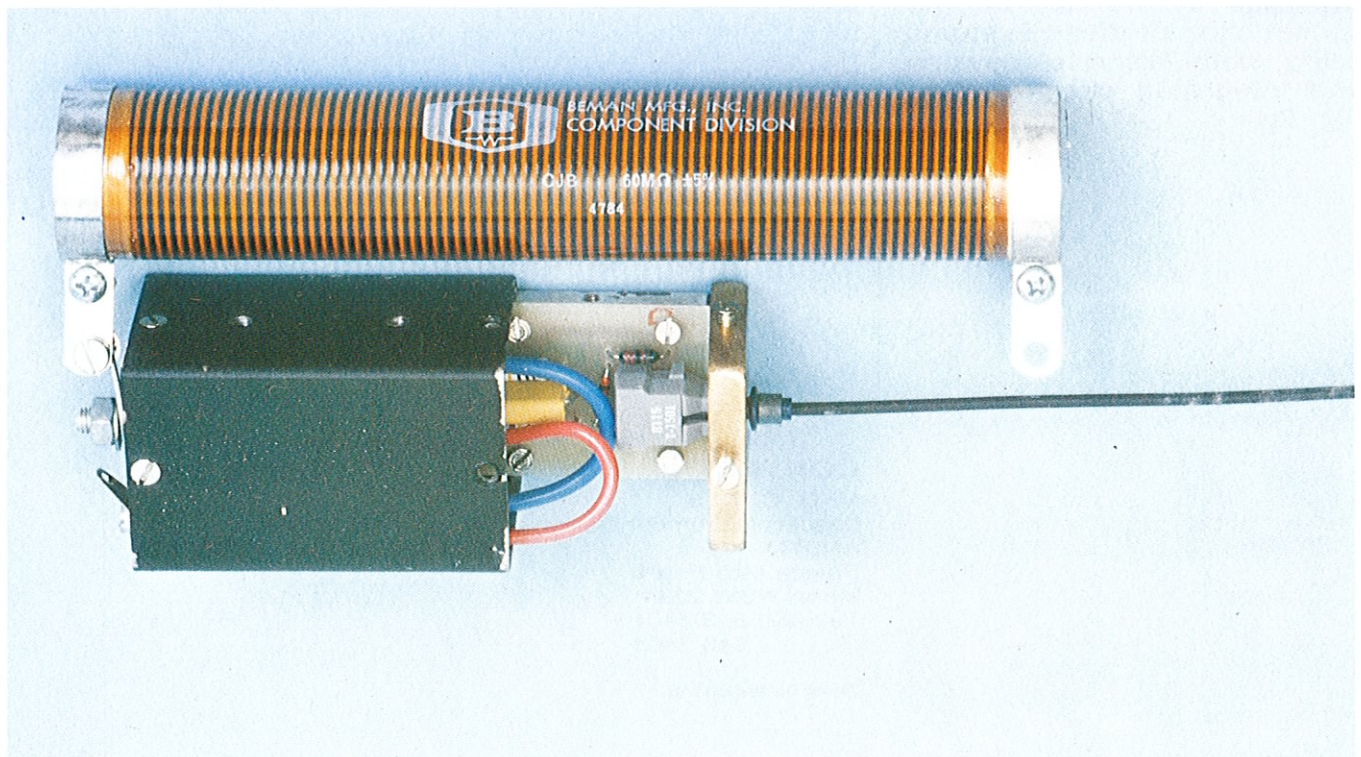


FIG. 1  
VOLTAGE-FREQUENCY CONVERTER FOR  
0-30 kV d.c. CALIBRATING RESISTOR AT TOP,  
SHIELDED HOUSING BELOW AND FIBRE-OPTIC  
OUTPUT CABLE AT LOWER RIGHT.

## HIGH-LINEARITY WAVEFORM TELEMETRY

A system for telemetering analogue waveforms with high linearity was provided for an experiment where RF or other sources of interference create significant inaccuracy. A typical system has a risetime of  $1 \mu\text{s}$  and achieved a high degree of waveform fidelity by means of a low-distortion ( $\sim 0.1\%$ ) digital encoder and high rejection ( $> 60 \text{ db @ } 1 \text{ MHz}$ ) differential input amplifiers.

## HIGH-SPEED AMPLIFIERS

Nanosecond-risetime amplifiers are often used for nuclear event-coincidence detection and timing and as high speed gain blocks for fibre-optic receiver systems.

The group has considerable expertise in the design and construction of these systems using both discrete devices and integrated circuits. (See Fig. 2).

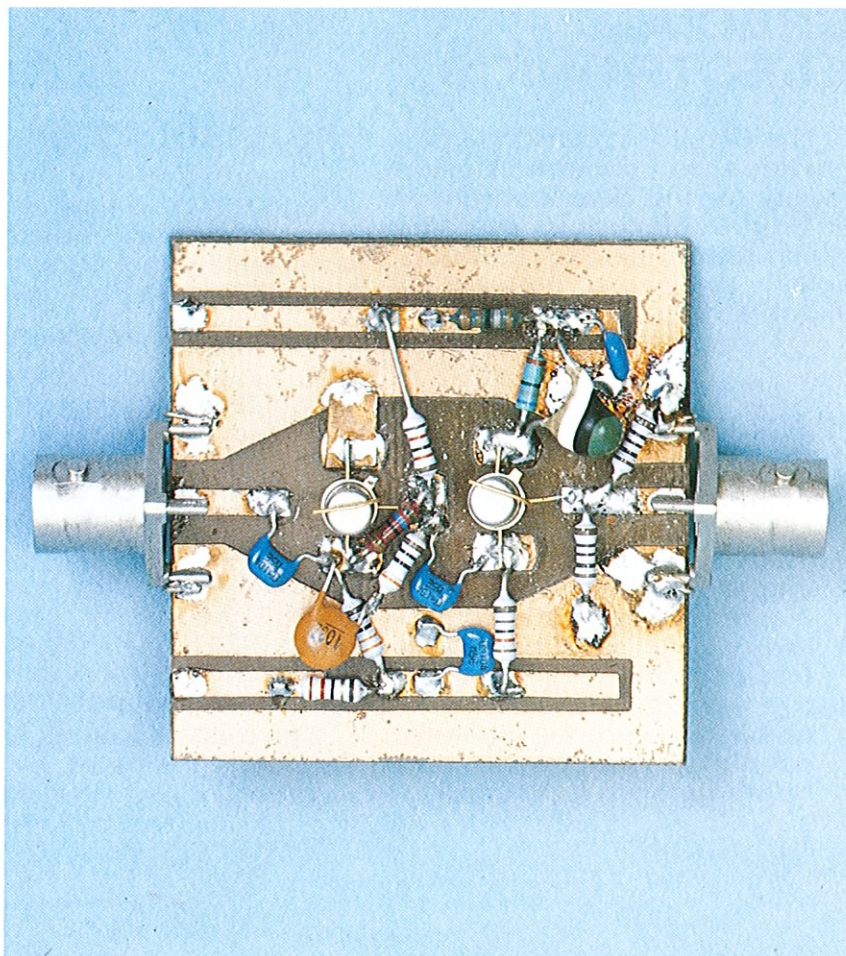


FIG. 2  
EXAMPLE OF A TYPICAL HIGH-SPEED AMPLIFIER:  
x5 GAIN; RISE TIME LESS THAN 1 ns; 50 OHM OUTPUT.

## CONTACT

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### WHOLE BODY PROTEIN

Protein is an important determinant in the metabolism of living forms and its measurement is crucial for understanding and countering the effects of wasting diseases in livestock and humans. The absolute measurement of protein can also be of value in quality control and classification of food products.

### TOTAL BODY NITROGEN (TBN)

Conventional techniques for the measurement of protein are either variable, slow, or destructive. However, the TBN technique offers a fast and accurate measurement of *in vivo* protein. Nitrogen, being a fixed constituent of protein, can be measured by prompt neutron activation. The subject is passed over a neutron source and the resulting neutron capture in the body produces prompt gamma rays that are characteristic of the nitrogen and hydrogen nuclei. These are counted by large NaI spectro-meters and the total body nitrogen is determined after appropriate corrections.

### APPLICATIONS

The technique is important for studies of patients suffering from wasting disease (e.g. cystic fibrosis, renal dysfunction, anorexia nervosa, trauma, etc.) for it provides a quantitative measure of the efficacy of supplementary nutritional regimes. Other applications relate to livestock or cereal studies, and the on-line classification of processed foods, packaged meat and cereals.

### SERVICES

A facility is available at Lucas Heights for collaborative research or service contracts. Consultancy contracts for the installation of turn-key systems can be negotiated.

### CONTACT

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## THERMOLUMINESCENCE DOSIMETRY SERVICE (TLD)

### ABSORBED DOSE STANDARD LEGAL UNIT

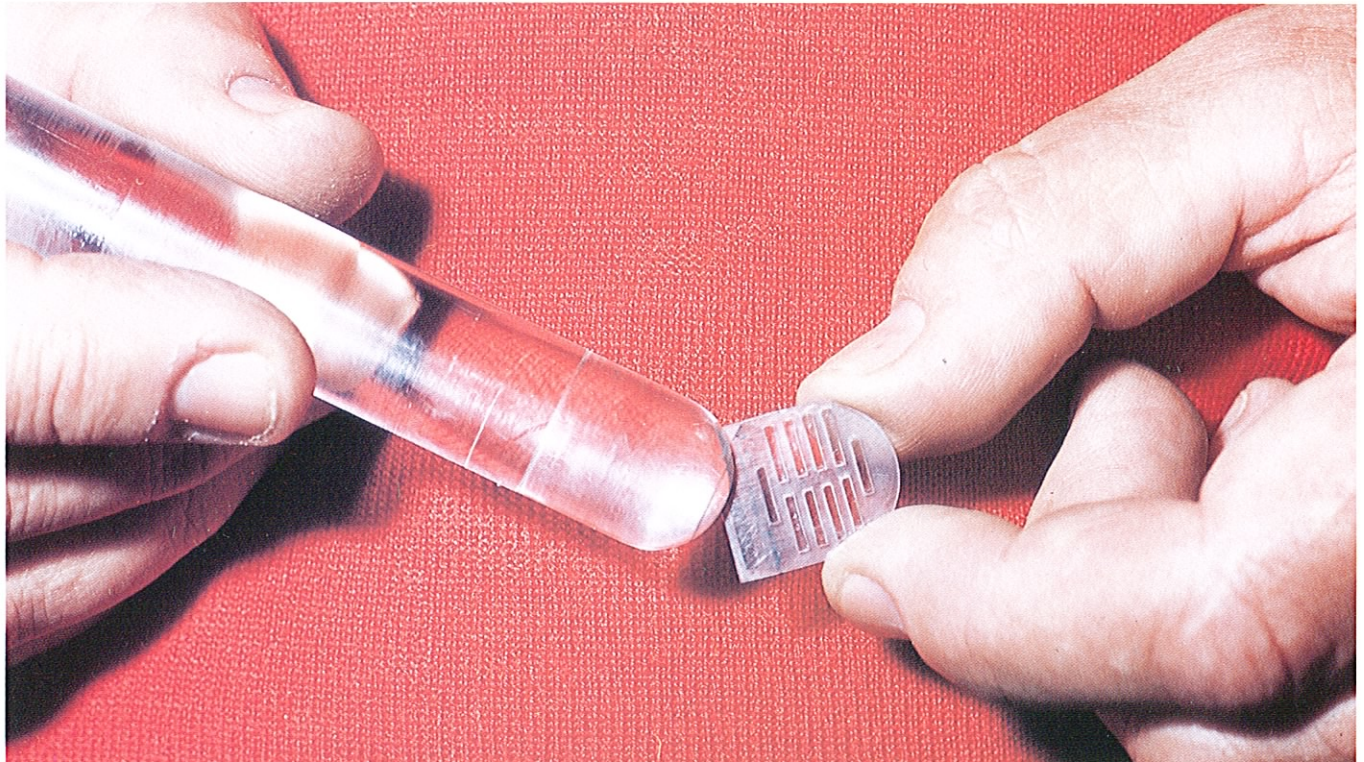
The Weights and Measures (National Standards) Act 1960 established the National Standards Commission, with responsibility for the legal and organisational aspects of maintaining a uniform national system of weights and measures within Australia. The Act confers on CSIRO through its Division of Applied Physics, responsibility for the technical aspects of maintaining national standards of measurement. In turn, CSIRO has delegated authority to ANSTO for the maintenance of the absorbed dose standard. This function is performed by the Radiation Standards Laboratory at Lucas Heights.

Consequently, the determination of absorbed dose by the Standards Laboratory represents the Commonwealth legal unit of measurement for the gray.

### MAINTENANCE OF THE ABSORBED DOSE STANDARD

“Maintenance” of the standards means the development and dissemination of the measurements. Since 1978, the absorbed dose standard has been determined at this laboratory by a graphite microcalorimeter, developed by D. F. Urquhart, for cobalt-60 gamma rays. In 1986, this instrument was adapted to full computer control by S. L. Sherlock. A Nuclear Enterprises secondary standard dosimeter, model #2560, is used as a working standard for absorbed dose in both graphite and water for cobalt-60 beams.

With the introduction of linear accelerators, having peak bremsstrahlung energies to 25 MeV, into hospital radiotherapy departments, there is a requirement for primary standard measurements of these beams. ANSTO is developing the appropriate standards.



A PERSPEX JIG WITH SLOTS FOR TEN THERMOLUMINESCENT DOSIMETER (TLD) RODS IS INSERTED IN THE DUMMY IONISATION CHAMBER

## **DISSEMINATION OF THE ABSORBED DOSE STANDARD**

ANSTO provides a calibration service for ion chambers, mainly the type Nuclear Enterprises models 2561 and 2571 (refer to Apdas Calibration 2/87).

In addition, the Radiation Standards Laboratory maintains a Pitman Instruments Toledo 654 TLD reader. Using Harshaw TLD-100 (LiF) dosimeters, a postal service for linear accelerator quality control is available.

## **TLD SERVICE**

In radiotherapy, absorbed dose dosimetry problems may arise from two principal sources – the calibration instruments and the linear accelerator dose termination ion chamber. Such problems may be insidious, developing over a period of years. Most thimble chambers are open to the atmosphere, allowing moisture and gaseous pollutants to contact the collecting electrode. Two Farmer type 2504 ionisation chambers developed crystalline growth on the collecting electrode over a period of ten years in the ANSTO radiation cell.

Thermoluminescence dosimetry offers a rapid and convenient check on such problems. The individual phosphors are calibrated against the Australian standard for absorbed dose at cobalt-60 energies. For measurements at higher energies, the energy response of the phosphors has been determined using the HPA 1983 X-ray calibration protocol for beam dose calibration.

The service is available for the following activities:

- Calibration checks.
- Hospital intercomparisons.
- Patient dose measurement in clinical trials.

## **CONTACT**

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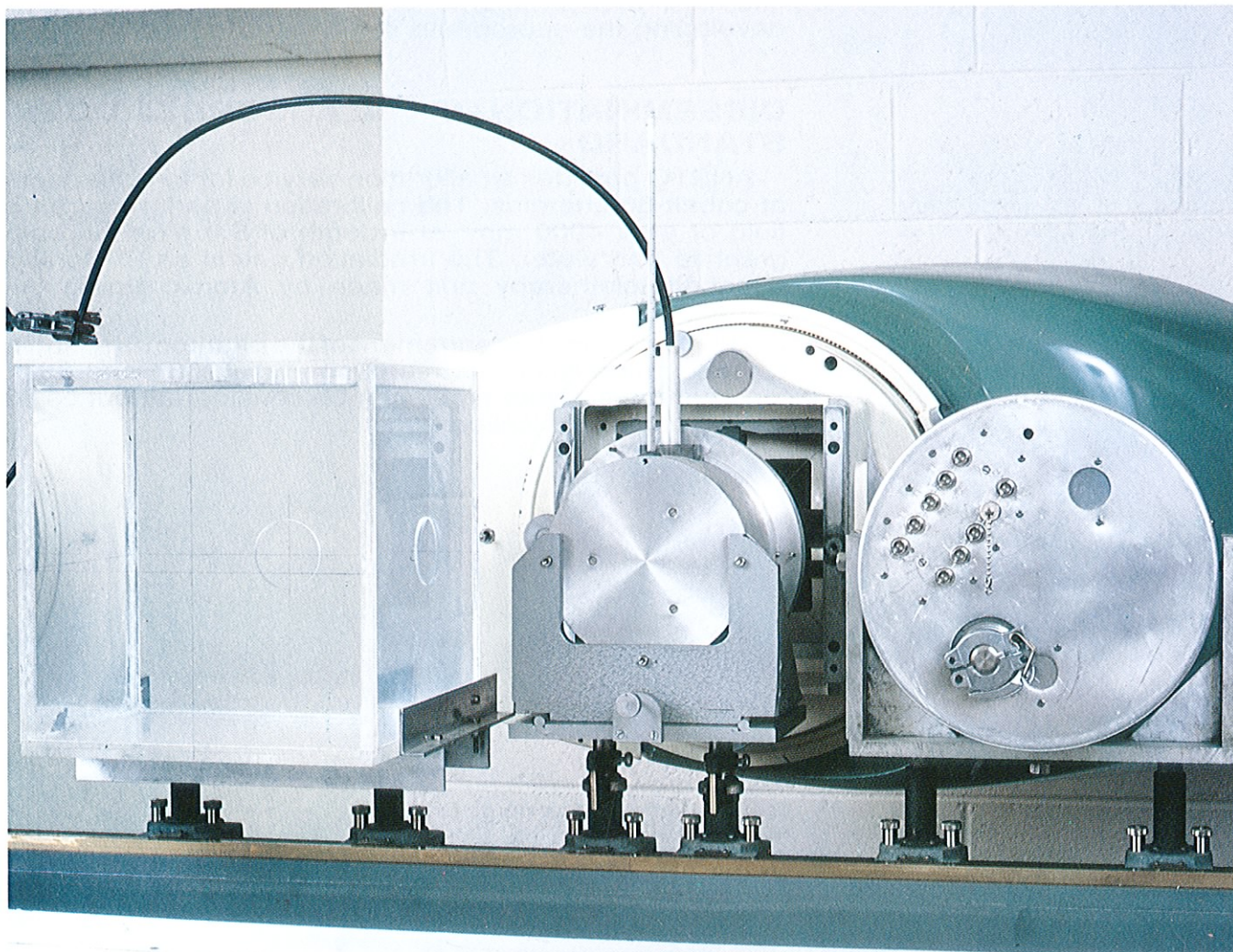
Apdas Calibration 3/87

## **ABSORBED DOSE CALIBRATION SERVICE**

### **ABSORBED DOSE STANDARD LEGAL UNIT**

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FROM LEFT TO RIGHT:

A WATER PHANTOM,  
A DUMMY CALORIMETER WITH ION CHAMBER IN  
PLACE AND THE AUSTRALIAN PRIMARY STANDARD  
FOR ABSORBED DOSE  
(THE GRAPHITE CALORIMETER).  
BEHIND THESE IS THE  $^{60}\text{Co}$  GAMMA SOURCE.

## **MAINTENANCE OF THE ABSORBED DOSE STANDARD**

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## **DISSEMINATION OF THE ABSORBED DOSE STANDARD**

ANSTO provides a calibration service for ion chambers at cobalt-60 energies. The calibration is performed for a field of area  $4900 \text{ mm}^2$  at a depth of  $5.0 \text{ g cm}^{-2}$  in both graphite and water. The irradiation unit is an El Dorado 6 cobalt teletherapy unit made by Atomic Energy of Canada Ltd.

The mechanical arrangement of the phantom is suitable for calibrating Nuclear Enterprises type 2561 and 2571 ion chambers. Other types can be considered, but could be more costly to calibrate.

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