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NASA TECH BRIEF

New Computer Program Solves Wide Variety of Heat Flow Problems

The problem:

Thermal limits of materials and components frequently restrict the design of a structure. Numerous analytical solutions are available for problems with simple geometries, when the differential equations are linear. For more complex geometries, steady-state solutions may be obtained graphically or by experiment. Such methods are quite tedious and usually not applicable to transient analysis, yet the transient solution is usually needed to predict the thermal requirements in critical design areas.

The solution:

A single program called BETA (Boeing Engineering Thermal Analyzer) which uses numerical methods to provide accurate heat transfer solutions to a wide variety of heat flow problems. This highly versatile program will solve steady-state and transient problems in almost any situation that can be presented by a resistance-capacitance network.

How it's done:

In heat transfer problems involving variable physical properties and complicated geometries and boundary conditions, numerical methods offer the best solutions. The BETA program assumes that the heat flow follows the potential flow law. Other physical phenomena that follow analogous forms of this equation may also be solved by this program.

The first step in the solution is to replace the continuous physical system by a "lumped" network system analogous to a resistance–capacitance network. Numerical equations that represent this network exactly are then solved. The solution is accomplished in a step-by-step or iterative fashion. Given a network of temperatures at each node, the computer makes a pass through the network using the numerical equations to predict the temperature at each node a short time later. This process of predicting the new temperatures from the old is repeated for many iterations until the problem is solved.

Notes:

1. Both transient and steady-state solutions can be obtained for almost any system that can be represented by such a "lumped" network. This includes heat transfer problems involving conduction, convection, and radiation; mass transfer (diffusion); electrical circuits; and many other systems. Problems may be one-, two-, or three-dimensional, and may be nonlinear.
2. This program was written for the IBM 7094 computer to be used under the IBSYS system monitor. The main program and most of the subroutines are written in FAP language; the remaining subroutines are written in FORTRAN II, version 3 source language or, in some cases, symbolic language.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10404

Patent status:

No patent action is contemplated by NASA.

Source: J. C. Almond
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Category 01