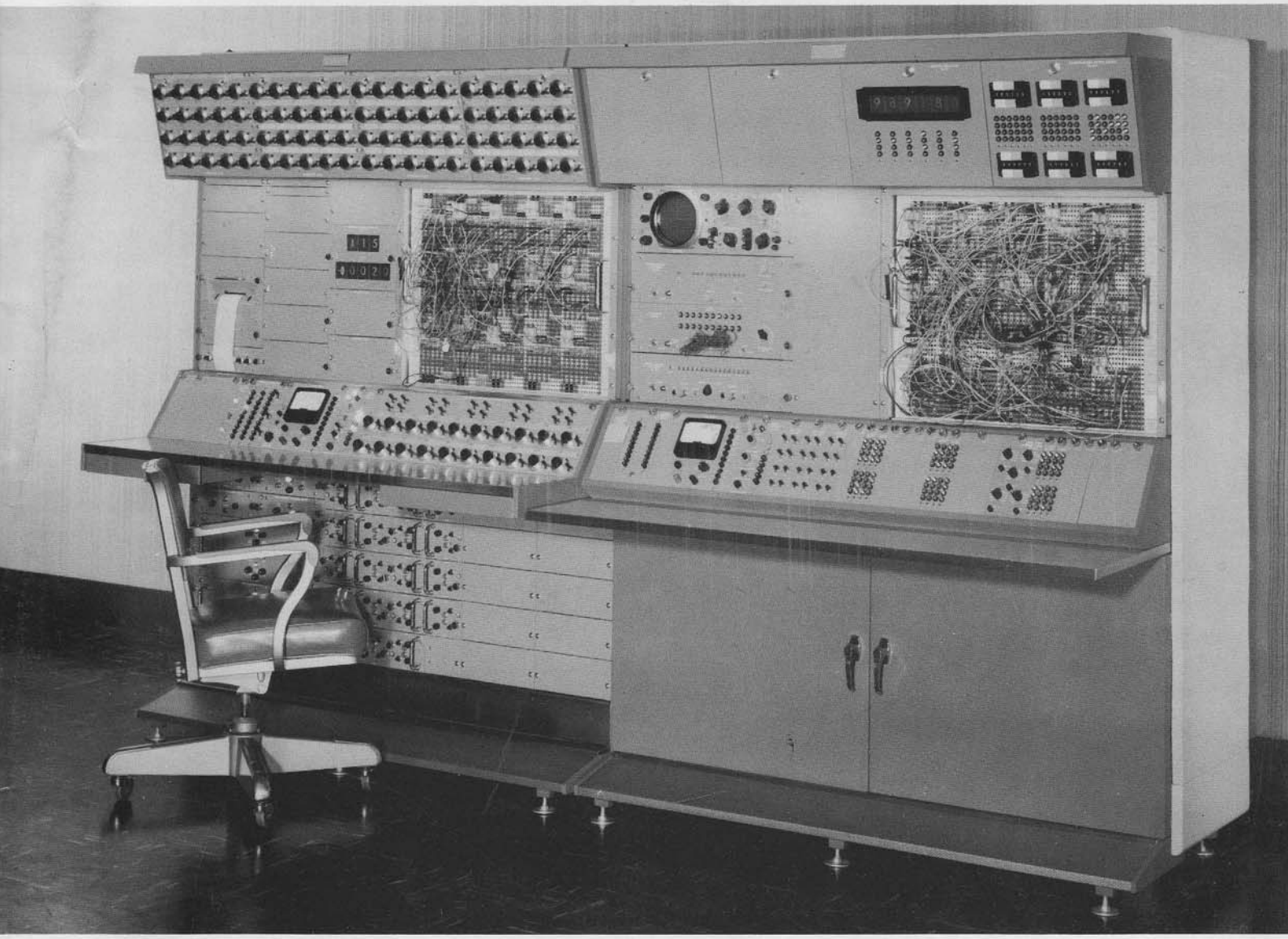
HYDAC

HYBRID DIGITAL–ANALOG COMPUTER *series 2000*

a general purpose computing system combining analog and digital operations



EAI ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

The EAI HYDAC Computer, Series 2000, represents a significant step forward in computer design . . . it introduces a new concept to engineering and scientific computation . . . that of providing the research and design engineer with a convenient means of applying both analog and digital techniques in the solution of his problem.

The HYDAC computer provides an economical alternative to the costly process normally associated with hybrid computation, namely that of tying up a complete data processing computer with an analog computer. HYDAC will be found to be an attractive first step to hybrid computation and, in many instances, a more practicable and effective approach. Analog *and* digital operations are combined in one integrated system to achieve a computational efficiency that is well beyond the limits of either analog or digital computers alone. The traditional advantages

EAI

of *both* analog and digital computers . . . the analog computer's speed, lower cost and ease of programming and the digital computer's unique capacity for data storage or memory, exceptional logic flexibility, and time sharing of components . . . have been combined to expand problem-solving capabilities at *lower* cost.

Since the digital operations required for hybrid computation schemes involve mainly those of timing, selection, sequencing, memory look-up, and calculation of simple functions, such schemes can be accomplished without the cost of large, data processing, digital machines. Digital operations can become an integral part of the expanded general purpose analog computer, making them available to computer laboratories that have no digital computers or during those periods when time is available on the latter. With the Series 2000 HYDAC, analog and digital computation can be centralized in a single laboratory eliminating costly scheduling and training difficulties.

HYDAC twin control consoles place best features of analog an

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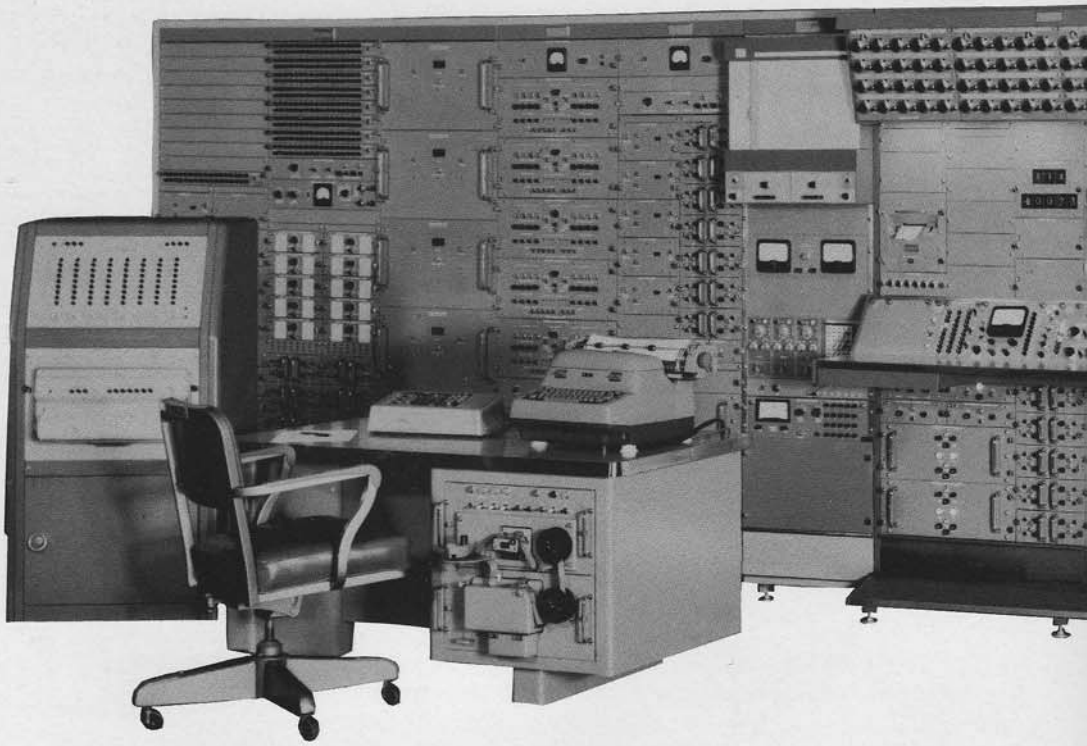
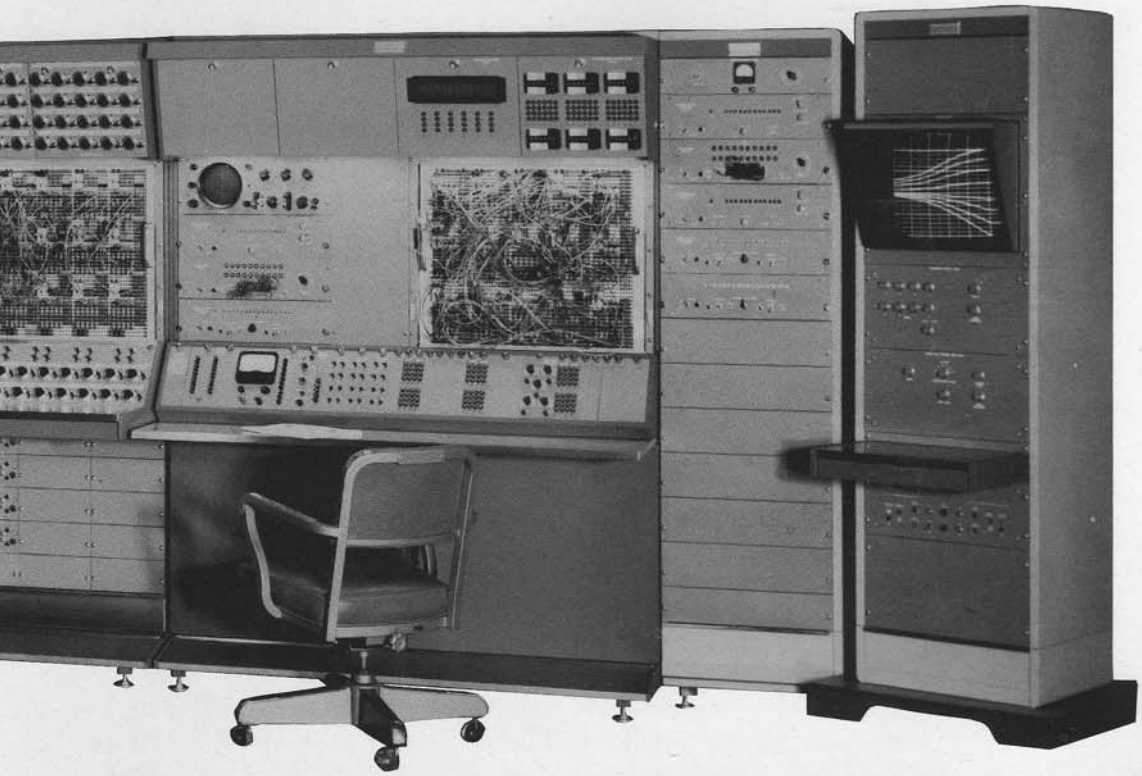


PROGRAMMING of the Series 2000 HYDAC is conveniently similar in principle to the approach familiar to analog computer users. Designed from the point of view of the computer user, by computer users, HYDAC affords complete flexibility in the organization of a problem solution. The transition from the use of relays and switches in the general purpose analog computer to logic devices is made very easy . . . extensive retraining of analog programmers is unnecessary.

ANALOG OPERATIONS of summation, inversion continuous integration, multiplication, division, an function generation are performed by the experience proven PACE 231R computing system that has becom the standard of the industry. All-electronic, wid bandwidth computing components ensure high dy namic accuracy for real time or repetitive mode o operation . . . multiplication and other non-linea operations are performed with signal frequencies i the kilocycle range . . . full advantage of the high speed digital circuits may thus be realized.

digital computation at the fingertips of the using engineer

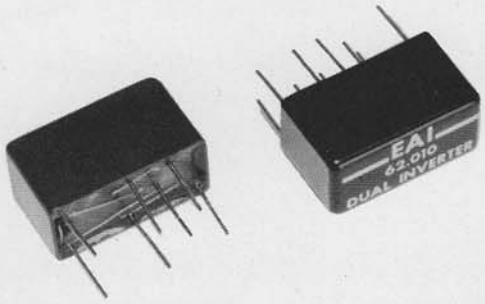
SERIES 2000 is backed by Electronic Associates' experience in the development, , and application of general purpose analog computers. Incorporating all of the proven the famed PACE Computers, it adds a new level of intelligence to the analog computer -reaching advantages. In computing flexibility, design, and in quality of workmanship— l, is the most versatile scientific computer ever produced.



DIGITAL OPERATIONS are performed by general purpose digital building blocks . . . housed in a digital console. Five major groups of components are available to provide: Programmed Digital Logic . . . Digital Memory . . . Analog Memory . . . Analog-to-Digital, Digital-to-Analog Conversion . . . Advanced Digital Arithmetic Operations. They may be obtained in any combination in the Series 2000 HYDAC Digital Console . . . this may consist of just one major group for special requirements or . . . it could include a selection of all major classes to provide general purpose problem solving capabilities.

MODULAR DESIGN of digital building blocks permits fullest advantage of the economy and flexibility of the pre-patch panel concept to be realized. Digital switching circuits employing one basic type of universal gating circuit for maximum flexibility and added economy are used to perform basic digital operations. Completely solid-state . . . with 20-megacycle switching capabilities . . . these basic circuits are combined in standard plug-in modules to perform complex operations.

The Series 2000 HYDAC is the result of a comprehensive design study by experienced computer users, programmers, and designers concerned with the basic requirements of hybrid computation. General purpose in concept and design, it consists of two major subsystems; the PACE Series 231R general purpose analog computer console with associated expansion equipment and a digital console. The digital console is designed to take fullest advantage of the economy and flexibility of the prepatch panel concept . . . interchangeable, modularized digital building blocks capable of performing basic digital operations permit the Series 2000 HYDAC to have many diverse capabilities by employing various combinations of building blocks . . . this flexibility results from a unique design employing standard connectors and plug-in components. Reliability . . . economy . . . ease of maintenance result from an all solid-state design.



Digital Basic Building Block. Circuit components are stacked in "cordwood" fashion for maximum density, welded and potted for reliability.

THE DIGITAL CONSOLE houses the digital building blocks that perform the DIGITAL OPERATIONS of logic, memory, basic arithmetic, data conversion, and switching, plus . . . facilities for control and slaving of the console to the analog computer, selector switches, flip-flop indicator lights and control buttons, power supplies with necessary wiring, etc., and the 3450-hole pre-patch panel system. A Clock Unit with timing signals terminated on the patch panel provides control timing and synchronization for the entire system.

CONSOLE EXPANSION units available include:

- Input/Output Unit consisting of paper tape reader and punch, electric typewriter, 10-key keyboard, an output display register and an oscilloscope.
- Binary-to-Decimal and Decimal-to-Binary Conversion Unit.
- Control Unit for advanced digital arithmetic units.

ANALOG/DIGITAL CONVERTERS include:
Standard EAI ADDALINK building blocks . . .

- Analog-to-digital converter; 4000 words/sec., up to 13 bits and sign available.
- Digital-to-analog converter; 2 channels per chassis, up to 13 bits and sign available; with two digital storage registers per channel.
- 20-channel analog multiplexer.
- 20-state ring counter.
- Control units to link to IBM-7090, 1401; CDC-160/160A; G-15; PB-250; etc.

Control signal converters . . .

- High speed, solid-state analog comparator, with output for use with digital logic circuits.
- High speed analog switch controlled from digital logic.
- Voltage-to-pulse-rate converter.

LOGIC BUILDING BLOCKS provide logic functions of:

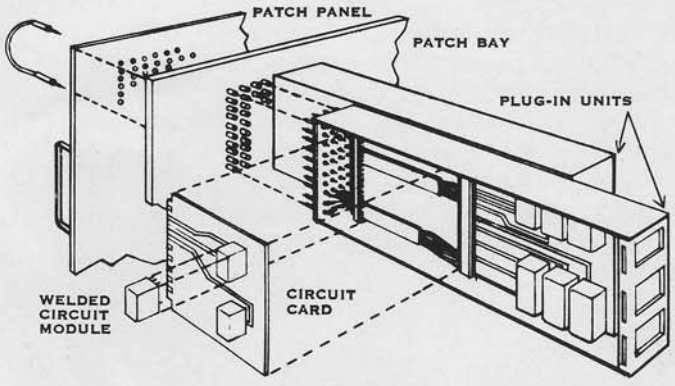
- OR, AND, NOR, NAND
- RST flip-flops, 4-bit shift registers, one-shot multivibrators.
- up/down counters, pre-set counters, ring counters, BCD counters, differentiators, buffer registers.
- adders, multipliers, special control units, timing units.

DIGITAL MEMORY BUILDING BLOCKS, known as Serial Memory Units, are provided in four different sizes:

- SM-8: 256 words (16 bits per word)
- SM-6: 64 words (16 bits per word)
- SM-4: 16 words (16 bits per word)
- MB, Memory Buffer: one word (16 bits)

ANALOG SWITCHING AND MEMORY including:

- MICRO-STORE, a combination package containing one high-speed comparator, two high-speed electronic switches with storage capacitors.
- Multiple-Point Analog Memory provides many points of capacitor storage per analog amplifier.
- Electronic comparators and switches.
- High-speed electronic mode switches for analog components.



ADVANCED DIGITAL ARITHMETIC UNITS consist of accumulators, adders, summers, input units, constant storage units, and comparators. These units provide the analog computer with digital units capable of high-precision computation. They may be interconnected to solve sets of non-linear differential equations, much as the analog computer does, but with digital hardware and discrete algorithms.

Digital Building Blocks are housed in modularized units which plug into standard connectors behind the patch panel . . . each is terminated in a four-by-ten-hole area of the patch panel.

The series 2000 HYDAC is a versatile computing tool for solving a variety of scientific problems

The combination of analog and digital operations not only allows more economic analysis of certain classes of engineering and scientific problems, but in many instances is a far superior method. Until now, the emphasis and philosophy of analog computers have been directed toward the solution of initial condition problems of ordinary differential equations. Although the range of applications falling under that definition is indeed wide, the additional ability to store and process data, and to use the results of this processing as input data for further calculations extends the scope of application of the analog machine. The Series 2000 HYDAC provides these capabilities and thus increases the range of problems that the analog computer can solve economically, thus injecting new meaning into the term "high-speed computation."

Among the more important applications of this computer are:

ITERATION AND OPTIMIZATION STUDIES — Problems of this nature arise in model building, process optimization, parameter studies, and end-point boundary value problems. A function dependent on the solution of a set of differential and/or algebraic equations containing adjustable parameters can be maximized or minimized by trial-and-error methods. Computation time is reduced markedly by the incorporation of suitable logic and switching functions to allow the analog computer to proceed automatically through a complete iteration procedure until an optimum is found. The same logic functions facilitate the automatic programming of parameter searches, performance curve-fitting, and matching of boundary values.

PARTIAL DIFFERENTIAL EQUATIONS—The solutions of many scientific problems are represented by the solutions of linear or non-linear partial differential equations. Solutions based on difference techniques utilizing function storage and playback permit equipment savings through the time-sharing of analog circuits. Such techniques allow the time-domain simulation of field problems where space variables are replaced by high-speed time scanning. Hybrid operations also facilitate the solution of boundary-value partial differential equation problems by the method of characteristics or by integral equation methods through the use of serial solution techniques and time-multiplexing.

SIMULATION OF LOGIC FUNCTIONS—Often a problem being studied is partially represented in its physical description by decision functions. Such problems occur with increasing frequency in the study of space vehicle characteristics and the control of complex processing. A prime example is the simulation of an adaptive control system. Here the dynamic behavior of the system being controlled is represented by normal analog elements while the logic of the control system is represented by the available digital logic elements.

INTEGRAL EQUATIONS — This important class of equations, whether arising directly, as in the application of quantum mechanics to the theory of the scattering process, or indirectly, as in the solution of partial differential equations, can be solved efficiently by a combination of analog and digital elements. More complex solutions now become economically attractive.

AUXILIARY MATHEMATICAL FUNCTIONS — Special operations such as multiplication, transport delay simulation, function generation, slow integration, etc. may be custom-designed, with suitable programming, for combined operations with analog elements. This expands the range of problems that the analog computer can solve economically by increasing the number of basic operations available.

ANALOG AND INCREMENTAL COMPUTATION—Certain sophisticated simulation problems have a requirement for greater computational flexibility in order to achieve greater speed and accuracy of solution. Such problems arise in the study of the performance of missile and space vehicle characteristics. The inclusion of digital arithmetic units in the analog computer permits the solution of such problems in faster-than-real time, with high precision and increased dynamic range. Obvious economies result from the combined operation of analog and digital computational elements in one centralized system.

Problems which have been programmed for solution with the HYDAC at EAI's Princeton Computation Center include:

- *a generalized optimization control program to optimize any non-linear function of* n *variables that is programmed for an analog computer.*
- *an eigenvalue problem for determining the normal modes of a vibrating beam.*
- *a reaction-jet space capsule control problem.*
- *iterative solution of tubular reactor and control system design problem.*
- *solution of partial differential equations by the method of characteristics.*
- *integral equation solution of a boundary value problem.*

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