December 1969

Brief 69-10760

NASA TECH BRIEF

Engineering Thermal Analyzer (BETA II)

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 II (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.

This new version of BETA increases its capabilities and broadens its options as well as making the program available to second generation computers such as the IBM system 360.

How it's done:

The basic feature of the program and technique is the concept of the "lumped parameter network". The physical system under consideration is first broken down into a system of sections or "lumps". The mass of each lump is represented by a point or "node" somewhere within the lump, and the paths for the conduction of heat from one lump to another are represented by conductors connecting the appropriate nodes.

The Thermal Analyzer solves the network system using numerical methods. These methods involve an iterative process. Given a network with temperatures known at each node, it is possible, by applying a numerical equation, to predict a new value of the temperature at each node a short time later. This pass through the network, predicting a new temperature at each node, is termed an iteration. This process of predicting new temperatures from old temperatures is repeated for many iterations until the problem is completed.

Two basic types of problems are possible: transient and steady-state. The operation of the Thermal Analyzer takes place in two phases, very much like two independent programs being executed in succession. The first phase is the Thermal Analyzer Compiler and the other phase is the Thermal Analyzer Executor. Since each phase is allocated and operated independently, only one phase is in core at any one time, thus alleviating core size restrictions.

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 is written in FORTRAN H and BAL for use in the IBM-360 system.
3. Inquiries should be made to:

   COSMIC
   Barrow Hall
   University of Georgia
   Athens, Georgia 30601
   Reference: B69-10760

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

Source: James H. Scates, and L.L. Steinberg of
The Boeing Company
. under contract to
Marshall Space Flight Center
(MFS-15055)