all of the shields and components which are to be represented in the problem. After the first-level shield unit has been specified, new shield units may be defined (using a different geometry than the first-level shield if desired), and portions of these new shield units may be embedded between the meshlines of the first-level shield unit. These new shield units become second-level shields.

The embedding process is telescopic, such that third-level shield units may be defined and embedded in the second-level shield units, and each new level of shield geometry is embedded in the next lower level. The meshlines which are specified in each shield may have variable spacing.

Each cell formed by the meshlines of each shield unit may then be specified to contain either a composition (that is, a void, element, compound, or mixture) or a cell-shaped portion of a higher-order shield unit. The highest-order shield unit(s) in a problem will therefore have a composition in every cell.

Multiple sources and detectors are allowed, thus simplifying some types of studies. Nine source and detector geometries may be defined in a SPAN-4 problem, and again the geometries may be rectangular, cylindrical, or spherical. Sources and detectors may be located arbitrarily with respect to any shield unit, and the regions of integration (or detectors) over which the flux, dose rate, or energy-absorption rate are calculated may be parts of rectangular solids, parts of cylinders, or parts of spheres.

The energy output or particle emission of each source is described by a general three-dimensional distribution function. The generality of the function requires that the integral be estimated by means of Gauss or Lobatto quadratures.

8. Status: In production.

9. Machine Requirements: 64K central memory and one system disk. Microfilm is required if the plot options are to be used.

10. Operating System: SPAN-4 is designed to operate under the SCOPE 3.1 operating system described in Ref. 2.

11. Other Programming Information: The program is structured into distinct parts which are loaded into central memory as required. These parts are referred to as OVERLAYs as described in the CDC SCOPE 3.1 basic reference manual (Ref. 2). Essentially an overlay represents the amount of program text in central memory. With overlay loading, the main overlay is always in memory; and, in addition, a particular primary and one secondary overlay may also be in central memory. The SPAN-4 program contains a main overlay, 6 primary overlays, and 7 secondary overlays. Overall program control is vested in the main overlay and the primary and secondary overlays are loaded and executed through the use of the NEXT subroutine described in Ref. 1.

12. Availability: The program and copies of Ref. 3 may be obtained from

    Argonne Code Center
    Attn: Mrs. Margaret Butler
    Argonne National Laboratory
    9700 South Cass Avenue
    Argonne, Illinois 60440

    Reference 3 may also be obtained from

    Clearinghouse for Federal Scientific and Technical Information
    National Bureau of Standards
    U.S. Dept. of Commerce
    Springfield, Virginia 22151
    ($3.00 - printed copy; $0.65 - microfiche)

13. *References:*

[1]C. J. PFEIFER, "CDC-6600 FORTRAN Programming" in "Bettis Environmental Report," WAPD-TM-668 (January 1967).

[2]"Control Data 6400/6500/6600 Computer Systems SCOPE 3.1 Reference Manual," Publ. No. 60189400A (February 1968).

[3]O. J. WALLACE, "SPAN-4, A Point Kernel Computer Program for Shielding," WAPD-TM-809 (December 1969).

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SPECTER

1. Name of Code: SPECTER

2. Computer for Which Program is Designed: IBM-7094 Programming Language: FORTRAN IV

3. Nature of Physical Problem Solved: SPECTER calculates the energy spectra of particles emerging from reactions of the types (y,n), (y,p), (y,α), $(y,2n)$, (y,np), (y,pn), and $(y,2p)$, where the incident particle y may be either n, p, or α. In addition, the code calculates the cross section for each of these reactions.

4. Method of Solution: SPECTER is an outgrowth of the previously published code EDISN.[1] Whereas EDISN is capable of handling only (n,n') and $(n,2n)$ reactions, SPECTER can treat all the reactions specified above. SPECTER makes use of the Weisskopf-Ewing[2] formula to calculate the energy distributions and reaction cross sections. The cross sections for compound-nucleus formation that are needed in evaluating this formula are calculated by the continuum theory of nuclear reactions.[3] Data required as input are the bombarding energy, the masses of all nuclear species taking part in the reaction, and certain parameters that specify the level density of participating nuclei.

5. Restrictions on the Complexity of the Problem: Ideally the code is suited to reactions that proceed through the formation of a compound nucleus (CN). In cases, however, in which the direct interaction mechanism (DI) is also operative, the code is useful in estimating the relative contribution from direct effects, provided the entire cross section for the process, σ_{CN+DI}, be known, e.g., from experiment. In addition, it is required that the level structures of all residual nuclei be adequately described by continuous level densities.

6. Related and Auxiliary Programs: For completeness, a subroutine for calculating the nuclear level density has been included. This subroutine makes use of

the commonly adopted level density formula $\rho = C \exp[2(aU)^{\frac{1}{2}}]$ derived from the Fermi gas model. U is obtained by adjusting the excitation energy to account for the pairing energy.[4] The user may wish to employ some other analytic expression for ρ or a table of values. In this event, the subroutine may be suitably modified or replaced.

7. Running Time: Running time is highly dependent on the number of energy increments used in the numerical integrations. The maximum degree of accuracy is attained with 50 increments. In this case, a typical calculation on ^{56}Fe at 14 MeV, which takes into consideration the reactions (n,n'), $(n,2n)$, and (n,p), takes about 3 min of IBM-7094 time.

8. Unusual Features: A table of cross sections for compound nucleus formation as a function of bombarding energy and target mass number is generated during the first run and written on magnetic tape for use in all subsequent runs. These cross sections are calculated by the continuum theory.[3] Optionally, the user could perform a more sophisticated treatment by replacing this table with a similar one generated from optical model calculations.

9. Status: The program is in use at Brown Engineering Company. Source decks and copies of a user's manual can be obtained from the Oak Ridge Radiation Shielding Information Center.

10. Machine Requirements: 29 K of memory is required. However, with some sacrifice in accuracy this requirement may be relaxed considerably by the reduction of certain array dimensions.

11. Operating System: IBSYS Version 13

12. Other Programming or Operating Information or Restrictions: None

13. *Acknowledgment:* This code was developed in connection with work performed under National Aeronautics and Space Administration Contract NAS8-20166.

14. *References:*

[1]R. SNOW and M. C. GEORGE, *Nucl. Sci. Eng.*, **35**, 409 (1969).

[2]D. H. EWING and V. F. WEISSKOPF, *Phys. Rev.*, **57**, *472*, 935 (1940).

[3]J. M. BLATT and V. F. WEISSKOPF, *Theoretical Nuclear Physics*, pp. 345-358, John Wiley & Sons, New York and London (1952).

[4]T. D. NEWTON, *Can. J. Phys.*, **34**, 804 (1956).

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Corrigendum

M. NATELSON, "On Comparison of Synthetic Kernal Transport Results," *Nucl. Sci. Eng.*, **40**, 153 (1970).

This letter to the Editor should be dated November 24, 1969. The editorial staff apologizes to the author for the omission.