INFORMAL PROGRESS REPORT

TO

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FOR

NsG 708

A GRANT IN SUPPORT

of

BASIC RESEARCH IN SEMICONDUCTOR DETECTOR-DOSIMETER CHARACTERISTICS, AS APPLIED TO THE PROBLEMS OF WHOLE BODY DOSIMETRY

from

SOUTHERN METHODIST UNIVERSITY
Dallas, Texas, 75222

February, 1965

INFORMAL PROGRESS REPORT
NsG 708

I. Experimental Progress

A. Lithium Drifted Silicon Semiconductor Detectors:

1. Forty three different detectors have been incorporated into this study. They represent a family of various sized devices ranging in size from 1 × 1 × 1 mm to 5 × 5 × 130 mm. Long detectors, i.e., having proton path lengths in silicon of 10, 20, 30, 50, 70, 100, and 130 mm are being used to totally absorb high energy protons. Shorter path lengths are used to measure stopping power ($dE/\rho dx$) in silicon.
2. Southern Methodist University now has the capability of fabricating Lithium-drifted detectors of any desired shape. New techniques of fabrication, mounting and encapsulation are being developed.

B. Stopping Power Measurements

Data has been taken using protons having energies of 5, 6, 8, 10, 11, 12, 13, 14, 15, 16, 36, 37, 40, and 187 Mev. Absorbers were used in duplicate sets of three different thicknesses permitting measurements on six different absorbers with each of two or more detectors.

a. Metals: Aℓ, Cu, Si, C.
b. Plastics: Nylon, plexiglass, polyethylene.
c. Tissue: Bone, muscle, fat.

C. Charge-pulse response of silicon detectors

The charge-pulse response of many of the detector have been measured for the proton energies listed in B as a function of proton energy, proton path length in silicon and operating conditions of the detector. The average energy required to produce an ion-electron pair has been obtained from both the stopping power measurements in silicon and from the protons totally absorbed in silicon. These data are required to translate the current from each detector produced by a known radiation flux density and stored in a calibrated condenser into doses, i.e., the total energy absorbed per unit mass of silicon.

D. Detector Life-time Behavior Studies:

The depletion depth, volume, noise level, charge pulse per Mev, dark current and capacitance are being measured for each detector used in the study. The complete age-usage history thus obtained over the two-year period will be used to (a) predict the usable life of a detector and (b) to pin-point and predict loss of reliability of data produced by the detector.

E. Field Trips:

1. To the University of Texas, Austin, Texas:
   Dates: October 10-11, 1964. Accelerator time: 36 hours.
   Proton Energies 5-14 Mev.
   Dates: December 28-29, 1964. Accelerator time: 36 hours.
   Proton Energies 8-16 Mev.
2. Oak Ridge National Laboratories, Oak Ridge, Tennessee
   Dates: November 21-29, 1964, Accelerator time: 80 hours.
   Proton Energies: 36-40 Mev.

3. University of Uppsala, Uppsala, Sweden
Dates: October 23 - November 8, 1964, Accelerator time: 100 hours, Proton Energy: 187 Mev.

F. NASA Participation:
Members of the NASA, Manned Space Center, Space Radiation and Fields Branch participated in the research effort at both the University of Uppsala and at Oak Ridge National Laboratory. At each facility additional research of special interest to this Branch were accomplished. These included exposure of nuclear track plate emulsions and calibration of various dosimeters. The accelerator time made available to NASA at no charge ranged from 16 to 24 hours at each facility.

II. Theoretical Progress

A. Linear Stopping Power Calculations:
A program for calculating linear stopping power, $dE/\rho dx$; based on the Bethe-Block equation

$$-\frac{dE}{\rho dx} = \frac{Z\, e^2\, 4\pi\, mc^2\, r_o^2\, N_o}{A\, \beta^2}\left[\ell n\, \frac{2\, mc^2\, \beta^2}{1 - \beta^2} - \beta^2 - \ell n\, I - \frac{\Sigma Ci}{Z}\right]$$

including shell corrections has been completed, tested and used on the S.M.U., CDC 1604 computer to calculate the correct thicknesses for the pure absorbers, $A\ell$, Cu, Si, and C. The mean ionization potential, I, has been evaluated experimentally for each element.

B. Monte Carlo Stopping Power Calculations:
The linear stopping power program has been incorporated into a Monte Carlo transport program which permits Coulomb interaction with both the orbital electrons and the nuclei. This program has been used to verify the stopping power measurement and the energy straggle measured experimentally.

C. Determination of Z, A and I for complex absorbers.
The above programs are being used to determine effective Z, A, and I values for water, bone, meat and fat based on the experimental stopping power measurements. The end result will be a program by which dose, i.e., the total energy absorbed per unit mass of the absorbing material, can be calculated as a function of flux density, type and energy of the ionizing radiation.

D. Calculation of Effective Z, A, and I.
The effective values of Z, A, and I for each of four plastics studied are being used to obtain a mathematical model for calculating these quantities where the chemical composition and relative abundance of a heterogeneous material is known.

E. Dose Calculation.
The Monte Carlo program is written to permit calculation of a depth dose distribution in a multilayer, i.e., skin, muscle, bone, fat, etc., absorber in a heterogeneous radiation environment. This program uses the experimental data and the mathematical models reported above and can be easily modified for use of additional data or other models.