

SPEC

A STORED PROGRAM
EDUCATIONAL
COMPUTER

PLUS A DIGITAL
DIFFERENTIAL
ANALYZER

PLUS A DIGITAL
LOGICAL DESIGN
IMPLEMENTER



SPEC

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COMPUTER CONTROL COMPANY, INC.

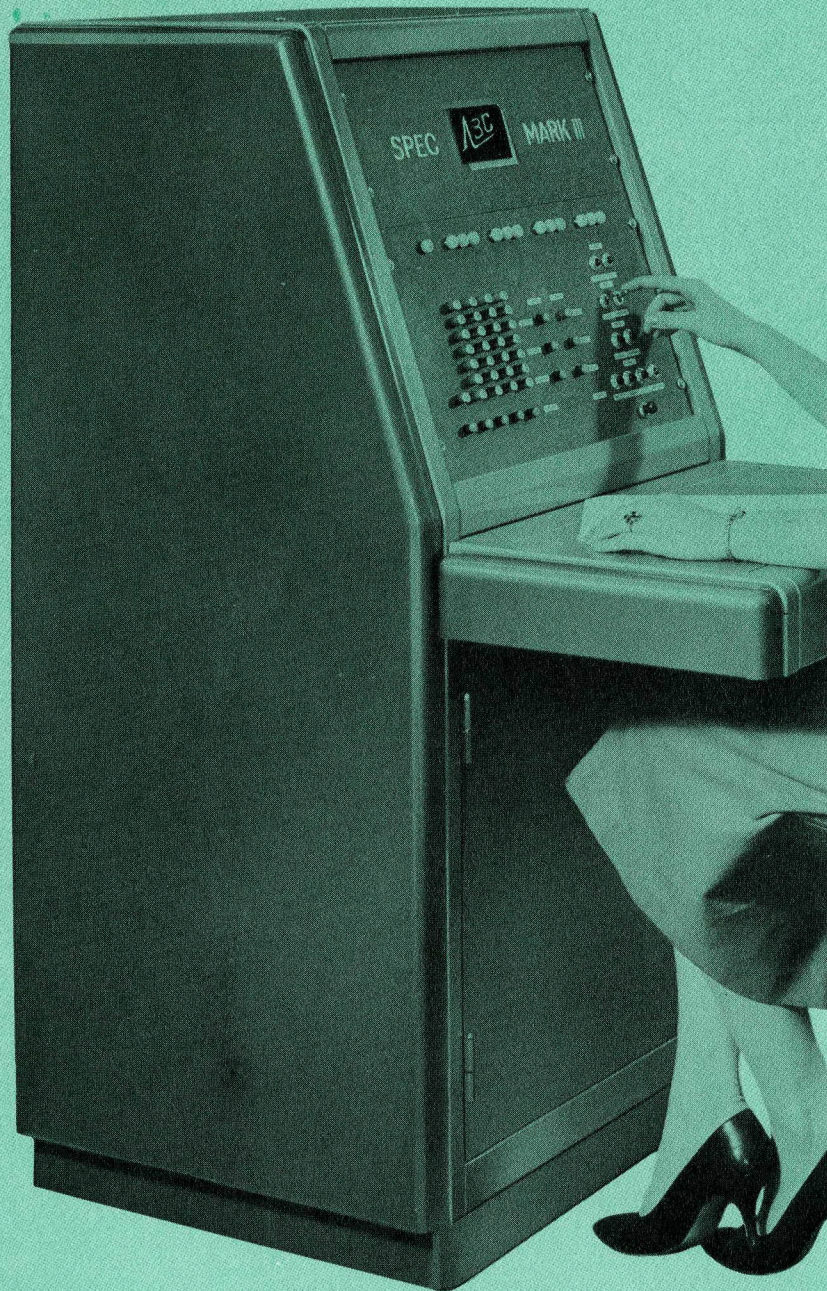
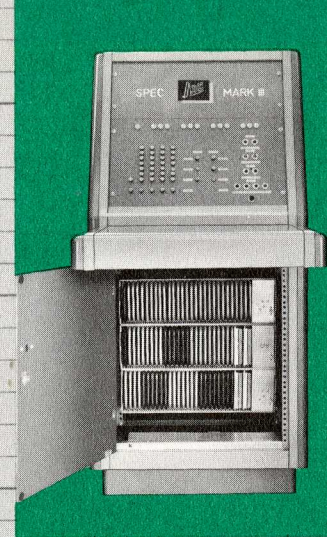


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GENERAL DESCRIPTION

SPEC is a general purpose stored program digital computer and digital differential analyzer. It has been designed specifically to be a useful laboratory and classroom tool for education, computation, and experimentation.

For educational usage—SPEC is a completely modularized and completely transistorized digital computer which utilizes proven yet up-to-date high speed digital circuitry. The command structure is well suited for teaching basic programming techniques. Word length, memory capacity, and operation codes are small enough to permit students to readily grasp the entire logic of the system without difficulty yet large enough to provide the programmer with a respectable tool on which to sharpen his talents.

For demonstration of modern construction and hardware techniques—SPEC is readily disassembled for classroom inspection and then readily reassembled and put into operation without delay since all logical elements and storage devices are plug-in units.

For serious computation—SPEC is a stored program single address machine with 128 words of fast access internal storage. All internal logical interconnections between the plug-in modules are effected via a removable plugboard patch panel.* By replacing the GPC (general purpose computer) patch panel with the DDA panel, SPEC is converted into a digital differential analyzer containing 20 integrators.

For experimentation—by utilizing additional patch panels, innumerable other logical arrangements or digital system designs of any nature can be implemented from the SPEC component elements. This feature permits effective utilization of SPEC in connection with homework and/or laboratory assignments related to the teaching of logical design. By distributing the relatively inexpensive patch panels to the students, the entire class is enabled to participate in performing a given assignment. Verification of the correctness of each design is quickly determined by insertion of the panel into SPEC for demonstration of proper performance.

*It is emphasized that the plugboard is not a device for program insertion into SPEC but rather a means whereby the internal logical wiring is "rewired" to permit the same logical elements to be used as a general purpose computer (via the GPC prewired panel), a digital differential analyzer (via the DDA panel), or in any other experimental arrangement desired.

GENERAL PURPOSE COMPUTER SPECIFICATIONS

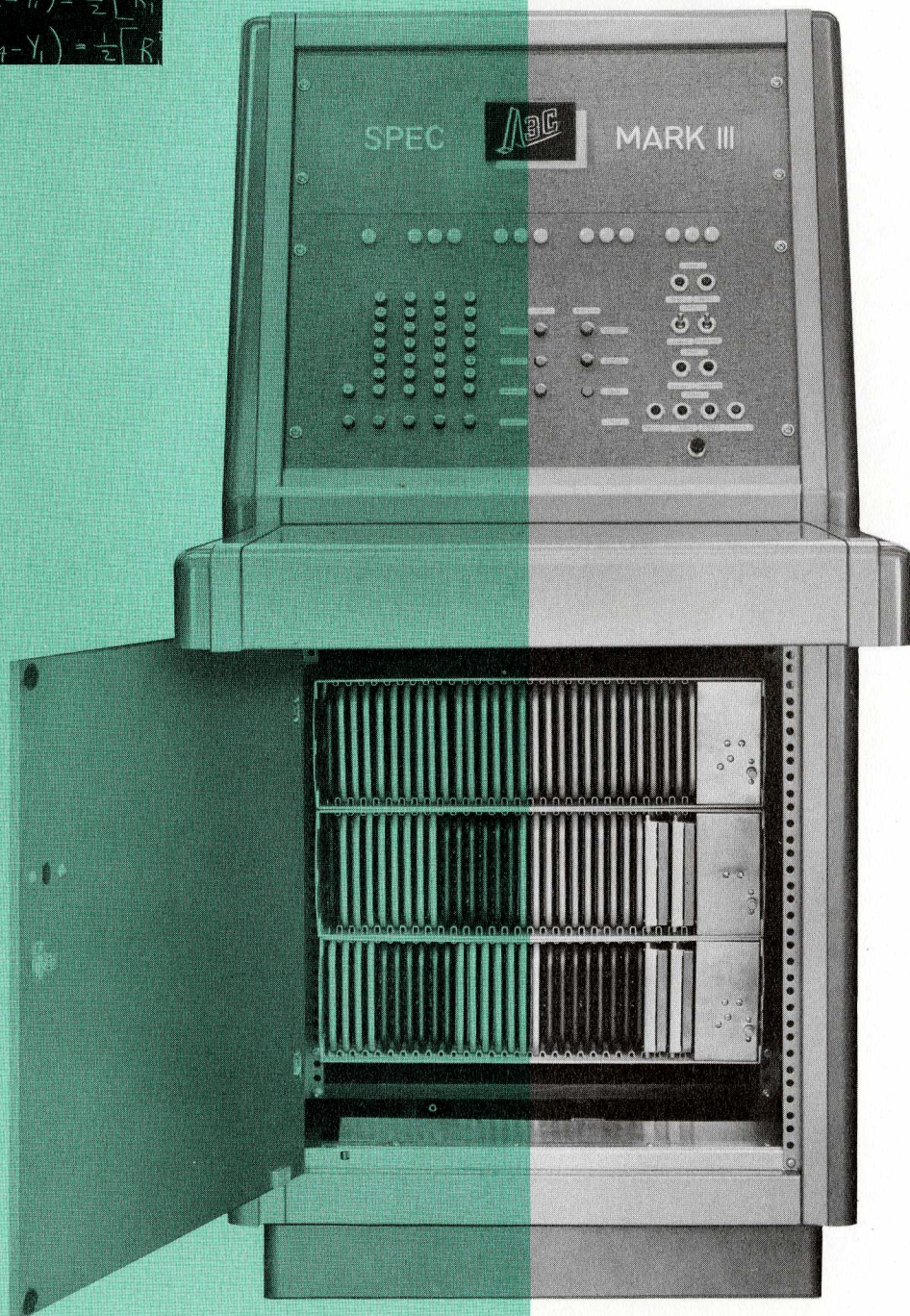
- TYPE:** Serial; Binary; Single Address; Stored Program
- MEMORY:** Magnetostrictive delay line; 4 lines at 32 words per line for a total of 128 words; average access time (= 1/2 line length) 192 microseconds
- WORD SIZE:** 12 bits (4 octal digits) plus sign
- WORD STRUCTURE:** Sign, 3-bit operation code, 7-bit address
- COMMANDS:**

OPERATION CODE (OCTAL)	ABBREVIATION	COMMAND
2	AD	Add to the accumulator
3	SU	Subtract from the accumulator
7	UT	Unconditional transfer of control
6	TN	Conditional transfer of control
0	SC	Store contents of accumulator and reset
1	SN	Store contents of accumulator without resetting
4	SR	Shift contents of accumulator right one bit
5	SL	Shift contents of accumulator left one bit

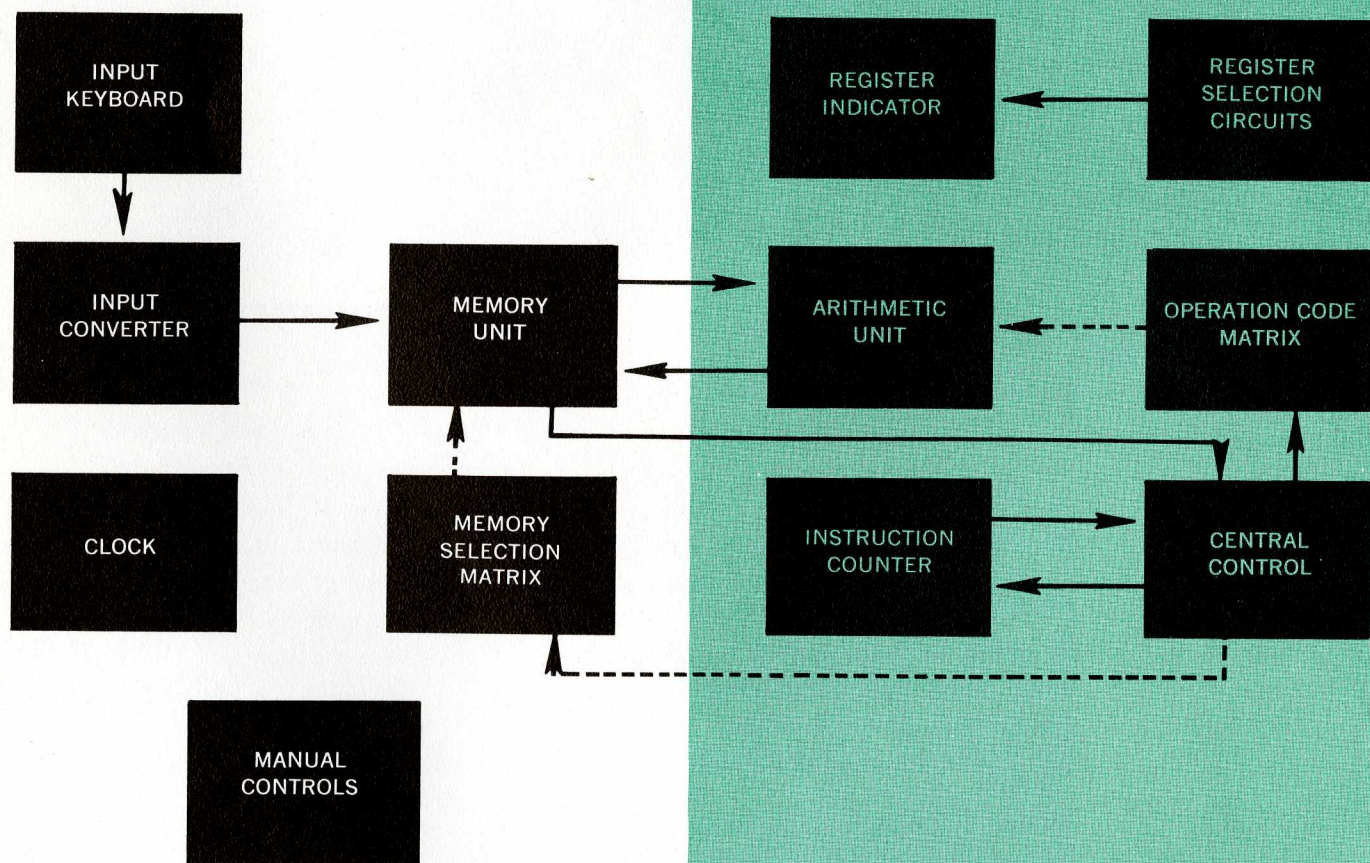
- SPEED OF INTERNAL OPERATION:** Approximately 2500 operations per second
- INPUT:** Manual via an octal keyboard
- OUTPUT:** Indicator lights and/or oscilloscope display
- OPTIONAL INPUT/OUTPUT:** Paper tape punch and reader, octal printer, Flexowriter, etc. SPEC can be expanded to include such items at any time, either by the user or by 3C



$$\cos \alpha_i = \frac{f}{\sqrt{(x_i^2 + y_i^2 + f^2)}} \quad \text{where}$$
$$\sin \alpha_i = \frac{f}{\sqrt{(x_i^2 + y_i^2 + f^2)}} \quad \text{tan}$$
$$R_i = H \tan \alpha_i \quad H =$$
$$R_i^2 = (X_i - X_L)^2 + (Y_i - Y_L)^2$$
$$\begin{cases} X_L(X_2 - X_1) + Y_L(Y_2 - Y_1) = \frac{1}{2} [R_1^2 - R_2^2] \\ X_L(X_3 - X_1) + Y_L(Y_3 - Y_1) = \frac{1}{2} [R_1^2 - R_3^2] \\ X_L(X_4 - X_1) + Y_L(Y_4 - Y_1) = \frac{1}{2} [R_1^2 - R_4^2] \end{cases}$$



BLOCK DIAGRAM OF GENERAL PURPOSE COMPUTER



TYPICAL PROGRAM

MULTIPLICATION SUBROUTINE MULTIPLY axb

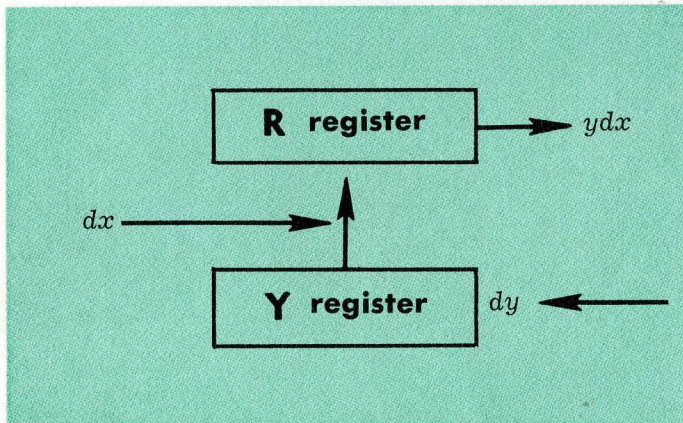
Relative Addresses:

m = First address of subroutine (excluding linkage)
 T = First temporary address
 t_a = Address of a
 t_b = Address of b
 C = Address of constant $(0001)_8$
 x = Excess address (where to store the residue)

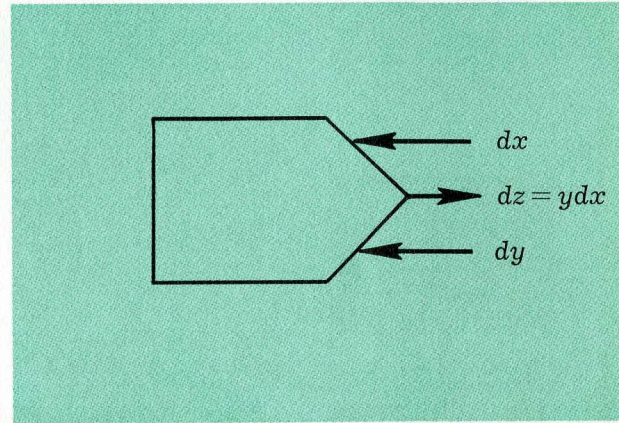
LOCATION OF ORDER	OP CODE	ADDRESS	COMMAND
m	0	x	clear accumulator
$m + 1$	0	T	set $T = 0$ (accumulator = 0)
$m + 2$	3	t_a	subtract a from accumulator
$m + 3$	4	0	shift a right
$m + 4$	0	$T + 1$	store in $T + 1$ (accumulator)
$m + 5$	2	$T + 1$	put $T + 1$ in accumulator
$m + 6$	5	0	shift $T + 1$ left
$m + 7$	2	t_a	add a
$m + 8$	6	$m + 13$	is accumulator negative?
$m + 9$	3	C	subtract 1 (accumulator = 0)
$m + 10$	2	t_b	add b
$m + 11$	2	T	add partial product
$m + 12$	0	T	store in T (accumulator = 0)
$m + 13$	2	t_b	add b
$m + 14$	5	0	shift b left
$m + 15$	0	t_b	store in t_b (accumulator = 0)
$m + 16$	2	t_a	add a
$m + 17$	3	C	subtract 1
$m + 18$	6	out	is accumulator negative? (exit)
$m + 19$	2	C	add 1
$m + 20$	4	0	shift right
$m + 21$	0	t_a	store in t_a
$m + 22$	7	$m + 2$	transfer

DIGITAL DIFFERENTIAL ANALYZER

GENERAL DESCRIPTION—The SPEC DDA is a stored program digital differential analyzer specifically designed to solve mathematical problems involving differential equations. Problem solutions are obtained by programming the appropriate interconnections between digital integrators in accordance with the specific nature of the problem. A digital integrator may be represented in block diagram form and symbolically as follows:



BLOCK DIAGRAM



SYMBOLIC REPRESENTATION

The SPEC DDA contains twenty such integrators. Integration capability with respect to any independent variable, including time, permits its utilization for the solution of a wide variety of linear and non-linear differential equations. Programming restrictions have been kept to a minimum to insure ease of programming. For example, all integrator outputs are available for use as inputs to all integrators. Also, overcapacity of any integrator will automatically stop the machine for analysis of the cause.

SPECIFICATIONS

NUMBER OF INTEGRATORS—20

INTEGRATOR MAXIMUM WORD LENGTH

20 Binary Digits

MAXIMUM ACCURACY—One part in 524,000

ITERATION RATE—47,600 iterations per second total or 2380 iterations per second per integrator

NUMBER SYSTEM—Binary

METHOD OF INTEGRATOR INTERCONNECTION

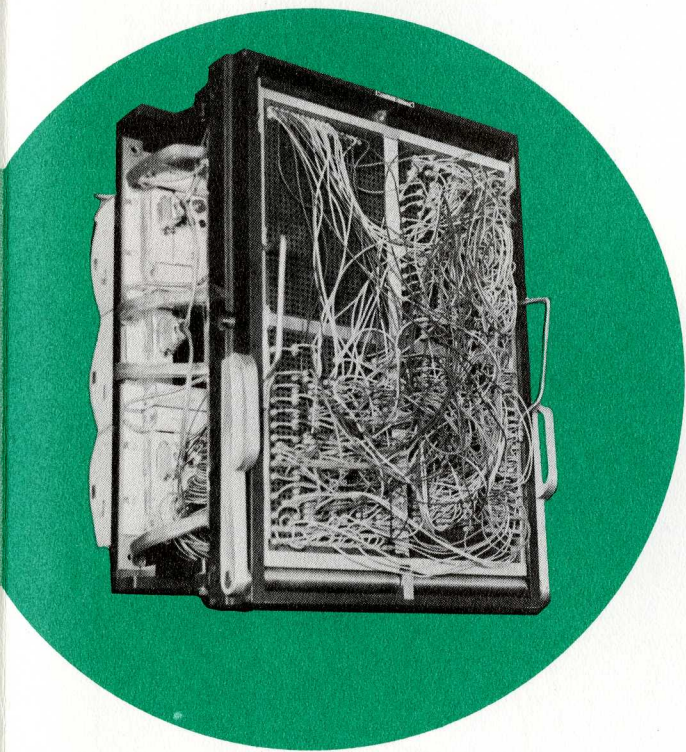
Interconnections are set up by the inserted stored program. Any integrator output may be used as an "independent variable" input. Any three integrator outputs may be summed into each integrator input.

METHOD OF LOADING—The Octal Keyboard is utilized to insert programming information and to set up scaling and initial conditions for the integrators.

OUTPUT—Digital-to-analog conversion of outputs from any two integrators is provided so that outputs may be displayed on an auxiliary oscilloscope or x-y plotter. The conversion circuitry is an integral part of the SPEC DDA. An indicator register is also provided for visual display of integrator contents or programming information.

INTEGRATION FORMULA—Integration utilizes the rectangular rule and a ternary system of increments.

MULTIPLICATION—Multiplication of variables is performed by the $d(xy) = xdy + ydx$ rule.



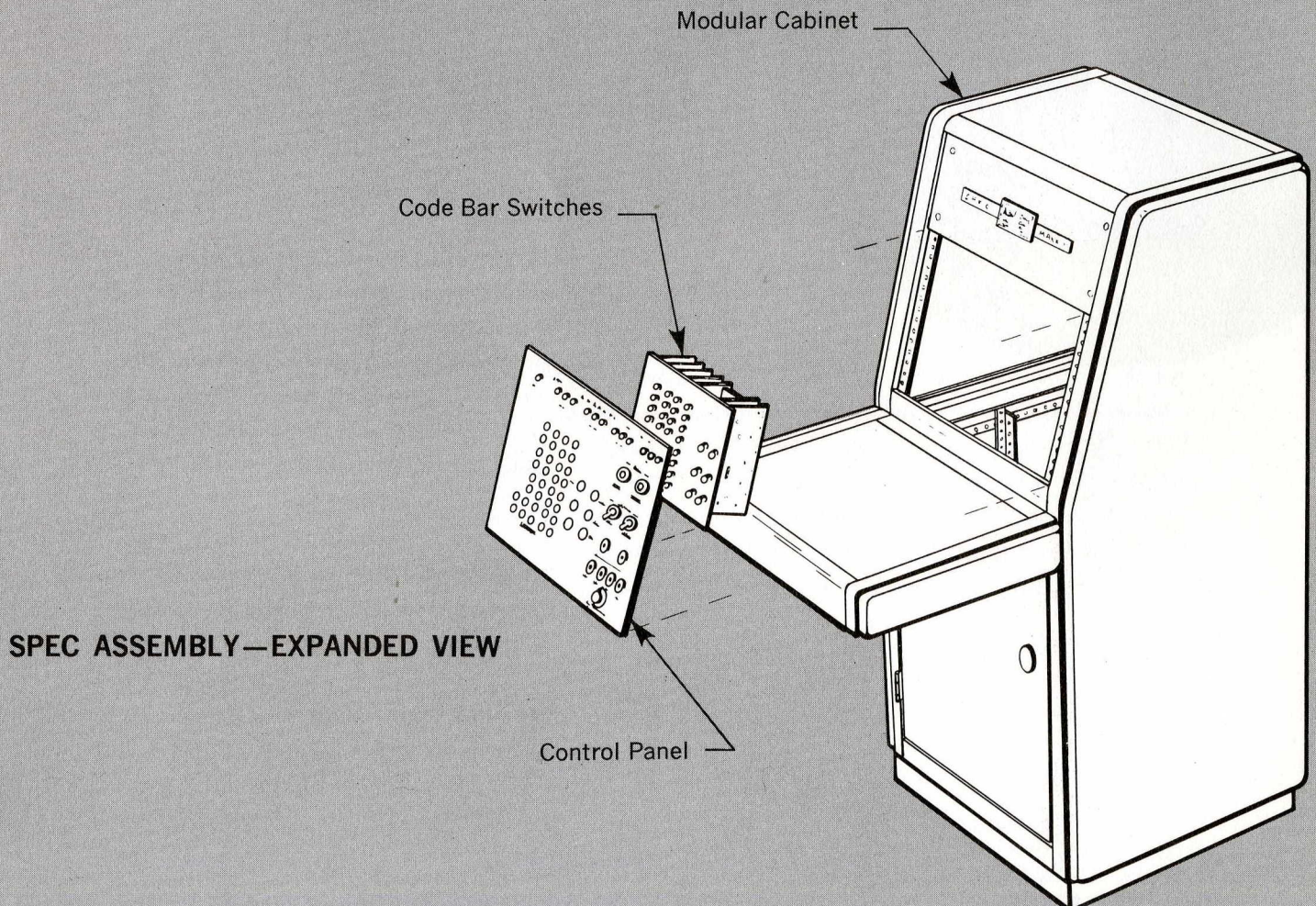
PHYSICAL COMPONENTS

LOGICAL ELEMENTS—The plug-in logical elements of SPEC are 3C-PACs Series T* manufactured by Computer Control Company, Inc. These are one-megacycle dynamic circuits which utilize solid-state components throughout. The basic T-PAC is the model LE-10. It contains 4 four-leg diode gates whose outputs are:

- a. Combined in a four-leg buffer
- b. Reshaped by a crystal-derived one-megacycle clock pulse
- c. Amplified
- d. Converted into bipolar low-impedance outputs which are delayed one micro-second relative to the input signals which generated them.

This basic logical configuration of a single LE-10 T-PAC enables it to implement all 256 functions of three binary variables and up to 53,614 functions (82 per cent) of a total of 65,536 functions of four binary variables.

MEMORY—Memory is provided by four T-PAC serial memory units, model SM-10. Each SM-10 unit is a plug-in package consisting of three basic sections:



SPEC ASSEMBLY—EXPANDED VIEW

- a. A driver circuit
- b. A nickel-iron magnetostrictive wire delay line
- c. An amplifier circuit

Each unit will store 32 words in a circulating loop at a one-megacycle pulse repetition rate. Total bit capacity per circulating line is 416 bits.

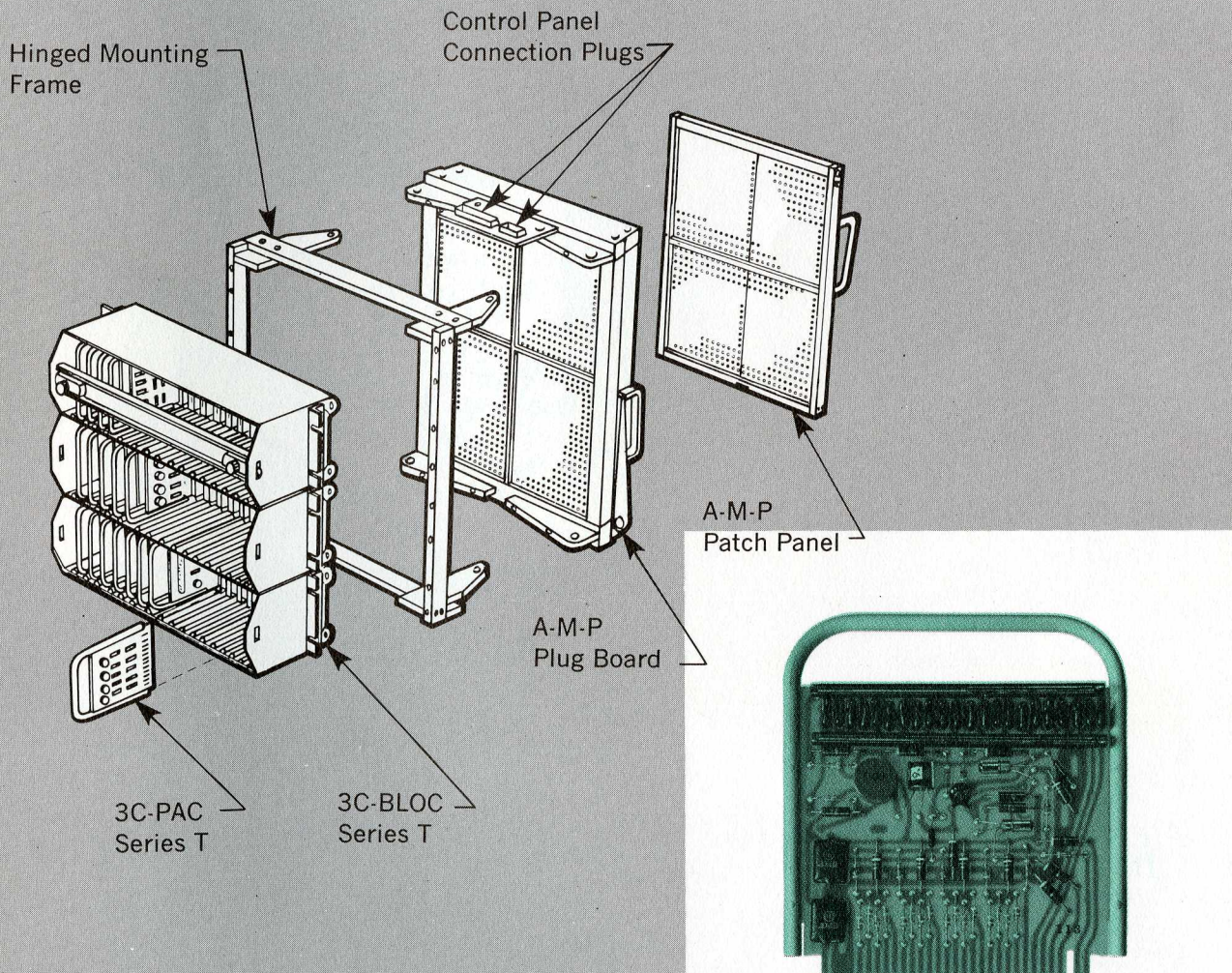
PLUGBOARD—SPEC utilizes an AMP Patchboard System, series P3264, containing 3264 contacts in a 48 x 68 array. All signal and other logical terminals of all plug-in units are available on the patchboard for signal monitoring, experimentation, modification, etc. The GPC and DDA prewired panels are supplied with SPEC. Additional panels for experimentation are available from AMP, Inc. as standard catalog items.

MISCELLANEOUS—SPEC is an integral unit ready for immediate usage when delivered. All power supplies, etc., are self-contained. Power input requirements are 110 volts \pm 10 per cent, 60 cycles, at approximately 60 watts.

**3C-PACs Series T are described in detail in Computer Control Company's Catalog T and supplementary bulletins which are available on request.*

EXPANSION POSSIBILITIES

The expansion possibilities for SPEC are significant primarily because of the relative ease with which they can be accomplished. This ease stems from the fact that plug-in logical elements are used throughout (except for keyboard and control console switches) and that these are interconnected by means of plug-in wiring. This elimination of solder connections plus the plugboard facility puts the burden of expansion upon the logical design phase. Implementation of the expansion, once designed, is reasonably uncomplicated. An obvious item of expansion that can be accomplished by the user is the addition of mechanical input/output equipment. Instructions for the addition of typical equipment of this nature are included in the SPEC instruction manual.

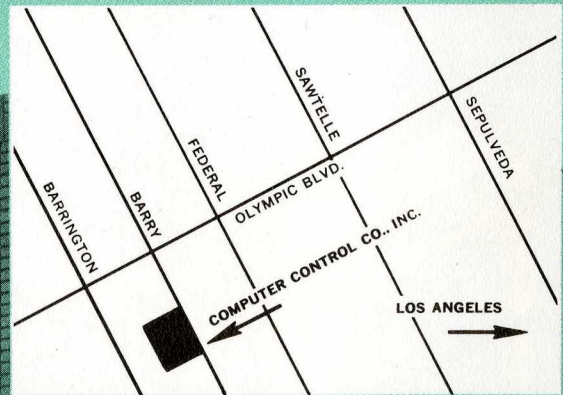


PRICE AND DELIVERY INFORMATION

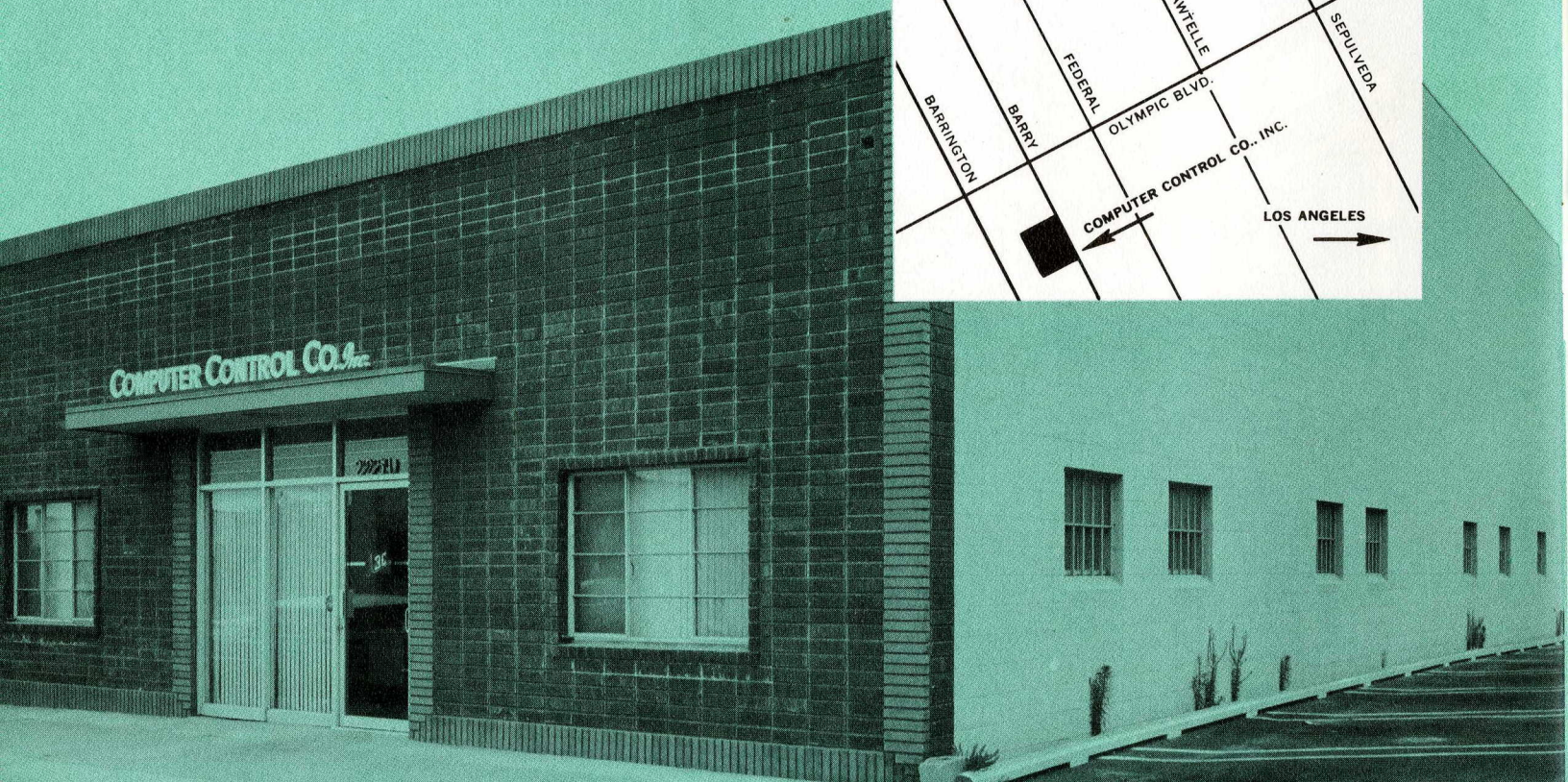
<i>SPEC MARK I</i>	<i>GP Computer without plugboard</i>	<i>\$17,695</i>
<i>SPEC MARK II</i>	<i>DDA without plugboard</i>	<i>\$19,195</i>
<i>SPEC MARK III</i>	<i>GP and DDA with plugboard wiring</i>	<i>\$24,895</i>

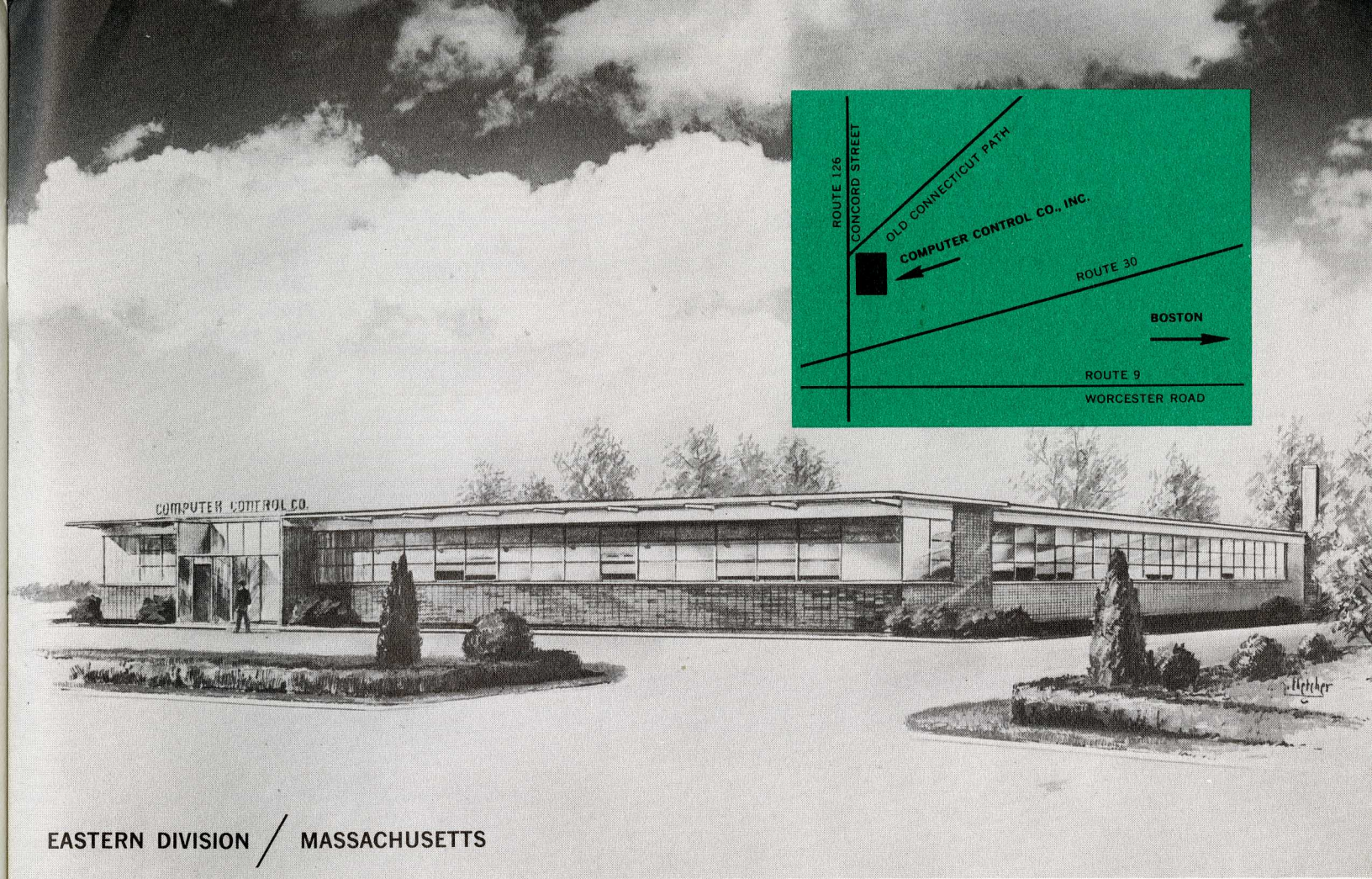
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WESTERN DIVISION / CALIFORNIA

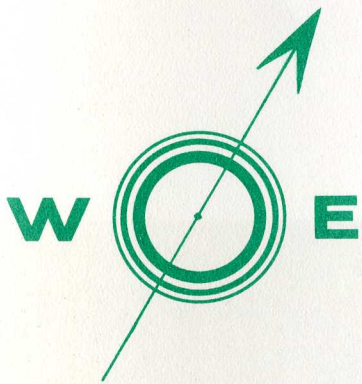


COMPUTER CONTROL CO., INC.





EASTERN DIVISION / MASSACHUSETTS



WARRANTY—a. The SPEC computer and its computer components are warranted by Computer Control Company, Inc. against defects in workmanship, materials, and construction under normal use and service for a period of ONE YEAR from the date of delivery except that liability for defective transistors and diodes shall conform and be limited to the obligations of the original manufacturers' warranties covering these components.

b. This warranty does not extend to any component parts of the SPEC computer which have been subjected to misuse, accident, or improper application; nor shall it extend to those components which have been physically altered outside of our factory.

c. For service under this warranty, please advise the factory promptly of all details pertinent to the defectiveness. Transportation charges covering return of defective products to our factory shall be at our expense if such products are determined to be defective within the limitations of this warranty. Computer Control Company, Inc. will repair or replace the defective item in accordance with its own best judgment.

AVAILABILITY OF 3C SERVICES—Computer Control Company, Inc. offers the services of its staff of logical designers, circuit designers, systems engineers and mathematicians for your digital problems. Our complete flexibility permits a variety of workable arrangements to meet your special requirements. We will share your problems to whatever extent you desire. Our services range from minor consultation to complete design, development, and construction of your special purpose digital system. Write, wire, or phone us for further information.

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