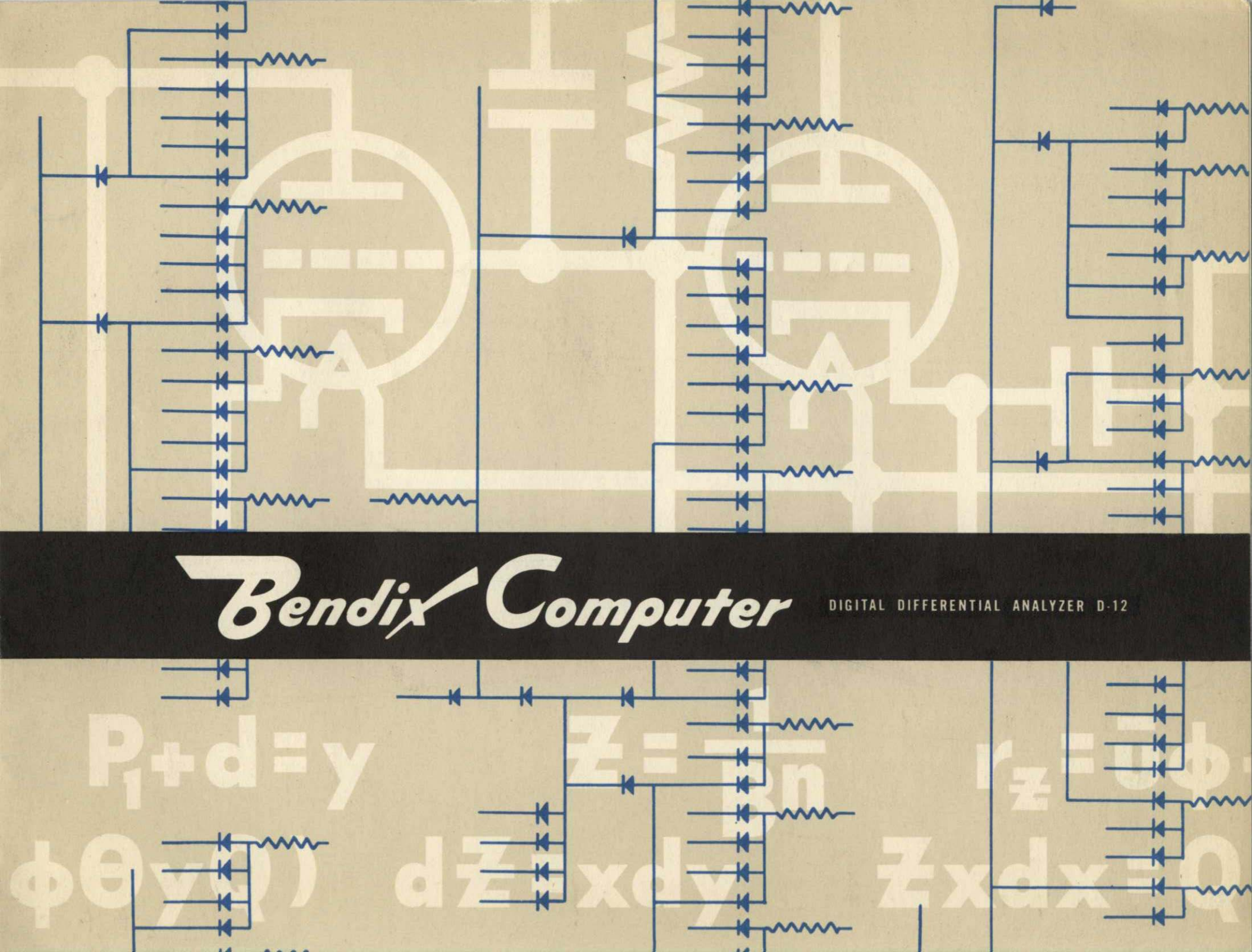


Bendix Computer

DIGITAL DIFFERENTIAL ANALYZER D-12


Bendix
Computer

DIGITAL DIFFERENTIAL ANALYZER

MODEL D-12

The Bendix Model D-12 Computer is a moderately priced digital differential analyzer. It is a high-speed electronic computer designed to numerically solve complicated mathematical problems with ease, accuracy and reliability. In addition, mathematical versatility is an inherent characteristic of the machine. Research, development and test departments actively engaged in design analysis and systems investigation will find that this electronic tool saves hours of calculation and increases efficiency by providing prompt and precise solutions to even the most complicated engineering problems.

This Bendix Computer will solve complex problems in the fields of optics, aerodynamics, chemistry and analytical mechanics. It is ideally adapted to the numerical solution of linear and non-linear differential equations, or simultaneous sets of such equations. It may be employed to solve integral equations, split-boundary value problems, and individual or simultaneous sets of linear or non-linear algebraic and transcendental equations. The computer also may be applied as a numerical simulator of certain physical phenomena.

This Bendix Computer is not only a flexible mathematical tool, but it is also a simple machine to operate. The decimal number system is used exclusively in the programming operations, as well as in machine calculations. Computer operators are easily and quickly trained in the techniques of machine programming.

The computer may be automatically programmed by punched tape prepared by the electric typewriter, or it may be manually coded through the operation of the monitor control panel. Decimal solutions to problems are conveniently displayed in both tabulated and graphical form. The usefulness of the computer has been greatly extended by providing a means of recording solution data on punched tape for later use in other computations. Graphical information and tabulated data may be used by the computer during computations. This information is recorded on punched tape and does not affect the computer's speed of operation.

Equipment maintenance has been simplified by the use of etched circuit plug-in packages. Critical electronic components used in the computer have been de-rated 50% from the manufacturer's specifications to insure reliable operation. All computer components, with the exception of tubes and diodes, are guaranteed against defects for a period of one year after installation. Tubes and diodes are guaranteed for a period of 30 days after installation and will be replaced at cost for the balance of the first year following installation. A 90-day free maintenance agreement is awarded every purchaser and is available on a year-to-year basis thereafter at modest cost.

INTEGRAL EQUATIONS

The integral equation:

$$y(x) = 0.25 + \int_0^x \frac{Ay(t)\ [1 + 0.14y(t)]\ [1 + 0.02752y(t)]\ dt}{[1 - y(t)]\ [1 - At]}$$

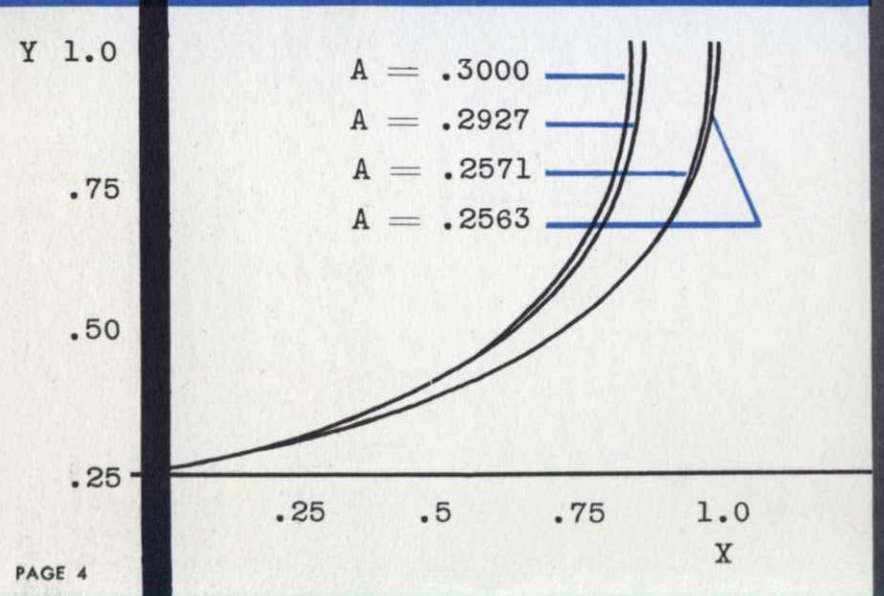
is given. The value of A is desired such that $y = 1$ at $x = 1$. It is of interest to note that the integrand has an infinite discontinuity at the point $y = 1$ indicating that the computer is adaptable to certain types of problems involving functions with singularities.

Although this problem can be solved exactly, the points to be illustrated in this example are that the computer will solve certain types of integral equations and will handle functions exhibiting certain types of singularities. To solve this example required the use of 17 integrators.

It was known that the value of A was approximately 0.3; this value was used as the initial condition.

Tabulated values of x at $y = 1$ for various values of A are shown. An entry in the A column, a computed value for A, is automatically reset in the computer leading to the next tabulated value for A. Curves plotted by the computer corresponding to some values for A are shown.

$x.10^3$	$y.10^3$	$A.10^4$
Initial conditions:		
0000	0250	3000
0854	1000	2927
0875	1000	2865
0894	1000	2812
0911	1000	2767
0926	1000	2730
0938	1000	2699
****	****	****
****	****	****
0993	1000	2573
0995	1000	2571
0996	1000	2569
0997	1000	2567
0998	1000	2566
0998	1000	2565
0998	1000	2564
0999	1000	2563
0999	1000	2563



NON-LINEAR DIFFERENTIAL EQUA

In the fields of electrical and mechanical enginee
often encountered. Such problems may be complica
non-linear function. An example of such a case is g
A typical equation for this class of problem is as f

$$\frac{d^2y}{dx2} = -0.5 \left(\frac{dy}{dx} \right| \frac{dy}{dx}$$

This equation has been solved using 10 integrator

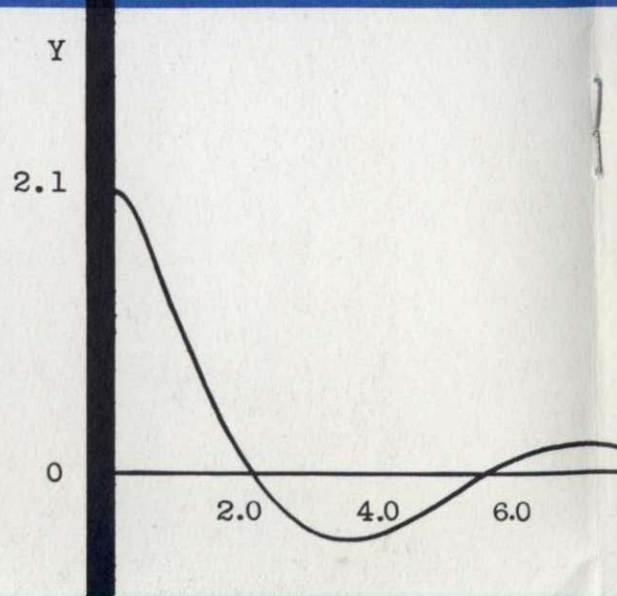
At $x = 0$,

$$y'' = \frac{d^2y}{dx2} = -2.10$$

$$y' = \frac{dy}{dx} = 0.00$$

$$y = 2.10$$

A portion of the numerical solution, as tabu
computer, is shown below. The tabulated
over 14 units of x and required approximatel
of running time on the computer. The curv
plot representing the tabulated data of y vers



UATIONS

ineering, problems in simple harmonic motion are
olicated by the introduction of a damping factor as a
is given below.
as follows:

$$\left.\frac{dy}{dx}\right| \Big) \quad -0.4 \quad \frac{dy}{dx} \quad -y$$

tors and the following initial conditions:

tabulated by the
ed data extends
ately six minutes
urve shown is a
versus x.

x.10³	y".10²	y'.10³	y.10³
00000	-210	0000	2100
00200	-182	-0396	2059
00400	-140	-0720	1946
00600	-095	-0954	1778
00800	-053	-1100	1343
01000	-019	-1170	1343
01200	006	-1182	1107
01400	025	-1150	0873
01600	037	-1087	0649
*****	***	*****	*****
*****	***	*****	*****
11800	-002	0069	-0015
12000	-003	0064	-0001
12200	-003	0058	0011
12400	-004	0051	0022
12600	-005	0041	0031
12800	-005	0031	0038
13000	-005	0021	0044
13200	-005	0010	0047
13400	-005	0000	0048
13600	-005	-0010	0047
13800	-003	-0018	0044
14000	-003	-0024	0039

8.0 X

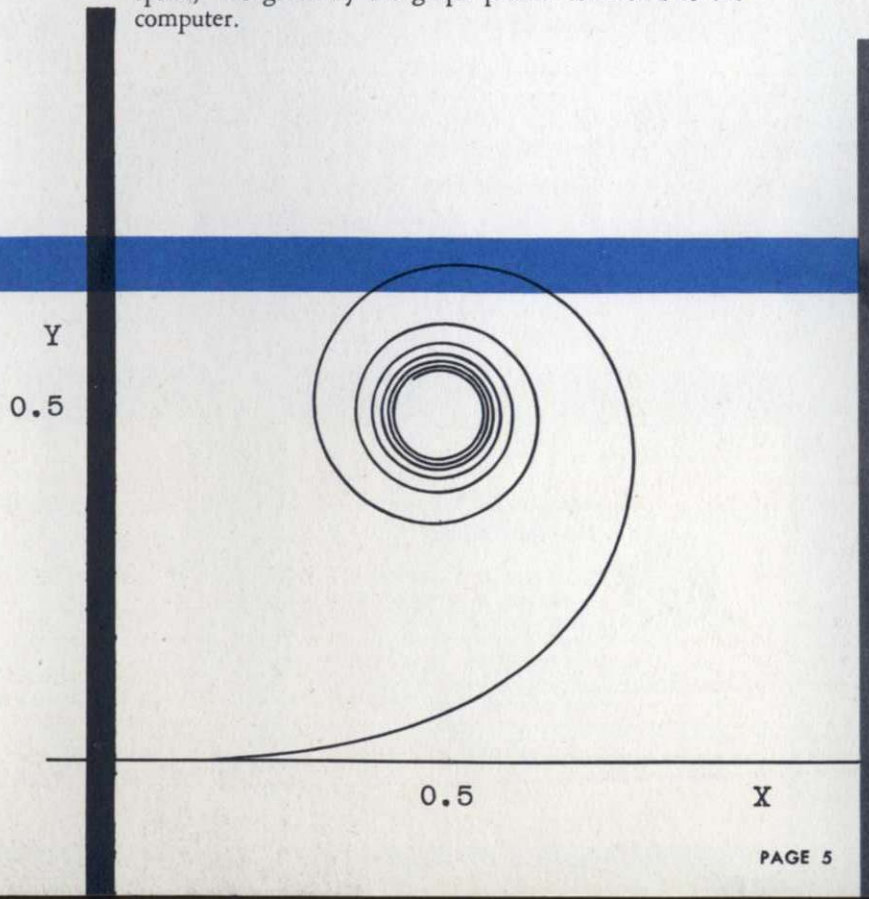
EVALUATIONS OF INTEGRALS

In the field of physical optics, the Fresnel Integrals frequently occur. The integrals are:

$$x = \int_0^t \cos \frac{\pi u^2}{2}\, du \qquad y = \int_0^t \sin \frac{\pi u^2}{2}\, du$$

and are ordinarily evaluated by use of infinite series. The Bendix Computer can make this evaluation either from series or directly from the integrals. Eleven integrators are required to evaluate these integrals.

The following tabulation was taken from the computer, evaluating the integrals directly. The accompanying graph, y versus x, known as the Cornu spiral, was given by the graph plotter connected to the computer.



t.10⁴	x.10⁵	y.10⁵
00000	00000	00000
01000	10000	00051
02000	19993	00417
03000	29941	01411
04000	39749	03333
05000	49235	06470
06000	58111	11050
07000	65967	17208
08000	72287	24928
09000	76485	33971
10000	77994	43819
*****	*****	*****
*****	*****	*****
41000	57375	47575
42000	54177	56316
43000	44949	55396
44000	43838	46223
45000	52607	43423
46000	56729	51615
47000	49148	56711
48000	43385	49671
49000	50021	43503
50000	56368	49915

FEATURES OF THE BENDIX DI

MATHEMATICAL CHARACTERISTICS

DECIMAL OPERATION

This Bendix Computer operates entirely in the decimal numbering system. All programming operations are performed in the "standard" decimal system. The available precision of the machine is seven decimal digits.

INTEGRATORS

The fundamental operation of the Bendix Computer is the numerical integration of any variable with respect to any other variable, linear or non-linear, which generates a third variable. Integrators may also be coded to perform addition, multiplication, division, comparison, limiting, decision, and servo operations.

INTEGRATION

In order to provide accurate problem solutions, truncation errors have been reduced to a minimum by employing trapezoidal integration methods. Rectangular, interpolative or extrapolative modes of integration are available and can be selected as required.

COMPUTER OPERATIONS

DOUBLE SPEED

This Bendix Computer normally operates at a speed of 100 iterations per second. Should a problem require 30 integrators or less, the iteration rate of the independent variable may be doubled to 200 iterations per second.

INITIAL CONDITION RESET

The initial conditions of a problem are retained in the computer's memory throughout computation. The initial problem parameters may be reset at any time by the operation of a push switch. Repetitive problems involving minor modifications of initial conditions may be solved quickly and efficiently by manual entry of new parameters.

AUTOMATIC PROBLEM PARAMETER VARIATION

This Bendix Computer may be programmed to vary initial problem conditions in accordance with computational results. When desired values are obtained, the generated parameters may be automatically inserted and the problem again solved using the new set of initial conditions.

INPUT-OUTPUT MECHANISMS

AUTOMATIC PROGRAMMING

This Bendix Computer is automatically programmed by decimal information recorded on punched paper tape prepared by the electric typewriter. Automatic tape programming facilitates the rapid entry of problems into the computer and establishes a method for inserting functions and tabulated data during computation.

TAPE LIBRARIES

As punched paper tape is used for programming of the computer, tape libraries may be established. Computed and empirical functions may be recorded on tape for efficient use in computations. The entire contents of the arithmetic and address channels may also be punched on tape for the continuation of computation at a later time.

DECIMAL TABULATION

Results of computation are recorded as columns of tabular data printed by the electric typewriter. True negative, as well as positive, decimal numbers are tabulated. The variables selected for tabulation may be recorded as a function of any variable generated by the computer.

INTEGRAND MAGNITUDE

The allowable magnitude of any integrand has been extended to include the interval $-2 < y < 2$. The magnitude of integrands, therefore, need not be scaled down in those cases where a variable attains the value of one such as in sine-cosine generation.

TERNARY TRANSFER

This Bendix Computer employs a ternary (three level) integrator intercommunication system for the transfer of incremental changes which result from computation. As compared with a binary (two level) system, ternary intercommunication allows each increment to be specified with a greater precision and this effectively increases the speed of computation.

OUTPUT MULTIPLIERS

In order to increase scaling efficiency, and thereby save valuable computing time, the digital output rate of any integrator may be multiplied by two or five. A single program digit codes an integrator for this operation.

EXPANDED CAPACITY

Expanded mathematical capacity may be attained through the use of eight input and eight output channels which can be used for the intercoupling of computers. These channels may also be used for the insertion of additional problem information or for connecting additional graph plotters when such are desired.

TIME REVERSAL

A switch located on the monitor-control panel permits the stopping or time reversal of the independent variable. Such operation facilitates the re-examination of any problem region desired.

ERROR DETECTION

Computation stops immediately on (1) the existence of prohibitive codes, (2) a double output from a single integrator or (3) the overflow of an integrator, except when coded for servo operation. Computation errors are indicated by lights on the monitor-control panel. A push switch provides for clearing of such stoppages.

DIGITAL GRAPH PLOTTER

A digital graph plotter is provided to record the functional relationship between any two variables generated by the computer. Additional graph plotters, to a total of six, may be connected to the computer for additional records.

MONITOR-CONTROL PANEL

All operation of the computer is controlled from a central point. All switches necessary for starting, stopping, insertion of problems, read-out, etc., are mounted on the monitor-control panel. In addition, an oscilloscope is provided which permits visual examination of all the information contained in any integrator.

SPECIFICATIONS

MATHEMATICAL

1. Method of fill: automatic program tape or manual
2. Numbering system: decimal
3. Capacity: 60 integrators
4. Precision: 7 decimal digits
5. Modes of integration: rectangular, interpolative or extrapolative
6. Speed: 100 iterations per second, 1-60 integrators
   200 iterations per second, 1-30 integrators
7. Input channels: 8 incremental channels
8. Output channels: 12 incremental channels

POWER

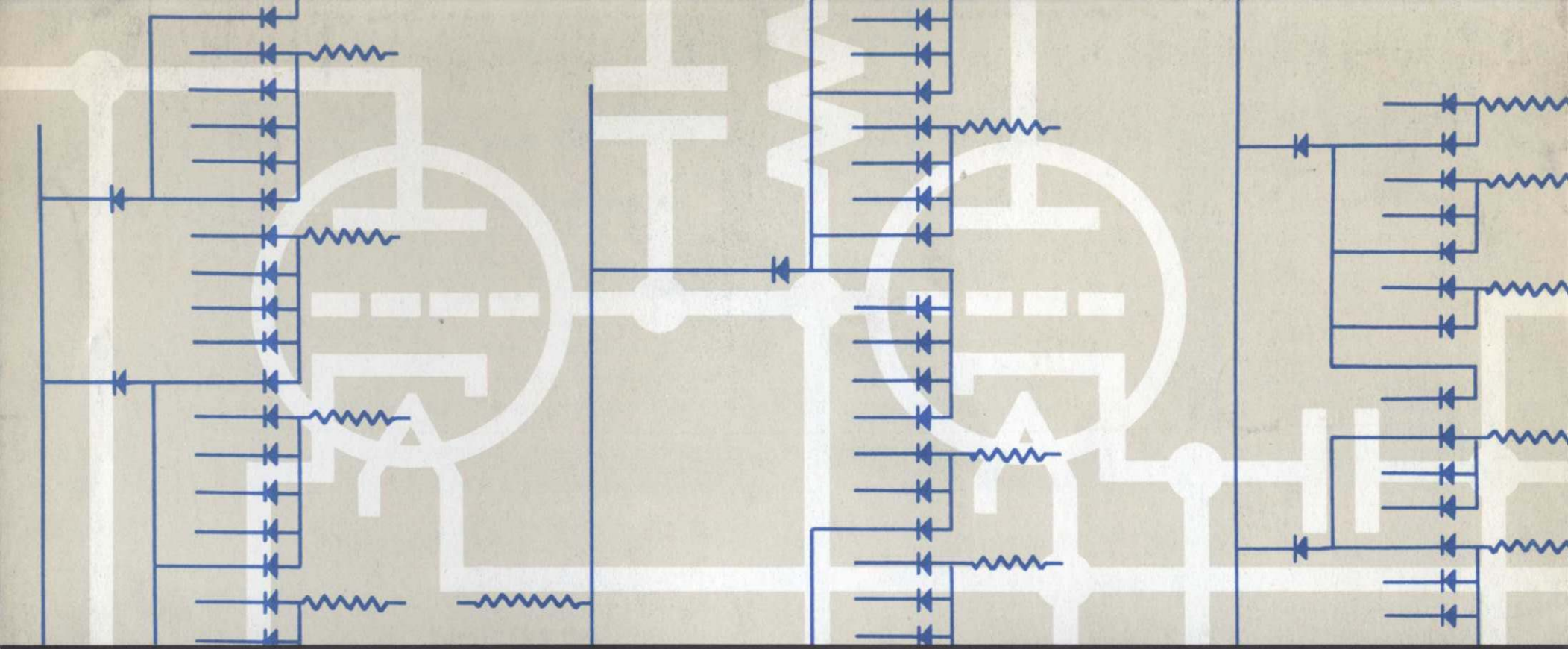
1. Power input: 208/230 volts ±10%, 60 cps single phase, 6 KVA

MECHANICAL

1. Computer cabinet: 27″ deep by 60″ wide by 72″ high
2. Control console: 32″ deep by 60″ wide by 37″ high
3. Cooling: forced air circulation
4. Gross weight: 2000 lbs.

EQUIPMENT

1. Computer cabinet containing:
   (a) Arithmetic section
   (b) Address section
   (c) Memory unit
   (d) Power supply
2. Control console containing:
   (a) Punched tape mechanism
   (b) Electric typewriter
   (c) Graph plotter
   (d) Control center
3. Interconnecting cable (20 ft.)
4. Operations and Maintenance Manual (2)
5. Spare plug-in packages (36)

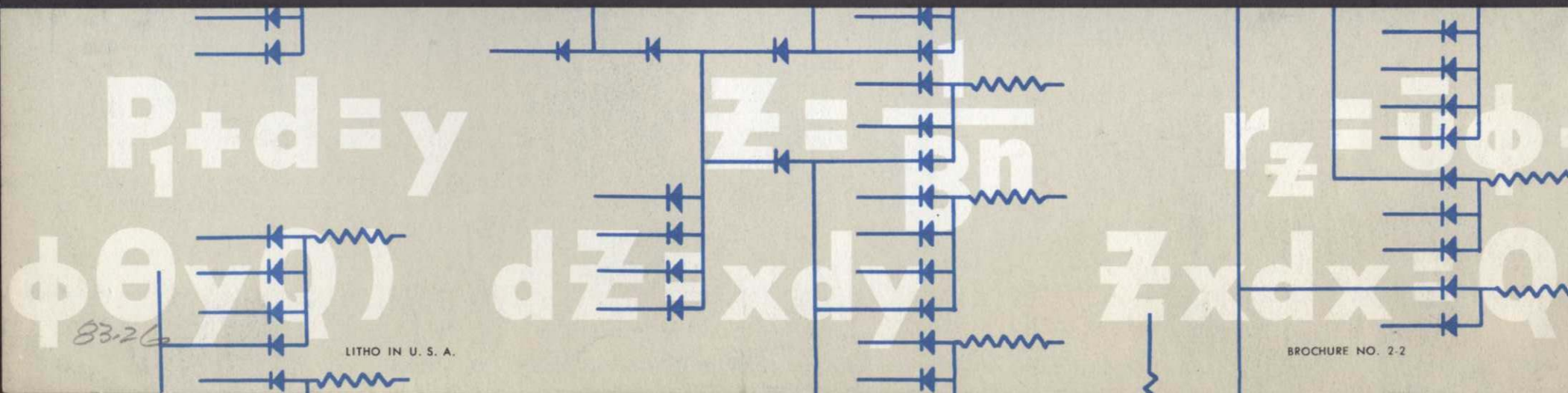


5630 ARBOR VITAE STREET

Bendix Computer

LOS ANGELES 45, CALIFORNIA

A DIVISION OF BENDIX AVIATION CORPORATION



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