LETTERS TO THE EDITORS

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High-Energy Electron Accelerators as Pulsed Neutron Sources

In the time-of-flight method of distinguishing between neutrons of different energies, various types of pulsed neutron sources have been used. So far, however, the use of pulsed sources of high-energy electrons for generating neutrons through the (γ, n) reaction has not been reported. Experiments reported in the following letter show that the X-rays from a 3- or 4-MeV. linear accelerator will produce useful intensities of neutrons from a beryllium target.

From these results it would appear that a 10-MeV. linear accelerator would provide a suitable source.

By such means, time-of-flight measurements could be made with reasonable resolutions up to energies hitherto unobtainable.

J. D. Cockcroft

In the preceding letter, Sir John Cockcroft discusses the possibility of using high-energy electron accelerators as pulsed neutron sources. To investigate the potentialities of the method, measurements have been made on the linear electron accelerator at this Establishment[1]. An experiment was performed when the accelerator was providing 100 m.amp. peak current in a 2-μsec. pulse of electrons of energy 3·2 MeV. The electrons were absorbed in a lead target, and the resulting X-radiation was absorbed in a container about 13 in. long (in the direction of the beam) and 5 in. square. The container was filled either with heavy water or with beryllium scraps, the latter giving a density of about 0·7 gm./c.c. The neutrons produced were absorbed in manganese sulphate solution in a tank surrounding the container. The neutron production was measured by comparing the activity of the manganese solution with that produced by a 200-mgm. radium – beryllium source inserted in place of the container.

Under these conditions, calculations based on the Bethe – Heitler theory of X-ray production from electrons predict a peak neutron production in the pulse of about 3×10^{12} neutrons per sec. (for heavy-water target). The experimentally determined value was $2 \times 10^{12} \pm 25$ per cent neutrons per second, the error being due partly to uncertain calibration of the radium – beryllium source and partly to uncertainties in the comparative geometry in the main and calibration runs. The beryllium target gave a neutron production 30 per cent lower than that from the heavy water.

It is apparent, therefore, that this method holds great promise for time-of-flight measurements. With higher energy linear accelerators, measurements with good resolution up to neutron energies of 20 keV. or more should be possible. Moreover, the high electron currents available at low pulsing-rates on machines using Marx-type generators might provide neutron sources of sufficient strength to work up into the 100-keV. region. The low pulse-rate would be a disadvantage, but measurements would be possible using very long time-of-flight paths, or, alternatively, a shorter path coupled with a short pulse and a high-resolution detector.

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[1] *Nature*, **160**, 351 (1947).

Effect of X-Rays on the Incorporation of Carbon-14 into Desoxyribonucleic Acid

It was observed by several experimenters[1] that the incorporation of phosphorus-32 into desoxyribonucleic acid of the Jensen sarcoma, and also of normal organs, of the rat is markedly reduced by irradiation with an X-ray dose of some hundred röntgens. This result strongly suggests the explanation that the rate of formation of desoxyribonucleic acid is reduced by the effect of ionizing radiation, though the objection may be raised that it is the re-phosphorylation of the molecule during incorporation of labelled phosphate which is hampered, and not the formation or the assembly of the main constituents of the nucleic acid molecule. To avoid this objection, the effect of X-rays on the incorporation of carbon-14 into the purines of desoxyribonucleic acid in the organs of rapidly growing rats has been studied.

About five microcuries of carbon-14 incorporated with the carboxyl group of sodium acetate were injected subcutaneously to each of 91 one- to three-week-old rats. The rats were killed after the lapse of six hours, and the desoxyribonucleotides were separated from the proteins by extraction with hot trichloroacetic acid[2]; the purines obtained by hydrolysis were twice precipitated as silver salts and their radioactivity was measured. Previous to the extraction of the kidney and muscle proteins, 20 mgm. of desoxyribonucleic acid, kindly presented by Prof. Hammarsten, were added to the trichloroacetic acid extract. Half the rats were previously irradiated with a dose of 950 r., the voltage applied being 165 kV.

As shown by the figures in the accompanying table, the amount of labelled purines formed in the irradiated rats was about half the amount formed in the con-

Ratio of carbon-14 content of 1 mgm. of purine isolated from desoxyribonucleic acid of non-irradiated and irradiated rats six hours after administration of about 0·4 mgm. of labelled carbon as acetate to each of 91 one- to three-week-old rats

Organ	Ratio of C^{14} content of purine from desoxyribonucleic acid isolated from non-irradiated and irradiated rats, respectively				Ratio of C^{14} content of 1 mgm. protein from organs of non-irradiated and irradiated rats, respectively		
	Group 1	2	3	4	Group 2	3	4
Intestinal mucosa	2·3	2·0	2·2	1·5	0·78	0·80	0·90
Liver	2·3	2·0	1·5	1·5		0·83	0·50
Muscles			3·1	1·8		0·91	1·0
Kidneys	1·0		3·0	3·7		1·0	1·0

Percentage of administered C^{14} incorporated in 1 mgm. intestinal mucosa

	Purine min.	Purine max.	Protein min.	Protein max.
Non-irradiated	$3·7 \times 10^{-5}$	$2·4 \times 10^{-4}$	$4·1 \times 10^{-4}$	$6·3 \times 10^{-4}$
Irradiated	$1·7 \times 10^{-5}$	$1·3 \times 10^{-4}$	$5·2 \times 10^{-4}$	$7·8 \times 10^{-4}$