user are the plate power generation rate, inlet enthalpy, and either the inlet mass velocity or pressure drop across the channel.

4. Method of solution: The channel flow distribution is determined at each axial level by neglecting the transverse pressure gradient ($\partial p/\partial y$) in the transverse momentum equation and applying the iterative method of Miller and Pyle (*2*). Integration of the axial momentum equation over the length of the channel is performed by an adaptation of the momentum integral model of Meyer (*3*). The hydrodynamic equations represent the conservation laws for the subcooled, nucleate, and bulk boiling regions of the fluid. In the two-phase region, the hydrodynamic model is that of separated or slip flow. Fluid friction is represented by the use of Blasius type friction factors with experimentally determined corrections of the Martinelli-Nelson type during boiling. Nucleate boiling heat transfer rates are predicted using the Jens and Lottes technique. Nonboiling heat transfer is represented by Dittus-Boelter type heat transfer correlations. The program predicts the distribution of enthalpy, density, mass velocity and pressure drop throughout the channel. Provision is also included for computation of departure from nucleate boiling heat flux. Heat transfer in the film boiling and superheat regions is not incorporated in the XITE program.
5. Restrictions on the complexity of problems solved:
   A. Restricting physical assumptions are as follows:
      1. Energy transfer between control volumes by thermal and eddy diffusion (or turbulent exchange for two-phase flow) is neglected compared to that transferred by convection.
      2. Frictional forces between the fluid boundaries of the control volumes are neglected in comparison to the shear forces at the wall boundaries of the control volumes.
      3. Neglecting the transverse pressure gradient is assumed to have a negligible effect on the flow distribution.
      4. The liquid and vapor velocities in the two-phase region may be different in magnitude but are assumed to act in the same direction.
   B. Restrictions on problem size are as follows:
      1. Number of axial mesh intervals, ≤ 30
      2. Number of transverse mesh intervals ("tracks"). ≤ 10
      3. Number of time-steps, no specified limit
6. Typical running time: If the running time is expressed as follows:

$$T = KN_pN_t$$

where

T = Philco 2000-211 time in minutes (10 μsec memory)
K = proportionality constant depending on the type transient (e.g., the number of iterations) in minutes per point per time-step
N_p = number of mesh points, given by the product of the number of axial and transverse mesh intervals
N_t = number of time-steps required during the transient

the value of the constant, K, will range from 1.0×10^{-3} to 1.7×10^{-3} (or from 60 to 100 μsec of machine time will be required per point per time-step). Hence, a problem with 150 mesh points and an average time-step of 10 msec would require 15 to 22.5 min of machine time for a 1-sec transient. These estimates are based on a Philco 2000-211 with a 10-μsec memory and include output preparation times. The time-step size may be specified as input and will be used in the calculations, provided it does not exceed the minimum fluid transit time through any mesh interval.

7. Unusual features: None
8. Present status: XITE is in production at Bettis. Copies of the program may be obtained from: TUG Executive Secretary, Philco Corporation, Computer Division, 515 Pennsylvania Avenue, Fort Washington, Pennsylvania.
9. *References:*

   1. R. P. Rose and R. S. Pyle, "XITE—A Digital Program for the Analysis of Two-Dimensional Boiling Flow Transients with Fluid Expansion," WAPD-TM-302 (April 1963).
   2. R. I. Miller and R. S. Pyle, "TITE—A Digital Program for the Prediction of Two-Dimensional Two-Phase Hydrodynamics," WAPD-TM-240 (February 1962).
   3. J. E. Meyer, "Hydrodynamic Models for the Treatment of Reactor Thermal Transients," *Nucl. Sci Eng.* **10**, 269-277 (1961).

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ADONIS (UNC Code-90-4)

1. Code name: ADONIS (UNC Code-90-4).
2. Computer for which code is designed: IBM 7090
   Programming system: FORTRAN and FAP
   A 32K core and 10 tapes are required
3. Nature of problem solved: ADONIS calculates the solution to the transport equation for primary neutrons (or gammas) in a three-dimensional rectangular geometry. The program computes either neutron or gamma fluxes and their standard deviations in each of up to 80 regions. By use of response functions, dose and strength of secondary gamma rays from any neutron induced reaction can be computed throughout the configuration. In addition, it is possible to generate a population of secondary gamma rays as input to a gamma ADONIS problem by appropriate editing of a tape record of interactions generated in an associated neutron ADONIS problem. In particular the code has proved useful in analyzing the penetration of neutrons or gammas through ducted shields.
4. Method of solution: ADONIS is a Monte Carlo program that tracks either neutrons or gammas through shields composed of rectangular parallelepipeds of differing compositions. Particle splitting is employed to improve the efficiency of the calculation by assigning importance weights to each of the regions.

   A source tape containing the position coordinates,

direction cosines and the initial energy of the neutron or gamma is required.

The ADONIS program considers the following neutron interactions:

1. Isotropic and anisotropic elastic scattering
2. Discrete and continuum inelastic scattering
3. Scattering by hydrogen
4. The (n, 2n) reaction in beryllium
5. Absorption.

The gamma portion of the ADONIS program considers the Compton scattering of photons. The photoelectric effect and pair production are regarded as absorption processes.

Particle histories in ADONIS are terminated when

1. an absorption occurs,
2. the particle degrades below an arbitrary cutoff energy,
3. a kill occurs due to splitting, or
4. the particle escapes.

Cross-section data for ADONIS are obtained from a Master Element Data Tape for either neutrons or gammas.

ADONIS is called in through the IBM-7090 Monitor System. It contains intermediate dump and edit procedures.

5. Restrictions on complexity of problem: Eighty regions (i.e., a region is defined as a rectangular parallelepiped of either finite or infinite dimensions. The totality of all such regions covers x, y, z space). A maximum of 80 complex surfaces is permitted. (A complex surface is defined as a side of a parallelepiped adjacent to more than one region.) A maximum of 10 energy bins in which fluxes are stored.
6. Typical running times: The computation time required for a given thickness depends upon the choice of the importance weights assigned to the various regions, and hence it is impossible to give a good estimate of the time required to obtain a given accuracy. However, in a series of problems having a two-foot shield of steel and paraffin, an average of 15 min/problem was required for statistics good to 25%, in a 40-region problem having 10,000 source neutrons.
7. Status: Code is in use and available through United Nuclear. Contact S. Preiser for additional information.

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SANE-SAGE (UNC Codes-90-7, 8)

1. Code name: SANE (UNC Code-90-7), SAGE (UNC Code-90-8).
2. Computer for which code is designed: IBM 7090
   Programming system: FAP and FORTRAN
   A 32K core and 6 tapes are required.
3. Nature of problem solved: Solves the neutron or gamma transport problem in spherically symmetric multilayer geometry. The programs compute neutron (SANE) or gamma (SAGE) fluxes at the interior of the assembly. Fast dose at the exterior is also calculated. By the use of response functions, and the SANE flux output, the strength of secondary gamma sources produced by any neutron induced reaction can be computed throughout the configuration. The SANE program handles volume distributed fission or monoenergetic sources. The SAGE program handles volume distributed monoenergetic gamma sources.
4. Method of solution: SANE and SAGE are Monte Carlo programs that track neutrons or gammas through spherical shields composed of different physical compositions.

   All physical boundaries are flux boundaries and can also be splitting boundaries. Particle splitting is employed to improve the efficiency of the calculation. Flux boundaries may be placed anywhere and can be used to get detailed results. The present programs allow for 75 radial regions and 40 output energy bins. The energy bins may be arbitrarily spaced.

   For the SANE program the source energies are picked from a complete or truncated fission spectrum. The neutron starting region and radius are picked by a rejection technique using starting probabilities supplied as input.

   The SAGE program handles a monoenergetic source. The source is specified as piece-wise exponential in the radial source regions. A rejection technique is used to pick from the exponential distribution.

   The SANE program considers the following neutron interactions:

   1. Isotropic and anisotropic elastic scattering
   2. Discrete and continuum inelastic scattering
   3. Scattering by hydrogen
   4. The (n, 2n) reaction in beryllium
   5. Absorption.

   The SAGE program considers the Compton scattering of photons. The photoelectric effect and pair production are regarded as absorption processes.

   Particle histories in both programs are terminated when:

   1. an absorption occurs,
   2. the particle degrades below an arbitrary cutoff energy,
   3. a kill occurs due to splitting, or
   4. the particle escapes.

   Cross-section data for the programs are obtained from a Master Element Data Tape. The SANE and SAGE programs each require a separate Element Data Tape. Cross-section data are stored on the tape by element. For each element the following data appear on the tape.

   1. Probability of exciting a given level, as a function of the primary neutron energy, by inelastic scattering (SANE only).
   2. List of possible excitation levels (SANE only).
   3. Tables of energies scattered with equal probability from the incident energy. For inelastic continuum scattering (SANE only).
   4. Tables of angular distributions for anisotropic scattering (SANE only).
   5. Probability of inelastic scattering (SANE only).
   6. Probability of elastic scattering.
   7. Probability of absorption.
   8. Microscopic total cross section.
   9. Energy table.

   Items 5–9 are tabulated as a function of energy in equal lethargy steps. The present programs allow for a maximum of 120 energies. Items 1, 3, 4 are tabulated for those energy steps in which they are applicable.

   The SANE and SAGE programs are at present on magnetic tape and are called in through the IBM-7090 Monitor System. The programs contain intermediate dump and intermediate edit options. It is possible to obtain