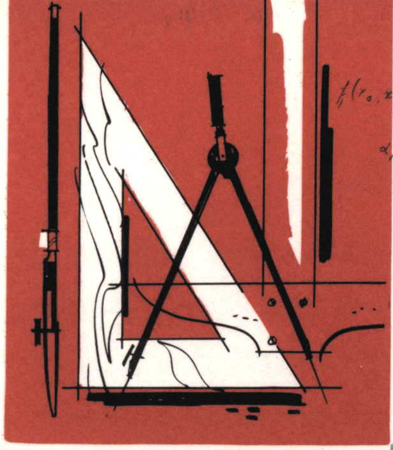
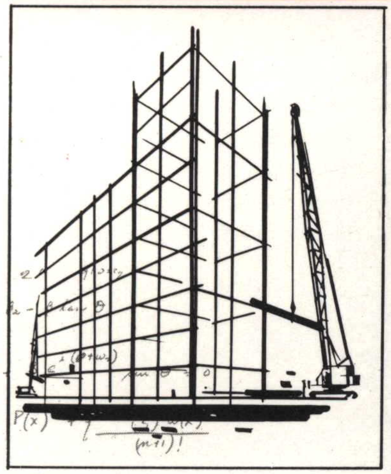
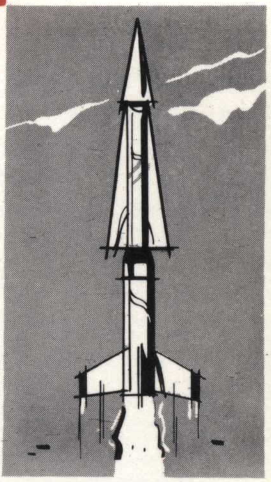


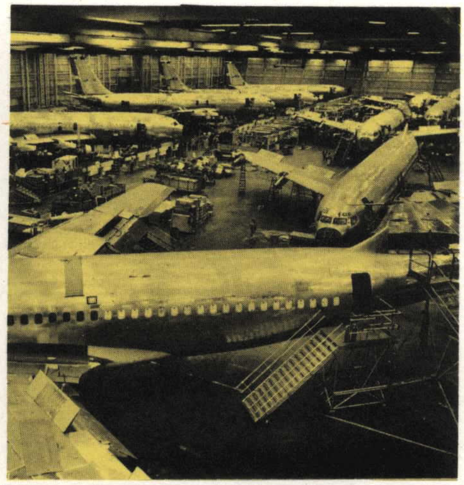
$x_i = \cos\left[\frac{(2i+1)\pi}{2n}\right]$

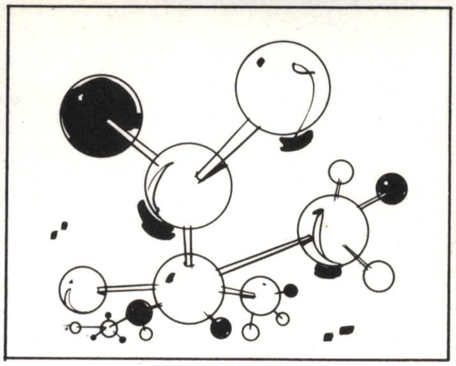
$f(x_0, x_1) = \int_0^1 f'[(1-t)x_0 + t x_1]\,dt$

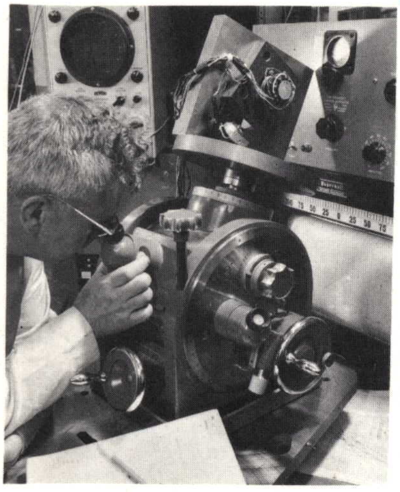
$\alpha_n = \frac{f^{(n)}(0)}{n!} + \frac{f^{(n+1)}(0)}{1!(n+1)} + \frac{f^{(n+2)}(0)}{2!(n+2)} +$







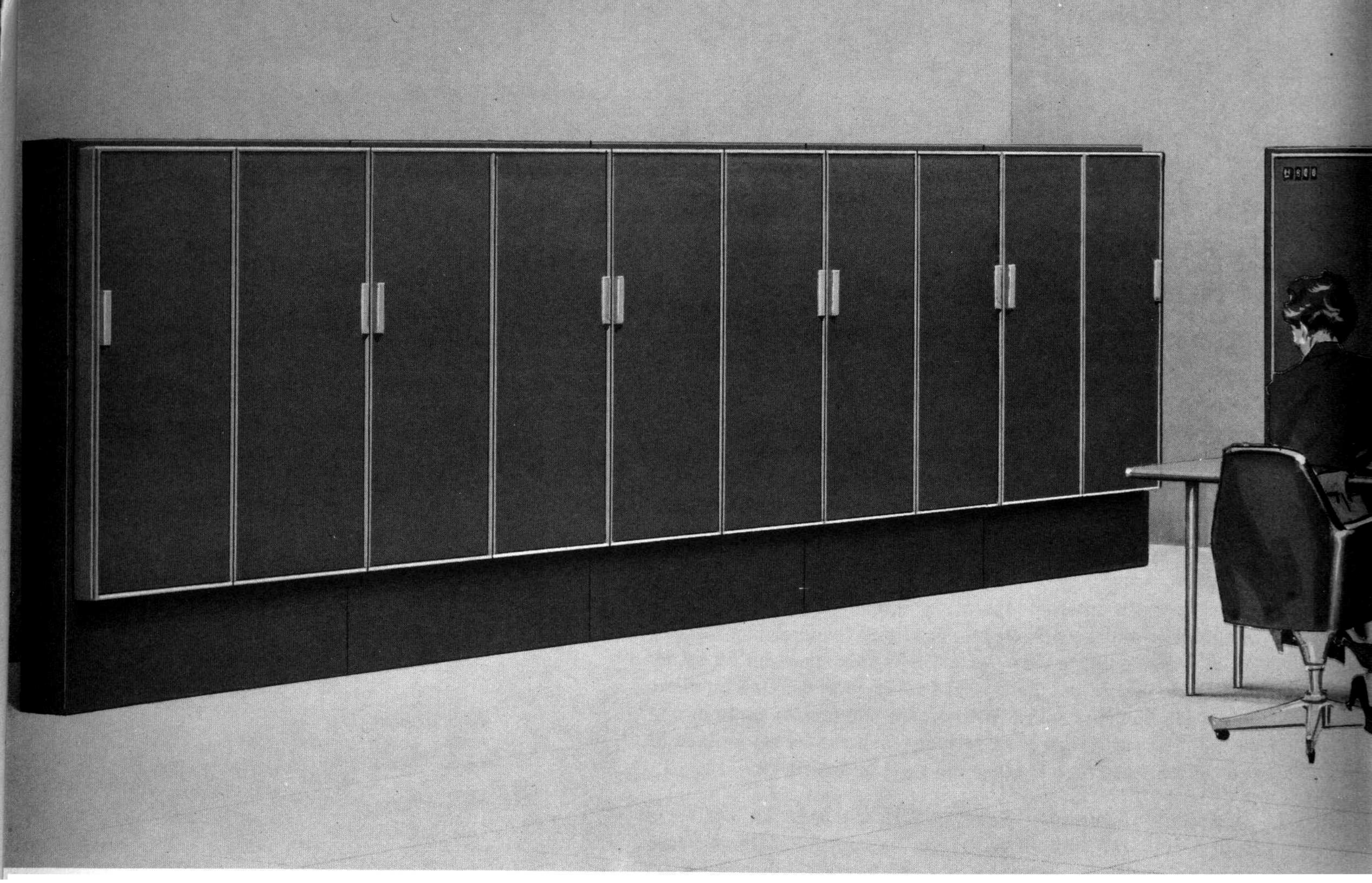




Honeywell 800 a superior scientific computer

$f(x_0, x_1) = \int_0^1 f'[(1-t)x_0 + t x_1]\,dt$

INDEX



BASIC SPECIFICATIONS

Central Processor

INSTRUCTION CODE: three-address

WORD LENGTH: 48 binary digits

ARITHMETIC: binary or decimal, fixed or floating-point

WORD STRUCTURE: (see chart below)

INTERNAL SPEEDS:
- Three-Address Operations — 30,000 per second (equivalent to 70,000 one-address operations per second)
- Information Transfer Rate — over 140,000 words per second
- Accumulations — over 125,000 per second

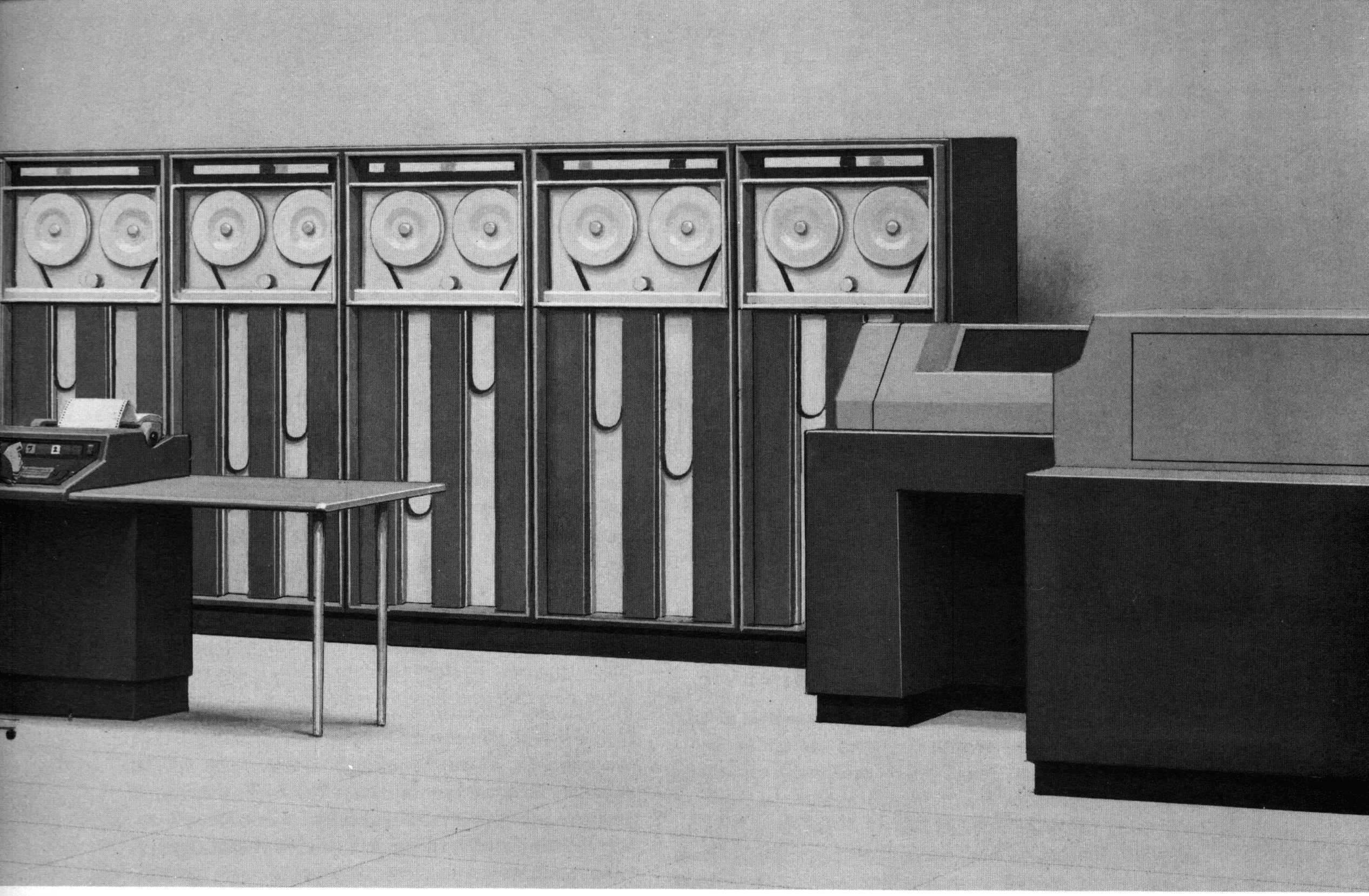
MEMORY SIZE: 4,096 to 16,384 words

RANDOM INQUIRY: Console keyboard and printer may be used independently or in parallel with operating programs.

<table>
<tr><th>Type</th><th colspan="24">Example</th></tr>
<tr><td>INSTRUCTION</td><td colspan="6">OPERATION CODE</td><td colspan="6">ADDRESS A</td><td colspan="6">ADDRESS B</td><td colspan="6">ADDRESS C</td></tr>
<tr><td>ALPHANUMERIC</td><td colspan="3">R</td><td colspan="3">O</td><td colspan="3">B</td><td colspan="3">I</td><td colspan="3">N</td><td colspan="3">S</td><td colspan="3">O</td><td colspan="3">N</td></tr>
<tr><td>DECIMAL</td><td colspan="2">+
—</td><td colspan="2">1</td><td colspan="2">2</td><td colspan="2">3</td><td colspan="2">4</td><td colspan="2">5</td><td colspan="2">6</td><td colspan="2">7</td><td colspan="2">8</td><td colspan="2">9</td><td colspan="2">0</td><td colspan="2">1</td></tr>
<tr><td>BINARY</td><td colspan="2">+
—</td><td colspan="22">(44 BINARY DIGITS)</td></tr>
<tr><td>DECIMAL FLOATING POINT</td><td>+
—</td><td colspan="3">EXPONENT*</td><td colspan="20">MANTISSA
(10 DECIMAL DIGITS)</td></tr>
<tr><td>BINARY FLOATING POINT</td><td>+
—</td><td colspan="3">EXPONENT*</td><td colspan="20">MANTISSA
(40 BINARY DIGITS — EQUIVALENT TO 12 DECIMAL DIGITS)</td></tr>
</table>

* (7 BINARY DIGITS)

(7 BINARY DIGITS)



PROGRAMMING FEATURES:
- Indexing
- Word Masking
- Bi-Sequence Operation Mode
- Automatic Programming Routines
- Library Routines

Magnetic Tape Units

READ/WRITE SPEED: 96,000 decimal digits per second (when operating in binary, this speed is equivalent to 112,000 decimal digits per second)

TAPE WIDTH: ¾″

TAPE LENGTH: 2500 feet

TAPE CAPACITY: up to 20,736,000 decimal digits

TAPE SPEED: 120 inches per second

PULSE DENSITY: 400 bits per inch, per channel

MULTIPLE TAPE OPERATIONS: up to eight reading and eight writing

MAXIMUM TRANSFER RATE: 1,536,000 decimal digits per second

MAXIMUM NUMBER DIRECTLY CONNECTED: 64

ADDITIONAL FEATURES:
- Tape can be Read in Forward and Reverse Direction
- Fast Rewind

Input Units

(both on-line and off-line units available)

CARD READERS:
- Standard Speed — 240 cards per minute
- High Speed — 650 cards per minute
- High Speed — 900 cards per minute

PAPER-TAPE READERS: standard and high speed models available

Special-purpose input equipment can be accommodated by system

Output Units

(both on-line and off-line units available)

PRINTERS:
- Standard Speed — 150 lines per minute
- High Speed — 600/900 lines per minute

CARD PUNCHES:
- Standard Speed — 100 cards per minute
- High Speed — 250 cards per minute

PAPER TAPE PUNCHES: standard-speed model available

Special-purpose output equipment can be accommodated by system

SPECIFIC EXAMPLES OF HONEYWELL 800 PERFORMANCE ON SCIENTIFIC-PROBLEM APPLICATIONS

Physical aspects of scientific problems differ widely. However, the expression of various physical phenomena such as the behavior of an airplane in flight, the guidance of a missile, the transfer of heat, the motion of a satellite and the location of oil, involve such numerical mathematical procedures as interpolation, quadrature, harmonic analysis, matrix manipulation and integration of ordinary differential and partial differential equations.

The following examples will indicate the speed and efficiency with which Honeywell 800 can handle the most complex scientific problems.

MATRICES

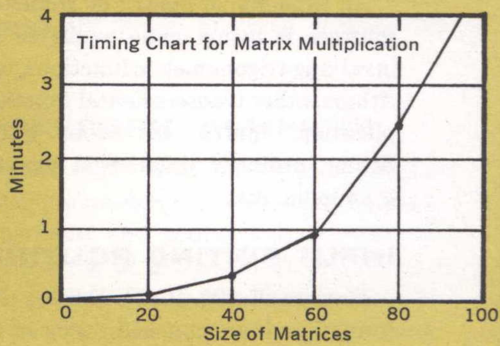
The speed and efficiency of Honeywell 800 three-address instructions, plus the features of indexing, indirect addressing and automatic incrementing, are particularly effective in matrix multiplication.

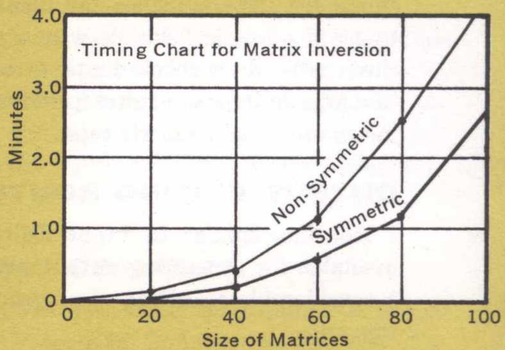
As an illustration, consider the problem A • B = C in which A is a rectangular m x n matrix, B is a rectangular n x p matrix and C is the resulting matrix formed when A is multiplied by B. The time required depends on the size of the matrices and is equal to 282 mnp x 10^{-6} seconds. (This formula and those of the following examples are based on operation in floating binary.) Thus, two 40 x 40 matrices can be multiplied in 18 seconds; two 80 x 80 matrices will take 144 seconds.

A flow diagram and the complete code for this general routine are included in the pocket at the back of this brochure.

Matrix Inversion. A symmetric matrix inversion on Honeywell 800 requires only 100 instructions and takes 138n (n + 1) (n + 3) x 10^{-6} seconds. A 40 x 40 matrix can be inverted in ten seconds; a 100 x 100 matrix takes 2.4 minutes.

Time for inverting a non-symmetric matrix is 276n (n + 1) (n + 5/2). When n is equal to 40, T equals 19 seconds; when n is equal to 100, T equals 4.6 minutes.





DIFFERENTIAL EQUATIONS

Many laws of science are expressed in terms of differential equations. These may be ordinary or partial, linear or non-linear. Ordinary equations are solved more often than partial equations because they are easier. Linear equations are solved more frequently than non-linear equations for the same reason.

Many numerical methods have been devised for the solution of systems of differential equations. The best method to use depends upon the character of the differential equations, the accuracy desired in the computation, the system on which the problem is to be solved, etc. One especially effective fourth-order method involves extrapolation and integration.

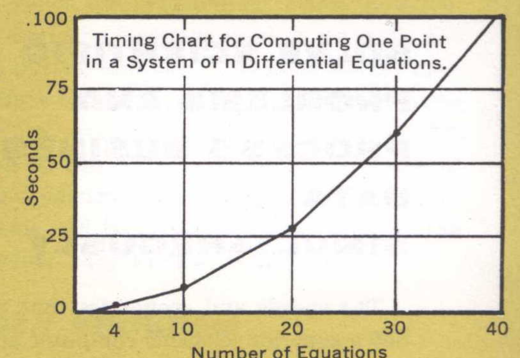
The time to compute one point on the Honeywell 800 by this method is:

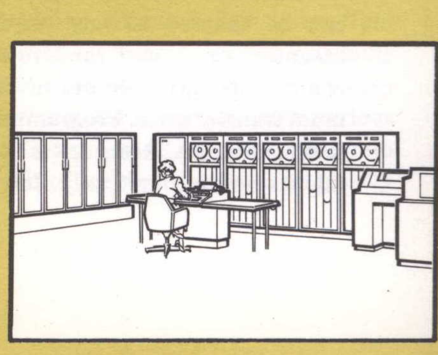
$$T = 3360n \text{ microseconds}$$

where n is the number of equations. This is exclusive of time to substitute values in the differential equations. If the system has constant coefficients, the time for substituting is:

$$552n^2 + 168n \text{ microseconds}$$

One hundred points can be computed in 2.2 seconds for a system of four linear equations with constant coefficients.





CURVE FITTING

In engineering research, a large number of measurements are often taken for different values of parameters. An attempt is then made to determine the behavior of a system by fitting curves to the data. A fit is made of a curve through a set of points in such a way that the sum of the squares of the differences between the points and the curve is a minimum. If the curve is a polynomial of n^{th} degree and the number of points is m, then the coefficients a_i of the polynomial can be expressed as:

$$a = B^{-1}z$$

where B is a symmetric matrix of $(n + 1)^{th}$ order whose elements are:

$$b_{ij} = \sum_{k=1}^{m} x_k^{2n+2-(i+j)}$$

and *a* is the coefficient vector with components a_i. Vector z has elements which are:

$$z_i = \sum_{k=1}^{m} x_k^{n+1-i} \quad y_k$$

The time to compute the elements and invert the symmetric matrix is:

$$T = [828mn + 138n\,(n + 1)(n + 3)] \text{ microseconds}$$

As an example, 100 points can be fitted with a tenth-degree polynomial in one second.

LINEAR PROGRAMMING

The use of data processing systems to reduce the cost of clerical work has, as a natural corollary, made data available for studying the best use of men, machines and materials. Though only one small area in the broad field of operations research, the application of computers to such problems holds considerable promise. Solutions of certain limited problems have resulted in highly useful and practical information previously unavailable in any scientific sense.

For a typical example, consider the problem of selecting the optimum locations for a group of canning factories to minimize the transportation costs of shipping canned goods to known markets. Solution of such a problem requires the special technique called linear programming.

This problem is stated mathematically as follows:

$$\text{Maximize } Z = \sum_{i=1}^{n} C_i \lambda_i$$

Subject to the restrictions:

$$\begin{array}{ccccc} \lambda_i\, a_{11} + \cdots + & \lambda_n\, a_{1n} & = & b_1 \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \lambda_i\, a_{m1} + \cdots + & \lambda_n\, a_{mn} & = & b_m \end{array}$$

The orders necessary to solve this problem by the simplex method are:

Multiply	Add	Compare	Divide
$2mn + 2m$	$5mn + 2m + n$	$3mn + 6m + 3n$	$m + 1$

For the case where $m = 39$ and $n = 64$, the time for one cycle is determined as follows:

Operation	*No. of Executions*	*Time in Seconds*
Multiply	3770	.701
Add	9402	.620
Compare	5919	.142
Divide	30	.009
		1.472

Typically, about $\frac{m}{2}$ cycles would be required.

SIMULTANEOUS COMPUTING AND PROCESSING

The unique ability of Honeywell 800 to process several programs simultaneously is of special significance to companies and organizations with both scientific computing and business data processing requirements. To illustrate the efficiency with which both types of work can be handled by Honeywell 800, a typical timing chart for a daily operation of a guided missile manufacturer is shown on the opposite page. The system in the example consists of a card reader, six magnetic tape units, a fast printer and a central processor and rents for less than $22,000 per month.

DATA PROCESSING APPLICATION

The data processing application illustrated is the maintenance of a parts inventory file consisting of two million records, each containing an average of 350 characters. Each day, approximately 80,000 inventory transactions in punched-card form are read by the card reader, edited and recorded on tape as 5 word items. Conservatively, this operation requires six and one-half hours and takes place from 8:00 A.M. to 12:00 noon and from 2:00 P.M. to 4:30 P.M. When the input program is completed, the input transactions are sorted to the order of the master file to prepare them for tomorrow's updating run. This is done with a two-way merge sort using four magnetic tape units, (plus an input tape) and takes approximately 12 minutes starting at 4:30 P.M.

While today's inventory transactions are being converted to magnetic tape, the master inventory file is being updated with yesterday's sorted transactions, and information for reports is being accumulated on a reports tape. This operation takes four hours including all tape changing and is completed at 12:00 noon. A third program, also starting at 8:00 A.M. and running concurrently with the input and updating operations, is the printing of various reports accumulated during yesterday's updating run and totaling some 250,000 lines. These reports require six hours of printing, conservatively, and are completed by 2:00 P.M.

SCIENTIFIC COMPUTATION

This manufacturer also wishes to use his Honeywell 800 for solving differential equations involved in a missile problem, permit several groups of programmers to compile programs, and complete several small scientific-problem production runs.

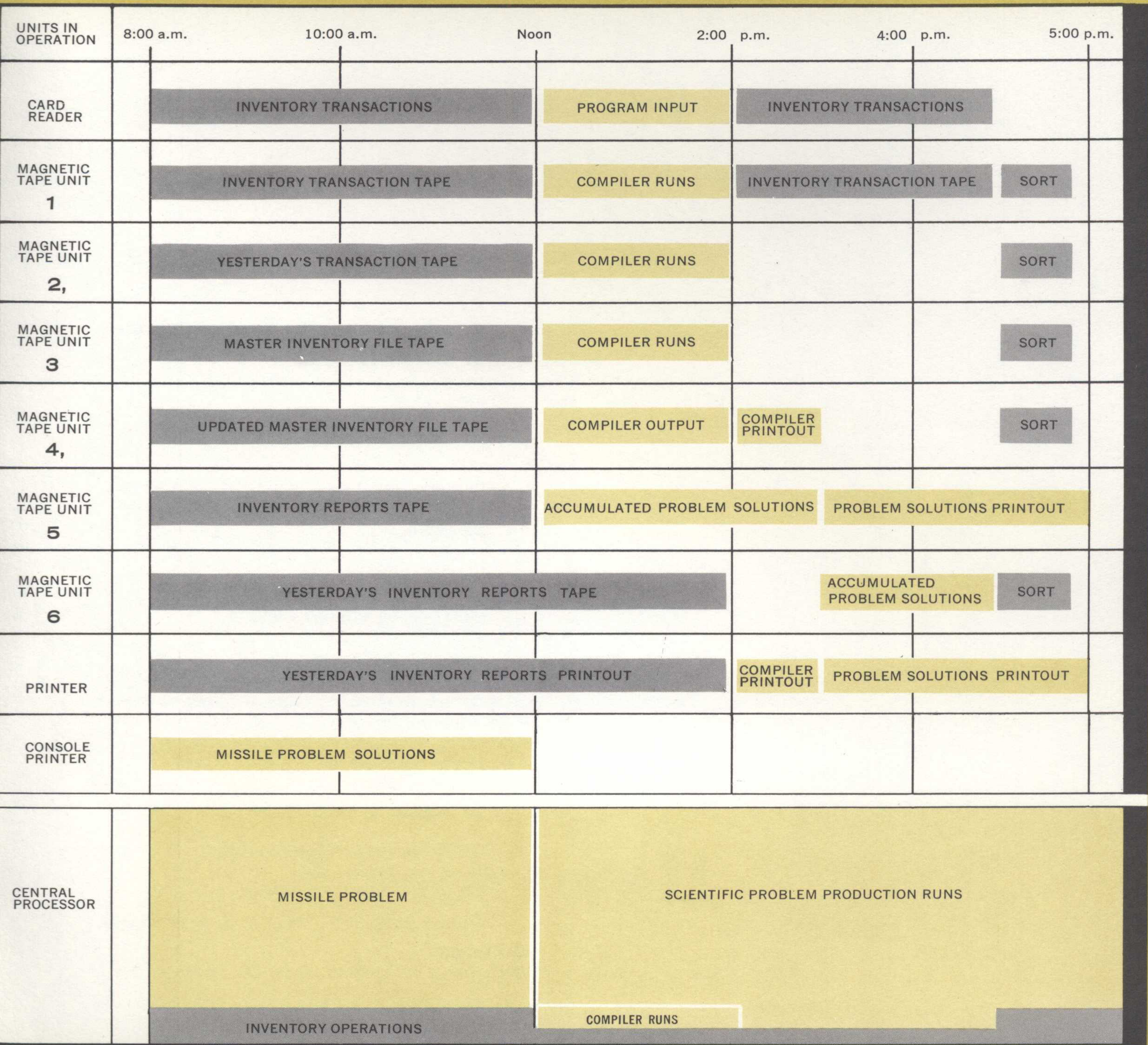
The differential equations concern the behavior of a guided missile in approximately 3000 different situations. From day to day, the design parameters of the missile are changed and the behavior recomputed. This problem, if run alone, would require 3 hours and 30 minutes of computing time. When run simultaneously with the data processing operations, it is slowed down by approximately 13% and requires four hours. Solutions to the missile problem are printed out on the console typewriter.

At 12:00 noon, the inventory updating run is complete. The inventory input operation is interrupted to permit programmers to compile programs utilizing the Honeywell 800 Algebraic compiler. This operation requires the card reader and four magnetic tape units. At 2:00 P.M. the card reader and one magnetic tape unit are released for continuation of the inventory input operation. The tape unit containing compiled programs continues in use to provide output information for the printer.

Also at 12 noon, other scientific computations are performed and the answers are accumulated on magnetic tape number five. At 3:00 P.M. these solutions are printed by the fast printer while new solutions are accumulated on magnetic tape number six.

In summary, the inventory updating program, alone, would require more than a single-shift operation on any competing computer. The missile guidance problem would stretch the capabilities of many far more expensive computers. Honeywell 800 takes either job in stride — and takes virtually no more time to do both jobs together.

TYPICAL HONEYWELL 800 DAILY SCHEDULE



KEY

SCIENTIFIC COMPUTING AND PROGRAM CHECKOUT OPERATIONS

BUSINESS DATA PROCESSING OPERATIONS

If you have a scientific application that would benefit from:

- HIGH SPEED
- LOW COST
- HIGH-PRECISION FLOATING-POINT ARITHMETIC
- INDEXING
- EASY SUBROUTINE MANIPULATION
- MASKING FOR MEMORY PACKING
- COMPREHENSIVE AUTOMATIC PROGRAMMING
- INDIRECT ADDRESSING AND AUTOMATIC ADDRESS INCREMENTING
- LOW-COST, BUILDING-BLOCK EXPANSION
- HIGH-SPEED MAGNETIC TAPES
- COMPREHENSIVE ERROR DETECTION
- AUTOMATIC ERROR CORRECTION
- ABILITY TO DO DATA PROCESSING IN PARALLEL

Contact:
Systems and Methods Department

DATAmatic Division
Minneapolis-Honeywell Regulator Company
Newton Highlands 61, Massachusetts

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