FIRST INTERNATIONAL CONFERENCE

on

MEDICAL PHYSICS

Abstracts of Papers

Harrogate
8th–10th September 1965

THE FIRST INTERNATIONAL CONFERENCE ON MEDICAL PHYSICS

HARROGATE, YORKSHIRE.

September 8, 9 and 10, 1965

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A

This volume contains the abstracts of the review papers and proffered papers to be read at the Conference. The time and place of each Parallel Session are shown. Participants are advised to bring this volume to the Conference.

A limited number of additional copies will be available at the Conference at the price of £1, (One Pound) each.

SYNOPSIS OF

PARALLEL SESSIONS

PARALLEL SESSIONS

held in the

LOUNGE HALL

WEDNESDAY, Sept. 8th:

Session	A - 1	2.15 - 3.15	Solid State Dosimetry
	A - 2	3.25 - 4.25	Solid State Dosimetry
	A - 3	4.50 - 5.50	Microwave Absorption

THURSDAY, Sept. 9th:

Session	A - 4	2.15 - 3.15	Particle Beam Dosimetry
	A - 5	3.25 - 4.25	Dosimetry, Special Problems
	A - 6	4.50 - 5.50	Isotope Dosimetry

FRIDAY, Sept. 10th:

Session	A - 7	2.15 - 3.15	Computer Applications in Therapy
	A - 8	3.25 - 4.25	Computer Applications in Therapy
	A - 9	4.50 - 5.50	Dose Distribution

PARALLEL SESSIONS

held in the

CROWN HOTEL

WEDNESDAY, Sept. 8th:

Session	B - 1	2.15 - 3.15	Scanners
	B - 2	3.25 - 4.25	Scanners
	B - 3	4.50 - 5.50	Brain Scanning

THURSDAY, Sept. 9th:

Session	B - 4	2.15 - 3.15	Uses of Isotopes
	B - 5	3.25 - 4.25	Uses of Isotopes
	B - 6	4.50 - 5.50	Neutron Activation

FRIDAY, Sept. 10th:

Session	B - 7	2.15 - 3.15	X-rays, Spectra & Diagnostic Applications
	B - 8	3.25 - 4.25	X-rays, Spectra & Diagnostic Applications
	B - 9	4.50 - 5.50	X-rays, Spectra & Diagnostic Applications

PARALLEL SESSIONS

held in the

MAJESTIC HOTEL

WEDNESDAY, Sept. 8th:

Session	C - 1	2.15 - 3.15	Physiology and Medicine
	C - 2	3.25 - 4.25	Physiology and Medicine
	C - 3	4.50 - 5.50	Physiology and Medicine

THURSDAY, Sept. 9th:

Session	C - 4	2.15 - 3.15	Biological Systems & Measurement
	C - 5	3.25 - 4.25	Biological Systems & Measurement
	C - 6	4.50 - 5.50	Biological Systems & Measurement

FRIDAY, Sept. 10th:

Session	C - 7	2.15 - 3.15	Radiation Biology
	C - 8	3.25 - 4.25	Radiation Biology
	C - 9	4.50 - 5.50	Ultrasonics & Optical Techniques

PROGRAMME OF

PARALLEL SESSIONS

WEDNESDAY, Sept. 8th

SESSIONS A-1, A-2 AND A-3

Chairman: Prof. J. S. Laughlin
Vice-Chairman: Dr. R. E. Ellis

Paper No.	Presented by:
1	F. W. Spiers
2	E. Shuttleworth
3	G. P. Naylor
4	I. Berstein
5	R. P. Parker
6	B. J. Morley
7	J. Keller
8	M. Mihailovic
9	M. Kent
10	D. E. Herbert
11	J. R. Mallard
12	E. H. Grant

SESSIONS B-1, B-2 AND B-3

Chairman: Dr. G. L. Brownell
Vice-Chairman: Prof. J. Fowler

13	H. A. B. Simons
14	J. R. Mallard
15	S. O. Fedoruk
16	R. J. T. Herbert
17	B. Westerman
18	W. G. Walker
19	B. R. Pullan
20	A. Lansiart
21	B. J. Perry
22	J. McAlister
23	M. H. Sutherland
24	M. Akerman
25	F. C. Gillespie

WEDNESDAY, Sept. 8th

SESSIONS C-1, C-2 AND C-3

Chairman: Dr. B. Jacobson
Vice-Chairman: Dr. S. Rowlands

Paper No.	Presented by:
26	H. Schneider
27	J. Tigyi
28	R. L. Coren
29	C. Pallotti
30	W. T. Suermondt
31	B. A. Goddard
32	S. A. Vincent
33	D. Rowan
34	A. S. Velate
35	H. A. B. Simons
36	C. M. Cade
37	D. G. Tilston
38	M. Gembicki

THURSDAY, Sept. 9th

SESSIONS A-4, A-5 AND A-6

Chairman: Prof. J. Keller
Vice-Chairman: Prof. J. W. Boag

Paper No.	Presented by:
39	W. M. Preston
40	S. B. Field
41	R. E. Ellis
42	L. S. Skaggs
43	F. O'Foghludha
44	J. E. Robinson
45	R. E. Lawson
46	A. Rakow
47	N. G. Trott
48	E. F. Focht
49	E. M. Smith
50	C. E. Newton
51	C. A. Sondhaus

SESSIONS B-4, B-5 AND B-6

Chairman: Miss S. O. Fedoruk
Vice-Chairman: Mr. G. R. Newbery

52	R. Oliver
53	L. Burkinshaw
54	J. Shimmins
55	L. A. Hawkins
56	R. Hesp
57	B. I. Tyson
58	C. D. Field
59	M. R. H. Taylor
60	J. M. A. Lenihan
61	S. Osborn
62	J. Rundo
63	D. Newton
64	A. Batchelor

THURSDAY, Sept. 9th

SESSIONS C-4, C-5 AND C-6

Chairman: Dr. D. V. Cormack
Vice-Chairman: Dr. G. W. Dolphin

Paper No.	Presented by:
65	J. White
66	F. Tattam
67	P. S. Lykoudis
68	A. Kaul
69	H. Branson
70	R. Ellams
71	C. Matthews
72	P. R. J. Burch
73	C. Kellershohn
74	J. B. Dawson
75	B. Jacobson
76	N. L. Gregory
77	S. Guha
78	F. Hepburn

SPECIAL SESSION

Chairman: Prof. W. V. Mayneord
Vice-Chairman: Dr. S. Benner

79	E. H. Belcher
80	G. E. Osman

FRIDAY, Sept. 10th

SESSIONS A-7, A-8 AND A-9

Chairman: Prof. J. Dutreix
Vice-Chairman: Prof. F. W. Spiers

Paper No.	Presented by:
81	J. Howarth
82	R. Bentley
83	J. C. Jones
84	J. S. Robertson
85	J. van de Geijn
86	C. S. Hope
87	W. A. Jennings
88	R. J. Shalek
89	K. A. Wright
90	J. Telich
91	P. G. Orchard
92	M. Cohen

SESSIONS B-7, B-8 AND B-9

Chairman: Mr. R. W. Stanford
Vice-Chairman: Prof. H. A. B. Simons

93	A. D. Rotenberg
94	P. Tothill
95	P. N. Goodwin
96	S. Lillicrap
97	G. A. Hay
98	M. Davison
99	A. Robinson
100	M. B. Heller
101	S. P. Ricci
102	J. R. Cameron
103	G. W. Reed
104	B. Keane
105	C. Greatorex

FRIDAY, Sept. 10th

SESSIONS C-7, C-8 AND C-9

Chairman: Dr. P. Failla
Vice-Chairman: Prof. L. F. Lamerton

Paper No.	Presented by:
106	C. H. Marshall
107	R. Oliver
108	J. Ovadia
109	M. L. Griem
110	G. Poretti
111	J. S. Orr
112	B. W. G. Morgan
113	D. V. Cormack
114	J. A. Newell
115	A. Sokollu
116	J. McKie
117	F. G. Parsons

ABSTRACTS OF

REVIEW PAPERS

Wednesday, Sept. 8th, at 11.45 a.m. in the Lounge Hall.

"COMPUTERS AND DATA PROCESSING"

by

Professor S. Gill,
Imperial College of Science,
London.

Although computers have reduced very greatly the time and cost of doing very long calculations, there are still limitations on what they can do. Whether a given task can be performed by a computer may depend on one or more of the following factors:-

computing speed; internal storage capacity; availability of data in a suitable form; ability to produce output in the form required; and the possibility of writing a programme.

The latter requires that a mathematical procedure exists, suitably expressed; advances in programming techniques are giving us new forms of expression for programmes, and this goes hand in hand with the evolution of new methods of solving problems.

In scientific research, computers can be used both to elaborate the consequences of hypotheses and to analyse the results of experiments and observations. In the latter area there are current moves to bring computers into more intimate contact with the experimental equipment.

Thursday, Sept. 9th, at 9.00 a.m. in the Lounge Hall.

"BLOOD AND THE SMALLER BLOOD VESSELS"

by

Dr. S. Rowlands,
St. Mary's Hospital
Medical School,
London.

The viscosity of blood depends on its protein and cell content, and also on the rate at which it is sheared in the experimental measurements. There are other liquids which have similar properties, but there is one anomaly which seems unique to blood; if the viscosity is measured from flow-rates in tubes smaller than $\frac{1}{2}$ mm in diameter, then the narrower the tube the lower the viscosity.

The explanation is that red cells are driven, by a force of hydrodynamic origin, away from the wall of the tube where the shear rate is maximum towards the faster moving central stream. There is good reason to believe that the same effect occurs in vivo. In the very smallest vessels the cells of the blood fill nearly the whole cross-section of the tube, and another type of anomalous flow occurs. The pattern of this flow produces much more mixing of the plasma than would occur if no cells were present, and this mixing probably facilitates the gaseous exchanges which take place between blood cells and the tissues or the alveoli of the lungs.

It is likely that the deformability of the red cells is the most important factor determining the flow of blood through the smaller blood vessels.

Thursday, Sept. 9th, at 10.00 a.m. in the Lounge Hall.

"THE PHYSICS OF HEARING"

by

Dr. B. McA. Sayers,
Imperial College,
London.

Physical studies of sensory systems are unique in that the overt response to an experimental procedure is often ultimately based on complex subjective phenomena of a little-understood kind. What a listener perceives is very much a function of the listener and is not available for direct objective inspection by the experimenter. A significant part of the task of elucidating the hearing mechanism thus necessarily involves specialized experimental techniques which can lead to adequately objective assessment of the data. The particular difficulties of the field, however, are centred on several main unresolved aspects of audition, in some of which engineering and physical techniques are particularly relevant.

First, although relations between acoustic waveform and basilar membrane response are becoming clear, the relationship between basilar membrane activity and perceived auditory impression is proving much more elaborate than might have previously been supposed. While information about the mechanical-to-neural conversion along the length of the basilar membrane is now available, even with simple signals the relevance of temporal fine structure in cochlear electrical activity to the identification of the signal is strongly debated.

Bekesy's work on the pure-tone mechanical response of the basilar membrane has permitted inferences about the time-course of membrane displacement at various positions in response to wide-band acoustic signals. Considerable evidence is available about the neural activity resulting from membrane displacement, although it is not certain if other than simple mechanical displacement of the membrane is relevant in the initiation of cochlear neural signals. Psycho-physical experiments based on these data have led to inferences about the architecture of neural pathways involved in the cross-comparisons of binaural hearing; other experiments have provided information about the relation between regional cochlear activity and the character of associated sound image perceived by the listener.

Second, the function and mode of action of many of the structures between the cochlear nerve and the auditory cortex and their role in a listener's perceptual behaviour, are understood only in a most incomplete way.

Third, the mechanism of the special human faculty for perceptual separation of simultaneous acoustic signals (as with separate but simultaneous speech messages) and the dependence of this ability on the physical parameters involved in spatial separation of the sound source, are both live topics of current work.

Finally, of many aspects of prosthetic devices, a particularly important one concerns the optimum use of the auditory pathway to support the visual sense (as in reading devices for the blind). Here, the problem is one of optimally coding the auditory presentation, and in a sense, is a problem of signal analysis.

In these and other aspects, concepts and techniques of modern physical science are relevant, and the review will also, therefore, consider the potential further applicability of such techniques in the further elucidation of auditory perceptual activity.

Thursday, Sept. 9th at 11.45 a.m. in the Lounge Hall.

"MICROWAVE SPECTROSCOPY"

by

Professor D. J. E. Ingram,
University of Keele,
Keele, Staffordshire.

Spectroscopy employing microwave or radar wavelengths has developed very rapidly since the war, and one particular branch of this, known as electron resonance, has found a large number of applications in the field of medical physics.

This paper will begin by outlining the general principles of the two new techniques which have been developed over recent years, i.e. nuclear magnetic resonance and electron spin resonance. The experimental equipment that is required in these studies will then be briefly described, and this will be followed by a summary of the general features which are observed in the spectra in both cases. Particular attention will be paid to the splittings which arise.

The particular application of the two techniques to problems in biological and medical physics will then be considered. In the case of electron resonance, these applications arise both from the study of free radical reactions associated with metabolic and enzyme activity, and from a study of transition group atoms which may form an essential role in biochemical activity, such as the iron atom in haemoglobin. Very interesting information is also becoming available from the combined study of these different effects in which free radical and enzyme activity can be plotted against change in valency state of the associated metal atoms. Other fields of medical interest in which electron resonance is also playing an increasingly important part, such as the study of irradiation damage, will also be briefly summarized.

The particular applications of nuclear magnetic resonance will also be considered, both in the more general form, such as the estimation of fluid contained in vivo, and in the more specific applications on the structural analysis of biochemically important compounds.

Friday, Sept. 10th, at 9.00 a.m. in the Lounge Hall.

"THE PHYSICS OF CELL DIVISION"

by

Dr. G. G. Selman,
University of Edinburgh
Department of Genetics,
Edinburgh.

Before about 1940, nearly all the hypotheses that were advanced to account for mitotic activity carried with them the assumption that a single kind of force was responsible for all the observed movements. Since the publication of the monograph by Schrader (1944) on "Mitosis", most cell biologists have abandoned this idea as being too simple. The complexity of intra-cellular organization, and the fact that it is almost impossible to affect a single subcellular structure or process by experimental means without simultaneously affecting many others, may have discouraged the application of the experimental method to this important branch of biology. Nevertheless, during the last twenty years much useful information has been gathered from measurements made from time-lapse films of cells in division using phase-contrast microscopy and from birefringence measurements on the spindle and cell cortex of dividing cells. Electron microscopy continues to reveal ultrastructural complexity which is not fully interpreted (e.g. the microtubules of the spindle). Measurements have been made of the stiffness of the cell surface during cleavage. Although we do not understand how a metaphase plate is established or what brings about the anaphase movement of chromosomes, these questions can now be considered in biophysical or biochemical terms.

The plane of cell cleavage is determined by the position occupied by the equator of the spindle at the late anaphase stage. The contractility of the cell surface appears to play an important role in the cleavages of certain animal cells. In all forms there is a growth of new cell surface which usually takes place in the cleavage plane.

Among the more promising lines of present research are the attempts being made to study contractility in defined cell fractions, to work with isolated cell spindles and to use microbeams of ultraviolet light to study the anaphase movements of individual chromosomes.

Friday, Sept. 10th, at 10.00 a.m. in the Lounge Hall.

"FUNCTIONAL REPLACEMENTS, (ARTIFICIAL ORGANS AND LIMBS)"

by

Dr. J. T. Scales,
Dept. of Biomechanics and
Surgical Materials,
Royal National Orthopaedic
Hospital, Stanmore, Middx.

The replacement of an organ or the correction of its function by an artificial member or device is neither new nor infrequent. Spectacles have been used for many centuries, while dentures are now required in such numbers that approximately 1,000 tons of polymethylmethacrylate dental polymer are used in the world annually.

Improvements in the treatment of disease or injury often follow developments in the field of chemistry, physics and engineering. Since 1945 a range of apparently inert plastic materials have become available which appeared to have suitable properties for a variety of surgical purposes. The limitations of devices constructed from these materials are now becoming apparent, and in orthopaedics in particular there is a return to the use of metals for major bone and joint replacements. Advances in the field of electronics, especially in the micro-miniaturization components, have made it possible to implant "active devices" in the body to control the function of organs, for example, the cardiac pacemaker.

The development of an artificial heart and its use in calves has recently led the Surgeon-General of the United States Armed Forces to prophesy that in twenty years artificial hearts will be in use.

We have the prospect of great and new opportunities in surgical treatment, but only a just appraisal of the hazards, judicious selection of both patients and materials, coupled with adequate standards of design and manufacture, can prevent many disorders.

Future progress is largely dependent on the close collaboration of the disciplines of biology and medicine, physics and engineering. Some of the biological and mechanical factors which can influence the successful outcome of replacement surgery will be discussed and illustrated with slides and a film.

Friday, Sept. 10th, at 10.00 a.m. in the Lounge Hall.

"FUNCTIONAL REPLACEMENTS, (ARTIFICIAL ORGANS AND LIMBS)"

by

Dr. M. Vitali,
Limb Fitting Centre,
Roehampton, London.

Functional replacement of limbs has been a topic for discussion between surgeons, engineers and prosthetists for many years. It has become apparent that even the most sophisticated mechanism would never replace a lost arm or leg but it may help in restoration of function, with a minimal amount of effort required.

With the progress of medicine and surgery, development of new materials and variety of new drugs, the expectation of life of an individual is much greater today, but the hazard of speed has resulted in an increase of road accidents. Drugs prolong life but fail to stop progress of such diseases as arteriosclerosis or diabetes, or may introduce complications of a previously unknown factor resulting, for example, in the thalidomide tragedy and congenital deformities.

It has become necessary to continue our efforts and to construct a team of specialists of different branches such as physiologists, neurologists, surgeons and physicists, to try and solve the problem of movement from every point of view. One has to remember that each patient is an individual, and certain variations of an original design may have to take place.

The main object of this paper is to give an outline of an existing modern type of prostheses for extremities, and to show what can be done for severely deformed children.

It is hoped that this short survey of our work will stimulate further co-operation and new ideas in all specialist fields.

Friday, Sept. 10th, at 11.45 a.m. in the Lounge Hall.

"WORK IN ABNORMAL ENVIRONMENTS"

by

Dr. K. G. Williams,
Vickers Research, Ltd.,
London.

The development of technological societies means that men have to work in environmental conditions which fall outside the limits for human survival. The depths of the sea and the strangeness of space must now be accepted as the frontiers of human exploration. Life in these environments is only made possible by engineering control of the environment in immediate contact with the man. But even with most advanced technology, physiological problems are still posed which influence the ability of man to live and work. Decompression sickness beneath the sea and weightlessness in space are among typical examples.

The glamour of such pursuits must not, however, be allowed to hide the fact that abnormal environments exist under standard atmospheric conditions. The extensive use of equipment and materials producing radiation, cybernation, a complex of transportation systems at increasing speeds and modern communication systems are among the technical problems which can influence human behaviour. The solutions to such problems are not always so clear-cut as those under dramatic situations. But because they influence a greater number of men their effect in the end may be more considerable.

The indirect influence of such abnormal environments in medical practice must not be underestimated. But in recent years abnormal environments have themselves become part of medical therapy. Hyperbaric medicine and units for the prevention of cross-infection exemplify this. Here both the medical staff and patients may be involved.

So the need to work in technical environments tends to spread through all aspects of society. As it does so, a general approach becomes necessary, for the solution of individual problems, often on an empirical basis, may in itself be uneconomic and not wholly successful.

ABSTRACTS OF

PROFFERED PAPERS

SOLID STATE DOSIMETRY

F. W. Spiers and G. Zanelli,
The General Infirmary, Leeds.

1. THE APPLICATION OF THERMOLUMINESCENCE TO PROBLEMS OF RADIATION DOSIMETRY IN BONE.

Thermoluminescent powders offer a unique opportunity to measure radiation dose in trabecular bone and on the surface of cortical bone. This calls for the use of thermoluminescent powders having a grain size smaller than normally found in commercially available salts.

The paper describes investigations of thermoluminescent response with variation in grain size and of the energy response in the photon energy range where photoelectric absorption is important. Methods are then described by which the fine-grain salt is introduced into the marrow cavities of specimens of trabecular bone, and removed for measurement after irradiation.

Some of the bone specimens are those for which the distribution of marrow cavity sizes has already been measured, and on the basis of which calculations of mean marrow dose have already been made. Comparisons are made between measured and calculated mean marrow doses. Further experiments compare the doses measured near cortical bone surfaces with those based on various theoretical treatments of the problem of secondary electron emission from bone.

E. Shuttleworth and J. F. Fowler,
Hammersmith Hospital, London.

2. LITHIUM FLUORIDE THERMOLUMINESCENCE DOSIMETRY.

Practical difficulties can arise in the use of thermoluminescence dosemeters. Agitation of lithium fluoride powder produces a spurious thermoluminescence, which can be suppressed by heating in an inert gas. Some investigations of this spurious thermoluminescence will be described. It has been found that the stored energy decays by 15% to 20% over a period of three weeks, and then largely recovers after a further few weeks. This recovery could explain why other laboratories have not reported decay after measurements over longer times.

Some applications and their problems will be described, including clinical measurements, intercomparisons between different centres by post, and finger-mounted dosemeters of low bulk.

G. P. Naylor,
Christie Hospital, Manchester.

3. SOME DEFICIENCIES IN THE PERFORMANCE OF CURRENTLY AVAILABLE LITHIUM FLUORIDE THERMOLUMINESCENT PHOSPHORS.

The limitations of lithium fluoride phosphors in the light of experience of their use in practical dosimetry will be discussed with special reference to:

a) deduction from a glow curve of the likely practical performance of a given phosphor,

b) dependence of response on radiation energy and its variation in phosphors with a non-linear light versus dose curve.

Some requirements for the "ideal" thermoluminescent phosphor will be indicated.

B. E. Bjarngard, R. C. McCall and I. A. Berstein,
Controls for Radiation, Inc., Massachusetts, U.S.A.

4. LITHIUM FLUORIDE PLASTIC DOSEMETERS FOR THERMOLUMINESCENT DOSIMETRY.

One of the desirable improvements in extending the usefulness of lithium fluoride thermoluminescence dosimetry is to make dosemeters which are easier to handle than the loose powder. In addition, it is desirable for medical applications to have dosemeters of various shapes and thicknesses, such as discs (100 to 200 ml in thickness), sheet, or rod.

Such dosemeters have been successfully fabricated using techniques of loading lithium fluoride phosphors in high melting polymeric tetrafluoroethylene and processing to desired configuration including thin films. These dosemeters have good energy independence and tissue equivalence and no danger of breaking.

Most other characteristics are determined by the properties of LiF itself. Special problems are associated with the choice of readout procedure, and the background phenomena during readout. Our experiences in overcoming these problems and in the use of LiF loaded polytetrafluoroethylene will be described. Some applications in radiology and personnel protection will be discussed.

SOLID STATE DOSIMETRY

R. P. Parker and B. J. Morley,
Institute of Cancer Research, Surrey.

5. P-N JUNCTION SURFACE BARRIER DETECTORS AS γ-RAY DOSEMETERS.

These radiation detectors, which are in many ways the solid state analogue of the gaseous ionization chamber, may be used as γ-ray dosemeters in both pulse-counting and DC modes. The former is the most sensitive method and may be used to measure dose-rates down to the order of 10^{-5} r/hr.

Less sensitive, but more convenient, measurements of dose-rate may be carried out by determining the radiation-induced potential across the P-N junction. This may be done by using a high impedance valve voltmeter, in which case the open-circuit voltage is found to be a logarithmic function of dose-rate over a range of exposure dose-rates. Alternatively, the short circuit current may be measured, when an approximately linear dependence on dose-rate results.

The paper will consider the relative sensitivities of these different methods and, in particular, will give information on the dependence on dose-rate, dose, energy and temperature for a number of different types of surface barrier detector. Ways by which certain adverse effects can be nullified will be described.

B. J. Morley,
Institute of Cancer Research, Surrey.

6. MEASUREMENT OF β-ACTIVITY USING SILICON SURFACE BARRIER DETECTORS.

There is a need for the measurement of low β-activities in small volumes within the body, for example, in the individual chambers of the heart, in the bladder, or in a tumour. Silicon surface barrier needle detectors, which combine small size with high sensitivity, are being developed for these purposes. Larger surface barrier detectors, already familiar to the nuclear physicist, are also being considered for superficial activity measurements.

The low energy response of the semiconductor devices is limited mainly by the noise level. The dependence of noise on operating bias and temperature has been investigated for several types of detector. The counting efficiencies for several isotopes in common use have also been measured as functions of depletion depth and temperature.

If the probe is to be used to scan an area of β-activity, e. g. to locate a brain tumour, then for sharp definition it must discriminate

against bremsstrahlung. Consequently a study has been made of the relative counting efficiencies to β- and γ- radiations.

An important property of any device contemplated for routine use is its stability and useful life, and a progress report on those detectors under investigation will be given.

J. Keller, W. Katkiewicz and M. Szawlowski,
Central Laboratory for Radiological Protection,
Warsaw, Poland.

7. APPLICATIONS OF THE FIELD EFFECT TRANSISTOR (FET) TO THE MEASUREMENT OF IONIZATION CURRENTS IN MEDICAL PHYSICS AND HEALTH PROTECTION.

The development of the field effect device which has high input impedance and high transconductance has opened up new possibilities through its use at the input stage of an amplifier driven from a current source. The range of signals in which an unipolar device can replace an electrometer tube is studied. The current-driven characteristics of FET are presented, the influence of temperature on the FET performance is measured, and the temperature coefficient and compensation considered.

A single FET current amplifier with gain of 5×10^5 and temperature drift of 10^{-11} amp/°C is developed. An ionization chamber monitor suitable for use in radiation physics is described. It contains a unipolar unit at the input and a planar bipolar transistor at the second stage. The circuit used is extremely simple and the device is very small.

The paper gives an outline of further possible work in this field.

M. Mihailovic, V. Kosi, M. V. Mihailovic and Z. Milavec,
University of Ljubljana, Yugoslavia.

A THERMOLUMINESCENT DOSEMETER AND DOSIMETRY READER.

8. A dosemeter for routine use has been developed using calcium fluoride thermoluminescent powder. The CaF_2 powder has been built

into a specially developed enamel and fixed by the enamel to the silver support.

The enamel coating gives a good protection against atmospheric and other influences. The dosemeter is completely free of triboluminescence.

Five hundred dosemeters have been tested for loss of stored energy. Suitably stored dosemeters show no loss of stored energy after five weeks.

With an active surface of 1 cm^2 and the use of a standard RCA 6342-A photomultiplier for detecting the light, the device detects doses of ^{60}Co rays in the 100 milliroentgen range, and is linear up to at least 10^4 roentgens.

Suitable shields are used to correct the energy dependence of the response. For an unshielded dosemeter the ratio of the response at 40 kV eff/ to that for ^{60}Co rays is approximately equal to 4. The dosemeters are very simple to produce, and consist of a CaF_2 coating on a silver support 0.12 mm thick and size 3 x 2 cm^2. The CaF_2 is coated with 1 mm of enamel.

The reading instrument integrates the thermoluminescence during the heating time, which is determined by an indra-red photoresistor. The doses may be registered by a recorder or simply read on an ordinary millivoltmeter. A system is built in to enable the reading of any dose with the same accuracy in any of the ranges: 0 - 100 mr, 100 mr - 1 r, 1 - 10 r and 10 - 100 r.

MICROWAVE ABSORPTION

M. Kent,
St. Thomas's Hospital, London.

9. TECHNIQUES FOR THE STUDY OF LIVING TISSUE BY E.S.R. AT 3 cm WAVELENGTH.

Special techniques have been developed during the past few years which enable measurements of E.S.R. signals from surviving animal tissues to be made; these are briefly described.

A multichannel analyser is also used to improve the signal-to-noise ratio by means of a continuous averaging technique. N successive sweeps of the E.S.R. spectrum are added in the memory of the analyser to give an improvement of $N^{\frac{1}{2}}$, and in addition, each channel of the memory takes the average of 10 samples of the signal so that the improvement becomes $(10N)^{\frac{1}{2}}$. The limit of the improvement has been found to be 100:1, and the optimum conditions of operation are at a sweep rate of 100 gauss in 4 - 8 seconds, with a time constant of 0.2 seconds.

With the use of differentiation facilities, the second derivative of the signal can be obtained automatically to give an easy and accurate measurement of the g-value of any signal; an accuracy of 1 in 10^3 - 10^4 has been obtained in g for signals from surviving tissue. The use of a magnetic tape recorder, in conjunction with the analyser, also permits the integration of the signal to give the total number of spins in the signal; the usual method of computation from a pen-recording gave errors of up to 10% in this integration, but the error is only 1% with the analyser. Finally, the analyser is invaluable in that backgro und spectra from sample cells can be stored and automatically subtracted from spectra obtained on samples and cell.

D. Herbert,
St. Bartholomew's Hospital, London.

10. THE EFFECTS OF MODE OF EXCITATION AND OF INTER-MOLECULAR COUPLING UPON THE PRODUCTION AND DECAY OF TRIPLET STATE MOLECULES.

The triplet excited states of molecules have been frequently implicated as possible transient intermediates in a wide variety of biologically significant energy transfer processes.

Recent theories have suggested, and recent phosphorescence studies have confirmed, that the probability of promotion of a molecule to its first excited triplet state is a function of the nature and strength of the inter-molecular couplings of the molecule and of the nature and intensity of the exciting radiation. More precisely, it has been found in several phosphorescence studies that the probability is enhanced by the coupling of the absorbing molecule with similar molecules via the hydrogen bond and van der Waal's interactions. This results in the formation of dimers, trimers, and polymers of high order (molecular excitons). The probability is also enhanced by the coupling of the absorbing molecule with dissimilar molecules through the exchange interaction to form complexes. Other phosphorescence studies have indicated that the probability of triplet state production may be greater for ionizing radiation than for ultraviolet radiation.

J. R. Mallard,
St. Thomas's Hospital, London.

11. ELECTRON SPIN RESONANCE SIGNALS FROM LIVING ANIMAL AND HUMAN TISSUES.

Commoner and Ternberg reported electron spin resonance signals from surviving tissues, which we have subsequently confirmed.

Using a much improved spectrometer, small slices of surviving tissues of 0.1 ml volume have been examined, including rat liver, kidney, heart muscle, muscle and brain, and also subcutaneous rat tumours. Considerable differences exist between the measured signals from tissue to tissue, the largest signals being observed from liver and kidney. The signals decrease with time (half period 30 minutes at 30°C), presumably due to death, and have g-values which suggest the presence of free radicals. The tumour tissues examined show much smaller signals than the normal tissue from which they were originally derived. Human blood also exhibits signals in the free radical region.

It has been found that the single signal previously observed is more complex, with up to 3 separate signals appearing at different g-values. Preliminary examination of cell fragments separated by centrifugation show that mitochondria exhibit similar signals to those observed in tissue, as shown by Sands and Beinert, but much

work remains to elucidate the origin of the signals, which may perhaps be due to trace elements in addition to free radicals involved in respiratory processes.

A number of research and diagnostic uses may lie in this new field of physics applied to biology and medicine.

E. H. Grant,
Guy's Hospital, London.

12. THE ELECTRICAL BEHAVIOUR OF ALBUMEN SOLUTIONS AT HIGH FREQUENCIES.

The dielectric properties of solutions of egg albumen and bovine serum albumen have been investigated in order to study the electrical behaviour of these proteins in an aqueous environment.

The measurements were taken in the frequency range 250 - 1200 Mc/s between 0° - 40°C, using coaxial line apparatus working on the following principle. Radiation from a tunable triode oscillator is coupled through an isolating attenuator and low pass filter to the experimental cell containing the protein solution. The experimental cell is a short-circuited line, and thus produces a standing wave which is displayed on the standing wave indicator as a probe moves through the cell. From the standing wave ratio and the distance between the minima the real (ε') and imaginary (ε'') parts of the dielectric constant can be computed.

A few determinations were also carried out at 25°C only between 500 kc/s and 200 Mc/s using a Boonton RX meter.

The results show a continuously falling dielectric constant over the range of frequencies examined, and this fact indicates the presence of a subsidiary (δ) dispersion region lying between the (β) protein dispersion and the (γ) water dispersion which are centred around 1 Mc/s and 3 kMc/s respectively. It is suggested that this δ region may be due to the water which is tightly bound to the protein molecule, although other possibilities cannot be excluded at present. This bound water would be expected to be present to the extent of 0.3 gm per gm of protein, which is in accordance with the value obtained by other methods.

The paper is concluded with a qualitative assessment of the biological significance of bound water.

SCANNERS

H. A. B. Simons, and J. M. Bailey,
Royal Free Hospital, London.

13. THE "FIGURE OF MERIT" OF DIFFERENT COLLIMATING SYSTEMS.

To enable a comparison to be made between the ability of different detecting systems to distinguish a region containing a different concentration of a gamma-emitting isotope from that of its surroundings, a "figure of merit" of the system was proposed by Dewey and Sinclair.

It is shown that this figure of merit can be calculated for simple collimating systems and plane targets, consisting of circles of uniform activity, in terms of non-dimensional parameters and the intrinsic detection efficiency of the scintillation crystal. Results are given of experimental investigations of figures of merit for various collimating systems, and targets of different radii are given which agree with the theory developed.

It is shown that the figure of merit is insufficient to enable a choice to be made of the collimating system which will give the best spatial resolution of the position of the target, and merely indicates the system which will best show the presence of a target.

J. Mallard and R. J. Wilks,
St. Thomas's Hospital, London.

14. A PHANTOM TECHNIQUE TO INTERCOMPARE THE PERFORMANCE OF RADIOISOTOPE SCANNING MACHINES.

A phantom technique is discussed to determine the performance of scanning machines in terms of the minimum diameter of tumour that can be detected at any given depth in phantom for a given clinical situation. Particular attention is paid to gamma cameras.

Hollow discs of 1 cm thickness and different diameters are filled with a substance of known activity, and lowered into a water

tank 30" x 30" x 13". The count rate is determined for each disc at each depth, and the c.p.s. per unit area μc/ml (n_o) is calculated for each depth. With the discs removed and the tank filled with the radioactive substance, the background count rate in c. p. s. per unit area per μc/ml (N_o) is obtained for the tank.

By assuming that a clinical lesion approximates to a cylinder whose thickness is equal to its diameter, the appropriate value of n_o is found from the summation of adjacent superposed discs. A graph of

$$\frac{n_o}{\sqrt{N_o}} \cdot \frac{1}{p^2}$$

for cylinders is drawn against diameter for different depths in phantom, (p is the diameter of the image on the crystal of the camera).

The count rate changes which can just be perceived on the cathode ray tube display are determined as a function of area and background count rate. By drawing this function on the graph for a particular camera the intersections give the minimum diameter of cylinder which can be detected at each depth.

A comparison is made between 5" and 7' cameras and typical scintiscanners.

T. D. Cradduck, S. O. Fedoruk and W. B. Reid.
Winnipeg General Hospital, Saskatoon Cancer Clinic and
Nuclear Enterprises Limited, Winnipeg, Canada.

15. ASSESSMENT OF PERFORMANCE CHARACTERISTICS OF A SCINTILLATION CAMERA USING "DIFFERENCE" AND "RATIO" CIRCUITS.

The information resulting from a scintillation camera detection unit may be processed in two different manners to obtain the final image, depending on the choice of analogue computer used for the data processing. If the position signals are applied directly to an oscilloscope the resulting spot position is dependent upon the difference of the position signals derived in the detection unit, and this in its turn is dependent upon the total energy deposited in the crystal detector. If, on the other hand, the difference is taken, and then the ratio between this signal and the total energy signal is applied to the oscilloscope, the position of the spot is largely independent of energy deposited by the incoming photon in the detecting crystal.

A scintillation camera, utilizing an 11" diameter NaI (Tl) crystal, 2" Perspex light-pipe and nineteen 2" photo-multipliers, has been used in conjunction with both a "difference" and a "ratio" type of analogue computer to determine the effects on performance of both types of data processing. The parameters which will be considered are sensitivity, spatial resolution and image distortion.

R. J. T. Herbert and M. A. Sheppard,
Liverpool Radium Institute, Liverpool.

16. SCINTILLATION COUNTERS WITH WEDGE FILTERS FOR "IN VIVO" THYROID UPTAKE MEASUREMENTS.

For a number of years two parallel Geiger counters have been used in Liverpool for thyroid counting such that the variation of sensitivity over the thyroid region is less than 5%. However, in this arrangement there is also a rather high contribution from extra-thyroidal radioactivity.

Conversion to a scintillation counter with a flat field collimator conforming to the recommendations of the I. A. E. A. Panel of Consultants (1962) is being considered. However, with a single counter there is considerably more variation over the thyroid region than with the two Geiger counters, although the extrathyroidal contribution is reduced, isocount curves being carried out on a phantom neck. The possibility of use of two counters, one directly behind and one directly in front of the neck with thyroid half-way between them was considered, but this gave a rather large extra-thyroidal contribution, though not as large as for the Geiger counters.

In order to make the thyroid region as uniform as possible two counters are being used, each directed anteriorly at 55° with 45° wedge filters. This is similar to the arrangement used for X-ray treatment of the larynx. Phantom measurements show a very uniform sensitivity over the anterior quadrant of the neck, with a variation not greater than 7% and a rapid fall-off outside this region.

Isocount curves for the various arrangements will be presented.

B. Westerman, H. I. Glass and P. C. R. Turner,
Hammersmith Hospital, London.

17. AN 11" GAMMA CAMERA: SOME PRELIMINARY PHYSICAL AND CLINICAL RESULTS.

Results are presented of the physical performance of a commercial Gamma Camera, utilizing a sodium iodide detector 11" diameter and $\frac{1}{2}$" thick, in terms of its resolution, linearity, sensitivity and uniformity.

The resolution with the collimator was examined with bulbs of 1 - 5 cm diameter containing ^{131}I, ^{197}Hg or other isotopes, immersed in a water tank. The display of the scan has received particular attention, in order to quantitate the result. Comparisons of TV closed circuit, a photocopying method, and a tape recorder playback method, will be presented.

Some preliminary clinical results obtained on various organs, including kidney and brain scans, will be presented.

W. G. Walker and D. H. Pringle,
Edinburgh.

18. SOME FACTORS INFLUENCING THE DESIGN OF A PARALLEL MULTI-HOLE COLLIMATOR GAMMA SCINTILLATION CAMERA.

Two quantities of prime importance in the design of scintillation cameras are sensitivity and positional resolution. These two interdependent factors are functions of several system parameters, and these relationships will be considered.

The sensitivity of the instrument depends primarily on the geometrical efficiency of the gamma-ray collimator, the photoelectric absorption efficiency of the crystal and the efficiency of the electronic circuits. Similarly, the geometrical resolution is a function of the collimator resolving capabilities, Compton scattering in the crystal, crystal edge effects and the electronic circuits used.

In practical systems it is possible to design the electronic circuits such that their inherent losses and errors, dead time, gain non-linearity, etc. are negligible compared with those of the physical system, i. e. the collimator and the crystal. Inaccuracies, however, are introduced due to the analyser window width which must have a reasonable practical value in order to accommodate the width of the spectrum photopeak.

In the gamma-ray collimator the diameter of the parallel holes, the septal thickness, the depth of the collimator and the material used are of great importance, each affecting sensitivity and positioning resolution. The crystal thickness, diameter and position with respect to the collimator and the photomultiplier tubes are also important in optimizing these factors, and in practice a compromise must generally be sought between sensitivity and positional resolution.

B. R. Pullan and B. J. Perry,
St. George's Hospital, London.

19. SPARK CHAMBER SYSTEMS WITH A POSSIBLE APPLICATION TO MEDICINE.

Work is in progress to develop two spark chamber systems which may have applications in the location of radioactive substances in patients.

The spark chambers consist of two parallel plates, one made of lead and the other of aluminium mesh. The chambers are filled with a mixture of argon and alcohol vapour, and if a suitable voltage is applied between the plates a spark can be made to occur at the position of any ions produced in the gas. The chambers have a theoretical efficiency for detecting gamma-rays of the order of 1%.

Two methods of operating the spark chambers are being tried. In the first method, a constant voltage is maintained across the chamber, and after each spark discharged the voltage is removed for a short time. The circuit is similar to that used with a Geiger counter. It is hoped that spark chambers operating in this manner can be used with a parallel hole collimator to delineate the thyroid, using radioactive iodine. In the second method, which is to be used with isotopes emitting annihilation gamma-rays, the spark chamber and a scintillation counter are placed on opposite sides of the radioactivity of interest, and the chamber pulsed with a high voltage every time a gamma-ray is detected by the scintillation counter. The principle is the same as that employed in the annihilation gamma-ray camera.

It is hoped that this device will be of use in following small, inert pills containing positron-emitting isotopes in their passage through the gut.

A. Lansiart and C. Kellershohn,
Gif-sur-Yvette and Orsay, France.

20. SPARK CHAMBERS AND IMAGE INTENSIFIERS USED FOR X- AND γ- RAY SCANNING.

The spark chamber consists of three parallel electrodes placed in an enclosure filled with Xenon and methyl vapour. Its sensitivity is determined by the absorption of the radiation emitted by the radionuclide, through 3 cm of Xenon at atmospheric pressure. The resolution depends on the solid angle accepted by the collimator and on the range of electrons due to the photo-electric effect in the gas. In practice, the resolution is set by the collimator. The sparks are photographed with a camera having an aperture of f/11. A chamber with a useful diameter of 20 cm mounted on a lead grid was used to obtain pictures of the thyroid in patients using iodine-125, and of the kidneys and spleen using mercury-197.

For comparison, the performances of different detector arrangements using image intensifiers are described. A device has been developed which includes a radiological image tube where the zinc sulphide scintillator is replaced by a 3 mm CsI(Tl) crystal. A second high gain image intensifier is triggered at a threshold level set by the operator, by two small photomultipliers placed outside the solid angle defined by the lens optical coupling. In this way a very high signal-to-noise ratio is achieved. Results obtained in vivo with the experimental device are presented.

BRAIN SCANNING

B. Pullan, B. J. Perry and D. Dowsett,
St. George's Hospital, London.

21. A DISPLAY SYSTEM WHICH PRESENTS SCAN INFORMATION AS PATTERNS OF EQUAL SIGNIFICANCE ABOVE BACKGROUND OR THE CLINICALLY NORMAL.

A scan display system is in course of construction which gives both the uptake pattern and a measure of the confidence which can be placed in the pattern. This is achieved by displaying the scan in the form of areas of equal-significant difference between the observed uptake and the clinically normal uptake at a given anatomical site, or between the uptake and the background. The measure of significance employed is Student's "T" test. Computation is by analogue means, and the final display is on a cathode-ray tube. "Bright-up" of the tube is allowed only for areas which are different from normal or background, to a chosen degree of confidence.

The display is achieved by recording the original scan on tape at a very slow speed and replaying at high speed. Pre-recorded on the tape are position and line-synchronization pulses which control the scanner, and a set of pulses corresponding to the normal uptake pattern over the site in question. Assessment of significance over the whole area of the scan will take about two seconds. The system has the facility for displaying the scan that would have resulted if a coarser collimator had been used, so that in some cases the significance of doubtful areas of difference from normal can be improved.

The apparatus is designed particularly for the analysis of brain scans, but it can also be used for the display of data from other scan techniques.

J. McAlister,
St. Bartholomew's Hospital, London.

22. THE USE OF TECHNETIUM-99m FOR BRAIN SCANNING.

There has been considerable interest in the use of low-energy γ-emitters for clinical scanning and also in the use of short-lived isotopes. Following the reports of Harper et al, we started using Technetium-99m for brain scanning in November 1964. The first results were encouraging, even though the scans were carried out using crystals and collimators not specifically designed for low energy work. Measurements on biopsy material have confirmed a higher uptake in tumour than in normal brain tissue. The value of this isotope for brain scanning will be assessed and the effect of varying different factors, e. g. the time at which the scan is performed, the size of crystal and the collimator design, will be discussed.

M. H. Sutherland and J. Mallard,
St. Thomas's Hospital, London.

23. THE QUANTITATIVE ANALYSIS OF SCINTISCAN DISPLAYS WITH SPECIAL REFERENCE TO BRAIN SCANNING.

In many scans it is not possible to be certain of the presence or absence of an abnormality and it is, therefore, of value to estimate the degree of confidence with which an abnormality can be detected. On certain types of scan this may be done by comparing the count rate over different regions on the same scan, e. g. for the detection of space occupying lesions in the liver and in the centre of the head. In brain scanning, however, it is usually necessary to take into account the normal pattern of count rate over the head.

A technique is described in which the count rate over anatomically equivalent regions of the heads of different patients may be compared. This has been done by means of a simple rectangular grid, the elements of which vary in size from patient to patient. The average normal pattern of count rate has been determined in this way. The significance of the difference between the dot density in a given grid position of the equivocal scan and that in the corresponding region of the normal scan may be obtained by expressing the difference as a multiple of its standard error.

The normal pattern has been established for two scanning materials (arsenic and human serum albumin). Results show that the method will detect space occupying lesions which are not immediately detectable on the black and white scintiscan, although some may be identified as equivocal on the colour scan.

A method is also described for the automation of scintiscan analysis.

M. Akerman and G. Guiot,
C. M. C. Foch-Unité de Recherche de Neurophysiologie Chirurgicale,
Suresnes (Seine), France.

24. DIAGNOSIS OF INTRACRANIAL MASS-LESIONS BY ASSOCIATION OF ECHO-ENCEPHALOGRAPHY AND GAMMA-ENCEPHALOGRAPHY.

Five hundred patients have been tested by both methods.; 134 presented a confirmed intracranial process (90 hemispheric process; 19 tumours of the base of the brain, the pituitary region or the third ventricle; 25 lesions of the posterior fossa or the brain stem).

The ultrasonics apparatus had a screen graduated from 0 to 10 cm. It was adjusted in order to obtain the distance between the transmitter pulse and the back reflection of the outer surface of the opposite side equal to half the bitemporal diameter. Midline reflections were tested in the temporal position, and also in frontal and parietal positions, facing the longitudinal fissure, thus allowing an approximative localization of the process. A 2 - 3 cm displacement was considered as pathological.

The isotopic investigation used R. I. S. A. or mercury-labelled Neohydrin. The radioactivity was counted on about fifty positions of the cranium. With R. I. S. A., repeated measurements and the study of the radioiodine fixation curve in the lesion allowed, in a great number of cases, the diagnosis of the nature of the lesion.

A significant displacement of midline reflections was only found in 60% of cases, while observation of a radioactive focus enabled the localization of the process in 84% of cases.

When considering only hemispheric lesions, both methods gave similar positive results, (84% and 87%). Echo-encephalography gave better results than the radioisotope technique in hemispheric gliomas only.

False positive responses were more frequent with radio-isotopes (11%) than with ultrasonics (4%). Electro-encephalography could sometimes correct the few cases where both methods were deficient. 89% of neuro-surgical intracranial mass lesions were detected by the association of echo and gamma encephalography, and 94% of hemispheric lesions. By this association false positive results were reduced to 4%. Discordant results can help the diagnosis of the nature of the lesion. Association of a normal echo-encephalogram with a radioactive focus was found in arterio-veinous aneurysm, softenings, and post-operative scars without tumour relapse. Midline reflections displacement with a normal gamma-encephalogram was most often found with astrocytomas.

F. C. Gillespie and A. M. Boss,
Regional Physics Department, Glasgow.

25. THE EFFECT OF DIFFUSION ON THE CLEARANCE OF RADIOACTIVE INERT GAS FROM THE BRAIN.

One of the assumptions generally made when determining regional cerebral blood flow, by the measurement of the rate of clearance of a radioactive inert gas from the cerebrum, is that the error due to diffusion of the gas from the regions of high concentration to regions of low concentration is small and can be ignored. An estimate of this effect is made for several arrangements of experimental parameters and the results are checked experimentally. The effect of the error on previous reported results is discussed.

PHYSIOLOGY AND MEDICINE

H. Schneider,
Depts. of Medical Physics and Cardiology,
University Hospital, Utrecht.

26. THE REACTION OF THE DOG HEART TO ELECTRICAL DOUBLE PULSES IN VIVO.

The stimulation of the heart by means of electrical pulses of fixed duration, amplitude and repetition frequency is of some considerable medical interest.

Physical aspects of stimulation will be discussed. The reaction of the dog heart in vivo to double pulses of very short duration will be compared with other types of stimulation. Experience has shown that when double pulses are appropriately phased in relation to the beat, summation effects can be demonstrated. The experimental arrangements will be discussed.

J. Tigyi,
Biophysical Institute of Medical University,
Pecs, Hungary.

27. PHYSIOLOGICAL EFFECTS OF IONIZING RADIATION ON HEART AND SKELETAL MUSCLE.

Relatively small doses of different types of ionizing radiations were used in investigations on the isolated frog heart and skeletal muscles, from the point of view of a possible physiological effect. Both internal (incorporated) and external radiations were used with an energy range varying from 7 KeV beta-rays of tritium to 15 MeV betatron beams.

Physiological (biopositive) effects of radiation were observed in the following cases: (1) Restitution of the function of isolated, potassium-blocked, frog heart by ^{42}K, ^{24}Na, ^{32}P and ^{131}I isotopes. (2) Restitution of the function of frog heart by a 15 MeV electron beam. (3) Increasing excitability of isolated frog heart-ventricle by electron irradiation. (4) Rise of action potential amplitudes on isolated frog sartorius muscle. (5) Increase of excitability of tritium treated skeletal muscles. (6) Prolonged survival time of tritium treated muscles. (7) Enhanced excitability (decrease of threshold stimulus voltage) of ^{60}Co irradiated skeletal muscles.

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All these phenomena are characterized as ones in which the physiological function was restored or increased. A semiconductor hypothesis is discussed as a possible theoretical explanation, with practical applications of these effects.

R. L. Coren,
Drexel Institute of Technology, Philadelphia, U. S. A.

28. UTERINE CONTRACTION AND INTRA-AMNIOTIC PRESSURE.

Results are presented of an analysis of the intra-amniotic pressure developed during the uterine contractions occurring throughout pregnancy. A simple model is developed mathematically, in which: 1) contraction takes place by the spread of activity from a pacemaker area, 2) a part of the myometrium cannot contract. Expressions are derived giving the pressure change in terms of the fundamental physical, elastic and contractible properties of the myometrium.

The analysis suggests that a quantitative study of the contraction and relaxation can best be made by examining the rate of pressure rise and the logarithm of the pressure respectively, as functions of time. In the pressure-rate representation one finds an initial linear rise ($dP/dt \sim t$), followed by a flat portion (dP/dt = constant) and a linear fall off ($dP/dt \sim -t$), representing the three phases of uterine activity. In the logarithmic representation the relaxation phase appears as a straight line. The slopes of these several lines and the pressures and times at their end points are related to each other and to fundamental tissue properties.

A study was made of several clinical pressure tracings, and qualitative and quantitative agreement with theory is found. The internal consistency of the theoretical model is very good, and agreement is excellent between the measured critical pressures and times and those derived from independent measurements. It is shown that the pressure-rate and logarithmic representations are extremely revealing of details of the active and relaxation processes. Certain deviations from the model and some systematic changes during the progress of labour are observed in this way. The significance of these features will be discussed.

C. Pallotti and G. Pallotti,
University of Bologna, Italy.

29. A MATHEMATICAL TREATMENT OF HAEMODIALYSIS IN THE ARTIFICIAL KIDNEY.

A study has been made of haemodialysis in the artificial kidney. The relevant differential equations have been integrated using constants appropriate to the problem. Curves have been calculated of the variation of concentration with time for different substances which have to be eliminated from the blood. These curves have been obtained for two values of blood volume and two flow rates. The form of the curves will be discussed and suggestions will be made for further work in this field.

W. T. Suermondt,
State University Hospital, Utrecht.

30. A BODY PLETHYSMOGRAPH FOR THE MEASUREMENT OF THE LUNG VOLUMES AND OTHER PARAMETERS OF THE MECHANICS OF BREATHING.

A constant pressure body plethysmograph is described with which it is possible to measure parameters of the mechanics of breathing and lung volumes.

With this type of plethysmograph the entrance is hermetically sealed with water and no bolts or levels are, therefore, required. It is possible to open the plethysmograph from the inside as well as from the outside; this adds to the mental comfort of the patient.

The problem with this type of plethysmograph is to obtain a fast response. To overcome this a special spirometerbell has been designed which has less inertia than a Krogh spirometer.

B. A. Goddard,
Dudley Road Hospital, Birmingham.

31. A FOETAL ELECTROCARDIOGRAPH.

The paper describes ways in which the foetal electrocardiogram, normally obscured by maternal signals and noise, may be obtained with increased clarity. Equipment built into a single unit is described which provides a foetal E. C. G. almost free of maternal signals and noise.

Improvement in the signal-to-noise ratio is achieved by adding signals obtained from several pairs of electrodes placed on the maternal abdomen. The maternal signal is then "gated out" by using signal delay provided by a magnetic tape recorder and pulse delay circuits. Further improvement in signal-to-noise ratio is obtained by feeding the successive foetal signals, accurately triggered, into a signal averaging device. The use of two such devices is described, - the first, a trace brightness integration system using an image storage tube, and the second an averaging computer; results from these instruments are compared. Traces are shown at each stage of signal improvement; photographs and circuit diagrams of the equipment are included, together with a block diagram of the whole apparatus.

Difficulties of foetal heart rate measurement are discussed, and an effective way of doing this is described.

S. A. Vincent,
Belfast, N. Ireland.

32. MECHANICAL AND ELECTRICAL MEANS OF CONTROLLING INCONTINENCE OF URINE.

The use of electrical pacemakers for heart conditions has led various workers to attempt similar methods in the treatment of incontinence of urine. In theory, two methods are available for aiding patients with incontinence of urine, particularly when it is due to spinal disease or injury.

One method attempts to make the bladder contract and empty its contents under the control of the patient by means of electrical stimulation. The other method attempts to make the bladder hold urine when the patient wishes to hold it, - voiding occurring in response to stopping the stimulation which is keeping the bladder outlet closed.

A method will be described of treating incontinence of urine which has been used in a series of 800 patients, and which is based on a mechanical concept of bladder control.

The act of passing urine can be stopped in normal people by slow, firm, upward pressure on the anal canal region. This pressure has been shown by cine-radiography to close the bladder outlet and to allow no urine into the urethra to cause discomfort. Appliances have been designed which maintain the pressure, and which are used for treating incontinence of urine. Cine-radiographs will be shown which illustrate the events occurring during the act of micturition, with particular reference to those mechanical effects which could be initiated by electrical methods.

D. Rowan and S. Alexander,
Regional Physics Department and Royal Infirmary, Glasgow.

33. EXPERIMENTAL EVACUATION OF THE BLADDER BY MEANS OF IMPLANTED ELECTRODES.

One of the principal problems in the management of the paraplegic patient is the occurrence of infection of the urinary tract as a consequence of bladder catheterization. In a recent review, incidence

of severe urinary tract infection was found to be 74% and the incidence of permanent incontinence 60%.

We have investigated the use of implantable electrical stimulators for the paralysed bladder controlled by an external radio frequency transmitter. The principal advantages of this technique are that it does not interfere with the virginity of the urinary tract or with later efforts to establish a functioning reflex or automatic bladder.

The response of the bladder to electrical stimulation requires to be elucidated before the design of these units can be finalized. Experiments were carried out on dogs using direct stimulation to establish effective stimulus parameters and the optimum location and type of electrodes. Measurements were made of the intravesical pressure and the degree of bladder evacuation. The problems encountered are described and solutions offered, together with some observations concerning the mechanism controlling the resistance to bladder outflow.

A. S. Velate,
Tavistock Institute of Human Relations, London.

34. PHYSICAL METHODS AS AN AID TO PSYCHOLOGICAL RESEARCH.

A psychological research project requires the objective measurement of the interaction between normal mothers and babies in their own home.

New-born babies have been used in a hospital-based preliminary study of various psychological variables to calibrate these against the psychologist's subjective judgements. These measurements include E. M. G., respiration, heart-rate, motility and crying. The responses to controlled stimuli such as light, sound and movement are being investigated.

With validation of the chosen variables, miniature transducer-telemetry devices are being developed. With suitable methods of attachment, it is hoped to record with the minimum of restraint and discomfort. Methods of recording the mother's proximity to the baby will be investigated.

A flexible aerial-receiver system, possibly involving relay links, will enable the data to be fed to a multi-channel tape-recorder from any p art of the volunteer's home.

Recordings of 24-hour activity will be computer analysed for subsequent comparison of subjects and environments. This study will be a system-proving trial, since the number of experiments is unlikely to be sufficient for valid statistical analysis.

H. A. B. Simons and A. Elithorn,
Royal Free Hospital, London.

35. A DISPLAY AND RECORDING UNIT FOR A COMPUTER GENERATED PSYCHOLOGICAL TEST.

In the past little attempt has been made to design tests of intellectual functions in a systematic manner. The present paper describes an apparatus for presenting perceptual maze patterns which can be fully described mathematically, and which can be generated systematically by an electronic computer. The apparatus consists of a triangular lattice having the properties of Galton's probability board. The lattice has 16 rows, excluding the apex, giving 2^{16} pathways. 152 miniature filament bulbs are placed at the lattice points of the array, and are illuminated in a pattern controlled by a punched card.

The subject's task is to track with a stylus, from the apex to the base of the pattern, a path which passes through a given maximum number of illuminated intersections. The stylus makes contacts at the intersection points, and cold-cathode trigger tubes generate a 16 digit binary number describing the path taken by the subject which is recorded on punched paper tape.

A similar task in a pencil and paper form has proved clinically useful as a test of focal brain damage. The present apparatus will allow the generation and presentation of a large range of patterns and will greatly facilitate the analysis of solving strategies adopted by normal and abnormal subjects.

C. M. Cade, A. E. Hanwell and K. Lloyd-Williams,
S. Smith & Sons (England) Ltd., London.

36. RECENT ADVANCES IN THERMOGRAPHY.

Research in Britain into infra-red thermography has included studies of breast cancer, placental location, rheumatism, burns and vascular disturbances. Speed of scanning is important in all of these, and raises difficult design problems.

The need to resolve small areas, yet to scan a total field large enough to provide reference points, means that many elements are viewed in each frame. High-speed scanning, therefore, implies

wide electrical bandwidth, and this raises problems of signal-to-noise ratio. Depth of focus is also a problem: if this is too shallow thermographs give unreliable data due to loss of focus. Much focal depth, however, implies large numerical aperture, hence loss of signal power.

In order to maximize efficiency, the dynamic range at the display (i. e. the number of shades which can be distinguished) must be matched to the signal-to-noise ratio at the input. The choice of display is thus partly governed by basic physical parameters.

Examples are shown of 40, 000 - element clinical thermographs scanned in 30 seconds, and showing a total temperature excursion of $1^{o}C$ from black to white, with more than 20 resolvable shades. The principles of scanner design optimization are discussed.

D. G. Tilston,
Regional Physics Department, Glasgow.

37. CARDIAC OUTPUT MEASUREMENTS USING Xe-133.

Cardiac output measurements using Xe-133 have been compared with direct Fick estimations using oxygen uptake. Both bolus and constant injection techniques have been used. The reliability and possible sources of error of this method, which enables rapid repeated measurements of cardiac output to be made, are discussed.

The method has been used for cardiac output measurements under conditions of high atmospheric pressure, and the effects of pressure on the cardiac output are discussed.

M. Gembicki,
Dept. of Internal Medicine of the Medical Academy, Poznan, Poland.

38. HAEMODYNAMIC CHANGES IN THYROID DISORDERS STUDIED BY ^{131}I - ALBUMIN.

Repeated haemodynamic examinations using ^{131}I human serum albumin as a tracer were carried out in patients with hyperthyroidism treated with ^{131}I and with hypothyroidism during thyroid replacement therapy.

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These studies were performed in 190 persons, of whom 31 without any cardiac and thyroid disfunction were taken as controls. Patients with hyperthyroidism were divided into two groups: (1) - 57 patients without electrocardiographic changes, (2) - 33 patients with thyrotoxic heart disease and usually with atrial fibrillation.

The remaining two groups consisted of 43 persons with normal thyroid function induced by ^{131}I treatment and 26 persons with hypothyroidism. This last group comprised patients with primary hypothyroidism as well as those with hypothyroidism induced by ^{131}I therapy of hyperthyroidism.

It has been found that in patients with hyperthyroidism without cardiac complications the cardiac output was greatly increased. On the other hand, in patients with thyrotoxic heart disease a decrease of cardiac output was observed. In patients with hyperthyroidism the pulmonary circulation time was shorter than in the control group. Also a diminution of the pulmonary blood volume was observed.

The normalization of haemodynamic parameters was observed after successful ^{131}I treatment of hyperthyroidism without electrocardiographic changes, but more difficult to obtain in elderly patients.

In hyperthyroidism with thyrotoxic heart disease we did not observe any haemodynamic improvement after ^{131}I treatment, although the thyroid function was normalized.

The thyroid replacement therapy in hypothyroidism gives rise to haemodynamic improvement in the form of shorter circulation times as well as the half time of the activity decline in the left heart and the rise of the cardiac output.

PARTICLE BEAM DOSIMETRY

W. M. Preston and A. M. Kœhler,
Harvard University, U. S. A.

39. PROTON BEAM DOSIMETRY AND DOSE DISTRIBUTIONS.

A group at Harvard and the Massacusetts General Hospital has for five years used the proton beam from a 160 MeV synchro-cyclotron for medical and biological purposes. A nitrogen gas ionization chamber is calibrated with monoenergetic protons and a Faraday cup. The residual range of a proton beam is varied by a water absorber, and at suitable intervals the total beam flux is measured with the ionization chamber. The lateral flux distribution is explored with a small silicon diode having a resolution of about 0.1 mm. We have checked experimentally the limitations, due primarily to multiple coulomb scattering, on the minimum practical diameters of pencil beams and on the thickness of "knife-edge" beams for use in radio-surgery.

Over 100 hypophysectomies have been performed, using a cross-fire technique in which the Bragg peaks of 14 proton beams (7 from each side of the head, about 8 degrees apart, in a plane) collimated by a 7.15 mm diameter circular aperture are superimposed at the target, the pituitary gland. Isodose curves in the planes of the co-ordinate axes can be calculated graphically without too much trouble. More complete information has been obtained from a computer programme. Because of the proximity of the optic and ocularmotor nerves to the target, this method requires excellent but, we believe, attainable accuracy in the control of beam range.

S. B. Field, D. K. Bewley and C. J. Parnell,
Hammersmith Hospital, London.

40. DOSIMETRY OF CHARGED PARTICLE BEAMS.

The Medical Research Council cyclotron is designed to produce alpha-particle and deuteron beams of large currents, with a nominal energy of 7.5 MeV per nucleon. Methods of measurement of the energies are described, and the dosimetry is discussed from a theoretical standpoint and related to experimental values obtained both by means of a Faraday cup and calorimetrically.

The techniques of irradiation of biological specimens are described, with special reference to the facility of variation of the linear energy transfer (LET) of both beams.

R. E. Ellis, S. Lovell, E. R. Rollinson, J. Rotblat and J. White,
St. Bartholomew's Hospital, London.

41. MEASUREMENTS ON A 15 MeV 750 mA ELECTRON LINEAR ACCELERATOR.

The commissioning measurements made with the new 15 MeV 750 mA electron linear accelerator will be described. The measurements carried out include the determination of the dose per pulse and the dose rate of X-rays and electrons under continuous running conditions using a variety of dosemeter systems. An estimate has also been made of the dose rate due to the dark current.

The energy spectrum of the electron beam has been determined using a magnetic spectrometer and has been compared with the electron range measured in aluminium and perspex.

The size and divergence of the beam has been studied using activated copper foils, and plans have been made to build a beam transport system to allow various experimental arrays to be permanently positioned.

The radiation protection measurements around the accelerator will also be described.

L. S. Skaggs,
University of Chicago, U. S. A.

42. A THIN FOIL CALORIMETER FOR ELECTRON BEAM DOSIMETRY.

Thin foil calorimeters of the transmission type have been developed as dosemeters for beams of fast electrons. The foil is designed to heat rapidly to an equilibrium temperature proportional to electron beam current, with the temperature being measured by a thermocouple. Recent development of D. C. amplifiers with low noise and good stability at sensitivities down to 10 nanovolts full scale, make the calorimeters usable at 10^{-9} amperes.

The foil may be made as thin as mechanical considerations allow, since both sensitivity and time constant are independent of foil thickness. For any given pair of thermoelectric materials and

diameter of the beam intercepting part of the foil, the sensitivity is only dependent on the inverse of the time constant for temperature equilibrium. Time constants of the most sensitive calorimeters used have ranged between 2 and 5 seconds.

In the relativistic energy region above 10 MeV the response is energy independent within ± 2.5%, and at 5 MeV the response is only 4% less than that at 10 MeV. This result is due both to the density effect of electron loss in solid materials and to the escape of secondary electrons of high energy that result from close collisions in the foil. Another advantage of the dosemeter is its inherent independence of rate effects in pulsed beams of low duty cycles.

DOSIMETRY - SPECIAL PROBLEMS

F. O'Foghludha,
Medical College of Virginia, U.S.A.

43. THE EFFECT OF RADIATION ENERGY SPECTRUM ON THE USE OF THE RECIPROCITY THEOREM FOR INTEGRAL DOSE MEASUREMENT.

The calculation of the photon energy spectrum obtained from extended gamma-ray sources by matrix inversion of the scintillation pulse height spectra is reported.

The integral dose in an extended absorber arising from a point source of radiation may be determined from the reciprocity theorem of measurement of the dose at that point, arising from a uniform distribution of activity throughout the absorber.

The effect of photon spectral shape on integral dose obtained in this way is investigated by theory and experiment.

J. E. Robinson and R. S. McDougall,
University of Maryland, Baltimore, U.S.A.

44. ELECTRON BEAM INSTABILITY AND ISODOSE ASSYMETRY ASSOCIATED WITH A 35 MeV MEDICAL BETATRON.

Initial dosimetry measurements on a Brown Boveri 35 MeV betatron indicated poor reproducibility of electron beam isodose distributions, with marked shifts from measurement to measurement.

An investigation showed that beam position and shape depended strongly upon a given combination of electron energy and extraction voltage. For a given energy, small changes in extraction voltage produced large assymetries in the radiation field, as did small variations in energy at a constant extraction voltage. The variability was apparently limited to the plane of the "doughnut."

The magnitude of these distortions was great enough to result in grave clinical problems if left uncorrected. A workable solution for the problem has been devised and adopted. Two cylindrical ionization chambers have been mounted in the fringe radiation field

on the inside of the collimator support structure. The amplified output of these chambers is fed to a null voltmeter located on the control console, and beam symmetry is indicated by a null reading between the two chambers. Beam symmetry is maintained by adjustment of the extraction voltage control, and to aid in fine adjustment an auxiliary rheostat has been placed in series with the main extraction control.

R. C. Lawson, D. M. Clare and D. E. Watt,
U. K. A. E. A., Chapelcross, Scotland.

45. (D,D) AND (D, T) NEUTRON DEPTH DOSE MEASUREMENTS IN A TISSUE-EQUIVALENT PHANTOM.

An elliptically-shaped phantom, filled with tissue-equivalent material, was exposed to collimated beams of fast neutrons from the D(d, n) and D(t, n) reactions. The components of absorbed dose were measured with Bragg-Gray type detectors at depth in the phantom for beams incident on the major and minor axes.

Thermal neutron flux distributions at depth were measured for various collimated beams incident on different sized phantoms. The experimental measurement of the diffusion length of thermal neutrons in tissue-equivalent liquid permits calculation of the transport mean free path, and hence the determination of an accurate flux depression factor for the lithium iodide detector used to measure the thermal flux.

The energy spectra of recoil protons change with depth in tissue, and the associated quality factors are discussed. The results are compared with the theories of Snyder and Neufeld, and of Randolph.

A. Rakow,
Deutsche Akademie der Wissenschaften zu Berlin,
Germany.

46. PHOTOGRAPHIC DOSIMETRY IN A PHANTOM

A method of producing isodensity curves by a direct photographic process not employing a microdensitometer will be described and illustrated. By a suitable calibration method most of the common sources of error in photographic dosimetry can be eliminated and the

photographic density correlated with absorbed dose. The energy dependence of the emulsion has been investigated both experimentally and theoretically, and the magnitude of the errors involved assessed. In moving field therapy there is some compensation of errors, and good agreement is obtained between the absorbed dose and blackening of the emulsion.

ISOTOPE DOSIMETRY

M. F. Cottrall and N. G. Trott,
Royal Marsden Hospital, Sutton.

47. PROBLEMS OF DOSIMETRY IN TRACER INVESTIGATIONS.

The applications of radioactive tracers in diagnosis inevitably involve some irradiation of the patient. In order to estimate the dose arising, detailed information is required on the distribution and retention of the radioactive material in the patient. Unfortunately, at the present time relatively little data of the type required are readily available. For this reason, at the authors' hospital, an attempt is being made, using a low background multiple crystal whole body counting system, to study the retention of a variety of radioactive tracers in a considerable number of patients attending for routine diagnostic tests. The counting system is located in a shielded laboratory, readily accessible to the hospital wards and outpatients' department. Methods being developed for analysing the data obtained will be discussed, these include the use of the facilities of a large digital computer.

Whilst the analysis of data is inevitably a complex problem, the counting system itself is relatively simple and inexpensive, incorporating four 7.5 cm diameter x 5 cm long NaI (Tl) crystals, but it has been found to have adequate sensitivity and flexibility for many studies of this type.

Results obtained with a number of radioactive materials, including ^{131}I Hippuran, will be reported. The significance of these results in considerations of the dosimetry of the tests will be discussed.

E. F. Focht, E. H. Quimby and M. Gershowitz,
New York Hospital, Cornell Medical Center, U.S.A.

48. GEOMETRIC FACTORS IN ISOTOPE DOSAGE AND REVISION OF AVERAGE $\bar{g}$ FOR CYLINDERS.

Existing tables which have been assumed to be average g factors, ($\bar{g}$), for cylinders containing uniform distributions of radioactive materials, actually refer to a point on the surface of the cylinder at the end of the axis. Using Bush's method the actual $\bar{g}$ values for cylinders of various radii and lengths for an effective μ of 0.028 have been calculated.

For the $\bar{g}$ for cylinders with no absorption, an expression of Bush has been set up in a form which can be evaluated by a computer. The ratio of $\bar{g}$ with and without absorption for each cylinder size gives a constant for that cylinder from which $\bar{g}$ for other absorption coefficients was obtained by another computer programme.

A scale factor method has been set up by which average or point g's can be obtained for any μ, if the value is known for one size object of any shape, and is to be obtained for another differing only by a scale factor.

Further computer programmes give tables of g at the centre of cylinders up to a length of 100 cm and radius of 35 cm for various absorption coefficients, for uniform and for surface distributions.

E. M. Smith, C. C. Harris and R. H. Rohrer,
Cornell Medical Center, U.S.A.

49. INTERNAL DOSE CALCULATIONS FOR ^{99m}Tc - AN ILLUSTRATIVE EXAMPLE OF CURRENT PROBLEMS IN INTERNAL DOSE CALCULATIONS.

^{99m}Tc emits a 140 KeV photon and decays with a six hour half-life. The specific gamma-ray constant is 0.72 R-cm^2/mc-hr, of which 29% is due to K_α and K_β X-rays (resulting from internal conversion.) These X-rays make up only 1.2% of the total photon energy released. The $\bar{E}_\beta$ for ^{99m}Tc is 14 KeV/disintegration (resulting from conversion electrons, Auger electrons and low energy photons).

Classical methods for calculating the gamma-component of the absorbed dose resulting from low energy photons underestimate the absorbed dose, when compared with Monte Carlo type calculations, by 17% for 80 KeV photons (photon energy similar to ^{197}Hg) and by 14% for 160 KeV photons (photon energy similar to ^{99m}Tc) if the radionuclide is uniformly distributed in a 70 kg standard man (ellipsoid).

These sources of error may be avoided if the Monte Carlo type calculations presented by Ellett et al are used. These consist of tabulated values for the fraction of the photon energy emitted that is actually absorbed for a given photon energy with a given radionuclide distribution in a phantom of given mass and shape.

^{99m}Tc in various chemical states (TcO_4^-, Tc-labelled serum albumin and Tc-sulphur colloid) is being increasingly used for various scanning procedures such as brain, liver, placenta, etc. The absorbed dose a patient receives from each of these procedures has been compared with that from the more conventional scanning agents. The dose received from 1 to 10 mc of ^{99m}Tc is less than, or similar to, the dose from other scanning agents, while giving much higher counting rates.

C. E. Newton, I. C. Nelson and K. R. Heid,
Pacific Northwest Laboratory, U. S. A.

50. TRANSURANIC ELEMENTS AND THORIUM IN MAN: ASSESSMENT, APPLICABILITY OF BIOLOGICAL MODELS AND NEEDED RESEARCH.

Progress in the development of methods for assessing body burdens of the transuranic elements and thorium has not kept pace with the increased exposure. The applications and limitations of the Langham model for readily soluble, and the Healy model for less soluble, plutonium for establishing internal depositions are reviewed. The need for prompt assessment of body depositions and the complications which arise from the variables introduced because of the influences of medical treatment are presented.

A case in point describes the results of fifty autopsy specimens from personnel who had possibly been exposed to plutonium, and who had been participants in a sensitive bioassay programme specifically

designed for the detection of this nuclide. Fractional picocurie organ depositions of plutonium were found in all cases, but in only one case was there a definite indication in the urine analysis.

Current research and areas in which research is needed are discussed, particularly those leading to improved methods of interpretation of body burdens of the transuranic elements and thorium as a function of the bioassay data.

C. A. Sondhaus and D. C. Lawrence,
California College of Medicine, U.S.A.

51. THE USE OF SOFT X-RAY EMITTING ISOTOPES IN INTERSTITIAL AND INTRACAVITARY IMPLANT THERAPY.

Physical tissue dose distributions, shielding factors and illustrative examples of background exposure doses to personnel during source and patient handling are presented for a newly designed type of radioactive seed containing 9.7 day Cs 131. These data are compared with the corresponding ones for conventional radium therapy, and some biological results of preliminary animal experiments are presented. It is shown that dose distribution within 2 cm of a source array of Cs 131 is closely similar to that for radium, but that doses to neighbouring tissue, to the therapist, and to hospital personnel, can be all but eliminated. Implications for improvement and extension of implant therapy methods are discussed.

USES OF ISOTOPES

R. Oliver and G. T. Warner,
The United Oxford Hospitals.

52. A WHOLE BODY COUNTER FOR CLINICAL MEASUREMENTS UTILIZING THE "SHADOW SHIELD" PRINCIPLE.

As this equipment, which has been developed for routine clinical measurements of uptake or loss of radioactive isotopes (particularly ^{58}Co and ^{59}Fe in haematological investigations) weighs only some $4\frac{1}{2}$ tons, installation within an existing hospital building has been possible. Two 4" x $3\frac{1}{2}$" No. 1 crystals are mounted 36" apart, above and below a motorized couch. Collimators limit the central field viewed to 20" across the couch and 6" or 12" along the couch, additional protection preventing direct background radiation from reaching the crystals.

The patient is scanned as the couch drives between the detectors, a recording ratemeter providing a "profile" of distribution, and a scaler "traverse count" a measure of total activity. Not more than $\pm$ 5% variation in traverse count was observed with variation of position of a small ^{58}Co source within a waterfilled body phantom, and the count obtained for the same activity in solution throughout the phantom was within 2% of the average value for this small source. Good agreement has been demonstrated between percentage retention derived from whole body counts and from measurement of faecal activity.

L. Burkinshaw, A. R. Wilson, B. E. C. Nordin and C. B. Oxby,
The General Infirmary, Leeds.

53. MEASUREMENT OF THE RETENTION OF BONE-SEEKING ISOTOPES BY WHOLE-BODY COUNTING.

20 μc of ^{47}Ca or up to 30 μc of ^{85}Sr have been given in single intravenous doses, and retention of the isotopes has been followed by whole-body counting for periods up to 35 days. In some instances measurements were made (a) on a counter consisting of three large plastic scintillators grouped around a chair, and

(b) on a counter made up of four 6" diameter x 4" thick NaI (Tl) crystals, two above and two below a horizontal couch.

The results have been compared with retentions calculated from the excreted activity. The sodium iodide counter has also given information about the distribution of these isotopes within the body, and markedly different distributions between one individual and another have been observed.

J. Shimmins, and D. A. Smith,
Regional Physics Department, Glasgow.

54. THE MEASUREMENT OF BONE FORMATION RATE USING STRONTIUM-85.

^{85}Sr is used as a tracer of calcium to study "bone formation rate." 30 mc of ^{85}Sr are given intravenously in the form of $^{85}SrCl_2$. A whole-body counter is used to measure retention of this tracer until its remaining activity is no longer statistically significant. Serum samples are taken, and an integrated specific activity from the time of injection calculated. From these data the "bone formation rate" is calculated, using the method of Bauer and the formula for Retention/Integrated Specific Activity.

The time at which the retention is measured is aimed to be late enough for all the tracer to be incorporated into bone tissue, and early enough so that no significant amount of the tracer has been resorbed by bone destruction. The bone formation rate calculated by the second method is lower than that calculated by the method of Bauer, and evidence is offered to show that the differences are significant and cannot be explained by experimental errors. The work of others supports this conclusion.

L. A. Hawkins,
King's College Hospital, London.

55. THE DISTRIBUTION OF ^{22}Na IN BONE.

When ^{22}Na is administered to mammals, a small fraction becomes fixed in bone, with a biological half-life of approximately one year. If deposition were even throughout the skeleton, the radiation dose would be trivial. However, there is evidence that

the ^{22}Na is selectively concentrated in particular sites, such as the periosteum and Haversian systems in process of formation at the time of administration, and it is of interest to estimate the radiation dose to cells at these sites.

The paper describes preliminary results of a study of ^{22}Na in young and adult rats injected with up to 100 μc. These were then sacrificed at intervals from 1 day to 9 months, the long bones being assayed for ^{22}Na content. Serial transverse sections were prepared for autoradiography to determine the sites of deposition and, using quantitative microdensitometry, the local concentration of ^{22}Na, and from this the radiation dose to small soft tissue cavities has been calculated.

R. Hesp and B. Ramsbottom,
U. K. A. E. A. Windscale and Calder Works, Cumberland.

56. THE EFFECT OF SODIUM ALGINATE IN INHIBITING UPTAKE OF RADIOSTRONTIUM FROM THE HUMAN GASTROINTESTINAL TRACT.

An experiment performed with the co-operation of a normal healthy adult male volunteer has shown that sodium alginate inhibited uptake of radiostrontium from the gastrointestinal tract by a factor of about 9. In the first stage of the experiment 0.36 μc ^{85}Sr was administered orally 20 minutes after an oral administration of 10 g sodium alginate. 26 days later 0.48 μc ^{85}Sr was administered orally. In both stages of the experiment samples of excreta and blood were collected, and body retention of ^{85}Sr was measured by means of the Windscale Whole Body Counter. The degree of inhibition of uptake of radiostrontium provided by sodium alginate were approximately 9.3, 9.2 and 8.3, as assessed from urine, blood serum and body retention respectively.

B. I. Tyson, S. Genna, R. L. Jones, V. Bikerman, R. Graham and B. A. Burrows,
Boston University School of Medicine, Boston, U. S. A.

57. ELECTROLYTE STUDIES WITH A TOTAL BODY COUNTER.

In man the normal total body K^+ was found to be 152.5 $\pm$ 10.1 (n = 25) mEq/litre intracellular water from ^{40}K measurements and ^{14}C inulin and tritium spaces calculated by computer programme. Further, weight per unit height ratio was found to show good correlation with a ^{42}K calibration factor, thus when body configuration of patients could be pair matched with a control, ^{42}K calibration was unnecessary. In two patients with primary aldosteronism good correlation was found between metabolic balances and body ^{40}K in restitution of potassium deficits in excess of 500 mEq. Of 30 patients with hypertension, potassium deficits were found which correlate with the severity of the hypertension.

In 20 healthy controls, 18 males and 2 females, ^{47}Ca retention was followed for periods of up to 40 days, following I. V. injection of 2 - 6 μc of ^{47}Ca. This retention curve could be resolved into at least two components; the faster with a half-time of 3 - 6 days was not responsive to dietary calcium changes, while the slower had a half-time inversely proportional to the diet calcium, ranging from 40 to 150 days. In one patient with a healing fracture the slow component half-time was significantly increased; conversely, in a patient with advanced carcinomatosis of bone and renal acidosis the slow component was extinguished. In two controls exchangeable ^{47}Ca and ^{24}Na were measured simultaneously with ^{40}K. In one of these, oral arginine loading was carried out and negative balances of ^{40}K and ^{47}Ca were found during the period of arginine loading.

C. D. Field,
University of the West Indies, Kingston, Jamaica.

58. LIVER CIRCULATION - STUDIES USING ISOTOPE DILUTION TECHNIQUES IN THE ISOLATED PERFUSED LIVER.

The condition of the liver was studied with regard to the relative importance and possible interaction between the portal venous supply and the hepatic arterial supply. Experiments were carried out on isolated canine livers, which were perfused with blood via the hepatic artery and portal vein. Physiological parameters affecting the flow of blood through the liver were recorded throughout. Separate aliquots of red cells from the dog were labelled respectively with ^{51}Cr and ^{32}P, and then re-suspended in plasma to form whole blood.

The experiment consisted of an instantaneous injection of a small volume of ^{51}Cr-labelled red cells into the arterial supply, and a similar injection of ^{32}P-labelled red cells into the portal venous supply, or vice versa. The output of both isotopes through the hepatic vein was monitored, and isotope dilution curves obtained for each isotope separately by the use of a two-channel scintillation spectrometer and a special detecting arrangement.

The dilution curves so obtained were analysed to find the mean circulation time of each supply through the liver.

From a knowledge of the mean circulation time and the respective rates of flow an estimation of "arterial space" and "portal space" could be made. The variation of these spaces with variation of flow rates, arterial and portal pressures were investigated.

Preliminary results indicate a considerable compensating mechanism in the liver which tended to maintain a constant "total liver space" (i.e. "arterial space" plus "portal space").

J. A. Harwood and M. R. Taylor,
Physical Laboratory, Trinity College, Dublin, Ireland.

59. IRON 55 AND IRON 59 MEASUREMENT FROM BLOOD SAMPLES USING A CAESIUM IODIDE CRYSTAL.

The simultaneous use of the isotopes of ^{55}Fe and ^{59}Fe is now common practice in clinical studies of iron metabolism and absorption. Because of the very soft nature of the ^{55}Fe X-ray radiation, the problem of detecting the presence of ^{55}Fe is not easy. Two Geiger tubes with different windows and filling have been used, and a liquid scintillation method using two energy windows has also been employed.

The paper describes a method of measuring ^{55}Fe and ^{59}Fe employing readily available conventional crystal phosphors. A thin CsI (Thallium-activated) crystal was used as the detector and two energy windows, one covering the entire ^{55}Fe spectrum (apart from some low level noise), and the other the ^{59}Fe spectrum were employed. Efficiencies of 2% for ^{55}Fe and 10% for ^{59}Fe were obtained with 10% cross-counting of the ^{59}Fe during ^{55}Fe estimation.

In spite of the need for electroplating the samples, the technique is easier than with a liquid scintillator. The photo-multiplier used must have very good noise characteristics, since the average number of electrons produced at the cathode by a ^{55}Fe photon is only of the order of 10.

Clinical results from a number of cases are given.

NEUTRON ACTIVATION

J. M. A. Lenihan,
Regional Physics Department, Glasgow.

60. CLINICAL APPLICATIONS OF ACTIVATION ANALYSIS.

The extraordinary sensitivity of activation analysis (representing an improvement of 1,000 or even 1,000,000 over alternative techniques of analysis for several elements) can be usefully exploited in a wide range of clinical problems.

The paper will illustrate these applications with reference particularly to work now in progress on: (a) trace element metabolism in tumours; (b) mineralization of teeth; (c) toxic hazards in dental practice, and (d) archaeopathology.

S. Osborn, and C. K. Battye,
King's College Hospital, London.

61. SOME ASPECTS OF NEUTRON ACTIVATION ANALYSIS IN VIVO.

In neutron activation analysis in vivo, the neutron dose must be kept small and the counting must, therefore, be correspondingly sensitive. The requirements for such a counting system will be outlined.

For such work in human subjects, in order to ensure uniform activation throughout the body, it is necessary for the neutron flux to have a wide energy range. The detectability of the various elements will be discussed in relation to experimental results in both man and animals.

J. Rundo and D. Newton,
A. E. R. E., Harwell.

62. NEUTRON ACTIVATION ANALYSIS OF LIVING SYSTEMS: INSTRUMENTATION AND DATA PROCESSING REQUIREMENTS FOR RADIOACTIVITY MEASUREMENTS.

This paper discusses the requirements for gamma-ray spectrometric measurements of neutron-induced radioactivity in small animals and in man, for the determination of some of the major

constituents. High sensitivity is a principal requirement when man is the experimental subject, because of the low doses of neutrons which may be administered; it may also be required for small animals because the increase in permissible neutron dose may be offset by the smaller body content and, therefore, smaller induced activity.

The determination of total body calcium by measurement of the induced 8.9- minute calcium - 49 requires repeated measurements of body radioactivity at short intervals in order to ensure that calcium-49 is being measured uniquely. This means that a fast read-out system is essential. The method used at Harwell will be described; the results of measurements on neutron-irradiated toads will be used to exemplify the possibilities of the technique and also some of the complications which can arise.

D. Newton and J. W. Smith,
A. E. R. E., Harwell.

63. NEUTRON ACTIVATION ANALYSIS OF LIVING SYSTEMS: IRRADIATION OF HUMAN SUBJECTS AND MEASUREMENT OF THE INDUCED RADIOACTIVITY.

Two important requirements of a method for the determination of elements in man by neutron activation analysis are: essential uniformity of irradiation throughout the body, both as regards intensity and energy distribution, and a counting system with a response largely independent of the distribution of the induced activity in vivo.

The authors will discuss how far these requirements are met by the techniques and equipment used recently at Harwell to estimate whole-body sodium, chlorine and calcium.

A. L. Batchelor and P. W. Edmondson,
Radiobiological Research Unit, Harwell.

64. SODIUM ACTIVATION IN GOATS EXPOSED EITHER BILATERALLY OR UNILATERALLY TO FAST NEUTRONS.

The level of activation of sodium in goats exposed to fission neutrons from a uranium converter plate in the reactor BEPO has shown a linear correlation with the dose measured in air at the place where the body of the goat would be exposed. The level of activation is essentially the same whether the irradiation is unilateral or bilateral. Current results suggest, however, that the biological outcome is different depending on whether the irradiation is unilateral or bilateral.

It is concluded that although the level of sodium activation is proportional to the "in air" dose, the biological outcome depends on the geometry of the exposure.

BIOLOGICAL SYSTEMS AND MEASUREMENT

J. White,
National Institute for Medical Research, London.

65. AUTOMATIC DATA PROCESSING TECHNIQUES APPLIED TO THE STUDY OF THE HYPOTHALAMUS.

It has been known for some time that the hypothalamus area of the brain plays an important role in the temperature regulation mechanism of the body. In this work the effect of temperature changes and other stimuli on the actual neurone cells of the hypothalamus are being investigated.

Neurone discharge impulses are picked up from the brain of a conscious rabbit by means of an implanted microelectrode, and are recorded on one channel of a tape recorder. Temperatures from various parts of the brain and body are measured by means of thermistors, and this information is recorded digitally on another channel, together with real time. During the experiment the temperature of the brain is varied by means of a heat exchanger attached to the carotid artery. On playback of the recording the signal from the microelectrode is fed into a pulse height discriminator so that the activity of one neurone cell may be isolated. These selected pulses are passed on to a ratemeter or interval timer; the resultant neurone discharge rate or interspike interval is then printed or punched out together with information from the temperature and time channels. The information thus obtained is processed by means of a digital computer so that correlation of induced temperature changes in the hypothalamus with neurone discharge rates and temperatures of other parts of the body may be obtained.

The normal time scale for analyzing such experiments is of the order of weeks. The resultant analysis now depends upon the turnaround time of the computer, but if it becomes necessary to have the results available during the experiment on-line facilities or direct computer access may be used.

F. G. Tattam,
National Institute for Medical Research, London.

66. THE ACQUISITION AND PROCESSING OF DATA FROM BIOLOGICAL EXPERIMENTS FOR SUBSEQUENT COMPUTER ANALYSIS.

The paper raises the problem of acquiring and processing data in a form in which the results are perceived by the experimenter's eyes. It is suggested that a television camera can sometimes be a

very useful tool in these instances. Several possible applications of a television scan system are mentioned, and a method of measuring the areas of the inhibited zones on an antibiotic assay plate is discussed in more detail.

In this application the zones to be measured are arranged in some predetermined way on the assay plate. An illuminated graticule is mounted behind the plate, so that the graticule lines can be seen distinctly only in the clear zones to be measured. The graticule pulses on the video waveform are counted for all the scan lines passing through a particular square area containing the zone to be measured. The area of the inhibited zone is proportional to the number of counts. The instrument punches out the result onto paper tape in a form suitable for statistical analysis on a digital computer.

P. S. Lykoudis,
Purdue University, Lafayette, Indiana, U.S.A.

67. THE FLUID MECHANICS OF THE UPPER URINARY TRACT.

The transfer of urine between the kidneys through the ureters to the urinary bladder is examined. The motion of the flexible boundaries of the ureter is assumed to be known (harmonic) and such quantities as velocity profiles and pressure distributions inside the ureter are determined as a function of space and time. The theoretical findings agree rather well with measurements of pressure performed through catheterization (urograms).

A "universal constant" is found for all healthy ureters linking the frequency and the speed of the contractile wave, the rate of urine discharged, and the minimum diameter of the lumen during contraction. The work explains why attempts documented in the medical literature to correlate two of the above quantities at a time have failed to yield information (such as rate of discharge with frequency of contraction). This finding suggests that controlled experiments in which all of these quantities are measured are necessary. If the theory is correct, any deviation of the experimentally measured "constant" of a particular ureter will signify a pathological condition.

The work concludes that for the transfer of urine to the bladder it is necessary that the contractile wave arrive very close to the ureterovessical junction. It is thus shown why urine is not transported in those cases for which the lumen is open but the lower part of the ureter is contraction-wise inactive.

A. Kaul,
Max Planck-Institute for Biophysics, Frankfurt/Main, Germany.

68. INVESTIGATION OF POTASSIUM DEPLETION BY WHOLE-BODY COUNTING AND FLAME PHOTOMETRY.

Di sorders of potassium metabolism are usually investigated by measurement of potassium concentration in blood plasma. In recent years some investigators have also measured red cell potassium as representative of intracellular potassium, although erythrocytes clearly differ from other body cells in both morphology and function.

We have, therefore, investigated total body potassium by whole-body counting as well as making measurements, by flame photometry, of potassium concentrations in plasma, erythrocytes, diet and excreta. So far two short series, each of four patients, have been studied.

In one series, daily ingestion of 200 mg of Chlorthalidon (a saluretic) for 8 days produced an average depletion of 7.7 per cent, or 11 g, in total body potassium. The measured decreases of 27.5 per cent and 3.1 per cent respectively, in the potassium concentrations of plasma and erythrocytes correspond to a total potassium depletion of only 4 to 6 g, compared with the total loss of 11 g measured by whole-body counting. The tests demonstrate that depletion in the intracellular potassium is greater than that observed in erythrocytes.

In the second investigation, whole-body counting of persons maintained on a low potassium diet for periods of 4 - 8 weeks showed an average potassium loss of 9 per cent, or 14 g. Potassium losses calculated from flame photometer measurements of potassium in diet and excreta were in agreement with the whole-body counting results within about 10 per cent.

The experimental methods and results of both series of tests will be discussed.

J . O. Lawson and H. Branson,
Howard University, Washington, U. S. A.

69. A FOUR COMPARTMENT MATHEMATICAL MODEL OF THE KIDNEY-BLADDER SYSTEM.

In experiments where materials labelled with isotopes are excreted through the kidney into the bladder, or in animal experiments with labelled materials introduced by puncture into the kidney, a reasonable model for mathematical analysis results from considering the material as being introduced into a tube (compartment a_1), from which it diffuses into the plasma (compartment a_2). The labelled material diffuses from the plasma into other tubes which may be lumped together as one (compartment a_3) and finally all tubes empty into the bladder (compartment a_4). A set of equations describing this system is:

$$\frac{\partial a_1(x,t)}{\partial t} = P_{12}\left[a_2(x,t) - a_1(x,t)\right] - v\,\frac{\partial a_3(x,t)}{\partial x}$$

$$\frac{\partial a_2(x,t)}{\partial t} = \frac{P_{21}+P_{23}}{P_{12}+P_{32}}\left[P_{12}\,a_1(x,t) + P_{32}\,a_3(x,t) - (P_{12}+P_{32})\,a_2(x,t)\right]$$

$$\frac{\partial a_3(x,t)}{\partial t} = P_{32}\left[a_2(x,t) - a_3(x,t)\right] - v\,\frac{\partial a_3(x,t)}{\partial x}$$

$$\frac{d}{dt}\left[S_4(t)\,a_4(t)\right] = v\left[\frac{\partial}{\partial x}\left\{S_1 a_1(x,t) + S_3 a_3(x,t)\right\}\right]_{x=e}.$$

The solutions for different initial and boundary conditions are expressed as integrals which have been solved numerically on an IBM 1620 digital computer. Graphs of the solutions and experimental results are compared.

R. Ellams,
National Institute for Medical Research, London.

70. COMPUTER ANALYSIS OF RENAL FUNCTION STUDIES.

Renal function studies using tracer techniques are an accepted diagnostic tool. The analysis of results has in the past been largely quantitative, but it is hoped that a quantitative study of the results will yield a more precise diagnosis. The paper outlines the derivation of an adequate model of the renal system using analogue techniques, and goes on to discuss the results so far of a study using analogue, digital and hybrid techniques to provide a routine analysis of renal function data.

The techniques developed are applicable to tracer studies of other compartmental systems.

C. M. E. Matthews, D. Read and E. J. M. Campbell,
Hammersmith Hospital, London.

71. ANALOGUE COMPUTER STUDY OF CO_2 STORES AND CONTROL OF VENTILATION.

The control of ventilation by means of tissue $^{P}CO_2$ or CO_2 concentration has been simulated with an analogue computer by Grodins et al, and this simple model has later been extended by others. All these models assume that the rate of exchange of CO_2 between blood and tissues depends only on blood flow. However, observations in man of the rate of rise of mixed venous $^{P}CO_2$ during re-breathing from a small bag, and of the kinetics of distribution of $^{11}CO_2$ and $^{3}H_2O$ indicate that CO_2 in blood exchanges vary rapidly with CO_2 in extracellular fluid, and that exchange between extracellular and intracellular CO_2 is comparatively slow.

We have simulated a model which includes exchange rates due to blood flow, and to exchange between extracellular and intracellular pools. Each of these rates becomes the limiting factor under different circumstances. The predictions of the model will be compared with experimental results for re-breathing from a bag, a step function change in inspired CO_2, hyperventilation, and others. The implications of the modifications made to Grodins' model will be discussed.

P. R. J. Burch,
The General Infirmary, Leeds.

72. MATHEMATICAL ASPECTS OF THE AGE- AND SEX-DISTRIBUTIONS OF CERTAIN DISEASES.

It has been found that when a 'latent period' is allowed for, the age- and sex-specific prevalence (N_t), and/or initiation-rates, (dN/dt) of many non-malignant, chronic diseases, fit one of the following mathematical expressions:

$$N_t = P_o (1 - e^{-kt})^n \quad \ldots (1)$$

$$dN/dt = n k P_o e^{-kt} (1 - e^{-kt})^{n-1} \quad \ldots (1a)$$

$$N_t = P_o (1 - e^{-kt^r}). \quad \ldots (2)$$

$$dN/dt = r k P_o t^{(r-1)} e^{-kt^r} \quad \ldots (2a)$$

$$Nt = P_o (1 - e^{-kt^r})^n \quad \ldots (3)$$

$$dN/dt = n r k P_o t^{(r-1)} e^{-kt^r} (1 - e^{-kt^r})^{n-1} \quad \ldots (3a)$$

P_o is a constant, equal to the proportion of the population at (genetic) risk with respect to the disease.

k is found to be a constant throughout postnatal life.

n may take values from 1 to at least 6.

r may take integral values from 1 to 5.

It will be seen that these are all stochastic equations. Equation (1) gives the age-specific prevalence of a condition that is initiated by at least n independent random events, each of average rate k per individual. Equation (1a) is the differentiated form of (1) and describes age-specific initiation-rates.

Equation (2) describes the age-specific prevalence of a condition that is initiated by r dependent random events of average gross-rate k per individual, and (2a) is the differentiated form giving initiation-rates.

Equation (3) combines equations (1) and (2) and describes the age-specific prevalence of a condition that is initiated by n independent sets of r dependent random events.

Examples of the fit of data to these equations will be shown. The simplest - and indeed the only plausible - interpretation of the conformity of numerous data to these equations is, that various diseases

are initiated by independent and/or dependent random events. Some of these diseases (inflammatory polyarthritis, rheumatoid arthritis, systemic sclerosis, chronic discoid and systemic lupus erythematosus, Hashimoto's thyroiditis, multiple sclerosis) are widely believed to be "autoimmune." It will be suggested that the pathogenesis of such diseases (and many others) is best interpreted in terms of Burnet's 'forbidden-clone' concept of disturbed-tolerance autoimmunity.

C. Kellershohn and P. de Vernejoul,
Commissariat a l'Energie Atomique, Orsay, France.

73. APPLICATION OF THE LAPLACE TRANSFORM TO THE STUDY OF A CATENARY SYSTEM UNDER PULSATORY WORKING CONDITIONS.

The variation of radioactivity in terms of time, in a series of cavities in succession, of constant volume, passed through a fluid with constant flow, after "instantaneous" up-stream injection of a radioindicator, is given by the solutions of a differential linear system with constant coefficients. These solutions are identical with the well-known relations of Bateman, which give the activity of the different members of a radioactivity family.

In the case of pulsating cavities in succession passed through a fluid with a flow which is itself pulsatory, the solutions are those of a differential linear system with periodical coefficients appearing like a generalization of Bateman's solutions with a periodical modulation. The Laplace transform, in principle available for the solution of a system with constant coefficients, remains nevertheless very useful to obtain these generalized solutions.

After having studied the case of the dilution of an indicator in a single pulsatory cavity, the theory is applied to two pulsatory cavities in series (ventricles) separated by a constant parameters system (pulmonary circulation). We explain the shape and characteristics of the curve representing the variation of the precordial radioactivity in terms of time (radiocardiogram). The theoretical interpretation given is applied to the determination of ventricular volumes and left-to-right shunts. Finally, the consequences of the pulsatory characteristics of flow in heart chambers on the classical Stewart-Hamilton formulae enabling flow and volume measurements are examined.

J. B. Dawson,
University of Leeds.

74. ACCURACY AND DETECTION LIMITS IN THE SPECTRO-CHEMICAL ANALYSIS OF CLINICAL MATERIAL.

This paper will consider the problem of the accuracy and detection limits of spectrochemical methods used in the estimation of elements in clinical material, particularly in systems using a photomultiplier as the radiation detector, and with special reference to reproducibility and to the validity of the calibration procedure.

The detection limit for any element (taken as the concentration of the element producing a signal equal to twice the standard deviation of the background) will be considered in relation to a multi-channel high speed scanning spectrophotometer which has been developed for simultaneous emission and absorption spectrophotometry. This apparatus, which employs an oscillating grating, has been designed to integrate and record the intensities of the emission times from up to six elements simultaneously. Procedures will be outlined by which reproducibilities of ± 0.5 to ± 1 per cent (standard deviation) can be achieved with an absolute accuracy of ± 2 per cent.

B. Jacobson and P. Edholm,
Karolinska Institutet, Stockholm, Sweden.

75. REFLECTION SPECTROPHOTOMETRY IN VIVO.

Research in atherosclerosis is hampered by the inability to study the development of atheromatous plaques in vivo. Thus, the effects of different therapy upon these plaques cannot be compared. For this reason we have developed a method of estimating the degree of aortic atheromatosis.

The technique is based on the difference in optical reflection spectra between atheromatous plaques and the normal aortic wall, utilizing two light guides consisting of flexible bundles of small glass fibres. Light is carried to the aortic wall through one light-guide, and the reflected light is transmitted back through the other light-guide to a measuring system.

Analogue electronic circuits are used for quantitative evaluation of the reflected light intensities. The ratio of reflected intensities is recorded independently of the absolute values, which vary with the degree of contact between the aortic wall and the tip of the catheter enclosing the light-guides. Also, the circuits indicate when too thick a layer of blood occurs between the catheter and the wall.

N. L. Gregory,
National Institute for Medical Research, London.

76. A RADIO FREQUENCY MASS SPECTROMETER COUPLED TO A GAS CHROMATOGRAPH FOR THE STUDY OF BIOLOGICAL EXTRACTS.

The mass spectrometer described was designed specifically for use with a gas chromatograph in the identification of scarce and impure chemical compounds of biological origin, and represents an attempt to combine high sensitivity and rapid scanning with moderate resolution.

The sample enters the spectrometer in the continuously flowing helium carrier gas stream through a heated metal inlet valve and stream splitters. Ionization is by electron impact at 30 eV.

Analysis is carried out at an ion energy of about 130 eV by square wave potentials applied between alternate members of a chain of twelve aligned grids. The square wave frequency is swept repetitively from about 800 Kc/s to 200 Kc/s in a period of about 15 secs to cover a mass range of from 16 to 200 atomic units.

Mass calibration is by means of calibration pulses derived from a crystal oscillator. The pulses are recorded with the mass spectrometer, and direct measurement of ion mass is possible to within one mass unit up to mass 100, and with reduced accuracy to mass 200.

In preliminary work satisfactory spectra have been obtained from chromatograms of .05 µl of single substances.

S. Guha and A. Richardson,
St. Louis University School of Medicine, Missouri, U.S.A.

77. PULSATILE ELECTROMAGNETIC PUMP.

The use of an electromagnetic field for the circulation of fluids has been tested and verified. From this, an electromagnetic pump consisting of no moving parts, and capable of circulating physiological saline (0.9%) and blood has been developed. The pump normally operates with alternating current, but under special circumstances direct current may be used.

By appropriate modulation of the electric and magnetic fields, both steady and pulsatile flows, or a combination of both, has been obtained.

The application of this device as a urinary bladder pump, in a heart-lung machine, and for vascular frequency response testing is under investigation.

F. Hepburn,
The General Infirmary, Leeds.

78. INCREASED PATIENT SAFETY FROM THE USE OF LOGICAL AND SIMPLE CONTROL-TAP SYSTEMS FOR INTRAVASCULAR PRESSURE RECORDING.

During routine cardiovascular investigations pressure monitoring apparatus is often coupled directly to the patient's vascular system, and considerable danger exists if methods of changing from one procedure (pressure recording, zero setting, calibration and catheter or manometer flushing, etc.) to another are not absolutely safe. Complications can vary in character from catheter blockage, due to inadvertent entry and clotting of blood and accidental continuous flushing of the catheter into the patient, to such untoward occurrences as the application of calibration pressures to the patient instead of the manometer, and the possible fatal consequence of air injection into the patient.

The functional requirements of a tap system have been analysed and logical design used to include the desirable safety restrictions. One system has been developed that gives safe,

comprehensive control, using four conventional three-way taps logically grouped and so arranged that the positions of the tap handles themselves prevent undesirable linkages.

The functional requirements are collected into four groups which concern: (a) manometer standardization, (b) character of the record, (c) supplementary actions and (d) flushing procedures. Each group of activities can be controlled by a single three-way tap, which automatically caters for the necessary restrictions.

The use of logically designed taps, in which the lever covers the outlet not connected, provides mechanical safety as well as a quick means of checking the tap settings.

Suitable tap labelling can be used to provide a reminder to check the positions of other relevant taps when changing to a new procedure. This, together with the avoidance of possible complications, reduces the risk to the patient and errors due to preoccupation of inexperienced operators.

THE ORGANIZATION OF MEDICAL PHYSICS

E. H. Belcher, M. Cohen, R. A. Dudley, G. Gomez-Crespo, G. J. Hine, J. E. Varela and H. Vetter.

79. THE WORK OF THE INTERNATIONAL ATOMIC ENERGY AGENCY IN THE FIELD OF MEDICAL PHYSICS.

An important part of the work of the I. A. E. A. lies in the field of medical physics. This work embraces not only the provision of training facilities through fellowships, exchange programmes and training courses, the sending of technical assistance in the form of visiting experts, equipment and supplies and the organization of conferences, symposia and seminars, but also a large number of research and international standardization projects and a variety of scientific and technical information services.

The I. A. E. A. has organized four international training courses on medical applications of radioisotopes and two advanced seminars on the physics of radiotherapy. A series of advanced seminars on medical applications of radioisotopes is planned. More than 30 experts in medical physics have undertaken assignments of periods from 3 to 12 months in different countries of the world. The I. A. E. A.'s research contract programme is concentrated on a limited number of specific topics involving studies with radioisotopes. Co-ordinated research programmes, for example, on the use of radioactive calcium in the study of bone metabolism and on the applications of whole-body radioactivity measurements in radiotoxicity studies have been found especially fruitful.

The work of the I. A. E. A. Laboratory includes a number of projects in medical physics, among which are various applications of the I. A. E. A.'s own whole-body counter, the evaluation of the performance of various instruments for medical radioisotope work and several international intercomparison and standardization programmes, for example, on the measurement of uptake of radioiodine by the thyroid gland and on the measurement of radiation dose in radioisotope teletherapy.

International symposia on many aspects of medical physics have been held by the I. A. E. A. in recent years; these include meetings on radiation dosimetry, whole-body counting, medical radioisotope scanning and radioisotope sample measurement techniques. The I. A. E. A. undertakes the collection and correlation of data concerning radiation dose in radiotherapy, operates a service providing radiation data for medical use, and also publishes a regular intervals a guide to recent literature in nuclear medicine.

The mode of operation of the I. A. E. A. will be discussed and the above activities described in detail.

G. E. Osman,
U. A. R. Atomic Energy Establishment, Cairo.

80. A PROPOSED PLAN FOR THE DEVELOPMENT OF PHYSICS AS APPLIED TO MEDICAL SCIENCES IN THE U. A. R.

In the U. A. R. a plan for a new central organization has been adopted by the U. A. R. A. E. E. who fostered the medical physics services in the country.

An organization plan for the physics services in hospitals and medical research institutes to suit developing countries is proposed. This plan includes various tables and operational diagrams.

The new medical physics division is aimed at developing into a regional training centre for the Arab States to train hospital physicists, biophysicists, radiologists, engineers and technicians.

The role of technical aid, international and inter-governmental, and a call for the efforts and experience of medical physicists of the I. C. M. P. to help to develop this field in other countries, are discussed.

COMPUTER APPLICATIONS IN THERAPY

J. L. Howarth,
University of New Mexico, Albuquerque, U. S. A.

81. APPLICATIONS OF COMPUTER TECHNIQUES TO RADIOLOGICAL PROBLEMS.

Some uses of computers in radiological problems other than dose planning will be discussed. Particular problems considered will include the calculation of dose distributions near boundaries in inhomogeneous absorbers and the construction of mathematical models for tumour growth.

R. E. Bentley,
Institute of Cancer Research, Sutton.

82. A DIGITAL COMPUTER FOR THE CALCULATION AND IMMEDIATE PRESENTATION OF DOSE DISTRIBUTIONS.

A general purpose digital computer which is small enough to be used in a hospital laboratory is now commercially available. This machine has been programmed so that isodose curves due to the superimposition of several X-ray fields may be displayed on a cathode-ray screen immediately the field arrangement has been decided upon. Dosage data for each X-ray field are stored on paper tape and entered into the computer. The position, angle of entry and weight to be given to each field are entered from a key-board. As one field is entered, a reproduction of its isodose distribution appears on the screen, at the appropriate position and angle. The combined dose distribution can be seen immediately after the input of each additional field. A large number of fixed field configurations can thus be examined in a short space of time.

Since the computer has a cycle time of only 1,6 μsecs it is possible to produce a 4 field distribution in about 1 second. The method is contrasted with the analogue technique described by Jones and Bentley in the next paper. The possibility of a hybrid device enjoying the lower cost of the analogue systems and the greater flexibility of digital methods is discussed.

J. C. Jones and R. E. Bentley,
Royal Marsden Hospital, Sutton.

83. AN ANALOGUE COMPUTER FOR THE CALCULATION AND IMMEDIATE PRESENTATION OF DOSE DISTRIBUTIONS.

An electronic analogue computer has been designed to present isodose curves on a cathode ray screen. For supervoltage X-ray machines and Cobalt units it has been found possible to generate the dose at any point in the x-y plane by using two diode function generators and two multiplying circuits of the quarter square type.

The whole plane is scanned in about 1 second by applying cyclically varying voltages of different frequencies to the x and y inputs. The same varying voltages are applied to the x and y plates of an oscilloscope, and it is arranged that the beam brightens up when the generated value of dose reaches a predetermined level. Isodose curves in the form of a series of discreet bright points appear on the screen. The display may be shifted by biasing the x and y inputs, and rotated by modifying the x and y voltages with sine and cosine potentiometers.

By replicating this circuit, the apparatus may be extended to present the resultant dose distribution from several x-ray fields applied to the patient. Several voltages corresponding to the dose due to each field are generated simultaneously, and added in a summing circuit. It is expected that the analogue method of rapid planning will be less expensive than a comparable digital method, but will probably be less amenable to refinement and development.

J. S. Robertson,
Brookhaven National Laboratory, U. S. A.

84. COMPUTER APPLICATIONS IN SOME SPECIAL PROBLEMS OF RADIATION DOSIMETRY.

Two special radiation dosimetry problems in which digital computer methods have been useful are: the dose from tritium in cellular geometries, and the dose from neutrons in neutron capture therapy of brain tumours.

Because of the low energy and short range of the tritium β-particle, the standard methods of dose calculation are not applicable in many situations, particularly when a labelled substance which

concentrates in the cell nucleus is used. The problem has been approached as follows. From the tritium β -spectrum and from range-energy relationships, the average amount of energy reaching a given distance from a point source is computed. From this function the energy that escapes from, or is absorbed in, a given geometry may be computed by numerical integration, as can the dose at any point.

Similarly, in computing the dose due to gamma-ray production in neutron exposures, the dose calculation methods that assume a uniform source distribution are not applicable without modification because of the rapid attenuation of the neutron flux with depth. This problem was approached by dividing the volume of interest (the head) into elements of volume by radial, transverse and coaxial slicing. Each element of volume is treated as a gamma source of intensity determined by the neutron flux at its centre. The dose at any point of interest is computed by integrating over the volume, taking into account the appropriate geometry, build-up, and attenuation factors for each element of volume. Comparison of the computed dose with measurements made in a tissue-equivalent cylinder shows close agreement.

J. van de Geijn,
H. Joannes de Deo Hospital, The Hague, Netherlands.

85. THE COMPUTATION OF THREE-DIMENSIONAL DOSE DISTRIBUTIONS IN ^{60}Co - TELETHERAPY.

Details were recently published in the Brit. J. Rad. of the use of a new, relatively simple theoretical model of the dose distribution produced by a rectangular beam of high energy X- or gamma-rays in a waterequivalent medium. A simple generating function can be derived by which the dose at any point in such a beam can be computed. Two computer programmes, based on this generating function, were developed, one for stationary fields and the other for moving beam techniques. In this way it is possible to compute three-dimensional dose distributions in individual patients.

The possible merits of the use of a fast digital computer on a regional or even a national scale are currently being investigated, with financial help from the Queen Wilhelmina Fund for Cancer Research.

Particulars are given about the number and the nature of both the fixed field data and the variable field data, with examples of individual problems. Details are also given about the display of the results. Finally, an idea is given of the overall costs per patient.

C. S. Hope,
Regional Physics Department, Glasgow.

86. THE APPLICATION OF COMPUTERS TO JUDGEMENT PROBLEMS IN RADIOTHERAPY.

A brief outline is given of:

(a) methods of preparing and processing field data used routinely for multified treatment planning;

(b) optimizing treatment plans by a simplification of field data, so that the computer can consider a wide range of possibilities: it can exercise judgement by selecting the best according to a compromise between the extent to which the plans satisfy several different criteria;

(c) a possible approach to the problem of selecting the best fractionation regime;

(d) diagnosis by comparison of symptoms.

An evaluation of the present and future importance of computers in radiotherapy is given in the light of experience gained with the above problems.

W. A. Jennings,
Royal Northern Hospital, London.

87. PROGRAMMED 3-DIMENSIONAL IRRADIATION.

The aim of this project is to extend confined high dose zones to irregular shapes, corresponding to the anatomical delineation of the tumour, or to its lines of spread. In practice, such treatment zones may be sinuous tracks of elliptical cross-section, - the eccentricity, orientation and dimensions of which may vary along the track. The achievement of uniform dosage over such zones entails the adaptation of an already versatile ^{60}Cobalt Unit, so that both the source-head and treatment couch form part of a co-ordinated motorized system. Further, it must be possible to programme easily the control mechanism for each patient.

Appropriate elliptical dose contours at successive patient-sections can be obtained by arc therapy in which the angular velocity and beam width vary during oscillations of the beam axis between selected reversal positions. The extension of a series of such sectional distributions along a 3D track is achieved by vertical and lateral movements of the couch-top during its translation at a variable speed along the axis of the revolving source head. Each parameter to be pre-set, or varied during treatment, is pre-calculated and expressed in the form of profiles. Combined chart-inserts of such data for each patient are employed, and photoelectric profile-followers for each movement transmit the requisite information to the Cobalt source-head and couch.

The basic dosimetric studies have been made with the aid of an Elliott computer, together with film and phantom measurements in a multi-section patient-phantom.

R. J. Shalek and M. Stovall,
M. D. Anderson Hospital & Tumor Institute, Houston, Texas, U. S. A.

88. AN EVALUATION OF RADIATION DOSE SPECIFICATION IN THE PATERSON-PARKER RADIUM SYSTEM.

There are now several methods for the calculation by computer of isodose curves around interstitial and intracavitary radiation treatments for individual patients. In order to improve the accuracy of the dose calculated, the radiation distribution from filtered linear sources has been reviewed in detail; and to aid in relating clinical experience accumulated with the Paterson-Parker system to these newer methods, a comparison has been made of the dose calculated by both methods for typical planar and volume implants.

It is concluded that the Paterson-Parker tables for linear sources are correct, if allowance is made for the change in specific gamma-ray emission, tissue absorption, and the conversion from exposure to absorbed dose. Other factors considered include the effective thickness of filter, radiation absorption in the radium salt, and the variable absorption coefficient of radium gamma-rays in platinum. For usual planar and volume implants a multiplicative factor of 0, 90 will convert the dose derived from Paterson-Parker tables into absorbed dose in rads, making allowance for the factors mentioned above and for a small correction due to oblique filtration.

DOSE DISTRIBUTION

K. A. Wright, M. I. Smedal, F. A. Salzman and J. G. Trump,
High Voltage Research Laboratory, Mass. Inst. of Techn.
and Lahey Clinic Foundation, Boston, Mass., U. S. A.

89. SYNCHRONOUS FIELD SHAPING IN MEGAVOLT X - RAY THERAPY.

Techniques involving the use of synchronously rotating absorbers for modifying the shape and distribution of the absorbed dose in typical tumour situations under 360° rotational treatment with 2 MeV X-rays will be described.

The method, resultant dose distribution, and preliminary clinical appraisal of providing individual kidney protection during wide-field 360° rotational treatment of the abdomen, as in disseminated cancer of the ovary, will be discussed.

The physical aspects, including field dosimetry, of spinal cord protection and eye protection during 360° rotation will be correlated with clinical observations on several hundred patients.

During the past 6 years, the use of synchronously rotating protective devices and field-shaping absorbers has evolved into practical and flexible procedures applicable to routine clinical radiotherapy. These techniques, we believe, achieve more closely the desired localization of absorbed radiation energy in the tumour-bearing regions.

J. Telich, G. Castaneda and G. Garcia,
Mar Banda, Mexico.

90. DEPTH DOSE CORRECTIONS IN NON-WATER EQUIVALENT MATERIALS UTILIZING TRANSIT DOSE MEASUREMENTS.

A simplified method for transit dose measurements is described; the method utilizes an ionization chamber or film as a detector. Special emphasis has been placed on obtaining correction factors for different zones of the irradiation field. Results of laboratory tests and of clinical cases are given. The routine use of the method is also described.

P. G. Orchard and L. R. King,
Royal South Hants Hospital, Southampton.

91. THE APPLICATION OF A DECREMENT SYSTEM TO THE RAPID CONSTRUCTION OF ISODOSE CURVES AT VARIABLE S. S. D. AND OBLIQUE INCIDENCE.

A practical system for the production of ^{60}Cobalt isodose curves is described, for any condition of incidence within a wide range of selected variables. It involves the use of a simple plotting table; isodose curves can be rapidly produced by a technician, and the system has been successfully used for the routine preparation of data for an isocentric Cobalt Unit.

The Cobalt Unit works at 75 cm source-axis distance, decrement diagrams are prepared from measurements at normal incidence at two source-surface distances (60 cm and 70 cm), and central axis data for all field sizes necessary are prepared for source-surface distances at 5 cm intervals from 55 cm to 70 cm S. S. D. The presentation of the latter gives the depth of each (10% interval) isodose curve at each decrement value. Both sets of diagrams are colour coded, and are used together on a plotting table to obtain the isodose curve required, variations in surface position being allowed for by using a "0. 6 times gap" correction associated with the central axis datum; the shape of the beam as defined by the decrement system is maintained in a correct relationship with the surface. Within the limits of the decrement system the accuracy of presentation of data is better than 3%.

I. Ragnhult, B. Roos and M. Cohen,
Radiophysics Institute, Gothenburg, Sweden, and I. A. E. A., Vienna.

92. A STUDY OF INTEGRAL DOSE EFFICIENCY FACTOR.

The concept of "efficiency" in radiotherapy is relatively new. ICRU Report 10d (1963) defined the Integral Dose Efficiency Factor as "The ratio of the integral dose in the target volume to the total integral dose to the patient." While the significance in radiotherapy of the integral dose as such is still controversial, there can be no doubt that, other things being equal, a high efficiency factor is advantageous. For defined tumours in actual patients the efficiency factor is easily calculated and serves as an index of the relative

merits, in physical terms, of alternative treatment techniques. In the present study, however, efficiency is considered as a general problem in clinical dosimetry, with particular reference to multiple-field teletherapy using high energy photon beams.

Important preliminary considerations are: (1) the significance of the phrase "other things being equal;" (2) the effect on efficiency of the assumptions made as to the target volume or area, including its shape and size; (3) the relationship between the area (i. e. single plane) and volume efficiency factors. The derivation of the area factor by graphical and digital computer methods is described. Most of the calculations in this study were made with an ALWAC computer at the ADB-Institute, Gothenburg. Area efficiency factors have been calculated for a series of hypothetical tumours in a "patient" of defined cross-section. The first results are presented showing the dependence of efficiency on the number of fields, the field size, radiation energy, position of the "tumour" and other parameters.

X-RAYS, SPECTRA AND DIAGNOSTIC APPLICATIONS

A. D. Rotenberg and R. A. Beique,
Montreal General Hospital, Montreal, Canada.

93. A GENERALIZED SOLUTION FOR THE ATTENUATION OF BREMSSTRAHLUNG SPECTRA.

The difficulties in understanding the properties of bremsstrahlung radiation has been due to the necessity of considering individually a large number of different photon energies. A simplified approach to the problem has been found, expressing the spectral distribution and the energy-dependent attenuation coefficients in terms of functions of dimensionless variables.

The material to be presented is based on Kramer's Law describing the thick target bremsstrahlung spectra, and on an empirical relationship, describing the energy dependence of the attenuation coefficients. An equation has been derived for the intensity of an X-ray beam after attenuation by any absorber. The intensity equation consists of the product of two functions: the first comprising the energy independent variables, while the second, in the form of an integral, accounts for the energy dependent variables. The integrand can be reduced to a function of a single dimensionless variable which can be integrated numerically.

It will be shown that the intensity equation depends exclusively on four independent variables which could be the accelerating voltage and current of the x-ray tube, and the atomic composition and thickness of the absorbers. Partial derivatives of the intensity equation give the properties of the beam, for example, the effective coefficient, the differential spectrum and the change of intensity with change in accelerating voltage.

Some of these functions will be presented showing how the generalized variables can be used in the understanding of the attenuation of bremsstrahlung radiation and the physics of radiography.

P. Tothill,
Medical Physics Department, The Royal Infirmary, Edinburgh.

94. THE RATIO OF TUNGSTEN K-CHARACTERISTIC RADIATION TO CONTINUOUS RADIATION DETERMINED USING BALANCED FILTERS.

In order to use attenuation methods of estimating the spectral distribution of X-rays, it is usually necessary to make allowance for the amount of characteristic radiation present. Measurements of this parameter were made for a range of operating voltages up to 250kV,. and three different degrees of filtration, using balanced filters to isolate the K-lines from tungsten. Solutions containing erbium and ytterbium were used as filters to isolate the combined Kc_1 and Kc_2 lines. A thulium-erbium pair did so only partially, owing to the closeness of the thulium absorption edge to the Kc_1 line and the finite width of the latter. The Kc_2 line was isolated by a tantalum-hafnium pair. The filters were used in conjunction with two ionization chambers, arranged so that the difference between ionization currents was measured. It was necessary to allow for incomplete balance for the unfiltered beam, for the amount of continuous radiation within the pass band and for the transmission of the filters. The maximum proportion of K-characteristic radiation expressed in terms of exposure rate was 12%. Good agreement was found between these measurements and others using a proportional counter.

P. N. Goodwin,
The Johns Hopkins Medical Institutions, Baltimore, Maryland, U. S. A.

95. THE SPECTRAL MEASUREMENT OF HIGH VOLTAGE AND SUPERVOLTAGE X-RAYS.

Measurements have been made of the spectral distribution of X-rays in the treatment beams of various X-ray generators covering the range 100kV to 300kV, and also at 2 mV. These measurements were made by using a scintillation counter to measure the radiation scattered by a thin sheet of low-atomic number material placed in the beam at the normal FSD. The results have been used to study the effects of collimators, wedge filters, open versus closed cones, and collimating devices, and also to obtain the rads/roentgen factors for these beams. The method of measurement will be described, and the results will be presented for all normal filter combinations in the range 100 - 300 kV and at 2 mV.

S. C. Lillicrap, R. E. Bentley and J. C. Jones,
Royal Marsden Hospital, Sutton.

96. SPECTRAL DISTRIBUTION OF X-RAYS FROM HIGH VOLTAGE THERAPY MACHINES.

The problems associated with the determination of X-ray spectra from generators in use for radiotherapy are discussed, and the results of investigations using a 3" x 3" No. 1 crystal as detector, on a 2 mV Van de Graaff generator and two nominally 6 mV linear accelerators, are presented.

The chief problem lies in achieving a sufficient reduction of the number of photons entering the crystal to enable individual photon encounters to be registered. It is not usually possible to reduce the intensity of the main therapy beam without altering the spectral distribution, and the distances available in a therapy room are severely limited. The difficulty has been overcome by the use of fine collimators and by scattering the beam through a suitable angle by a sheet of aluminium. This procedure has the additional advantage of reducing the photon energy and thus making possible the use of smaller crystals.

The problem is aggravated in the case of the linear accelerators by the pulsed nature of the radiation beam. Since resolution of counts inside the radiation pulse is impossible, the counting rate has to be reduced, so that the probability of more than one count per pulse is small. This severely limits the background counting rate that can be allowed. The considerable amount of lead shielding necessary has, however, been reduced by using the shielding provided by the layout of the concrete walls at the entrance to the therapy room.

G. A. Hay,
University of Leeds, Leeds.

97. A THEORETICAL BASIS FOR THE OBJECTIVE MEASUREMENT OF X-RAY IMAGE DETECTOR PERFORMANCE.

Image degradation in X-ray image detectors has hitherto been measured by simple subjective methods. The accuracy is naturally limited by subjective variations, but this factor can be minimized by careful experimental design: such methods are being continuously developed, and we have shown them to be of considerable practical value.

The development of objective methods has been greatly retarded by the complex nature of image transfer processes, which in general include both technical and statistical (noise) factors. Considerable progress has been made for relatively simple image detectors, such as the radiographic screen-film combination, in which statistical factors are relatively unimportant: the technical limitations may in general be measured and expressed in terms of the well-known modulation transfer function. For the more complex detectors, such as image intensifier television systems, where statistical factors may predominate, there is no objective method of measurement at present available.

In the paper, a theoretical basis is suggested for comprehensive objective measurements of system performance. A particular feature of the presentation is a method, thought to be complete and rigorous, of describing the statistical deficiencies of an image. In the application of these principles, the parameters of the output image are measured and those of the corresponding input image are either measured or computed. The transfer properties of the image system are then expressed in output-to-input ratio form in terms of three principal functions:

(1) mean intensity transfer function,

(2) modulation transfer function,

(3) noise transfer function.

Brief reference will be made to work already in progress in this laboratory on the measurement of the noise transfer function.

M. Davison,
Regional Physics Department, Glasgow.

98. TELEVISION TECHNIQUES AND IMAGE QUALITY.

Closed circuit television links used in fluoroscopy or for remote viewing of radiographs are often seen to be poorly adjusted and not giving optimum performance. Two types of test are more useful for routine hospital use than are the methods previously proposed for determination of the quality of an X-ray image. The first is an elaborate investigation in terms of contrast transfer functions to give the optimum capability of any particular system. The second is the simple subjective test routinely used to prevent unnoticed deterioration which leads to lost information. Both types of test are carried out and portable instruments are being developed in the light of this experience.

A. Robinson and J. Fox,
Hammersmith Hospital, London.

99. QUANTUM NOISE AND OTHER LIMITING FACTORS IN X-RAY DIAGNOSTIC BEAMS USED TO MEASURE DYNAMIC CHANGES IN LUNG DENSITY.

An X-ray method has been developed for measuring the transient changes in lung density due to the pulsation of blood at each heartbeat, in order to estimate cardiac function without the necessity of cardiac catheterization.

A 2" diameter beam of 40 - 60 kVp X-rays is transmitted through the lung, and the intensity measured by a zinc cadmium sulphide phosphor and photomultiplier. The sensitivity and frequency response of the system have been made adequate, after a number of problems have been overcome. The limit of sensitivity is set by the shot noise due to the small number of X-ray quanta absorbed by the detector within the integrating time of the system, which must be sufficiently short to respond to cardiac frequencies. The necessary compromise will be discussed, with experimental results.

M. B. Heller,
New York University Medical Center, U. S. A.

100. A PROCEDURE FOR CALCULATION OF GONADAL X-RAY DOSE IN DIAGNOSTIC RADIOGRAPHY.

The paper presents the procedure used in calculating gonadal X-ray exposure resulting from diagnostic radiographic examinations conducted in private physicians' offices in New York City. The data collected in this study include technical and patient information relating to 47,000 radiographic exposures gathered in a sample consisting of 680 offices, each supplying data on all examinations and patients for a one month period. Since direct measurement was precluded by the nature of the sample, a unique approach was devised to calculate the gonadal dose for each exposure for the purpose of ultimately arriving at the genetically significant dose to the population.

The method is predicated on: (1) a one point calibration of each radiographic unit which includes output and H. V. L. determination; (2) a procedure which can predict output and H. V. L. at any KVP for that unit to within 3%; (3) an accurately determined set of measured gonadal doses in a realistic human phantom; and (4) a procedure for realistically modifying these doses for the anthropometric characteristics of any patient and the technical variables associated with specific examination.

The gonadal doses for certain examinations and the technical variables responsible for their excess are discussed.

S. Piermattei Ricci and A. Casnati,
C. N. E. N., Rome.

101. AN ANALYSIS OF THE ABSORPTION METHOD FOR DERIVING RADIATION SPECTRA.

Knowledge of radiation spectra is of importance in dosimetry and radiation biology. In this paper the measurement of the radiation spectra by means of absorption analysis is described. The equipment and the experimental procedure required are relatively simple and, therefore, make this method a useful supplement to standard techniques of scintillation spectrometry.

The method involves the reconstruction of the radiation spectrum from transmission data by solving a Freedholm first kind integral equation. Equations of this type can be solved by means of an integral transform. In our case the transmission data are fitted with a suitable Laplace transform and the spectrum is derived from the inverse transform. We obtained absorption curves over a range of 100% to 1% transmission, using a 300 kV X-ray apparatus under different working conditions and with different filtrations.

Our aim is to make a critical analysis of the method in order to study (1) the influence on the spectrum shape of the mode of analysis of the experimental data; (2) the modification induced on the spectrum by different choices in number and thicknesses of the absorbers, and finally (3) the minimum set of absorbers which give still good results.

The numerical calculations have been performed using a 1620 IBM computer, and the spectra have been derived for two different types of absorber. A comparison is made between theoretical spectra given by Kramer's theory and experimental data. Similar measurements are in progress to determine the thermal neutron spectrum of a channel of the RC-1 Triga Mark II reactor existing in our centre.

M. B. Heller,
New York University Medical Center, U. S. A.

100. A PROCEDURE FOR CALCULATION OF GONADAL X-RAY DOSE IN DIAGNOSTIC RADIOGRAPHY.

The paper presents the procedure used in calculating gonadal X-ray exposure resulting from diagnostic radiographic examinations conducted in private physicians' offices in New York City. The data collected in this study include technical and patient information relating to 47,000 radiographic exposures gathered in a sample consisting of 680 offices, each supplying data on all examinations and patients for a one month period. Since direct measurement was precluded by the nature of the sample, a unique approach was devised to calculate the gonadal dose for each exposure for the purpose of ultimately arriving at the genetically significant dose to the population.

The method is predicated on: (1) a one point calibration of each radiographic unit which includes output and H. V. L. determination; (2) a procedure which can predict output and H. V. L. at any KVP for that unit to within 3%; (3) an accurately determined set of measured gonadal doses in a realistic human phantom; and (4) a procedure for realistically modifying these doses for the anthropometric characteristics of any patient and the technical variables associated with specific examination.

The gonadal doses for certain examinations and the technical variables responsible for their excess are discussed.

J. R. Cameron and J. A. Sorenson,
University of Wisconsin, U. S. A.

102. IMPROVED INSTRUMENTATION FOR BONE MINERAL MEASUREMENT IN VIVO.

An improved device for the measurement of bone-mineral content has been constructed and is presently in use at the University of Wisconsin Hospitals. The photon source and scintillation detector are mounted on a turntable which is driven through a rack and gear system on its circumference. The linear scanning speed used is 0.8 mm/sec, and is easily varied by changing drive gears. The change in apparent width of the bone scan, caused by the fact that the source travels on a circular path rather than in a straight line, is less than 1% for bone diameters up to 1.5 cm. The scanning time for a bone such as the radius is about 30 sec. The photon transmission rate is continuously measured with a pulse height analyser, precision ratemeter, and potentiometric recorder.

A 35 mc ^{125}I source was constructed by an ion exchange method. This well-collimated source, of dimensions 1 mm dia. by 7 mm, gives a counting rate of about 400,000 cpm in air. A flexible rubber tube (Penrose drain) filled with a 2% solution of potassium sulfate in water, is wrapped around the arm, and flattened between Plexiglas holders to provide a constant thickness of tissue equivalent plus bone throughout a scan of the radius. In vivo scans with this improved device show standard deviations of less than 2%, and are reproducible on a daily basis to within 4%, over periods of several weeks.

G. W. Reed,
The General Infirmary, Leeds.

103. THE ASSESSMENT OF BONE MINERALIZATION FROM THE RELATIVE TRANSMISSIONS OF ^{241}Am AND ^{137}Cs RADIATIONS.

An apparatus has been constructed in which either of two finely collimated beams of radiation may be directed accurately through a selected bone in the living patient and the transmission measured with a scintillation detector and pulse analyser. The sources of radiation are of widely differing energy; the one is Americium-241 and the other Caesium-137, giving effectively monoenergetic radiation of 60 KeV and 662 KeV respectively. The absorption of the ^{241}Am radiation is particularly sensitive to atomic number and, in bone studies, is dominated by the calcium present; the absorption of the ^{137}Cs radiation is insensitive to atomic number and is determined by the mass of material in the beam. Comparison of the two transmissions thus provides a measure of the calcium in the path traversed. The use of monoenergetic radiation and the reduction of scatter to a minimum overcome many of the difficulties inherent in radiographic techniques applied to the measurement of bone mineralization.

The construction, performance and calibration of the apparatus are described and its application to clinical studies outlined. In addition to its clinical potentialities the apparatus provides a convenient and rapid method for the determination of effective atomic number (e.g. in testing the suitability of materials as phantom constituents) and its application to the in vitro study of bone specimens in various forms is also described.

B. E. Keane,
Sussex.

104. IMAGE QUALITY IN STEREOSCOPY.

The requirements for stereoscopy in medicine are reviewed in the light of existing and possible applications. Limitations imposed by image distortions, introduced during the taking and viewing processes, are discussed and methods of estimating the magnitude of these distortions in practical cases are described.

The peculiar characteristics of stereoscopy which make a rigid analysis elusive are investigated in the light of information theory, and the paradox of storing information from a volume on only two planes of limited capacity is resolved.

From these theoretical studies, practical conclusions are drawn in the form of optimized techniques for particular purposes and a guide to the choice of apparatus for medical applications of stereoscopy.

C. A. Greatorex,
Institute of Cancer Research, Sutton.

105. A FOUR CHANNEL RADIATION RADIOTELEMETRY SYSTEM.

In studies of the uptake or distribution of radioactive sources in vivo it may be advantageous in some cases to allow the subject considerable freedom of movement whilst measurements are being carried out. A telemetry system is described in which the signals derived from up to four radiation detectors may be transmitted by radio link to a receiver.

A carrier frequency of 26.5 Mc/s is used and channel selection is obtained by means of pulse-code modulation. The information obtained from each detector is displayed on its associated strip-chart recorder.

The apparatus has been used in preliminary experiments designed to measure the transit times of food through various sections of the gut. In these experiments the subject swallowed a small Perspex sphere in which was sealed a 20 μc source of ^{57}Co. The γ-radiation from this source was detected by four Geiger counters strapped at suitable positions on the subject's abdomen, and continuous recordings were obtained of the counting-rate in each detector as the sphere passed through the alimentary tract. A comparison of the counting-rates in the different channels enabled estimates to be made of the positions of the source and of its transit time between specific points.

RADIATION BIOLOGY

C. H. Marshall,
St. Bartholomew's Hospital, London.

106. PULSED RADIOLYSIS AND FLASH SPECTROSCOPY STUDIES ON AMINO ACID SOLUTIONS.

The new 15 MeV Vickers electron accelerator at St. Bartholomew's Hospital Medical College is being applied to the problem of studying the transient chemical effects of a single pulse of radiation on amino acid solutions. A constricted air spark has been used to produce an absorption spectrum photograph of the solution shortly after the irradiation. Some details of the apparatus used will be given.

The problems involved in measuring the dose delivered by a single pulse of radiation of a few microseconds duration will be discussed. Ferrous sulphate, lithium fluoride, Perspex and secondary emission foils have been used for this purpose.

The transient absorption spectra observed in air equilibrated and deoxygenated aqueous solutions of glycine, alanine, tyrosine and tryptophan will be shown, and these results will be discussed in the context of the chemical and biological effects of radiation.

R. Oliver and B. J. Shepstone,
The United Oxford Hospitals, Oxford.

107. THEORETICAL GROWTH RATE CURVES FOR VICIA FABA ROOTS UNDER CONTINUOUS RADIATION EXPOSURE AT LOW DOSE RATE.

Using models for the meristem of Vicia faba proposed previously, theoretical curves of growth rate have been computed for conditions of continuous radiation exposure at low dose rate (1 - 10 rads/hr.) These have been compared with experimental results. The best agreement is obtained assuming cell death at the second division following radiation damage, allowing for some gradual increase in cell cycle time during irradiation, and postulating that at any rate at the lower dose rates, sterilized cells differentiate and contribute to root elongation. The match between

theoretical and experimental curves suggests a value for D_o of about 240 rads for the "single hit" type of mechanism assumed to apply at these dose rates. It is predicted that if the cell cycle time is varied, similar growth rate curves should be observed for the same dose received per cell cycle (rather than for the same dose rate).

A. Halko and J. Ovadia,
Michael Reese Hospital & Medical Center, Chicago, U. S. A.

108. STUDIES OF RADIATION EFFECTS IN WATER, SALINE, AND SUSPENSIONS OF BACTERIA USING RADIOACTIVE OXYGEN - 15.

The radioactive isotope of oxygen, ^{15}O, has been used to study the incorporation of oxygen in irradiated water, saline, and E. coli 0111:B4 in saline suspension. O is produced by the reaction $^{16}O(\gamma, n)$ using 30 MeV bremsstrahlung from an electron linear accelerator on a liquid oxygen target. The isotope is detected through its associated 0.51 MeV annihilation gamma-ray. Samples to be studied are irradiated with 15 MeV electrons (below the oxygen photoneutron threshold) immediately after ^{15}O production at dose rates of the order of 40,000 rads/min in a volume of 80 cc. The incorporation of ^{15}O in water and buffered saline was studied from 0 to 200,000 rads. It increases linearly with dose until approximately 90,000 rads and then begins to exhibit an approach to saturation at higher doses. This observation is consistent with published results on hydrogen peroxide production in irradiated water. The formation of H_2O_2 was measured by spectrophotometric observation of the oxidation of iodide ion; the relation between ^{15}O incorporation in water and H_2O_2 concentration will be discussed. The incorporation of ^{15}O in irradiated bacteria suspended in buffered saline was studied up to doses of 210,000 rads; the concentration of ^{15}O is greater in bacterial suspensions than in either water or saline, and shows no approach to saturation.

M. L. Griem and R. J. M. Fry,
Argonne National Laboratory, Argonne, Illinois, U. S. A.

109. THE EFFECTS OF IONIZING RADIATION ON THE ELONGATION AND TENSILE STRENGTH OF RODENT VIBRISSAE.

Since it has been observed that ionizing radiation causes narrowing of the hair shaft and thinning of the cortex of growing or anagen hair, it was postulated that such changes might alter the physical properties of hair as measured by elongation and tensile strength under varying load. Because symmetrically paired vibrissae show similar growth patterns, measurements were made on symmetrically paired untreated rat vibrissae which showed a like correlation in tensile strength and elongation. A pilot study was carried out as follows:

The right cheeks of rats were irradiated with acute single doses of 100 KVF X-rays (FSD 15 cm, 1 mm Al filter, 1.5 cm cone, HVL 1.35 mm Al). Graded exposures of 50 to 1500 R were used. The opposite cheek was shielded. At 250 R and above there was a decrease in the tensile strength when testing the portion of hair produced at the time of irradiation. There was an indication of a decrease in the tensile strength of hair produced one month after the single exposure of 750 R in a portion of the hair which showed no visible change. This observation is being investigated further. The use of this type of investigation in irradiation and ageing studies will be discussed.

G. Poretti,
University of Berne, Switzerland.

110. MEASUREMENTS WITH A LIQUID WHOLE BODY COUNTER OF A REPRESENTATIVE GROUP OF THE SWISS POPULATION.

The radioactive content of about 5, 500 visitors to the Swiss National Exhibition in Lausanne (April to October, 1964) has been measured with a liquid whole body counter. The content of caesium-137, potassium-40 and radium-226 was measured for two minutes, and the distribution of the activity according to sex, age and different regions of Switzerland was calculated with an IBM computer. The results show a general increase of the caesium content; typical differences in potassium content between males and demales was also detected.

Precise determinations of the radium content were not possible owing to unfavourable measurement conditions in the exhibition hall.

It is concluded that a liquid scintillation counter is a very suitable instrument for rapid and precise measurements of radioactivity in large groups of population.

J. S. Orr,
Regional Physics Department, Glasgow.

111. MEASUREMENT OF OXYGEN TENSION BY ELECTROCHEMICAL POTENTIAL.

Continuous monitoring of oxygen tension with very low consumption of oxygen is required for studies of the radiosensitivity of tissues in hyperbaric oxygenation conditions and the growth of bacteria. An investigation has been made of the possibilities of direct measurement of the electrochemical potential of oxygen electrodes under conditions in which their behaviour approaches reversibility. Useful results have been obtained both with metallic electrodes and with the Berl graphite electrode. The latter also shows a response to hydrogen peroxide which may be useful in dosimetry.

B. W. G. Morgan,
St. Bartholomew's Hospital, London.

112. OXYGEN TENSION MEASUREMENT IN NORMAL AND TUMOUR TISSUES OF THE MOUSE BREATHING VARIOUS GAS MIXTURES AT NORMAL AND ELEVATED PRESSURES.

Oxygen tension measurements have been made in mouse tissues by means of the oxygen-cathode technique. The levels found in the tissues at rest, during air breathing, are compared with those in the tissues with the animal breathing nitrogen, oxygen and carbon dioxide, oxygen or oxygen at high pressure. These results in normal tissues will be compared with those in the Ehrlich ascites tumour grown in solid form and the spontaneous mammary tumours in C_3H mice. Some of the implications of these relative tissue oxygen tension measurements will be discussed.

D. V. Cormack,
University of Saskatchewan, Canada.

113. DISTRIBUTIONS AND AVERAGE VALUES OF LINEAR ENERGY TRANSFER.

Distributions of absorbed dose as a function of LET were calculated for the following radiations: 25 MeV betatron bremsstrahlung, 2 MeV electrons, ^{60}Co gamma-rays, 250 KVP X-rays, 50 KVP X-rays, tritium beta particles and heavy ions with energies 1, 10 and 100 MeV per a. m. u. The effect on the distribution of the choice of cut-off energy is considered. For each radiation, both track-average and dose-average values of the L. E. T. were calculated. The determination of an "effective" LET for use in the analysis of RBE studies will be discussed.

ULTRASONIC AND OPTICAL TECHNIQUES

J. A. Newell,
Queen Elizabeth Hospital, Birmingham.

114. PHYSICAL LIMITS IN ULTRASONICS: FOCUSING AND RESOLUTION.

The wave nature of ultrasonics limits the degree of focusing and the resolution that can be achieved. The limit in dimensions of the focal area and in resolution are both of the order of a wavelength. The wavelength can, of course, be reduced by increasing the frequency. However, ultrasonic absorption in biological tissue increases approximately linearly with increasing frequency.. This places a practical limit to the increase in frequency that can be tolerated. When focusing ultrasonics for treatment, there must still be left a workable gain in intensity in the focal area. When propagating pulses of ultrasonics through tissue for locating interfaces, the returning echo pulses must be detectable above noise. The limit in size of the focal area, and the limit of resolution, can both be expressed in terms of the frequency coefficient of absorption and the depth at which focusing or location are required. This is a physical limit independent of apparatus.

A. Sokollu and E. W. Purnell,
Western Reserve University, Cleveland, Ohio, U. S. A.

115. ABSOLUTE MEASUREMENT OF TOTAL RADIATED POWER OF ULTRASONIC TRANSDUCERS FOR BIOMEDICAL USE.

A calorimetric device with proper acoustical match has been designed to measure total ultrasonic radiation emerging from a narrow orifice of a medical power-transducer. It contains a pair of thermocouples and a stirrer, providing averaged temperature readings. After irradiation, a cooling system returns the calorimeter to the starting temperature. A built-in electrical unit supplying energy to a heating element placed close to the irradiation point allows the calorimeter to be heated.

This energy measured electrically permits calculation of the radiated ultrasonic power within an accuracy of 4%.

J. McKie,
Regional Physics Department, Glasgow.

116. IMPROVEMENTS IN ORTHOPTIC EQUIPMENT.

Amplyopia is treated in young children by simple procedures such as occlusion of an eye, after removal of the causative squint or refraction defect. Difficulty is experienced when the eccentric fixation persists into later childhood or maturity. Foveal vision may be restored by exercise, if the patient is made conscious of the direction associated with foveal vision. This can be done in the clinic by means of an after-image. It may be achieved more readily by using the phenomenon of Haidinger's Brushes - the recognition in the fovea of the direction of the electric vector of plane-polarized blue light. Although a satisfactory physiological explanation of the phenomenon is lacking, the practical use requires very simple equipment. Light of wavelength less than 4, 900 A is used, and the plane of polarization slowly rotated. Apparatus loaned to the patient employs Polaroid discs rotating in an eyepiece. For group therapy, pictures are projected on to a metalized screen through a rotating polarizer. Other applications of technology to devices used in the re-training programme allow training sessions to be increased by reducing boredom and obviating the need for the continuous attention of an Orthoptist.

F. G. Parsons,
Technical Operations Research, Burlington, Mass., U. S. A.

117. MEDICAL APPLICATIONS OF ISO-PHOTOMETRY.

The analysis of radiographs, photographs, and other records on which information is stored in a continuous-tone, two-dimensional optical density pattern can often be aided by reconstructing the record as an isodensity contour plot. Such plots, which we have produced with the Tech-Ops/Joyce-Loebl scanning iso-photometer, not only present the "photometric" information contained in the record in a directly useful, scaled, and quantitative format, but also improve the accuracy of "photogrammetric" measurements on objects with diffuse edges. In addition, scanning slit size and contour interval step can be varied to suppress film grain and

enhance contrast, thereby improving detection of low-contrast features. Applications of isodensity-tracing techniques to medical research and diagnosis include production of plots showing lines of constant X-ray absorption (for measurement of material densities or thicknesses); generation of takeup contours of substances containing radioactive tracers, from autoradiographs; three-dimensional measurements of cell dimensions, from birefringence microphotographs; detection of several types of low-contrast inclusions on radiographs; accurate determination of the sizes and shapes of diffuse-edged structures on electron micrographs; highly accurate location of the centre of X-ray and electron diffraction spots, electrophoresis spots, and spectral lines, and measurement of structure in those records; and production of contour lines of equal isotope takeup by body organs (from photographically-recording gamma-ray scanners) and surface temperature (from thermograph records). Examples of these applications are shown and discussed.

PAPERS RECEIVED AFTER COMPLETION OF PROGRAMME

The following papers have not been included in the programme, mainly because of late arrival. They will be read at the Conference, if time permits; details will be given on the notice board near the registration office in the Lounge Hall.

G. L. Brownell,
Massachusetts, U.S.A.

1. MONTE CARLO CALCULATION OF GAMMA-RAY DOSE.

A Monte Carlo programme has been prepared for the calculation of absorbed dose delivered by point sources and distributed sources of gamma-emitters in a tissue equivalent phantom. The basic programme traces the path of gamma-rays through an infinite tissue-like medium, recording location and energy transfer of each interaction on magnetic tape. Tape records containing 40,000 to 60,000 gamma-ray histories for various gamma-ray energies are used as the input data for a programme which determines energy absorption in various phantom geometries. The results are presented in terms of absorbed fraction, which is defined as the fraction of energy emitted by the gamma-ray source which is absorbed in the phantom.

Monte Carlo calculations extending the work described in previous reports will be discussed and results presented. In particular, the application of this type of calculation to ICRP recommendations will be discussed.

G. Poretti,
University of Berne, Switzerland.

2. SOME MEASUREMENTS WITH A POSITRON SCANNER.

A positron scanner for lateral and frontal measurements of the head is described, and some results are given of phantom measurements with the positron emitters ^{64}Cu and ^{74}As. Pulses from the coincidence unit are registered on a tape recorder and scintigrams are made on a photographic film. To improve the contrast of the scintigrams the number of pulses from the patient can be artificially increased in proportion to the pulse frequency; the multiplication factor can be varied.

H. Hart,
New York, U.S.A.

3. THEORETICAL RESOLUTION OF FOCUSING COLLIMATOR COINCIDENCE SCANNING SYSTEMS.

The maximal resolution of various idealized types of scanning systems will be evaluated. If N is the number of collimator channels and $N\lambda$, the detection efficiency of a focally emitted gamma-ray, it will be shown that the resolution obtainable using focusing collimator coincidence scanning (F.C.C.S.) is $\sqrt{\frac{N^2\lambda}{2}}$ times the standard single gamma resolution.

For large solid angle and large N, F.C.C.S. detection systems may, therefore, result in a significant improvement in scanning resolution. Practical considerations in equipment design and isotope selection will be indicated.

V. K. Vransky, K. Dascalov and L. Saeva,
Sofia, Bulgaria.

4. A SPECIALIZED ELECTRONIC COMPUTER FOR AUTOMATIC DIFFERENTIAL DIAGNOSIS OF TOXIC DISEASES.

Many diseases caused by toxic substances present a great variety of symptoms, and rapid and accurate diagnosis may be decisive for the treatment and its outcome.

In order to accelerate diagnosis and improve accuracy, an electronic hybrid diagnosing apparatus has been built. Information concerning the various toxic diseases and their symptoms is stored in a diode-resistor matrix. On the basis of preliminary statistical data 247 symptoms of 100 diseases have been stored. The information is fed into the computer by a push-button board. Simultaneously a card is being punched, which can be used later as an objective document. Within a few seconds the physician receives back a list of those diseases stored in the matrix, of which a given percentage of the symptoms is covered by the input symptoms.

Thus the computer can be considered as a very fast consultant-assistant which helps the physician in the diagnosis.

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5. THERMOLUMINESCENT DOSIMETRY.

The general characteristics of TLD will be presented and the following specific topics will be discussed.

Basic Mechanisms: 1) Sensitivity of LiF as a function of dose. 2) A mathematical model that fits the experimental data for LiF. 3) Variation of sensitivity due to pre-radiation annealing. 4) Loss of stored thermoluminescence during iso-thermal annealing. 5) Determination of energy and frequency factors of the electron traps. 6) Energy dependence of LiF and Al_2O_3.

Applications: 1) Determination of radiation quality by the paired TLD system using LiF and Al_2O_3. 2) Measurement of the absorption and build-up factors for radium, ^{60}Co and ^{137}Cs. 3) Measurement of the radiation distribution around radium needles with small single crystals of LiF. 4) Use of single LiF crystals for personnel monitoring. 5) Dose evaluation in clinical studies.

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6. HIGH RESOLUTION DOSE-DISTRIBUTION MEASUREMENT AT PHANTOM INTERFACES.

The radiation colouring of dye-cyanides in solid solution with gelatin or plastic has been found to have unique capabilities for visualization and measurement of megarad dose-distributions on a microscopic scale. Applications of these systems in radiation processing have already been suggested, since the material is essentially water-equivalent, highly stable, light-insensitive, and can be incorporated in a number of materials. The suggestion now is that, although the system requires relatively large doses for colouration (10^5 to 10^8 rads), there are potential medical applications in the measurement of dose-distributions close to interfaces of different tissue phantoms. Colourless triphenylmethane dye cyanides, such as pararosaniline nitrile, formylviolet

nitrile, etc. take on very deep colours upon irradiation with G-values of the order of 10^2 to 10^3, depending on the dye. Since their solid solutions in gelatin are molecular in structure they form high-resolution grainless images. Measurement of density gradients by means of suitable microdensitometric tracings provides a convenient record of dose variations within distances from interfaces of the order of microns.

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