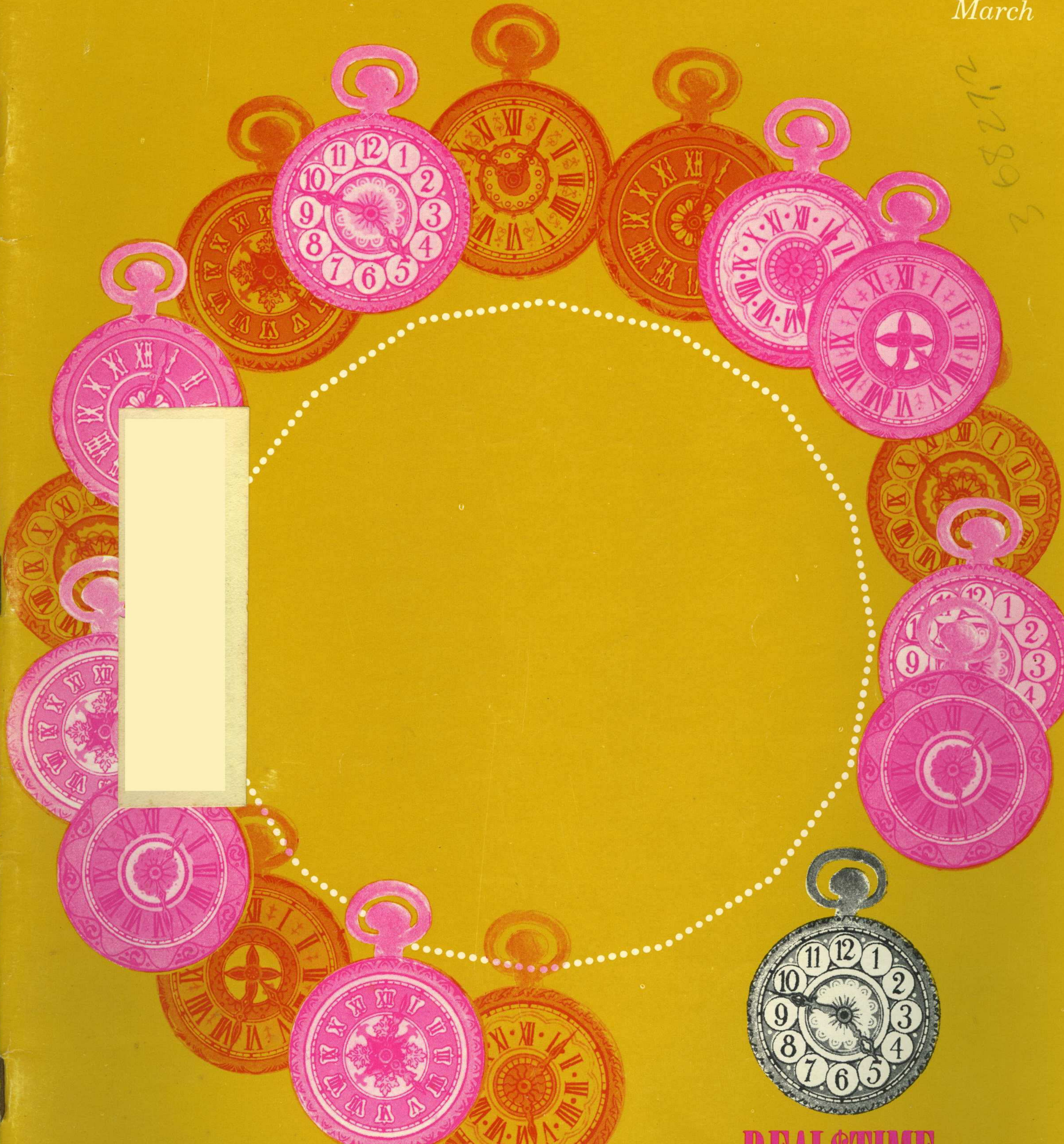
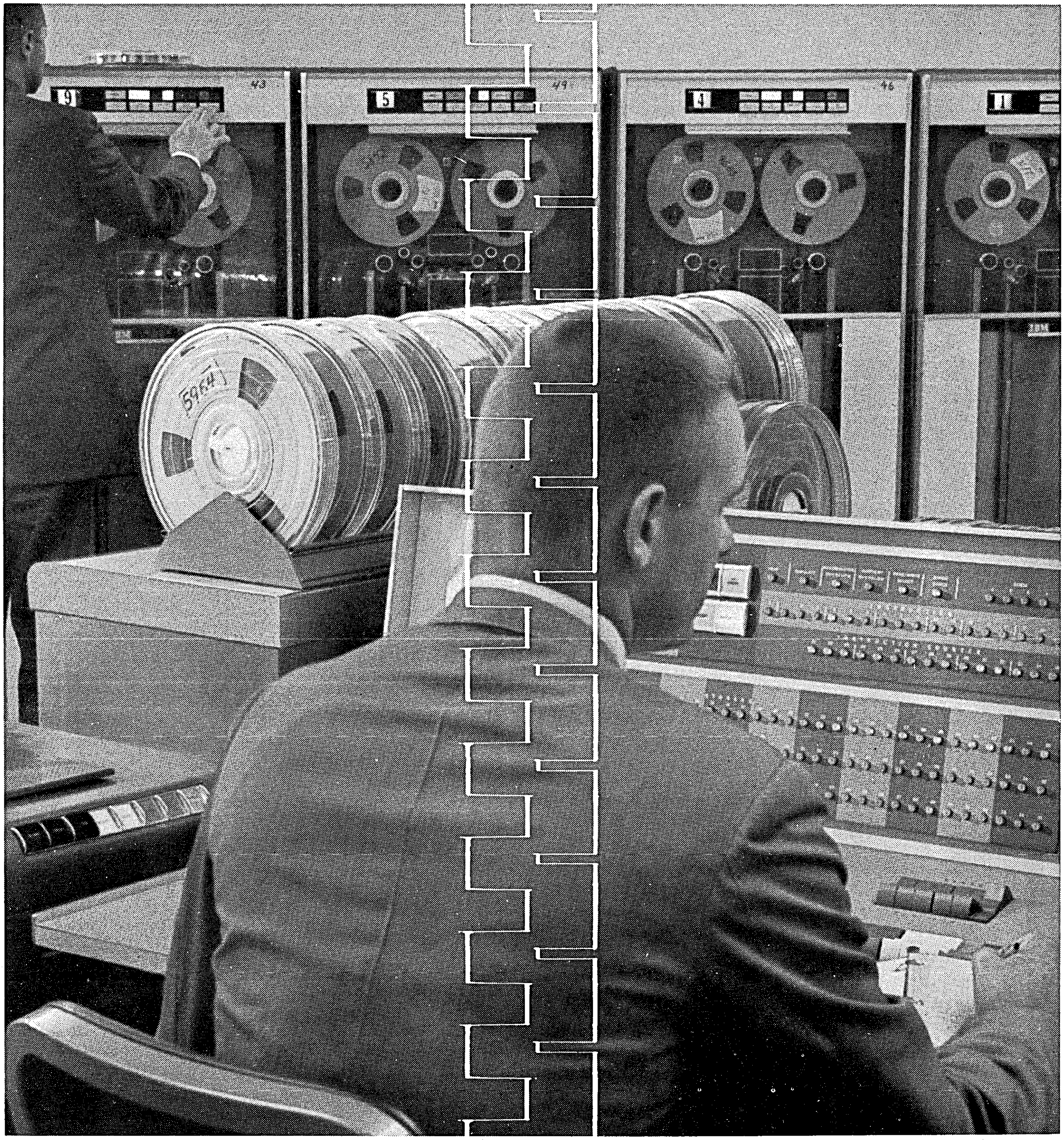
DATAMATION 64®

March



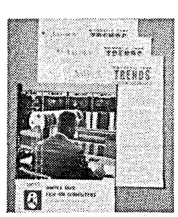
REAL$TIME

PHOTO COURTESY OF LOCKHEED CORP.



Now: who's got news for everyone with an IBM computer system? AMPEX

The news is inside an eight page booklet. It tells the what, the why and the how of Ampex computer tape—the tape that provides superior performance in IBM computer systems. If you think you might find the booklet helpful, just write and ask for it. Also, we'll put your name on our mailing list and regularly send you our informative periodical, "Tape Trends." It's a good way to keep abreast of the fast changing tape technology. In it, the latest tape developments are clearly explained by Ampex tape



AMPEX

experts—the same experts who application-engineer Ampex tape to your system. This is just one of the many ways we assist you in obtaining maximum system efficiency. In addition to engineering the tape to your system, Ampex digitally checks each reel from end to end, and guarantees its performance. Write for free booklet, "Ampex Tape for IBM Computers," and your copies of "Tape Trends." Ampex Corporation, Redwood City, California. Sales and service engineers throughout the world.

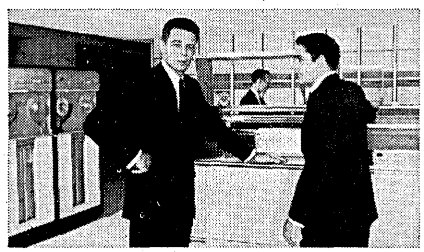
CIRCLE 1 ON READER CARD

PROGRAMMERS

COMPUTER SCIENCES CORPORATION—one of the world's largest firms engaged exclusively in computer-oriented services—offers outstanding career opportunities in Los Angeles, San Francisco, Houston, and New York.

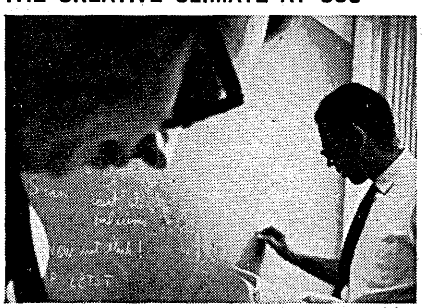
Since its inception in 1959, CSC has performed services for nearly all major computer manufacturers and many of the largest computer installations in all fields of business and science. In less than five years, CSC has grown from a small team of specialists to several hundred senior analysts and programmers. This page depicts some of the people and the working atmosphere responsible for CSC's impressive growth.

THE STAFFING PHILOSOPHY OF CSC



CSC's technically oriented management provides an unequaled professional climate, challenging projects, incentives and rewards well in the forefront of the computer field. This professional environment at CSC provides recognition and advancement in both technical and managerial directions to follow immediately upon performance and demonstration of capability.

THE CREATIVE CLIMATE AT CSC



CSC staff members are widely recognized throughout the computing profession for major contributions to the state of the art. Professional capabilities at CSC extend over the complete range of computers produced by all equipment manufacturers and include the design and implementation of programming systems in current use throughout the business and scientific communities. The CSC staff includes such well known professionals as Roy Nutt, Owen Mock, Charles Swift, Lou Gatt, Joel Erdwinn, and others. Above all, CSC is a problem analysis and programming organization—these are primary functions, not secondary to any other product.

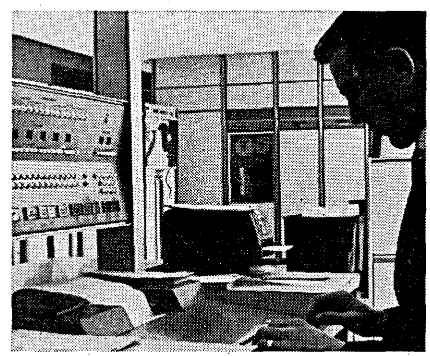
CSC'S CLIENTS

Today, CSC is solving problems in the computer sciences for such distinguished clients as IBM; UNIVAC; Lockheed Missiles & Space Company; Litton Industries; Philco; Douglas Aircraft; Hughes Aircraft; Union Carbide; Jet Propulsion Laboratory; Standard Oil Company; Lear Siegler, and many others.

VARIETY OF CSC APPLICATIONS

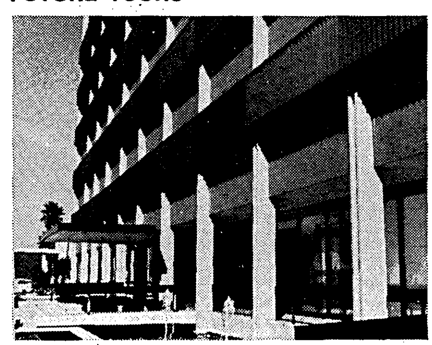
From advanced business and scientific language compilers to real-time communications with space vehicles, CSC projects cover a broad spectrum of activity. CSC has designed and produced programming systems for more than 20 machines including complete integrated systems for both medium and large scale computers. In the space sciences, CSC has designed and implemented programs for orbit determination, data acquisition and analysis, and video data reduction for such projects as Surveyor, Mariner, Ranger, Dyna-Soar, and Apollo. In business applications, CSC has developed advanced PERT/COST techniques and implemented major management reporting systems.

LARGE SCALE COMPUTING AT CSC



A recent expansion of CSC facilities includes installation of large scale computing equipment in Los Angeles, marking CSC's entry into the Service Bureau field and providing programmers with highly advanced equipment to implement the solution of problems. CSC's 1107 computer features 65K words of main memory and over six million words of drum storage with the industry's fastest and most efficient programming system. A remote data-link with other CSC offices makes the 1107 available to the entire company.

MAKE CSC'S EXPANDING FUTURE YOURS



Immediate career opportunities exist for outstanding problem solvers in commercial, scientific and systems programming. A minimum of three years experience and degree is required. Exceptional salaries and a profit sharing plan are provided. CSC is an equal opportunity employer. Write:

COMPUTER SCIENCES CORPORATION

650 North Sepulveda Boulevard, El Segundo, California • New York, Houston, London, San Francisco

CIRCLE 75 ON READER CARD

HOW TO BECOME THE HOTTEST SOFTWARE OUTFIT AROUND... IN ONE YEAR FLAT!

Start with two people. And the notion that all the world needs is another software and consulting outfit. Just one more. One dedicated to the proposition that Total Competence, total excellence in the three critical areas of systems programming — compilers and computer software, real time systems, and scientific applications — is essential to success in any one area or in any computer science problem. One with no commitments to a hardware maker, directly or through a service bureau. One determined to deliver Total Competence in systems programming.

Take these basic ingredients, add nothing but uncommonly gifted personnel, lots of hard, conscientious work and a little luck. Soon, if you happen to be us, you'll suddenly find you've sprouted to a staff of 100 some top pros, thoroughly experienced in systems programming for almost every main frame ever built — having racked up a 12-month record of:

9 COMPILERS

FORTRAN II, FORTRAN II EXTENDED, FORTRAN IV, STOL, VAP, and special purpose compilers. All tailor made — not off the shelf carbon copies — to take advantage of customer hardware systems and existing software. COBOL, JOVIAL, NELIAC, CS-1, and other software packages by the score.

21 REAL-TIME SYSTEMS

Spacecraft checkout, space booster instrumentation and data acquisition, jet engine checkout, multiple hypersonic wind tunnel systems, command and control applications, telemetry data acquisition and information processing systems.

60 SCIENTIFIC APPLICATIONS

6D general purpose trajectory for earth orbit and planetary intercept, spacecraft TV transmission data processing, satellite data acquisition, chemical equilibrium studies, communication engineering, orbit determination, math modeling and analysis.

20 INDUSTRIAL SYSTEMS

Integrated computer software packages for process control applications, special software packages for open and closed loop operations, project management for on-line operation of chemical processes, and over 25 commercial EDP applications.

And getting repeat business from customers the likes of Aerospace, Autonetics, Beckman, Bendix, Bunker-Ramo, Computer Control, Douglas, General Precision, Hughes, JPL, Librascope, Northrop, North American Aviation, RCA, TRW, Univac, U.S. Navy, plus lots of other equally astute software buyers. And privileged to contribute to major space projects including Apollo, Saturn SIVB, Mariner, and Ranger.

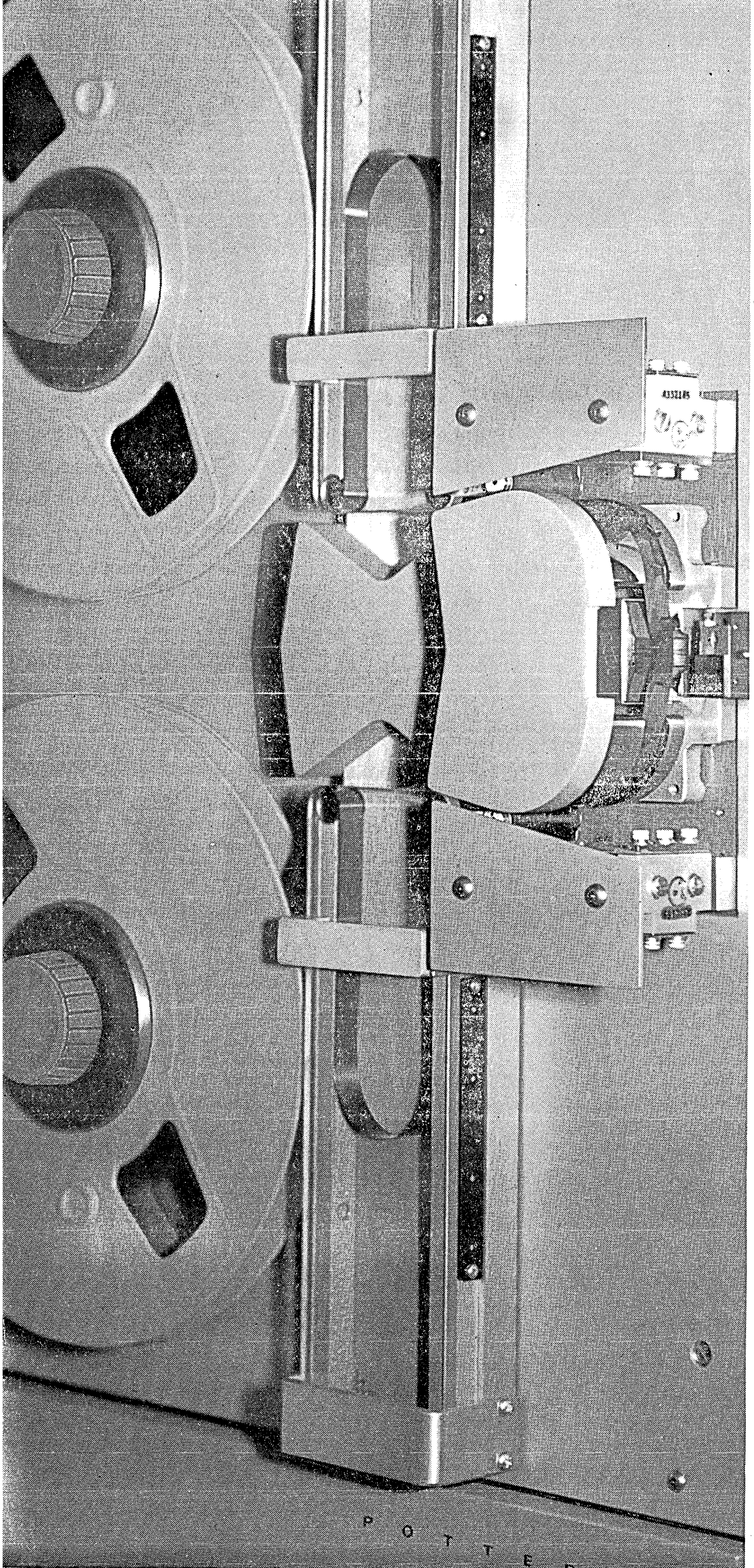
Nothing much to it, really, except that all we offer — and deliver — is Total Competence in each of the critical, interwoven areas of systems programming: compilers, real-time systems, scientific applications, and industrial systems. Nothing else. Naturally, we'd welcome a chance to add you to the list of those that keep coming back for more of the same. So a letter will bring you more specifics on what we can do, have done, and are doing.

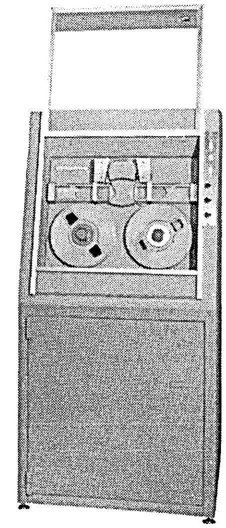
We're still on the grow, of course, carefully adding more hard-charging above-average people. Real talent is a must. If you qualify, write us. We are an Equal Opportunity Employer.

SYSTEMS PROGRAMMING CORPORATION

1833 East 17th Street, Santa Ana, California
Phone: (714) 547-0069
Offices in Inglewood, Pasadena, Washington, D.C.
An affiliate of Mesa Scientific Corporation

FOR RECRUITMENT INFORMATION CIRCLE 90 ON READER CARD





A very big transport in a 2-foot package

This is Potter's MT-24, a new vacuum column, digital magnetic tape transport which is already proving big in the field. Packed into its mere 24″ height (or length if you prefer to mount it sideways) is all the dependability and performance of tape drives costing over twice as much. Here are the facts:

PERFORMANCE — Read/write tape speeds from 3 to 36 ips, data transfer to 28.8 kc, 200 commands per second. (50 ips and 40 kc performance available in the MT-36 companion unit at very little increase in price!)

RELIABILITY — Use of thoroughly field tested components in combination with new vacuum column construction has resulted in improved transport dependability. Reliability warranted 1 in 10^8 bits read.

COMPATIBILITY — The MT-24 is compatible with IBM's 7330, with packing densities of 200, 556, and 800 bpi. One inch tape and other computer formats are readily accommodated.

ECONOMY — MT-24 (and MT-36) costs less per effective bit transferred than any other transport on the market . . . and with greater operating dependability and data transfer reliability than tape drives costing more than twice as much.

Potter is shipping MT-24's NOW. Delivery within 4 weeks. Want details? Write — Sales Manager.

POTTER
INSTRUMENT CO., INC.
151 Sunnyside Boulevard, Plainview, New York

TM.

CIRCLE 5 ON READER CARD

DATAMATION 64

the automatic handling of information

volume 10 number 3

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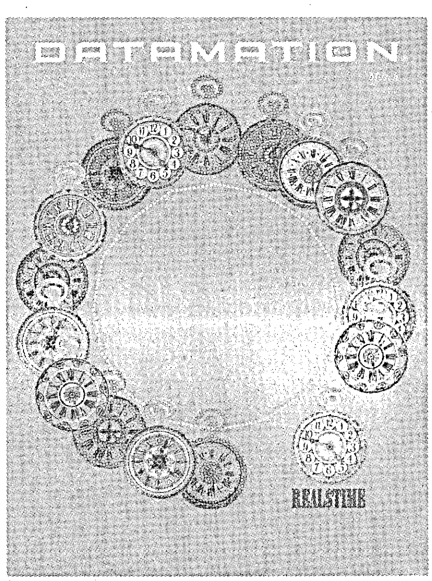
Feature Articles

Departments

THIS ISSUE — 46,807 COPIES

Cover



The chimeric world of time, both "real" and not so real, is the subject of several articles this month. Each focusses attention on a specific phase of this topic, symbolized by the watches floating in the pink mirage of our cover. Design is by Art Director, Cleve Boutell.

Circulation audited by Business Publications Audit — BPA

Member, National Business Publications — NBP

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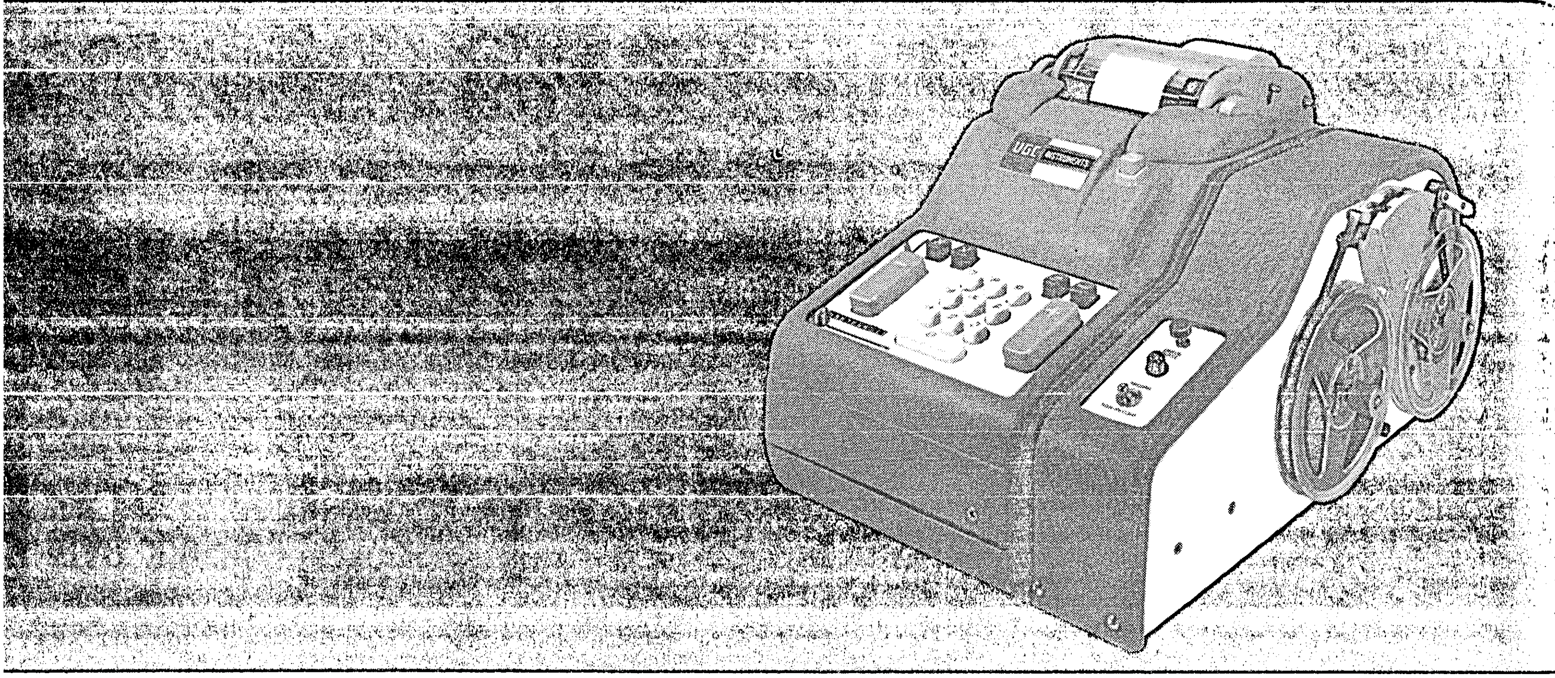

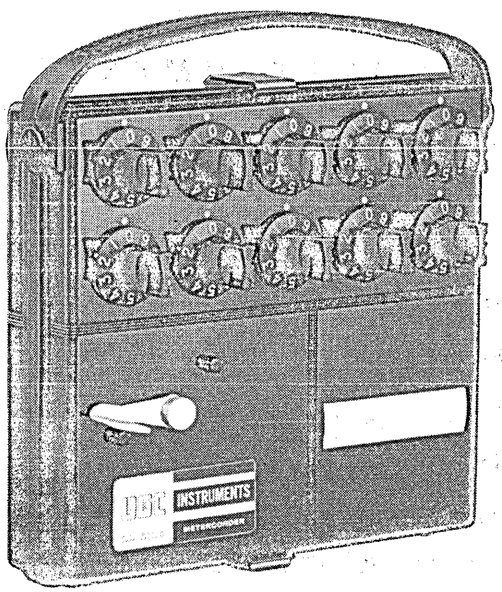
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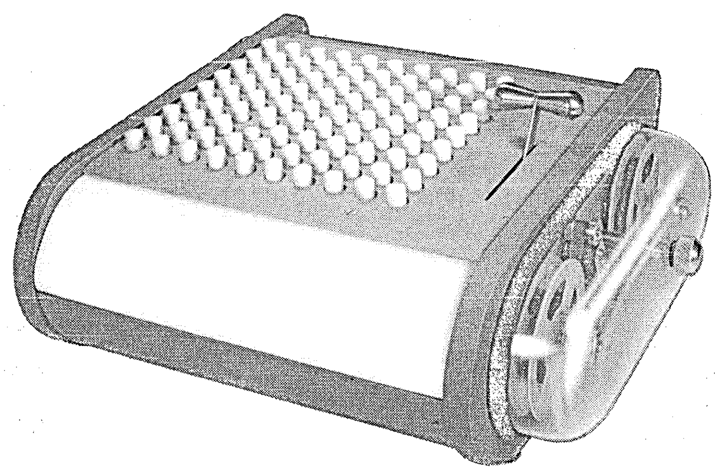

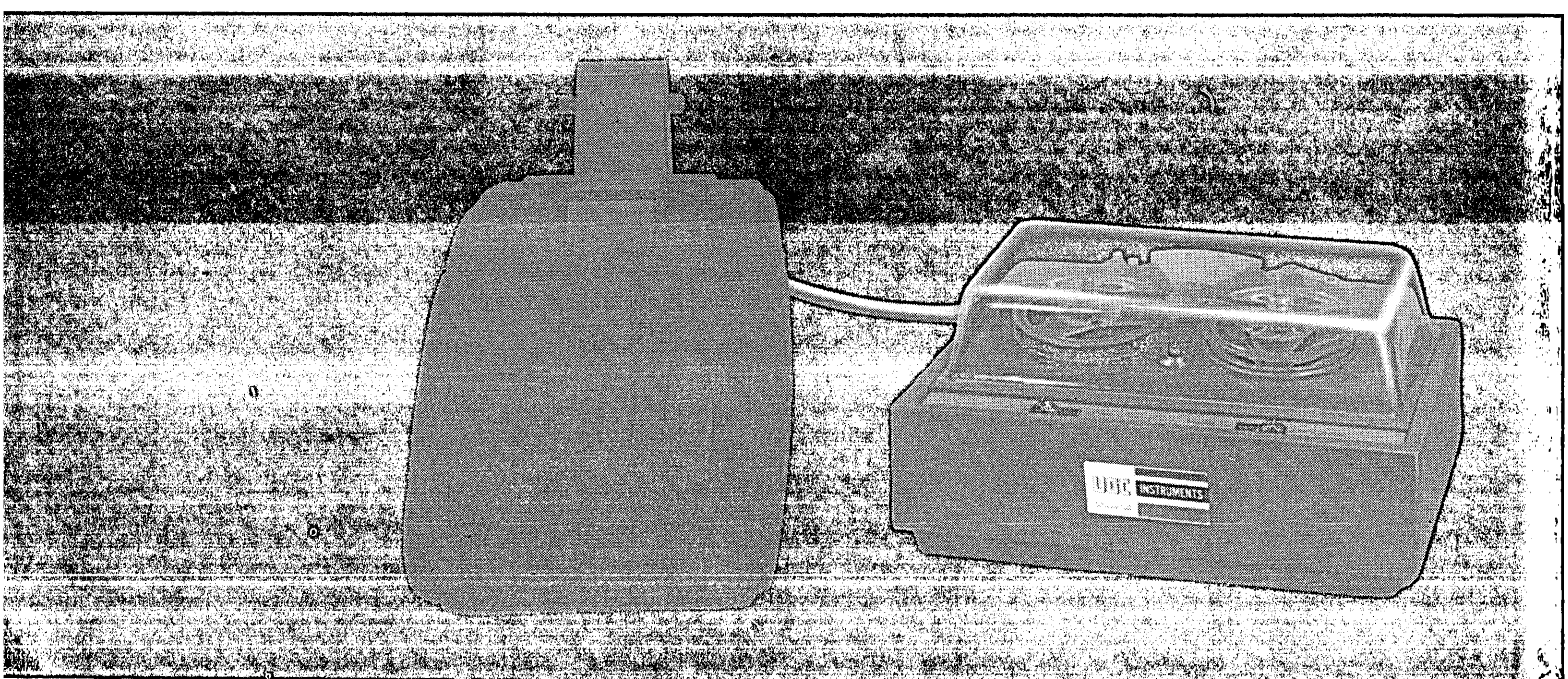
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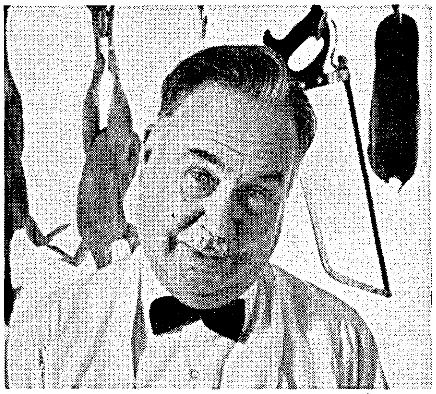
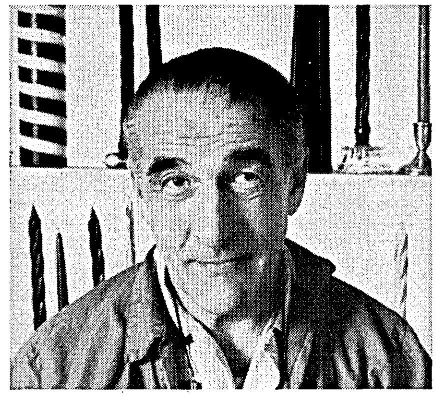
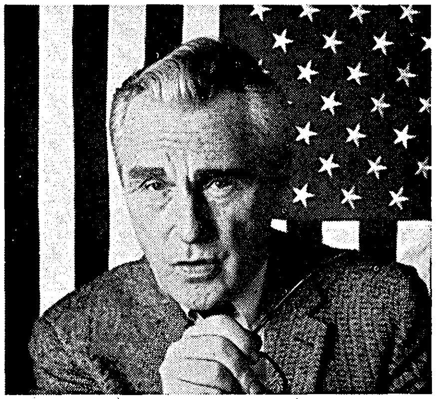


Butcher

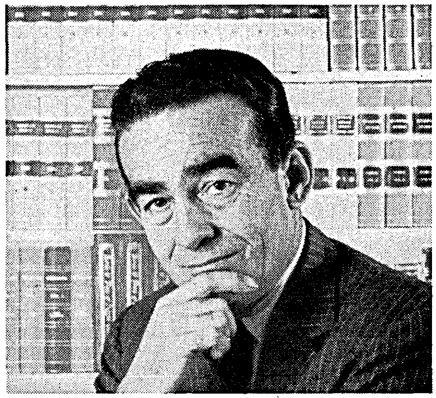
Baker



Candlestick Maker



Educator



Lawyer

Auto Maker

You don't have to be big to benefit from the UNIVAC Data Processing Center network.

You just need the ambition and the address.

Once data processing was the special province of giants. The U.S. Census Bureau. Major universities. Big business. Today electronic data processing is a necessary fact of life for a business of *any* size.

That's why UNIVAC has built a network of Data Processing Centers serving 29 major cities in the U.S. and parts of Canada. With over 15 million dollars worth of equipment. Including UNIVAC® III and UNIVAC 1107, the world's only thin film commercial computer. Designed to service every business and scientific problem.

We have staffed the UNIVAC network with over 750 highly trained people: scientists, mathematicians, engineers, consultants, programmers, systems analysts. Anyone any job would require.

We're ready. As ready as anyone can get for big jobs, small jobs, workaday jobs, one-shot jobs. Any job.

Now what did you say your job is?

UNIVAC DATA PROCESSING CENTERS

UNIVAC DIVISION OF SPERRY RAND CORPORATION

CIRCLE 7 ON READER CARD

DATAMATION calendar

● The spring meeting of the Honeywell 400 Users Assn. will be held April 15-17 at the Executive House, Chicago.

● The 1964 national convention of the Assn. for Educational Data Systems will take place at the Miramar Hotel, Santa Barbara, Calif., April 19-22.

● The Spring conference of the Univac Users Assn. will be held April 20-22 at the Sheraton-Chicago Hotel.

● The 1964 Spring Joint Computer Conference will be held at the Sheraton Park Hotel, Washington, D.C., April 21-23.

● The spring meeting of CUBE (Burroughs Users group) will be held April 22-24 at the Ben Franklin hotel in Philadelphia.

● A course on "Audit and Controls for Electronic Data Processing," sponsored by the American Institute of Technology, Phoenix, Ariz., will be given April 27-May 1.

● A two-day workshop on Analog Computers in Process Industries will be held April 28-29 at the Illinois Institute of Technology, Chicago.

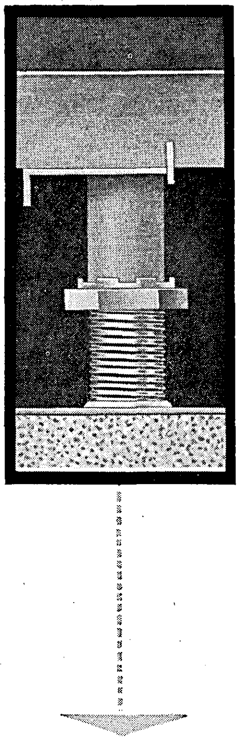
● The annual conference of the Industrial Communications Assn. will be held at the Williamsburg Lodge Conference Center in Williamsburg, Va., May 3-6.

● GUIDE International (large scale IBM edp machine users group) will hold its next meeting at the El Cortez Hotel, San Diego, May 5-8.

● The fourth national conference of the Computing and Data Processing Society of Canada will be held on May 11-12 at the Univ. of Ottawa.

● The ninth annual Data Processing Conference will be held at the Hotel Stafford, Tuscaloosa, Ala., May 12-13. Sponsors include DPMA, National Accountants Assn., U. of Alabama, and Certified Public Accountants.

● The POOL 1964 annual general meeting will be held May 12-14, at the Palmer House in Chicago.



Infin-ac(TM) ...the precision engineered

ELEVATED FLOORING SYSTEM

for today's Data Processing Equipment

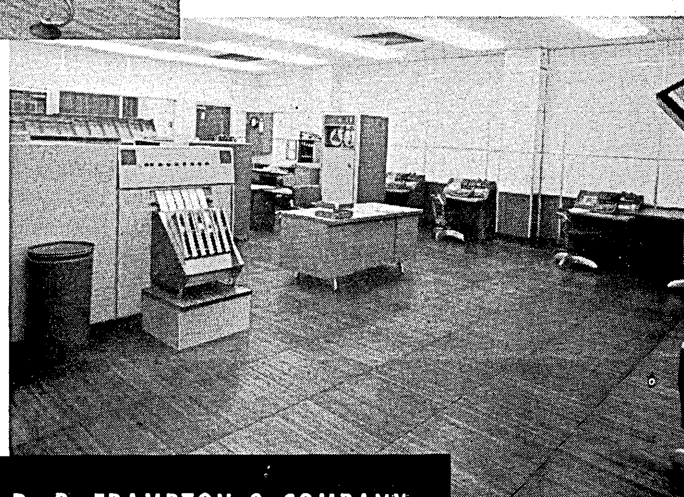
The <u>strongest</u>, most attractive, infinite access flooring available to complement your important investment in electronic computing units.

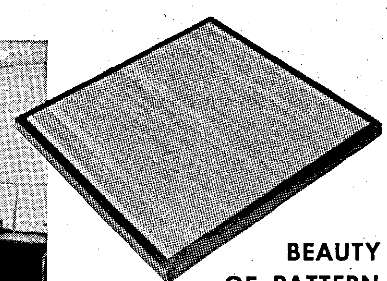
No Sagging — No Denting — No Delamination

● Infin-ac's advanced engineering of combined underframing and removable edge-grain panels provides super strength, supporting the largest, intricate units with safety. Non-conductive wood panels cause no concern should short circuit occur within the system and their resiliency cuts down employee lag from foot fatigue too. Maintenance is easier and more economical. Every installation is under careful supervision of our engineering staff and we will gladly lend counsel on structural problems when needed.

EASY, FAST ACCESSIBILITY

View above shows Infin-ac's individual hardwood panels being removed for immediate access to complex underfloor electrical wiring and air conditioning system when service is needed. Tapered edges permit easy removal by manual vacuum lift.





BEAUTY OF PATTERN

Flooring panels are available in either plain finish or with walnut banded edges as shown above. (Vinyl tile finish or carpeted panels if preferred.)

When assembled, these flooring components create an over-all pattern of beauty and distinction. The plain finish (at left) shows an installation in the data processing department of a large financial institution.

INFIN-AC DIVISION — D. B. FRAMPTON & COMPANY
Huntington Bank Building • Columbus, Ohio 43215

Yes, we are interested. Please send the Infin-ac brochure

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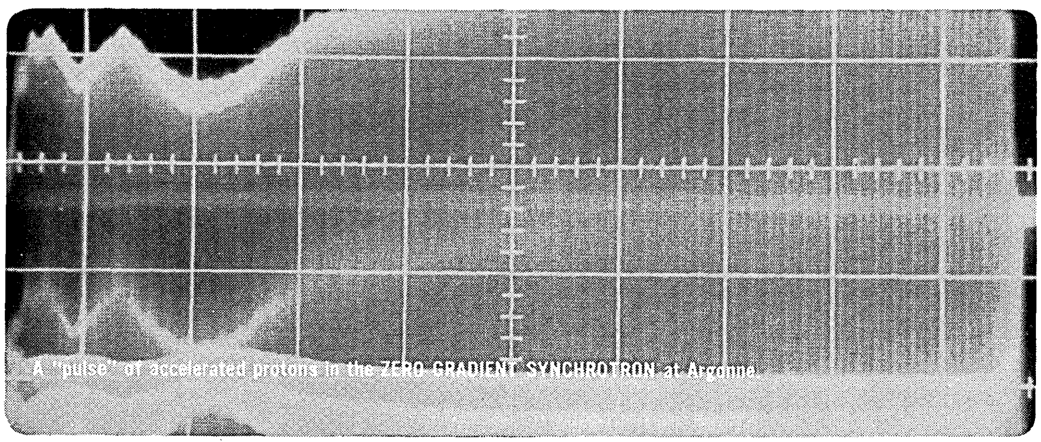
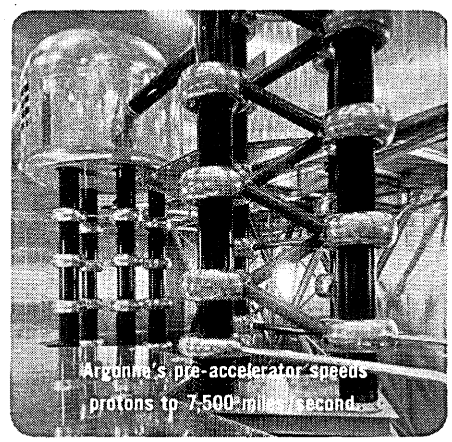
Send for more facts and figures. They're all in this ← attractive brochure.

CIRCLE 9 ON READER CARD

A CONTROL DATA 3600 used with the ZGS at Argonne.



A "pulse" of accelerated protons in the ZERO GRADIENT SYNCHROTRON at Argonne.



Argonne's pre-accelerator speeds protons to 7,500 miles/second.

Photos courtesy Argonne National Laboratory

ARGONNE'S 3600 ACCELERATES SCIENTIFIC ANALYSIS TOWARD PEACEFUL USE OF THE ATOM

At Argonne National Laboratory in Illinois, science is proving how nuclear energy can benefit the world through peaceful application. In their experiments, Argonne scientists produce vast amounts of information enabling them to harness nuclear energy and use it constructively—for heat, light and fuel, for deeper understanding of man's biological make-up, and for discovery of new methods and materials to achieve peaceful progress.

To preserve the value of this increasing volume of experimental data, they use a **CONTROL DATA 3600** Computer System to rapidly analyze the data and produce practical computations—analyses that are assisting in the development of nuclear fuels, new methods in medical radiology, new power reactor designs.

The problems being solved by Argonne scientists are paralleled by other progressive organizations the world over who are putting the **CONTROL DATA 3600** to work in science, industry, and economics. The reason: the **CONTROL DATA 3600** offers more computations per dollar than any other commercially available computer system in operation today.

For more detailed information on the **CONTROL DATA 3600,** we invite you to inquire direct or through your nearest Control Data representative.

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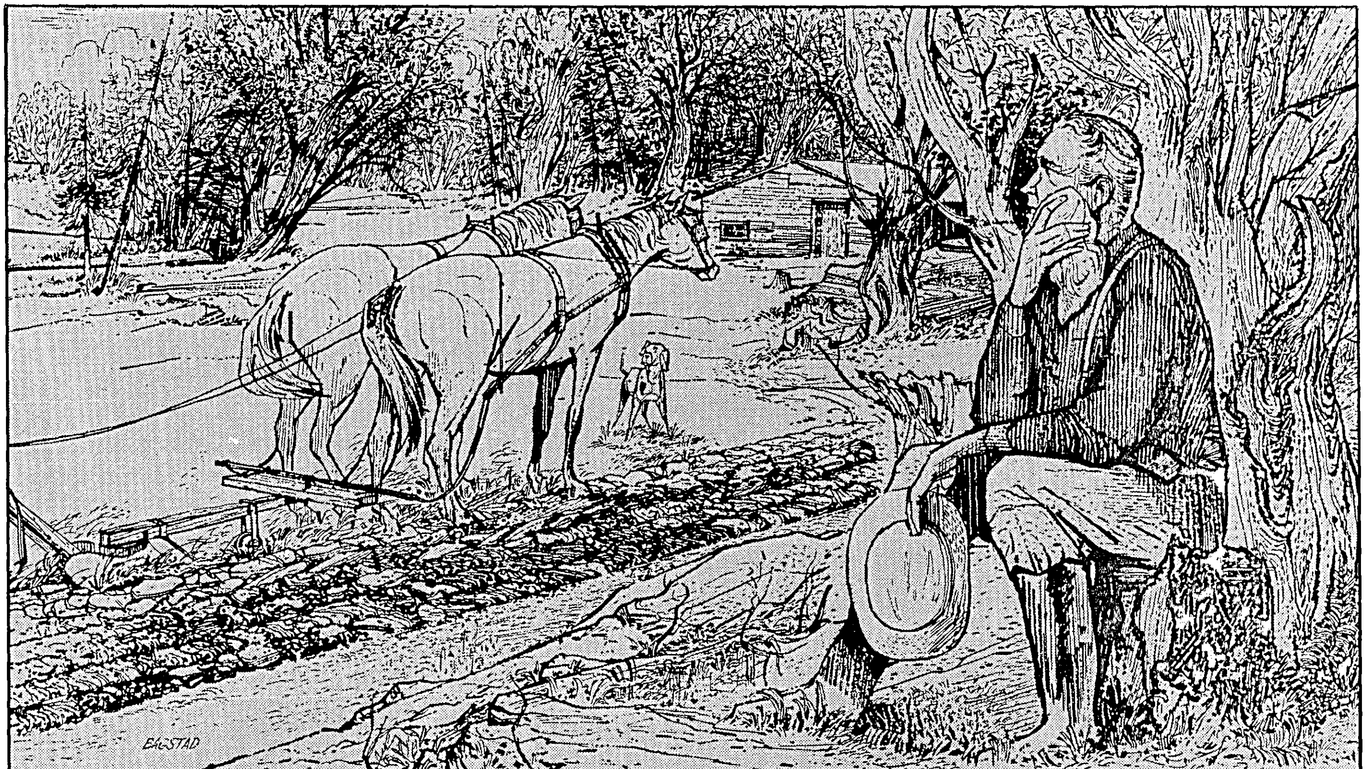


letters

automation & leisure

Sir:

I am delighted to see Dr. Fein's "Automation, Unemployment, and Utopia" in your January issue. It seems to me something of a symbol that the field of data processing and automation is maturing; we can talk about fundamental issues in professional and trade publications . . .

I fully agree that it is necessary for management, labor, and government (as representatives of the consumer) to seek solutions for our problems. There are some (far too small, as yet) projects under way already. The crux of the matter is time. We cannot afford to spend years on research projects, decades before the findings are explained to our notoriously backward lawmakers, and possibly a century before the lawmakers feel they can risk saying publicly what they are so painfully slowly learning in private . . .

Your magazine has made an auspicious and courageous start. I hope you will do a great deal more publishing about the ethos and economics appropriate to our state of technology.

ALICE MARY HILTON
A. M. Hilton and Associates
New York, New York

Unfortunately, space forbids publication of more of the letter. Miss Hilton, however, will deliver a paper on this subject at the SJCC (see p. 57).

tigers & marksmanship

Sir:

You might be interested to learn that 1964 is apparently the Year of the Dragon and 1962 was the Year of the Tiger. Personally, I prefer your choice of a title. Long live poetic license!

BRIAN A. EDGAR
The Dominion of Canada General Insurance Co.
Toronto, Canada

Sir:

With the opening statement in your "Year of the Tiger" (Jan., p. 37), you immediately dispell all belief that your article will be truthful and unbiased. The second not ony confirms your bias, but makes one inquire as to when was the last time you objectively evaluated any manufacturer but IBM. If one was to believe your article, all users would be justified in using IBM equipment only, with the rationale that all else are "Chinese" copies or paper tigers . . .

R. M. MEYERS
Philadelphia, Pennsylvania

Sir:

In two paragraphs, you have raised—and properly—a number of questions on "people and education" . . . Within our faculty, we have some differences of opinion about the DPMA certificate program, but there is no question about its providing a stimulus to extending the education of workers in the field, both in breadth and in depth.

But I do think you are not quite fair to ACM in your characterization of its education program. From my observation, the ACM has made a great contribution in a number of geographical areas. I know this is true in the Washington area, and we have contributed to the program. On the other hand, I don't think it is clear that a professional society such as the ACM has a mandate to establish an educational program and educational standards as you imply. Perhaps its role should more properly be direct liaison and stimulus to universities in the development of their programs.

We are offering ADP and related courses in government locations, thereby making substantial contributions in the education of public officials, which you referred to as important and missing.

LOWELL H. HATTERY
School of Government and Public Administration
The American University
Washington, D.C.

Sir:

W. R. Lonergan's "A Manufacturer Speaks," and "A User Speaks," writer unknown, prompts me to protest that statements made regarding what colleges are doing about the training of people in the systems analysis and computer fields are in error. To be sure my department chairman of Systems Analysis and I share many of the comments made by the authors especially about the difficulties which manufacturers and users are having in obtaining competent personnel.

With counsel from a leading manufacturer Miami Univ. spent over one year developing an undergraduate program in Systems Analysis . . . For all practical purposes, major enrollment and emphasis began in the fall of 1963. We had an enrollment of 148 students, including 20 majors . . . The second semester, which began Feb. 5, already has 200 students, including 35 majors . . .

GEORGE BOWERS
School of Applied Science
Miami University
Oxford, Ohio

seac, eniac, siss boom bah

Sir:

In his article, "Government Research" (Jan., p. 27), Dr. James Ward asserts that "the first electronic digital computer was the SEAC, completed in May 1950 for the Department of Commerce" . . . The first was actually the ENIAC, completed in 1945 for the Ordnance Corps, U.S. Army.

JOHN H. GIESE
U. S. Army Ballistic Research Laboratories
Aberdeen Proving Ground, Maryland

To the many ENIAC fans who spotted this, our apologies. Actual dates are elusive but, for historians, we believe ENIAC went on the air in January 1946.

software-patent research

Sir:

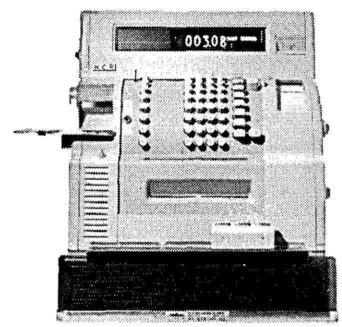
Following an EE degree from MIT and three years in the electronics field, a desire to become a patent attorney drove me to Columbia Law School, where I have been asked to research the question of copyright protection for programs by the Columbia Law Review. Perhaps your readers can assist me:

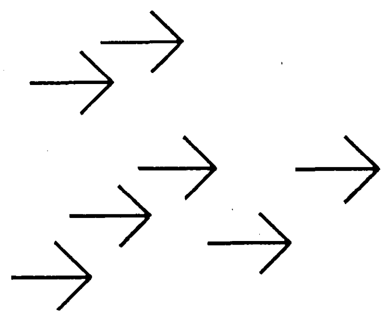
1. Has anyone attempted to copyright a computer program? Result?
2. Any previous research on this problem? Results? Where published?
3. What is size of financial interest involved? Cost of "average" program? Total cost of all programs now in existence?
4. Is there serious need for protection of computer programs or are there strong reasons for their remaining in the public domain?

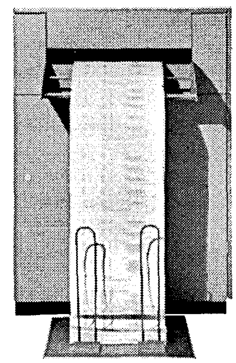
I would appreciate references to published documents wherever possible. I will be happy to give credit in my article for any information received and used.

JOHN F. BANZHAF III
Columbia Law Review
Columbia University
New York, New York

Why NCR is No.1 in Total System Capability.







Executives well-informed in the ways of electronic computers know that an EDP system is only as good as the input machines where the processing cycle begins. Input equipment must be fast, simple, easy to operate or the speed and efficiency inherent in the computer is limited. In computer jargon, this is called "input limited." □ Many EDP manufacturers have great difficulty in solving their "input limited" problems. Since they haven't been in the business of manufacturing a complete line of input machines, as NCR has, they must usually rely on duplicating data in a second operation with other devices. □ NCR is not "input limited." And NCR's answer is the most practical and economical. All NCR original entry equipment...cash registers...adding, bookkeeping and accounting machines...can be linked to an NCR electronic computer system —or even someone else's computer. NCR takes you all the way—captures the necessary information for linkage to a computer as a by-product of recording the transaction at the source. □ For example, the On-Line Savings System for banks. The teller's machine (input device) is linked directly to an NCR 315 Computer (maybe miles away) that instantly verifies a transaction, transmits data back to the teller's machine which then updates the passbook (output). One uninterrupted process that takes only seconds. This is an excellent illustration of what we mean by total system capability. □ Also, a retail store can now automate their sales records, inventory and accounts receivable...and data enters the system when the sale is recorded. For example, as a by-product of recording sales, punched paper tape or optical journal is produced which can be processed directly by a computer. □ NCR users do not have to duplicate original entry information. □ NCR users are also dealing with a company that has been designing business systems for over 80 years. Experience that counts for a lot in creating the total system "software package" that goes with an NCR EDP System. COBOL and NEAT, for instance, and other advanced programming techniques are available now. And 7500 servicemen keep NCR products "on the air." □ If you're in banking, industry, retailing, government or education and thinking EDP, think in terms of total system and call your local NCR representative or NCR, Dayton 9, Ohio. □ And see the NCR Pavilion at the World's Fair, New York.

THE NATIONAL CASH REGISTER COMPANY ®

CIRCLE 12 ON READER CARD

When it comes to computers twice as fast as a 7090 at 25% the cost...SDS wrote the book.

SDS 9300 The SDS 9300 is a general-purpose digital computer comparable in speed and other features with large-scale scientific and systems computers. In price, however, the 9300 is comparable to medium-scale computers – basic *system* prices start at approximately $250,000. The 9300 thus represents a significant reduction in the cost-per-answer of computing equipment.

The SDS 9300 is the third computer manufactured by Scientific Data Systems. It is logically and electrically similar to the other SDS computers – the SDS 910 and the SDS 920 – and incorporates the same high degree of reliability and flexibility.

The SDS 9300 has the following characteristics:

- 24-bit word plus a parity bit
- 48-bit word for floating point arithmetic
- 3 Index Registers and Indirect Addressing
- Basic memory of 4096 words expandable to 32,768 words, all directly addressable, with:

  0.7 μsec access time

  1.75 μsec cycle time
- Memory non-volatile with power failure
- Execution times, including all accesses *and indexing* (using overlapped memories):

Fixed Point

1.75 μsec	Add
3.5 μsec	Double Precision Add
7.0 μsec	Multiply
5.25 μsec	Shift (24 positions)

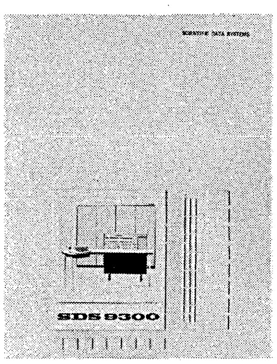
Floating Point
(39-bit mantissa, 9-bit exponent)

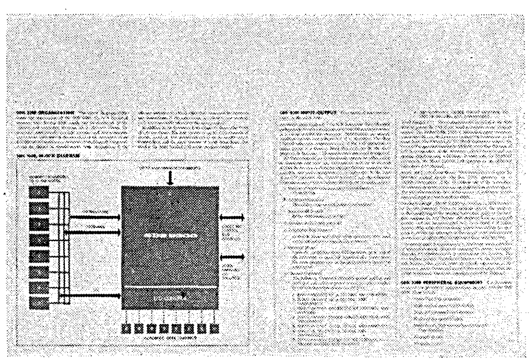
14.0 μsec	Add
12.25 μsec	Multiply

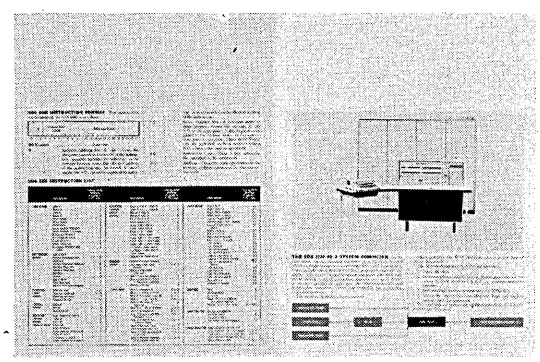
- Extensive repertoire of powerful instructions (more than 110)
- Byte operations which permit manipulation of 3, 6, 9, 12, 15, 18, or 21-bit Bytes. Two 12-bit Bytes may be multiplied in 3.5 microseconds
- 6-bit Flag Register with set/reset/test instructions which provides fast, easy-to-use program switches for logical decision making. Each position may be set or reset under program control and the status used to control program flow
- 11 high-speed search operations operate at 1.75 microseconds per item
- Multi-level indexing and indirect addressing
- Index Registers which contain and operate with a base value and an increment or decrement
- REPEAT instruction which operates with variable size incrementing or decrementing; when used with Input/Output, permits Gather-Read and Scatter-Write
- Extensive shift and inter-register instructions for data manipulation
- Flexible and easily programmed subroutine execution
- Up to 8 Automatic Data Channels each capable of fully buffered operation at one word every 1.75 microseconds *simultaneously* with full speed computation
- Automatic Data Channels which operate upon either words or characters. The number of characters per word is under program control
- Addressing of I/O operations can be both indexed and indirect to facilitate Gather and Scatter operations
- Parity checking of Memory and I/O operations
- Searching of magnetic tape, discs, etc., can be accomplished independently of the memory and requires no computer time
- A Parallel Word I/O system in addition to the Automatic Data Channels to facilitate operation upon certain types of asynchronous information under program control
- SDS 910 available as a satellite I/O Processor
- Up to 32,000 output control signals and input test signals
- A complete priority interrupt system with up to 1024 priority levels. These can be individually enabled and disabled under program control
- Automatic program loading from cards, paper tape, magnetic tape, drums or discs
- Complete display of all programmable registers with extensive manual controls
- Six Sense Switches, two Manual Interrupt Switches and a Selective Halt provide complete capability for console control during execution
- FORTRAN, Symbolic Assembler, and a Monitor System as part of a complete software package
- No air conditioning required for computer proper – operating temperature range 10°C to 40°C
- Small size and simple installation – over-all dimensions, including expanded memory, approximately 6 x 8 x 2 feet plus an operator's console
- Low power requirements: 4 KVA
- All silicon semi-conductors for high reliability; small component count yields long Mean Time Between Failures

Here's page three.

You'll have to write for the rest.







SDS 9300

SCIENTIFIC DATA SYSTEMS 1649 Seventeenth St., Santa Monica, Calif.

CIRCLE 14 ON READER CARD

POUNDS TO BE GAINED IN AUSTRALIA

Hardware manufacturers are vying for some £700K ($1,960,000) of computer-purchasing power placed in the palms of five Australian universities by the government. Among machines being proposed are the B5000, FP 6000, 7040, 3200 and PDP-6. For this burgeoning market, DEC has formed a subsidiary, Digital Equipment Australia Pty. Ltd., which will engage in manufacturing and engineering support. Reportedly large in interest down under is time-sharing.

ANOTHER MYSTERY MACHINE FROM CDC: THE 3400

As predicted in the January Datamation, Control Data announced its 3400. Primarily a scientific machine, it evidently replaces the 1604 in the CDC product line. Announced as part of a "family" (3200, 3400, 3600), the 3400 has program compatibility with the 3600; but no mention was made of any downward compatibility in a brief news release.

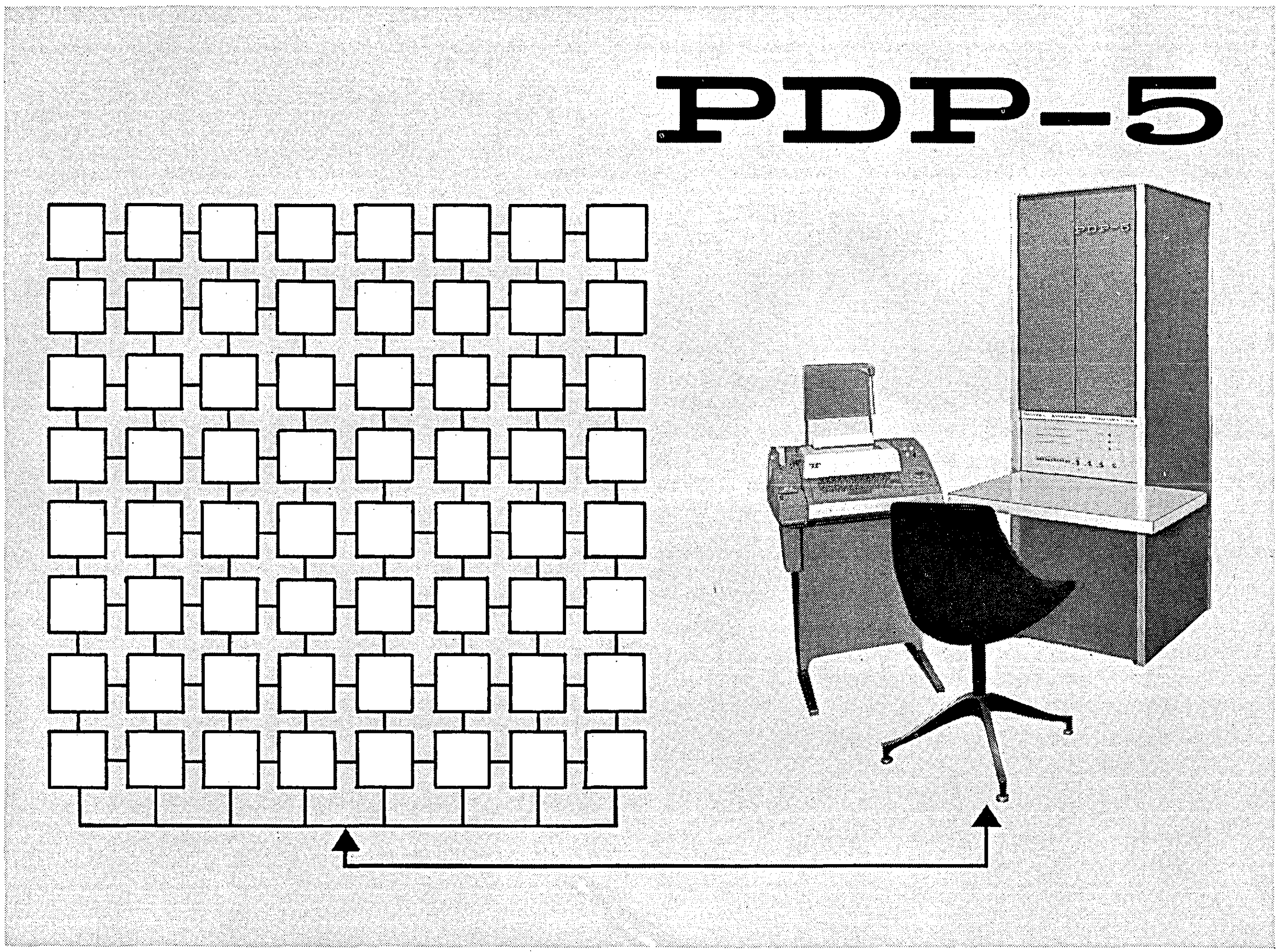
Preliminary specs include a basic core memory of 16,384 48-bit (plus three parity bits) words; cycle time of 1.5 usec; two instructions per word; six 15-bit index registers; up to four buffered I/O channels of three types (12, 24 & 48-bit); maximum I/O transfer rate is over 1-million 12-bit characs/sec. A 48-bit floating point add requires 3 usec, including access.

DOD COMPUTER PURCHASES NEARS 40% MARK

The Defense Dept. has scheduled the purchase of 225 megabucks worth of computers. Net savings: $65.9 million/yr., once the break-even point is reached (see p. 21). After purchase, DOD (which has set aside $201 million for the big buy) estimates it will own 40% of its computing gear, according to U.S. Comptroller General Joseph Campbell.

RUMORS AND RAW RANDOM DATA

That RCA 3301 COBOL contract went to Computer Applications, Inc., NYC . . . The 1004 and the new, gp version of the Univac 1050 will be marketed abroad by Univac International, not by ICT . . . We hear that GE has included thermoplastic recording in one of its dp proposals . . . A CDC spokesman says the company thinks it can sell between 16 and 50 of its big 6600 systems . . . Rumor is that initial Autodin updating will be restricted to 10 new overseas switching centers; some 10 proposals have been received -- a decision is expected in several weeks . . . Two new, if radically different, anthologies of interest to computerites are out: Computers and Thought (McGraw-Hill), and A Stress Analysis of a Strapless Evening Gown and Other Essays (Prentice-Hall). Both contain articles previously published in Datamation . . . John Postley has been appointed chairman of ASA's X3.6 subcommittee on problem description and analysis . . . The DCA contract for the first phase of a study of a new command & control language has been held up by LBJ's economy drive.



FOR ECONOMICAL SYSTEMS CONTROL—THE GENERAL PURPOSE PDP-5 DIGITAL COMPUTER AT ONLY $24,000.

Installation by installation, DIGITAL's Programmed Data Processor-5 is delivering more value per dollar in control applications than any other general purpose computer on the market. It can receive signals from or generate commands to as many as 64 external devices directly connected to its input-output buss. It has a fast, 6-microsecond memory cycle time which permits real-time data compilation and processing or recording. And it comes with a complete software package based on simplified instructions for ease of programming.

Among the many other PDP-5 features:

- 55,555 additions-per-second computation rate
- 2-megacycle bit input via built-in data channel
- 24-bit arithmetic
- 1024- or 4096-word, random access, magnetic core memory
- Analog-to-digital converter wired into basic machine (converter modules optional at slight additional cost)
- Software package includes FORTRAN, assembler, double-precision, floating point, and maintenance routines

Computer with 1024-word memory, printer-keyboard, and paper tape reader and punch is only $24,000; 4096-word memory option, $3000 additional.

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CIRCLE 16 ON READER CARD

WASHINGTON REPORT

DOD'S PURCHASE POLICY AROUSES FUROR

The Defense Dept.'s recent decision to purchase some $200 million in computers now under lease (to be implemented by the end of Feb.) has aroused considerable apprehension among second-rank manufacturers -- that is, all except IBM. Their worry is that DOD will select its purchases largely from its supply of 1401's, 7080's, etc., thus locking the DOD market even tighter in the IBM grasp and, adding insult to injury, with what competitors consider to be outmoded equipment.

Criteria for selection of hardware to be purchased, according to a DOD spokesman, are that the computer be a "stable" system (unlikely to need replacement soon) and that its "payoff" be assured. "Payoff" date refers to that time when accumulated rental fees exceed the purchase price. According to the DOD, no system is being purchased with a payoff date of more than 40 months.

The General Accounting Office, however, has lamented that equipment picked for the purchase treatment would not in all cases yield the greatest economic benefit to the government. Having been a strong advocate of computer purchases as opposed to lease, GAO is following DOD buy-activities closely. The watchdog agency feels that by failing to purchase late-model equipment which may not necessarily meet DOD stability specs, the military is not achieving "optimum" use of the funds available, since this equipment could well be used second-hand by other agencies.

Meanwhile, back on the civilian side of the fence, there was more or less general chagrin about the sudden blizzard of purchase orders from DOD (outside of the serene IBM bailiwick). The DOD move was made "damn fast," according to one disgruntled computer marketing executive who claimed to have lost several prime sales prospects through the action. Others were doleful about the future. "We'll have to go into the used computer market to close a lot of deals now, and what am I going to do with a second-hand 650?" asked one non-IBMer.

A few silver linings, however, were seen by some in the cloud. The purchase decision may provide a lever in future sales to divert at least a portion of the vast IBM share of the government market to other manufacturers. "New specs will easily show up the inadequacy of much of the equipment being purchased," noted one computer sales executive, "and we'll be able to start more or less even on replacement bids."

Also, a number of manufacturers, faced with perennial cash binds, are not unsympathetic with pur-

Continued on page 77

EDITOR'S READOUT

POINT OF ORDER

The news that a proposed standard for flowchart symbols has been submitted to the American Standards Association may not cause wholesale cartwheeling, multi-gun salutes or parades. But it does signal another significant, if small, step forward along the rocky road to clearer man-to-man communications concerning information processing problems.

Unfortunately—or fortunately—the approval of the ASA will not automatically make the proposed standard a real standard, any more then the entry of a word in a dictionary means that people will pronounce or define it "correctly."

The real fate of the proposed standard lies in the hands of its potential users—analysts and programmers, primarily—people sometimes noted for their inclinations toward individualism, which can be defined here as the love of elaborate, arbitrary symbols. This love affair continues until the programmer moves up a notch to a supervisory capacity . . . at which point he begins to hunger mightily for a little more order.

The current proposed standard offers such order. It is a carefully thought out set of 19 symbols which represents a synthesis of the most widely used flowcharting symbols.

Several manufacturers have issued templates which conform in spirit, if not in letter, to the proposed standards. We'd like to suggest that those of you who use a template for something more than a status symbol contact your friendly local computer salesmen for free templates. Compare several against the proposed standard as described in the *Communications of the ACM*, October, 1963, p. 601. Then choose the template which provides the best match of a) the proposed standard, and b) your own eccentricities.

a hazardous exploration

THE FABULOUS WORLD OF REAL TIMELAND

by T. B. STEEL, JR.

In an unusual burst of winter enthusiasm, your Kindly Editor has charged this Humble Author with the task of providing both torch and guideline, the better to lead you, Gentle Reader, through those tortuous caverns opening into the arcane and mysterious world of Real Timeland. Once there, you will be given the opportunity to read the accounts of several former travellers of that realm. Each reports on some particular wonder to be found there. As we venture forth, Gentle Reader, caution must be our handmaiden, for there is no other world of fact or fable that yields taller tales or more exotic myths. For reasons unbeknownst to your Humble Author, the atmosphere of Real Timeland contains some heady potion that elicits from each voyager an epic, usually recounting his adventures in the course of slaying an especially fierce and monstrous dragon. In order to gain a good perspective for judging these accounts, we must reach the heights overlooking Real Timeland and observe that fabulous territory in panorama. Be warned, Gentle Reader, that attaining those heights is not for the faint at heart, for along the way we must meet and vanquish such perverse demons as the Naive Beginner, the Practical Realist and the Knowledgeable Expert, as well as a host of lesser shades; e.g., the Real Time Machine Designer and the High Priest of On-Line.

The problem that confronts us in our journey toward Real Timeland is as simple to state as it is vexing to resolve. What, exactly, characterizes the land that we seek? How will we know when we are there? We cannot take its measure unless we know its boundaries. Care is necessary, however, for it is the function of the various demons we will meet along the way to give us facile but misleading answers to these queries. If we become so foolish as to accept one of these insidiously persuasive half-truths, we will be turned aside from our proper course and unceremoniously dumped into the Sea of Confusion. Upon emerging from these waters we would find our perspicuity sadly dimmed. Thus, we would undoubtedly return to Here and Now effervescing with our own accounts of tantalizing mysteries and fabulous monsters. Forewarned, and armed with courage and a questioning spirit, however, we may safely venture forth with the hope of ultimate success.

As is traditional with such journeys, the first obstacle that must be surmounted is the easiest to overcome. When we meet the Naive Beginner, we will recognize him as a member of an ubiquitous species. He is *always* naive, but unfortunately, *not* always a beginner. It is his task to persuade us that a system is part of the scenery of Real Timeland in the event that the *time* available for the system to perform its assigned tasks is regulated by the *real* world in some fashion. After a moment's reflection, the preposterousness of this position will be apparent to sophisticates such as the Gentle Readers of *Datamation*.

In order to parry this thrust we must first note that, by the phrase "real world," the Naive Beginner means the environment of the system: that portion of physical reality external to the established limits of the system under consideration. It is essential that we adopt this meaning if we wish to give the Naive Beginner's notion any substance, despite its consequence of relegating those parts of the world comprising the system to a limbo of *unreality*. Otherwise, we are confronted with a tautology rather than a definition. We are left, then, with the proposition that a real-time system is any system whose time of performance is constrained by considerations external to the system itself.

Now, Gentle Reader, we are going to perform an extremely clever act. Let us ask the Naive Beginner to

As head of the Information Processing Research staff at System Development Corp., Santa Monica, Calif., Mr. Steel is responsible for directing pure and applied programming research. He is particularly concerned with applications of mathematical logic to dp theory. He is AFIPS rep to the IFIP TC-2 Programming Language committee, secretary of X3.4, and ACM national program committee member. He holds a BA and MA in math from U. of California.

supply us with an example of a system that is *not* a real-time system according to his prescription. Such a system can only be one in which the time available for it to discharge its duties is regulated, if at all, only by the system itself. Short of producing a golem, he is hard put to comply. If it literally does not matter when a system completes its functions, then it seems appropriate to say that the system has no purpose. If we are charitable, we will accept certain apparently purposeless systems as existing for the entertainment of their designers. It would appear that we search in vain for constraintless systems.

In the absence of pointless systems, we might ask if there are any systems that are subject solely to internal constraints. If the sole regulation of an object's behavior is internal to the object, we would be well advised to treat the object as a creature and not a simple automaton. The system would exist for its own sake and be unresponsive to external control. Happily, such systems can be found today only in the pages of science fiction. Should the day ever arrive when a system of this kind has been given embodiment, this Humble Author will quickly employ his *sabots* as missiles, join the Luddites and beg forgiveness for his part in the creation of Frankenstein.

Clearly, if we restrain ourselves to a rational context, *all* systems have time constraints imposed by the world external to the system.[1] Thus, we can conclude, according to the view of the Naive Beginner, all systems that have any purpose and that are safe to build are real-time systems. Obviously, this won't do! There is enough literature available on the general subject of real-time systems to make it plain that the information processing community has some *special* notion in mind when it refers to them. Recognition of this fact disposes of the Naive Beginner's argument and points to our actual problem: how do we capture that special notion and make it sufficiently precise to permit us to determine at least most of the time, whether or not a given system belongs in Real Timeland. Other demons lay in wait to confound us in this matter, however.

Often, when confronted with the argument delineated above—that all systems are, in some sense, externally constrained—the Practical Realist[2] attempts to demolish us with the observation that a system is a real-time system only when it is a matter of serious concern for the designers and programmers of the system that there is a time constraint applied by the external environment. Is this the essence of a real-time system—that it is hard to meet the specifications? This seems to miss the point. It is, perhaps, being a trace—but only a trace—unfair to the sincere proponents of the Practical Realist's view to observe that this notion is equivalent to the claim that a system ought to be considered a part of Real Timeland only if the central data processor of the system is not quite adequate for the task at hand. Would SAGE no longer be a real-time system if, given the same specifications, the programmers were permitted to wallow around in a STRETCH instead of an AN/FSQ-7?

The point raised by the Practical Realist is an important (and practical) one, and it must be given due weight in the proper place. It cannot, however, be considered relevant as a diagnostic instrument for the determination of what is and is not a real-time system. Confusion will reign if the method of attacking a problem is not distinguished from the problem itself. The answer is not the question!

Although we have easily thwarted the Practical Realist with our nasty question, we must beware of overconfidence. The next demon we meet is the most formidable of all, the Knowledgeable Expert. He will commend us on our astuteness in penetrating the muddy thinking of the Naive Beginner and the Practical Realist, and then he will aver that we must surely agree to the assertion that the true nature of real-time systems is the fact that they must meet deadlines. He can support his position by citing the instance of the 1957 Eastern Joint Computer Conference whose theme was "Computers with Deadlines to Meet." Forty-eight papers were presented to that meeting and most of them dealt with systems that we would, intuitively, like to classify as real-time systems. There is, indeed, something persuasive and inviting about the idea that meeting deadlines is *the* characteristic feature of real-time systems. We must take care, Gentle Reader, and remember that the Lorelei was inviting also.

The difficulty with using deadline meeting as the diagnostic criterion for a real-time system is the fact that there are many systems that must meet real deadlines—e.g., payroll—that we would not wish to classify with the real-time systems. Or would we? Certainly the Knowledgeable Expert would not; he means a deadline that is *now* and not next week. There is somewhat the flavor of the Practical Realist in this position—the deadline must somehow *make a difference* to the designer and programmer. Can we quantify the deadline and save the phenomenon? No—the only natural quantification points are zero and infinity, neither doing us much good as the first says there are no real-time systems and the last says that all systems are real-time. We are left with the inescapable conclusion that the Knowledgeable Expert may have the right general idea, but he has clearly oversimplified.

Having surmounted the challenge of the major demons—creatures guilty of the Sin of Sloppy Thinking—let us frame our own characterization of real-time systems with the advantage of our newly gained insight. The essence of the above is that real-time systems are those systems where there is a deadline externally imposed that matters. The piece of the puzzle we have yet to unravel is how to decide when the deadline does matter. We have already rejected—and rightly—any care for whether it matters to the system designers and implementers. Does the deadline matter to the customer or user? There is little operational utility in attempting to answer this question, for the user will always *say* that it matters, even when he doesn't plan to look at the ton of listings that will be sent him. Can we find a more constructive criterion?

Given a system and a job that has some objective utility, we can always establish some performance measures.[3] For example, in a scientific job shop, engineering man-hours saved is a candidate. For an air defense system, lives saved is an obvious, if not entirely satisfactory, performance measure. Commercial data processing systems abound with dollar measures of effective performance. Often we will be able to cite several different measures for the same task, not all of which proceed to their optimum in the same direction. Thus, we frequently have a conflict between elapsed time to completion and total cost. With several relevant measures it is possible to construct meaningful

1. Even the little gadget known as "the world's most perfect machine," a box with a single switch that, following depression of the switch, opens, disgorges a hand that flips the switch and, thereby, shuts itself off, would cease to serve its ostensible purpose of entertainment if it took a hundred years to perform. Would the Gentle Reader patiently wait a decade to get back a debugging run?

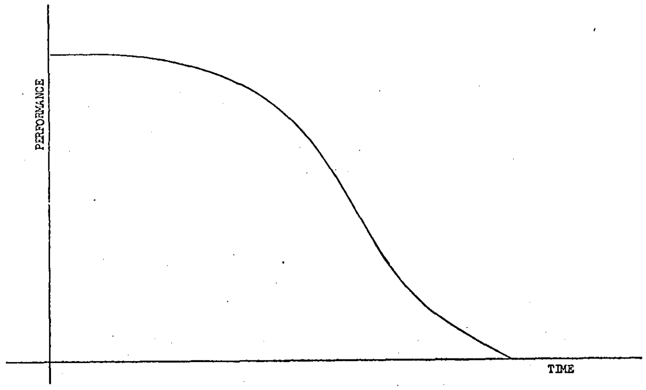
2. The Practical Realist is a common fellow. He is against rigor, theory and philosophy, and he accepts research only when it is conducted with someone else's money. For him, reality begins and ends with today's job file. Tomorrow's tasks are ephemeral and the day after tomorrow is nonexistent. He is accurately classed as the slave of that terrible ogre, Unenlightened Management.

3. Since there are people who will challenge any positive statement, this one undoubtedly will be questioned. We are on sound philosophical ground if we insist that, in the absence of a performance measure for a given system, the burden of proof is on the other fellow to show that the system has any utility. If utility is demonstrated, it can be measured.

linear (or non-linear, if you know what you are doing) combinations of the sundry basic measures. At all events, it seems reasonable to take for granted the existence of one or more objectively calculable performance measures, given a particular task involving an information processing system.

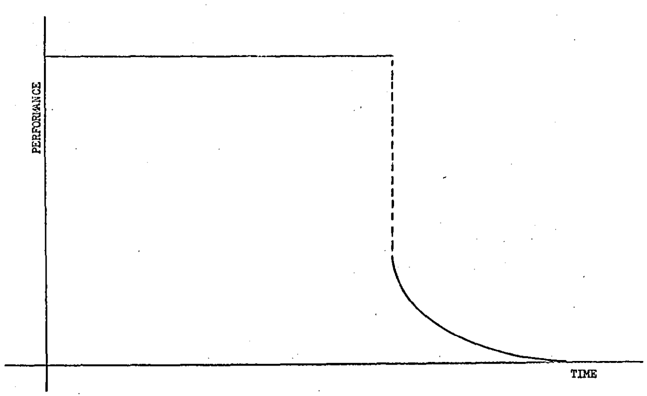
Accepting the existence of a performance measure, let us look at this measure as a function of time of performance of the task. Consider a graph of performance, measured along the ordinate in arbitrary units, against time to completion, measured along the abcissa, perhaps logarithmically. Fig. 1 shows such a curve that is probably typical of an engineering job shop that has yet to succumb to the lure of on-line. Three features of this figure are of note. First, for a range of short response times there is no significant difference in performance. This is representative of the fact that it usually makes no difference to an engineering shop if turn-around time is 30 minutes instead of 15. Second, at some point in time that will vary from application to application, the performance value attained begins to degrade *continuously* with increasing elapsed time. In other words, the longer you wait, the less it's worth. Finally, the performance drops to zero eventually. *That* happens when the airplane disintegrates in the air on its first test flight because the flutter analysis never got done.

Fig. 1



Now let us look at Fig. 2, which shows a different picture. The key feature of this curve is that it has a discontinuity at some point in time. The value of the completed task alters drastically when some established deadline is not met. A guidance system is like this; so is an air defense system. Further, a payroll application has this property (if you think not, just try getting the paychecks out a day late), and an airline reservation system does not. Since the astute will have perceived that we are going to identify systems that behave as illustrated in Fig. 2 as real-time systems, it is worth elaborating on the point that SABRE and its ilk are *not* real-time systems despite usual claims to the contrary. Is there some specified length of time that the potential passenger will wait for his reservation to be processed, after which he will depart for the railroad station? Hardly; he just gets progressively more and more annoyed (thus, a continuous degradation of performance for the system) and eventually leaves, his time constant being an individual function, dependent, among other things, on the state of his stomach, the persuasiveness of the attendant and whether his trip was to visit his mistress or mother-in-law. The specifiers of the system may say that the customer is not to wait more than X minutes, but this is not related to any *real* discontinuity in the behavior or may not be big enough and fast enough for use in some of the system. If the programmers can't quite meet an established deadline of, say, five minutes, the system specifiers can relax their requirements a bit, make the deadline six minutes and the loss in performance is hardly catastrophic.

Fig. 2



As has been pointed out by that demi-demon, the Penetrating Critic, it is true that an objective deadline can be found for the airline reservation system: when the plane takes off. When the system is being used by customers lined up at a counter at the airport, there can be a real-time flavor to its performance. However, the principal utility of these systems is for advance telephone reservations and the considerations of the previous paragraph apply. If the system designer's main concern was making sure the system responded in time for takeoff, even when that deadline is two weeks away, your Humble Author would pawn his Air Travel Card and buy Southern Pacific.

We have now left the darkness and reached the light, Gentle Reader. The True Nature of real-time is before us. What insights does this view give us? First, let us look back at our diagnostic Fig. 2. Prior to the critical time the curve is flat. While this is not necessary for a real-time system, it is usually the case. As long as everything is accomplished by the deadline, it doesn't matter how long it takes; in most real-time systems the works simply idle if things get done ahead of time. Thus, there is no virtue in minimizing the time taken in contrast to the non-real-time situation. One could argue from this that real-time programmers don't have to be as good as others, as long as they are good enough. On the other hand, outside of real-time, the sloppy programmer is less likely to get caught, for he can slowly fritter away performance without having a brink to fall over.

A second observation we can make is that classification of a system as real-time or not is dependent on the performance measure chosen. To an accountant who measures performance in terms of dollars expended, the approach of a budgetary ceiling may signal a discontinuity in the performance curve, while a researcher, who could care less about a slight overrun in project cost, may be glad to get results whenever he can. Thus, the classification of systems is relative to the performance measure.

Finally, let us note that real-timeness is *not* identical with on-lineness as is sometimes implied by those prone to revere that slightly suggestive word "symbiosis." Let us further note that the idea of a general purpose computer being a real-time computer is foolishness. A machine may or may not be good for a given application and it may or may not be big enough and fast enough for use in some given real-time system, but it cannot be designed for real-timeness any more than it can be designed for non-real-timeness.

Having been guided this far, Gentle Reader, you can now be safely left on your own to explore the byways of Real Timeland and distinguish in passing between those monsters that are real (and there are many) and those that are imagined (of these there are also many). Good luck and good hunting. ■

ON-LINE MANAGEMENT INFORMATION

Part one: planning a system

by NORMAN J. REAM

The past decade has seen the evolution of the use of electronic computers and the evolution and recognition of formal management information systems. The planning and formalization of these management information systems and the accompanying necessity of integrating them on a company-wide basis is a massive and difficult undertaking. The development of integrated information systems on a batch processing basis is difficult enough, but when we consider an attempt to place such systems on a true real-time basis, the problem becomes so large it staggers one's imagination.

Paralleling the evolution of more formalized business systems was the use of computers in process control, probably the first major use of computers in the real-time business environment. Examples are the introduction of numerically controlled machine tools into manufacturing operations and the development of computer controlled chemical process operations.

Closely associated with these latter developments was the development of military command and control systems that combined control of a process with the production of formally structured information. An example here is the SAGE system.

A real-time management information system may be defined as a system whose primary product is management information, as opposed to systems, such as process control and command and control, in which the production of such information is treated as a byproduct. This field is new although there are examples of limited applications of such systems. As in any new area there are many problems to be solved.

Management and the information system within which they must operate are inseparably interdependent. The accelerating pace of technological advancement and the anticipated accompanying shorter product life-spans, together with the increasing rapidity of changes in marketing climates, means that management reaction time to change in all areas must be speeded to the greatest degree possible. Consequently, we must recognize that management cannot continue to rely upon existing reporting cycles nor can they continue to place their dependence on historical information. Rather, management must have immediate

Mr. Ream is director of Systems Planning for Lockheed Aircraft, Burbank, Calif. Listed in American Men of Science, he was a U.S. delegate to the U.N. conference in Geneva on the Application of Science and Technology for Less Developed Areas. He is a member of the CODASYL executive committee and the Senior Planning Council of the American Management Assn. His former associations: Lever Bros., IBM, George Fry & Assoc., Touche, Niven & Co., Pure Oil Co.

access to the effect of changing conditions on their present management climate as well as a means of determining the effect of current conditions on planning strategy.

The problem facing management today is not what actions should be taken to meet present conditions, for those actions should have been taken yesterday; rather the problem is what action must they take today to meet future conditions and to insure corporate survival.

My intent here is to point out some problems involved in implementing real-time management information systems and to suggest some solutions to these problems. Basically the problems fall into three categories: hardware, systems design and programming, and management use of these systems.

what is a real-time management information system?

A control system is a combination of a data processing system, a management information system, and a feedback system. If corrective action is taken while the process is still going on, we have a real-time control system. Further, there are three levels on which a real-time system may operate. First, if the system accepts input directly, processes it, compares it with predetermined parameters, and issues instructions to men and/or machines, we have a real-time control system. Second, the computer may inform affected parties of this information as it develops. This level may be termed real-time communications. Finally, suitable condensations of the information derived are prepared for higher levels of management. Here we have a real-time management information system.

Generally then, we may define real-time systems as those systems that keep pace with "live" operations, accept data directly without manual conversion, process these data and establish relationships among data of disparate types. Further, they output data, on demand or as a result of programmed logic, to men and/or machines in a *timely* and *digestible* form.

For purposes of this paper, however, a line must be drawn between command and control systems and real-time management information systems.

If a system exerts direct control over the physical environment from which it accepts data, I will classify it as a command and control system. Examples of these systems are the SAGE, BMEWS, and Mercury systems.

We can define a real-time management information system as one which monitors the physical environment but exerts control only indirectly by the production of management type reports or displays. Examples here include existing airlines real-time reservation systems, various savings bank systems, and Lockheed's Automatic Data Acquisition (ADA) system. These systems may have primary functions other than management reports. However, they all use the data gathered by the computer to provide management with structured information. This latter type of system will be the one which this paper will discuss.

why a real time management information system?

In order to answer this question we must first define the term "management information system."

Managers need communications systems or reports. These reports may be considered under the general headings of Planning, Control, and Operating reports. In order to exercise control, management also needs specifications of objectives, criteria for evaluation of performance, decision rules for corrective action, and a feedback system to evaluate the effectiveness of corrective action.

Planning reports evaluate the position of the company in industry as compared to other comparable business entities. These reports include alternate courses of action available under a series of predetermined premises.

Control reports inform top management of operating performance as compared to predetermined performance standards.

Operating reports inform functional management of the current performance of operations within a given function. Normally these documents include a comparative analysis of current operations and operations for a previous period, as well as current performance as compared to predetermined detailed standards.

In addition to these reports, a real-time management information system can develop byproduct data to produce new criteria for performance evaluation, particularly of a statistical nature, at virtually no additional cost.

For instance, tighter control of materials and more efficient production scheduling are being realized through the Lockheed Shop Order Location system. Reductions in clerical and data origination costs are being attained in many systems through the use of real-time recording of payroll and labor distribution transactions. An increase in sales may be brought about by real-time inventory control which allows management to make better use of available inventory.

In addition, the use of a real-time system can make more profitable use of computer time. Using the classic batch-processing techniques of file updating and reporting, approximately 40% of the computer time is spent in sorting. Additionally, about 20% is spent on set-up time. The random up-dating of files eliminates most sorting and set-up time.

We are finding that in today's complex corporate world, data origination is rapidly becoming prohibitively expensive. The high cost of recording, accumulating and converting operating data to machine sensible language, combined with the fact that batch processing techniques cannot supply "time current" information, have led to an increasing need for on-line, real-time systems.

Early real-time systems were usually quite large and even today most real-time systems being installed use large scale computers as their central hardware. However, there have been real-time management information systems on a rather small scale.

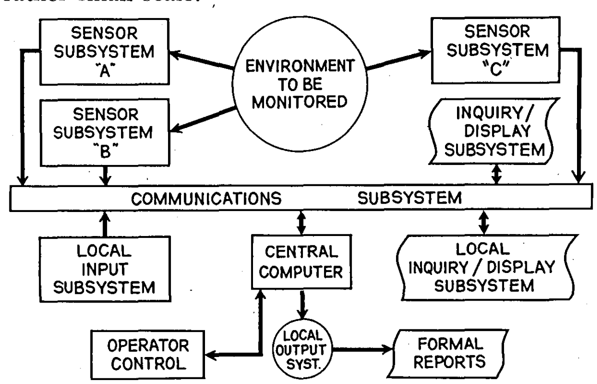


Fig. 1 Organization of a Typical Real-Time Management Information System.

As an example of one of these, an electric typewriter plant has installed a real-time quality control system centered around a small scale random access computer. The system has proved very profitable to the manufacturing operation and yet the total machine rental is less than $5,000 a month.

real-time system components

All real-time systems are composed of generally the same subsystems (Fig. 1).

There is always a number of data acquisition or input devices, a communication system including any necessary interfaces, a central computer, and an input and output system within the computer center. Usually the system will also include remote inquiry and output devices.

Input sensor devices usually allow the use of a coded badge or card together with a punched card and variable keyboard information. Needs in this area run to lower cost units of higher reliability and more flexible operation.

Output devices are generally of one of two types. The printing device such as the teletype page or strip printers and the flexowriter, or the newer CRT display devices. Requirements here again are the classical ones of lower cost and greater flexibility.

The communications network invariably plays a large part in the real-time system. Present networks commonly make use of multipart cable, standard telephone lines, radio or TV channels, or microwave links. Generally, capacity of these systems varies with the cost.

The central computers in a real-time network may occur in varying configurations and each of these configurations has its inherent advantages and disadvantages. The choice of a particular configuration depends in large part upon the system's requirements and in turn has a strong effect on the overall system performance.

Because the choice of a particular configuration is of such importance to the design of a system and to its eventual success, let us examine the seven basic hardware configurations.

The simplex system (Fig. 2) provides no standby equipment. Among its advantages are: It is the least

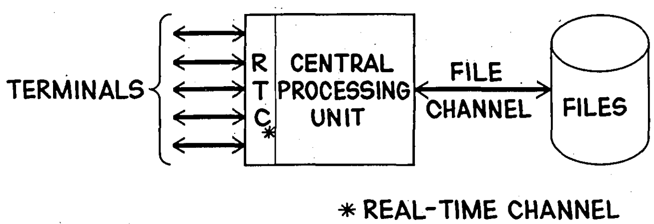


Fig. 2 Simplex System

expensive from a hardware standpoint and, therefore, tends to be easier and cheaper to program as there are no complex routines for switching between two or more computers. Significant savings can be realized through the use of a simplex system, providing one is willing, or able, to lower system performance standards in the area of back-up. The system must be off-line during maintenance, and recovery in the event of hardware unavailability must be manual. This, of course, requires that part of the savings in equipment and programming costs be reinvested in an extensive manual back-up system.

If it is satisfactory, for instance, for the system to operate 16 hours a day rather than 24 and if it requires, say, 90%, rather than all of the transactions to be handled immediately, the simplex system may well be the best.

The next configuration is the simplex system with an input-output multiplexor (Fig. 3). The multiplexor is a

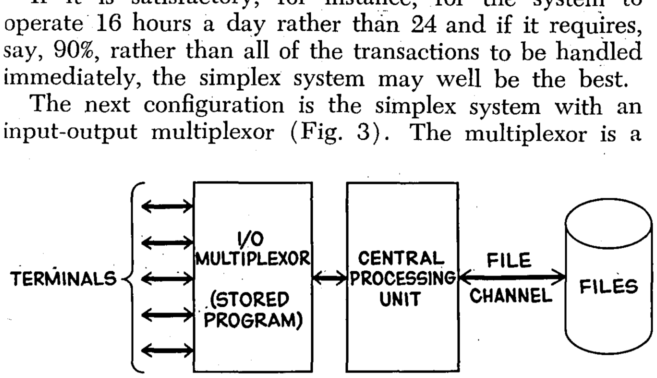


Fig. 3 Simplex System with Input/Output Multiplexor

simple stored program computer which acts as an interface between the communication terminals and the computer. It may be a simple buffer or may be more sophisticated to the point of accessing the main computer only when access to the files is necessary. The advantages of this configuration include added modularity—changes can be made in the multiplexor to effect different scan rates, changes in priority, etc., without disturbing the central processor programs. Also, the memory allocations within the central processing unit are simpler because input-output and queue functions are controlled within the multiplexor. The disadvantages of this system are higher equipment cost, program interface considerations, and more complex reliability considerations. In addition, program testing begins to get complicated.

In this configuration (Fig. 4) we have added a file multiplexor, which acts as an interface between the com-

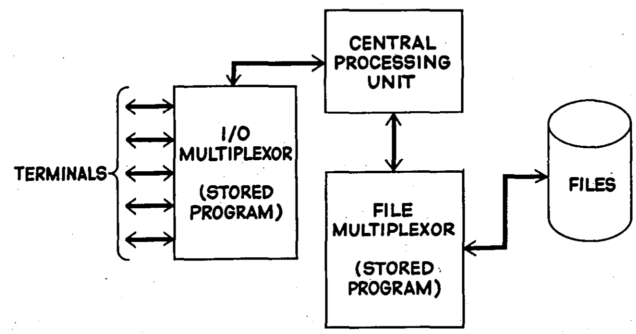


Fig. 4 Duplex System with Input/Output and File Multiplexors

puter and the data files, to the previous system. Now the central computer is free of all specialized functions. The advantages and disadvantages are the same as for the previous system except that we have the added advantage of removing file access considerations from the central computer and the added disadvantages of programming for still another machine and of further complicating hardware reliability considerations and testing procedures. Incidentally, a new possibility is opened here of a direct route between the I/O and file multiplexors, by-passing the central computer altogether except when processing is necessary.

Here (Fig. 5) we have the first step in the configuration hierarchy that employs two computers. This system is well suited for any situation where a heavy load of

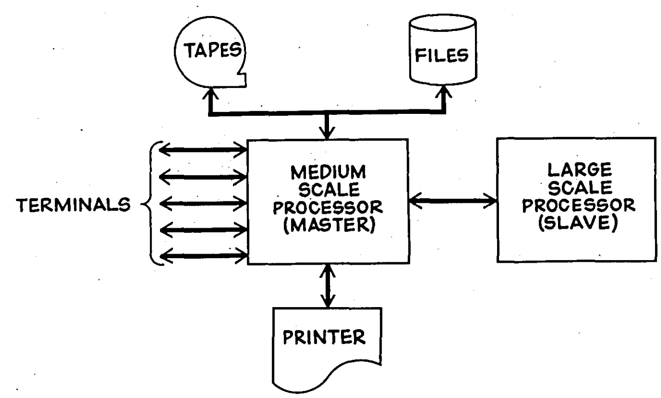


Fig. 5 Master/Slave System

internal computation exists. All housekeeping and scheduling functions are taken care of in the medium scale master computer, leaving the slave, a powerful large scale system, free to perform computations. Typically, the master receives data or information requests from the outside world and prepares all necessary tables, files, subroutines, etc. It then sends the entire package to the slave which in turn performs the calculations and sends the resultant data back to the master for formatting and output. The advantages of this configuration are more computation capability per dollar, provided the medium scale computer's cost can be justified, and automatic, one-direction back-up, i.e., the master can continue to receive, prepare, and batch input while the slave is unavailable. The disadvantages include high equipment cost and the complexity of the control programs.

The fifth configuration is called the shared-file system (Fig. 6). It is quite similar to the master-slave configuration and in fact the master-slave complex could use

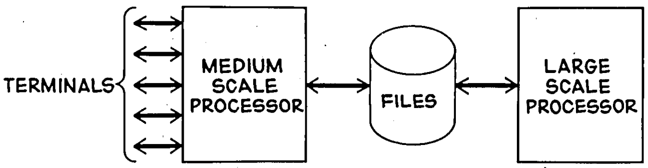


Fig 6 Shared-File System

the shared-file concept. Here again the medium scale processor is the scheduler and controller and the large scale machine is the computation device. There is added flexibility here because the medium scale computer can prepare jobs and place them on the file while the large system is busy. Both systems scan the file at intervals, the large system to pick up jobs and the medium size computer to get the answers. As in the previous configuration, this system need not operate in real-time. The advantages and disadvantages here are the same as those for the master-slave system with the added disadvantage of having to develop programs to accomplish data transfer between the file and both of the CPU's.

Here we have the duplex or dual configuration (Fig. 7): two complete hardware systems, either of which is able to perform the total job.

In the duplex system the second machine is not on-line and must be switched over if the primary system fails

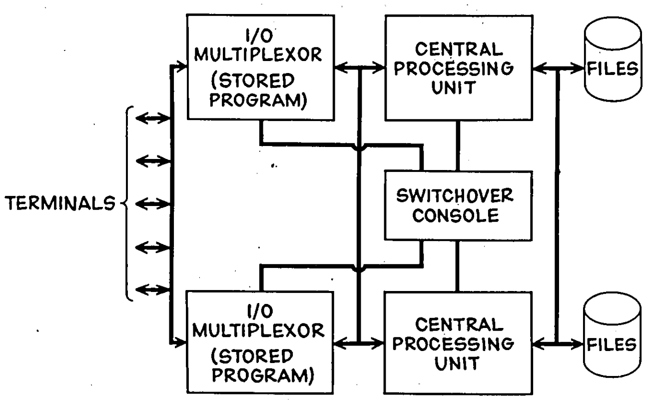


Fig. 7 Duplex or Dual System

or is taken off-line for any reason. The standby system, therefore, may be used for off-line batch processing, although it must have an interrupt built into its program monitor. In the dual concept both systems are on-line in parallel, performing the same functions except that output is generated by only one computer. Checking is carried on constantly, comparing the results obtained by the two systems. The dual system is generally considered the ultimate in reliability, but interestingly enough carries with it some fascinating problems, such as which machine is right when they are in disagreement? The dual system is, of course, more expensive than the duplex in terms of work accomplished, but also provides more reliability. Programming considerations are extremely important here as the complexity of control, monitor and switch-over programs may readily be seen. Most problems inherent in this type of system concern themselves with the transferring of information from one system to the other, the ability to update a system that has been off-line without interrupting the system that is functioning in real-time and the ability to preserve memory contents under an equipment failure. The general question here is "How far does the user go in search of reliability?" Project Mercury is a full dual system while Sabre, the American Airlines reservation system, is a duplex configuration.

Finally, the multiprocessing system (Fig. 8). Here we have two or more computer systems each doing more

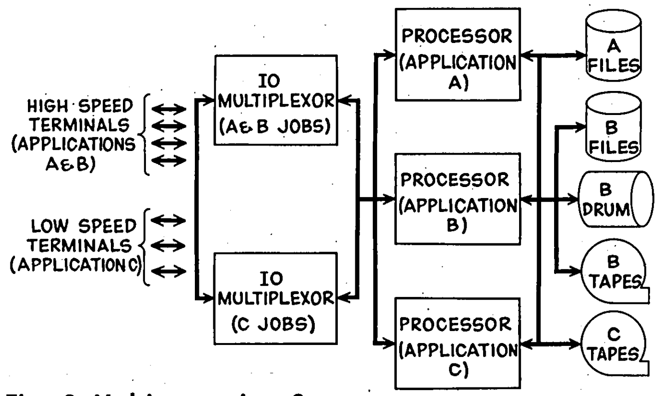


Fig. 8 Multiprocessing System

than one job. Standby in this system is on a "degraded" basis. That is, when one system goes off the air another in the network may pick up the load. Because the computer picking up the load must also continue to perform its own tasks, a lengthened system response time usually results. Hence, the term, "degraded service." Depending on the configuration of the individual computers, any one may not be able to take over any other's task. These systems tend to be geographically separated. When one center goes off the air, another temporarily takes over its duties. SAGE has this type of standby ability. However, in addition, each SAGE site is duplexed as well as being a multiprocessing system. The advantage of the multiprocessing system is standby reliability at a lower cost than for a duplex system. The disadvantages include a lower quality of service when one system is down, the difficulty of performing reliability analysis on the system because of the complex interdependency of the units, and the fact that the planning, development and testing of programs and specially of control programs is extremely difficult. ■

(Next month, the author will examine installation considerations, general implementation problems, with special emphasis on the organization of the programming effort. He will consider the problems of auditing a real-time system, of training the personnel involved in implementation and operation of the system, and the peculiar problem of protecting the information stored in the system's files from misuse. Also, he will consider what he believes to be one of the most important factors in the development and use of any real-time management information system: the participation of management.)

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A REAL-TIME DATA HANDLING SYSTEM

communication among decentralized computers

by WALTER BAUER and SHELDON SIMMONS

The Real-Time Data Handling System (RTDHS) of the Pacific Missile Range will provide the basic range capability for communicating, processing and displaying data for and during operational tests and missions which fall under PMR cognizance. It will provide an important control and coordinating capability for much of the instrumentation of the range. The RTDHS is, therefore, of critical importance to the basic mission of PMR in providing a capability in the Pacific Ocean area for support to the Navy's and the nation's missile and space programs.

The system is equipped with 10 modern computers of the Naval Tactical Data System type, seven UNIVAC 1218's and three USQ-20B's. These computers are organized into primary sites at Pt. Mugu and Pt. Arguello, and peripheral sites in island and instrumentation locations throughout the range. The computers are linked together with high-speed digital data links, making the system one of the largest real-time systems in the world. It is being installed and implemented during the period of July 1963 to June 1964.

RTDHS mission and requirements

Pacific Missile Range extends geographically across the Pacific Ocean from Pt. Mugu (see map, pg. 32). Its mission is to provide range support for the Department of Defense and other designated government agencies in guided missile, satellite and space vehicle research, development, evaluation, and training programs.

Current U.S. missile, satellite, and space vehicle plans define the need for the following complex of sub-ranges:

1. *A Sea Test Sub-Range,* extending westward from Pt. Mugu for a distance of 500 miles and along the coast to Half Moon Bay. This range will support development of air-to-air, air-to-surface, surface-to-air, and short range surface-to-surface missiles, and fleet training with these missiles.
2. *An IRBM Sub-Range,* extending generally westward 1500 miles from the Naval Missile Facility, Pt. Arguello.
3. *An ICBM Sub-Range,* extending westward to an area between 150 degrees and 165 degrees East longitude from Pt. Arguello.
4. *A Polar-Orbit Sub-Range,* for launching satellites

Dr. Bauer is president of Informatics Inc., Culver City, Calif. He has been engaged in gp computations, missile simulation, and real-time control with digital computers since '51. In '54 he joined Ramo Wooldridge Corp., was director of the Computation and Data Reduction Center at STL and manager of the RW Div.'s Information Systems Dept. He was general chairman of the '61 WJCC and U.S. delegate to the '62 IFIP Congress in Munich. He holds a PhD in math from Michigan.

Mr. Simmons heads the dp branch of the Instrumentation Systems Div., Range Development Dept. at the Pacific Missile Range, Pt. Mugu, Calif. Since 1957 at PMR, he has specialized in data recording and display techniques using both analog and digital systems, and has guided development of computer-based tracking data handling systems for the past 2½ years. He holds a degree in history from UCLA.

southward into polar orbit from Pt. Arguello.

5. *An Equatorial-Orbit Sub-Range,* for launching satellites eastward from Pacific Islands in the vicinity of the equator.
6. *An Anti-Missile Missile Sub-Range,* for developing and testing anti-missile missiles, using as targets ballistic missiles fired from the West Coast.

The initial functional requirements of the PMR RTDHS are to provide data handling support for the following:

1. Ballistic impact prediction to insure range safety,
2. Tests involving airbreathing, air-to-air and ground-to-air missiles,
3. Ballistic or perturbed (controlled) impact prediction to facilitate recovery,
4. Orbiting vehicle control to alter free body path as for insertion into orbit, conjunction of two freely orbiting vehicles, or re-entry control of free-orbiting vehicles.

All four of these initially specified functions imply careful consideration of the following data handling and processing operations: recording, assessment, conversion, correction, correlation, selection, computation and transmission. They are involved in the PMR operations discussed in the following paragraphs.

Range Safety is a requirement to be satisfied in every launching operation. The protection of inhabited areas and the range itself is accomplished by methods now well established; however, it is expected that these methods will change as the character of vehicles and tests changes. As the dynamic performance of the vehicles obviates the use of human decision due to response time, semi and fully automatic range safety decisions, now in early use stages, will become more frequently used. However, human decision and override capability will be an essential part of range safety for years to come.

Sea Test Range Operations are heavily dependent upon the operation of the RTDHS. The sensors and the RTDHS are of more importance here than in ballistic or space vehicle launch operations since they provide command operations capability in addition to normal range safety support. Among the more challenging of the sea test range operations from a data processing standpoint are the air-to-air and ground-to-air missile firings. These tests require command and control of the delivery and target vehicles. These aircraft must be acquired, tracked, and commanded in order to carry out the missions within the framework of the mission profile, system configuration and the time and safety constraints. Because of the variety, these operations provide a continuously challenging requirement to the system.

Recovery Point Impact Prediction by tracking methods poses a difficult problem, particularly if there are no sensors in the immediate area of impact. However, if sufficient instrumentation and mathematical accuracies are achieved in tracking, and if the programmed mathematical models of the earth and other parameters are adequate, impact prediction for recovery can be very good even though the source data used for prediction are taken a long distance from the impact point. The accurate and rapid calculation of vehicle trajectory for timely transmission to down-range tracking stations places a heavy responsibility on the RTDHS.

Orbital Vehicle Control or control to enable vehicles to be placed into, removed from, or altered in orbit, is a function which has been done only in the most rudimentary fashion to date. It is expected that with testing programs on more sophisticated vehicles, the need to exercise control more precisely and reliably will exist. In fact, the precision with which this can be done will spell success or failure for many programs. A large step toward the achievement of orbital vehicle control is in attaining a tracking and computing capability of such a degree as to provide extremely accurate real-time data of vehicle paths.

In time, the RTDHS will be subjected to improvements and modifications. These will result from an increased rate of launchings and an increase in the number of multiple launchings. Also, pre-launch operations will become more automatic and more complex, and additional computational requirements will result from increased accuracy requirements, more intricate range safety problems, and the increase in dynamic missile performance. Many of these changes are tied into man-in-space programs and space probes.

There are a number of ways of describing the functions which the RTDHS is to perform. The following paragraphs are a discussion of the various functions to be performed by the system from the operations viewpoint.

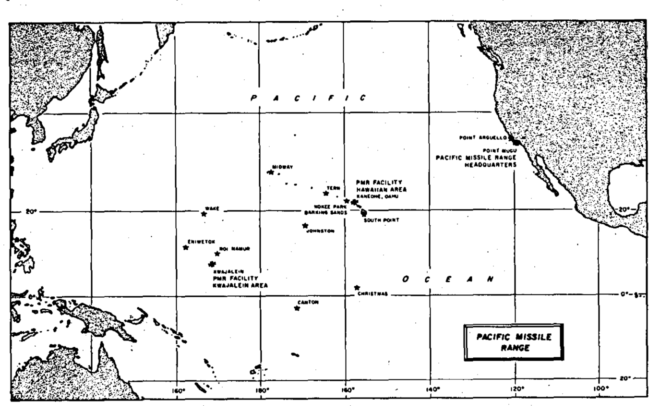
Impact Prediction. Range safety operations are of primary importance for the system. Computers must perform operations which predict the surface impact of a missile at any instant of time. This aspect of impact prediction is associated with the powered flight phase of the mission. After termination of thrust, computations must be made to predict the re-entering vehicle's impact point for recovery or anti-missile operations. One operation which is associated with impact prediction is the prediction of an impact area as a function of "no-data" status, a period when data is lost, unavailable or is invalid for a number of successive cycles. Concomitant with impact prediction are command control and destruct functions which base their decisions upon the predicted impact point and whose program subroutines have priority in the processing queue during critical phases of flight as, for example, during periods of "no-data."

Tracking. The basic source of data for all RTDHS activities are the sensors engaged in tracking the missile or aircraft. This requires proper reception of the data at processing sites and the appropriate processing necessary to obtain, within the proper parameters, the trajectory of the vehicle or vehicles. Inherent in these parameter restrictions are functions such as data smoothing, data point rejection, and "statistical best" selection of data.

Radar Acquisition and Handover. Since all radars in the system cannot, because of horizon distance or topographical limitations, "see" the target at all times, target tracking data must be passed from radar to radar during the first phases of the operation. The computer therefore performs the important task of assigning primary tracking responsibility from radar to radar. Handover refers to the act of assigning primary tracking responsibility to a sensor which can now "see" the target, is actively tracking it, and is sending the computer "good" data.

Orbital Computations. A growing requirement of in-

The Pacific Missile Range



strumentation data handling systems is assistance in the determination of the orbits and re-entry trajectories of orbiting or space vehicles. Future range operations will require increases in the use of the system to refine orbital data based upon sensor measurements and to assist in the re-entry and landing operations of future manned space vehicles in the Pacific and Western U.S. areas.

Data Handling. There are large amounts of data which must be collected and appropriately routed to various instruments during any range operation. An important computer function may be to gather radar data and simply transfer it to a communications buffer for transmission to another site; here the computer is acting much like a store-and-forward center in a communication system. Another example is the preparation of data for display purposes. This may involve outputting data to light indicators or other similar devices, or might require the transformation, scaling, formatting and outputting of data for continuous output to plot boards.

Pre-Launch Operations. The system must perform self-diagnosis checks, and aid in the diagnosis of mission-dictated on-line instrumentation. Computers must check themselves to see if they are working properly and then provide data handling operations to check the collection, transmission and display of data. Likewise, certain operations are necessary to prepare parameter data for the real-time operation. An example is the analysis of winds aloft to determine whether they will have a serious effect on impact prediction.

Post-Launch Operations. This involves the analysis of data which has been collected during an operation or the preparation of it for future reference or analysis.

From the point of view of computer or data handling operations, the functions of the RTDHS may be listed as follows:

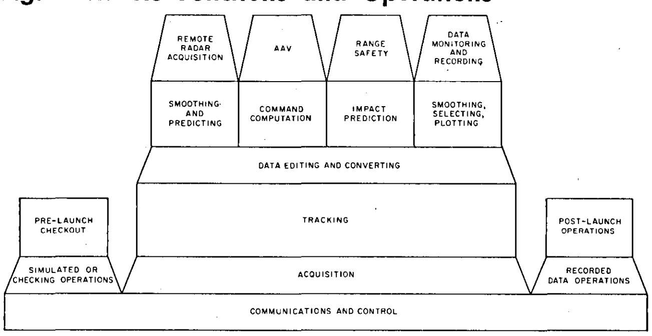
1. The handling of communications from local sensors, remote sensors, and/or to and from control points. These data are then used to control instruments such as sensors, communications equipments or display devices.
2. The recording of data on various storage media such as magnetic tape.
3. The output of data to display, plotter or printer devices for real-time or "off-line" uses.
4. Data computations for mathematical and logical decisions.[1] In this function, the computer provides "intelligence" for the system and enables rapid decisions based on preformulated criteria.

In Fig. 1 there is presented a schematic of a number of the functions and operations which RTDHS performs.

system organization and implementation

There are a number of possibilities for organizing RTDHS, ranging from one super-scale centralized installation to numerous smaller installations, perhaps one for each FPS-16 radar. Also, many control approaches would conceivably be feasible—centralized control, decentralized control of independent installations, etc. The following considerations are important to the equipment selection and system organization.

Fig. 1 RTDHS Functions and Operations

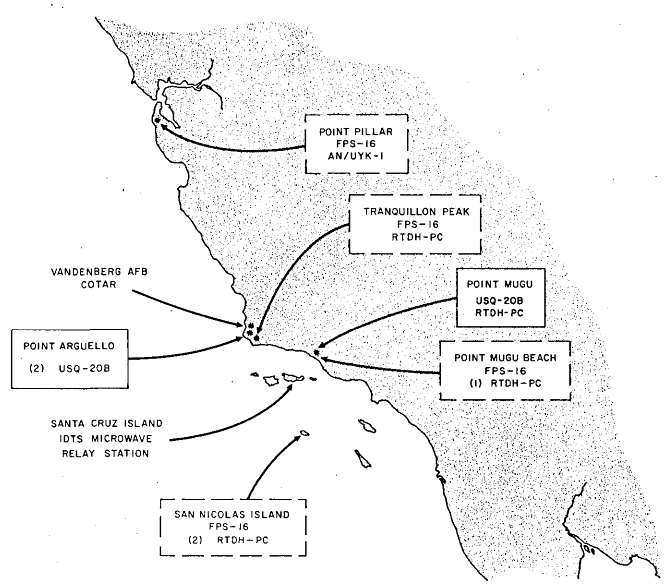


1. A computer capability at the sensor location to accommodate efficient handling and control of instrumentation. Because of this decentralization of the data processing effort, added flexibility would be achieved by the system's ability to operate independently of the central computers. Inherent in the decentralization concept is a reduction in communication problems.
2. The system must be communication oriented. It must always be capable of automatically scanning at high speeds all data lines, and be able to switch various functions and responsibilities to and from subsystems in real time. In addition, it must record data from these subsystems.
3. A computation capability which would provide efficient performance of required mathematical and input/output operations within the stated time parameters; and designed to operate on the philosophy that during future years the cycle time parameters will be inversely proportionate to the number of input/output operations to be performed.
4. The expansion and growth capability which comes about through the addition of computer modules which can be added to the system at the various system node points.
5. A flexibility in system design which would allow a variety of configurations, and the option to subdivide a number of subsystems into separate entities, each having its own control point.

Two groups of computer equipments were selected to meet the above requirements. They are the 1218 (or AN/UYK-3A[2]) and the CP642B/USQ-20, both manufactured by the Univac Div. of the Sperry Rand Corp. These computers will be placed at various system node points, providing a modern approach to data handling systems, and offering the following:

1. They are members of the family of equipments used in the Naval Tactical Data System (NTDS). They

Fig. 2 Geographical Location of Equipment



[1] For example, impact point computation and selection of "best" data from two or more radars.

[2] Unoffical designation pending final Naval acceptance and designation of the computer. Hereafter referred to in the text as the RTDH-PC.

are real-time communication oriented, and have many common characteristics.

2. They are militarized equipments of proven high reliability, and are familiar to Naval operations due to their widespread use.

Fig. 2 presents a map showing the geographical locations of the various equipments in the system and the sensors associated with the system. The larger computer, CP642B/USQ-20, called the Q-20B, is located at Pt. Arguello and Pt. Mugu, which are referred to as "primary sites." The smaller computer, the RTDH-PC, will be located at Pt. Pillar,[3] Tranquillon Peak, Pt. Magu beach area, and San Nicolas Island. These locations are referred to as "peripheral sites." Note that multi-computer installations are planned at Pt. Arguello, Pt. Mugu, and San Nicholas Island.

Generally speaking, the primary sites perform high level, real-time command and control functions, both communication and program dictated, and impact prediction for a variety of operations. Peripheral sites provide a local or "on-site" capability for real-time communication, data editing and processing.

Certain examples of operations may be derived from Fig. 2. For Western ICBM launches, Pt. Arguello radars (including Tranquillon Peak) first acquire the missiles along with the COTARS (Correlated Orientation Tracking and Range System) at Vandenberg Air Force Base. Subsequently, Pt. Pillar and San Nicolas Island range instrumentation radars designated FPS-16's acquire the targets, based on acquisition data sent them from Tranquillon Peak and Pt. Arguello.

For sea test range operations, tracking data for aircraft flying a general north-south direction along the coast are passed between San Nicolas, Pt. Mugu, Pt. Arguello and Pt. Pillar radars. The computers at each location must receive and act upon tracking data when primary tracking responsibility is assigned them, and also perform required communications and computational tasks while actively tracking. During all of this, the Q-20B is providing the basic command and control functions from the primary site at Pt. Mugu.

The basic system philosophy evolving for the RTDHS is one of equipment decentralization with, however, an organization of communications and command/control to effect centralized coordination, and allowing, at all times, the ability to configure into a number of smaller, autonomous systems. The advantages of this philosophy are increased system flexibility and reliability, and a reduction in communications requirements. For example, it is clear

Fig. 3 Site Missions and Functions

PERIPHERAL SITES

RANGE OPERATIONS	CONTROL FUNCTIONS	COMMUNICATIONS	DATA SOURCES AND DESTINATIONS	EQUIPMENT
Raw Radar Operations	Local Monitoring and Control	DATA IN	SOURCES	Character Buffering
Communications Handling		Raw Radar	Radars	Single Computers
Data Recording		Command/Control		Minimal Peripherals
Pre-Launch Checks		Acquisition Radar		
Local/Terminal Impact Prediction*		DATA OUT		
Acquisition Data Computation*		Raw Radar		
		Corrected Radar		
		Acquisition Data*		

PRIMARY SITES

RANGE OPERATIONS	CONTROL FUNCTIONS	COMMUNICATIONS	DATA SOURCES AND DESTINATIONS	EQUIPMENT
Raw Radar Operations	System Communications Monitoring	DATA IN	SOURCES	Word Buffering
Communications Handling	System Computer Monitoring	Raw Sensor	Radars	Multi-Computers
Data Recording	Computer/Communication Task Assignment	Corrected Sensor	Cotars	Extensive Peripherals
Pre-Launch Checks	System Mode Changes	System Status	Ship Gyros	
Impact Prediction		DATA OUT	DESTINATIONS	
Acquisition Data Computation		Command/Control	Peripheral Sites	
Handover Computations		Aircraft Vectoring	Aircraft Data Links	
Aircraft Vectoring		Acquisition	Primary Sites*	
		Handover		

*Future Characteristics of Capabilities Depending on System Expansion of Operational Philosophy

[3] The Point Pillar installation may include an AN/UYK-1, another NTDS computer, rather than the RTDH-PC.

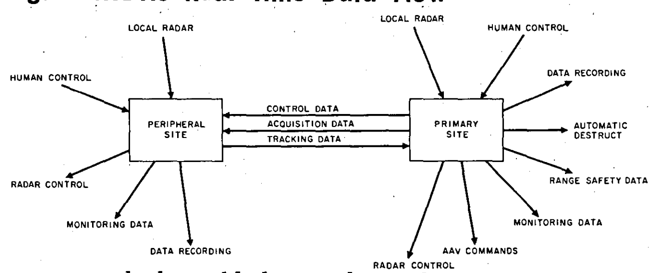
that the peripheral site operations of communications, data handling and recording/display are best performed by a local or "on-site" computer. This trend toward decentralized multi-computer systems is rapidly gaining momentum in a number of military and industrial applications, an example of which is AMR's Radar Data Chain of UN/UYK-1's.

system operational concept

As stated in the previous section, there are two types of sites in the RTDHS, primary and peripheral. Fig. 3 illustrates some of the operations, functions, data sources and equipment characteristics of both types of sites. The primary sites are required to provide the system with high speed, large computer capacity and master control during even the most complex and demanding of range operations. The inherent communications required to support these capabilities dictate a large number of input/output operations, and, therefore, a complex equipment inventory. Subordinately, the peripheral sites are required primarily to perform data gathering operations and exercise, at best, only local control.

Data communications at the primary and peripheral sites are shown in Fig. 4. The peripheral sites receive local sensor data for editing, conversion and manipulation purposes, and also receive manual inputs from the computer

Fig. 4 RTDHS Real Time Data Flow



operator which could dictate data selection criteria, program mode change or sensor control. The manual input or control data could be generated locally or could originate at another site, usually one of the two primary sites. Peripheral sites output data to be used for acquisition, display and recording at local and/or remote locations.

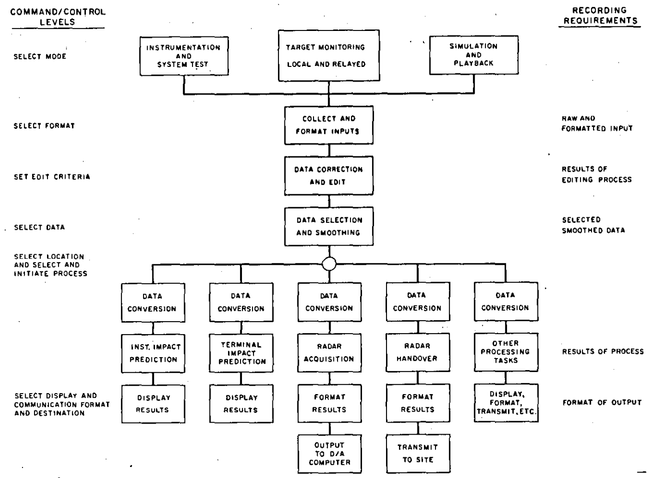
Primary sites receive and transmit data of similar content and in much the same manner as the peripheral sites. In addition, primary sites output command control and destruct data for automatic aircraft vectoring and various range safety functions, and for peripheral site tracking and control operations.

Fig. 5 is an outline of real-time data flow throughout the RTDHS from a functional and control viewpoint. The primary sites at Pt. Arguello and Pt. Mugu must perform all functions indicated and, in addition, may be required to perform them for multiple launch operations. The peripheral sites will perform subsets of the indicated processes which are in direct support of their own efforts. These include acquisition, data handling, recording and communications, as required.

Mission objectives of the RTDHS require a command/control function to control assignments to the various sites and the phasing of those assignments. The basic input data, such as that from radar tracking, must be distributed and used appropriately. The left hand column of Fig. 5 indicates the levels at which command/control decision can be implemented to achieve the required flexibility. The portions of the programming system which accomplish command/control are imbedded in the master control program.

The right hand column of Fig. 5 indicates possible points in the flow for recording the data. These recording points are located where significant changes to the data have been made and where either derived results or new formats have been created.

Fig. 5 RTDHS Functional Data Flow



The flow of Fig. 5 shows the requirement of the RTDHS to process both instrumentation or system test data, and simulation or play back data. This requirement is difficult to implement in a system unless advance planning has taken the requirement into account. The distinction between actual data and non-real-time or test data tends to get obscured without adequate control.

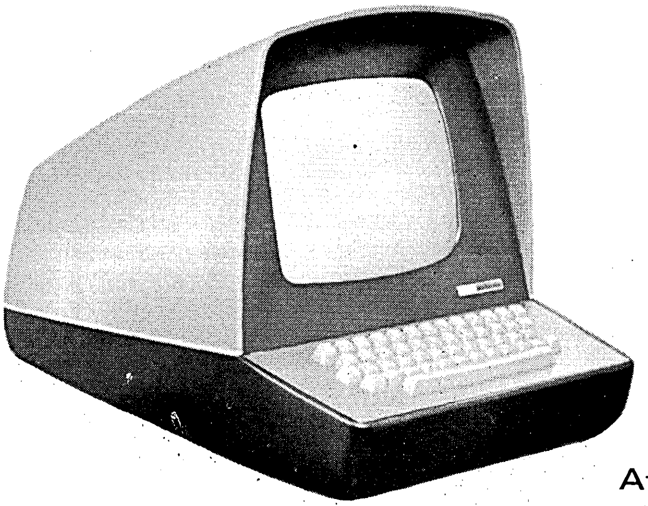
The three processing boxes labeled "Collect and Format Inputs," "Data Correction and Edit" and "Data Selection and Smoothing" can be considered the raw radar data processing section of the data flow. These processes have been performed by the operation center in the past because the collecting sites have not had this capability. With the advent of the RTDH-PC, this function can be performed at remote locations and thereby release the primary centers for over-all system computations.

The small circle after the processing sections represents the point at which command/control designates the function that is to be performed by the system. At the peripheral sites this will be instrumentation tests before launch, and after launch time will be those processes in support of the local collection effort. At the primary sites the functions of impact prediction for range safety and radar acquisition/handover operations will be performed as required. Other tasks such as automatic aircraft vectoring, as well as pre-launch and post-launch operations, are represented by the box labelled "Other Processing Tasks." Associated with these tasks will be requirements for display consoles, plotters and printers in order to communicate and record data.

conclusion

The PMR Real Time Data Handling System represents a design concept which will be employed with increasing frequency. It is the concept of decentralized computers which communicate with each other with great facility. It is an integrated system yet one which has the flexibility of possible use of a number of independent cells (the peripheral site computer operating independently of other peripheral site computers and perhaps independently of the primary computer). The primary peripheral computer relationship allows control of many functions of a more service nature at remote locations while still retaining control and inter-site coordination centrally. The system can be very responsive to the needs of the range instrumentation data handling problem at PMR where flexibility and intersite coordination are of vital importance to the range mission. ■

Retrieve Information...



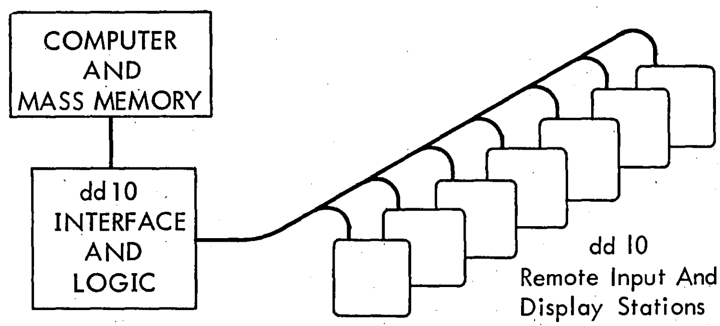
At Lowest Cost...

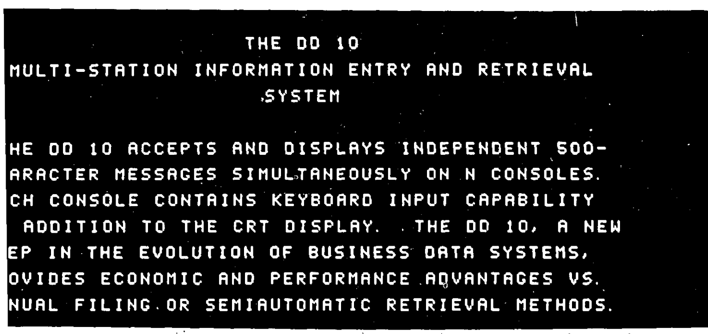
'he dd 10, developed by Data Display, Incorporated, is a modular, multi-station a entry and retrieval system that permits all stations to be used simultane-ly for rapid retrieval of information from a computer memory. Each station :apable of displaying 500 character messages, which are received from a ıputer and displayed in a fraction of a second. The central logic of the dd system is capable of handling in excess of 20,000 inquiries or entries per r.

ach dd 10 station has a full alphanumeric keyboard and a cathode ray tube ›lay. Up to 64 dd 10 stations may be connected to the dd 10 central unit, ch provides memory and display generation for each station.

everal dd 10 options are available that allow efficient adaptation of the dd :o a variety of applications. Character-code association is arbitrary and may ›asily changed to meet users' needs. Input interfaces are available for digi-computers, telephone subsets and other digital data sources.

DI systems applications engineers will show you how the dd 10 can cut data retrieval costs and improve your service. Write or call for an ap-ıtment.





This is an unretouched cathode ray tube photo

Operation of the dd 10 is simple:

1. Type an inquiry, verify it on the CRT, correct it, if necessary, and press the inquiry key that transmits the inquiry to the computer.
2. The computer retrieves the response data, formats it, and transmits the response message to the dd 10.
3. The dd 10 displays the message on the appropriate station and frees the computer dd 10 interface for other inquiries.
4. The dd 10 keyboard may also be used to enter data into the computer, to update records or to store new information.

DATA DISPLAY INCORPORATED
1820 COMO AVENUE • SAINT PAUL 8, MINNESOTA

CIRCLE 18 ON READER CARD

ON-LINE STOCK QUOTATION

with voice output

by HANS VAN GELDER

The nation's security brokers provide a growing market for up-to-the-minute market information which can be obtained only through an on-line communications network connected to a central intelligence maintained by real-time data processors.

For generations, the universally-known stock ticker has filled a part of the brokers' needs by making known the latest price of each security within a minute or two after each trade is consummated on the trading floor of a stock exchange.

In addition to the last-sale price as shown by the ticker, the broker needs to know the price being bid for a given issue (the bid) and the price sellers are asking (the ask, or the offer) before he can intelligently execute orders for his clients. The major exchanges for many years have operated a bid-ask telephone service for their member brokers. The basic information is fed from the exchange floor to operators who read the figures to brokers upon receiving a spoken request over the phone. With steadily increasing trading volume, it has become increasingly difficult to provide up-to-the-minute service without the subscriber encountering busy signals at times. A system called Televox has now been developed by The Teleregister Corporation for the American Stock Exchange in which a computer will receive, process and store current prices and will "read" the price of any desired security over the phone to the broker upon receipt of a dialed query. A 100% server multiplexer eliminates busy signals.

the data processing system

From a systems viewpoint, the data processing requirements can be best realized by examining the various processor inputs and outputs. The system inputs consist of Teletype information (tickers) concerning almost all of the nationally traded securities and commodities, plus other special information of use to the brokerage industry. The system outputs contain all this information in a digested and totalized form so that various outlying equipments, of less intelligence, can impart this information to subscribers.

Of all the inputs, the best known to the lay public are the New York Stock Exchange and American Stock Exchange last price tickers. These are the familiar ticker tapes that may be seen in any brokerage office. Between them is contained the latest trading information on a major part of the total dollar value of listed securities that change hands in this country. However, these tickers contain only past history, and the person who wishes to buy or sell a stock is more interested in the bid and asked prices of the stock. The system accepts this information from two bid-ask tickers, one from each exchange.

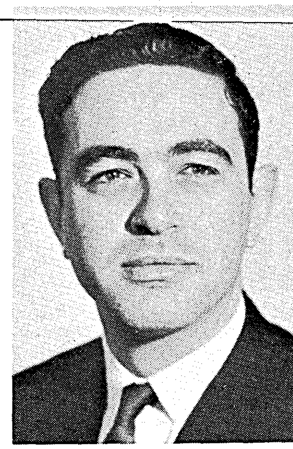
The information on the above tickers contains the bulk of the day's trading activity. The remaining trading is done at other exchanges, such as the Chicago Board of Trade, the Midwest Stock Exchange, etc. In all, the system requires information from more than 10 other trading centers. While it is true that the total volume of information from these centers is not as great as the NYSE and ASE volumes, their trading tends to peak at certain periods during the day. The information from these other exchanges is transcribed from their various tickers by Teletype operators.

In addition to these inputs there are inputs from query/reply devices, or interrogation units. A broker (operator) uses one of these devices to question the processing system concerning the latest status of some security. Three types of interrogation devices are provided: standard telephones, modified Teletype machines, and special Telequote keysets. Provision is made for 1,000 interrogation telephones, for 50 interrogation Teletype circuits, and for an unlimited number of the special keysets. No changes are introduced in the processor records by these querying devices.

There are five outputs from the system. One feeds a chain of satellite processors, which in turn feed the quotation boards and the Telequote III query/reply keysets throughout the country. Another output feeds the telephone query/reply network, which basically serves New York City subscribers, and a third feeds the Teletype interrogation network. A fourth output is to the American Stock Exchange for their end-of-day reports. The fifth is for fallback and supervisory functions.

In general, there is at least a three-to-one ratio of output to input information. The data processing system does not generate information as such. Nevertheless, if an item of information has to be transmitted in two distinct formats it appears to the system as a double output. A further complication results from the need to maintain an accessible updated record on the drum for the interrogation services and a consecutive record on magnetic tape for off-line processing requirements.

The message handling capability of the system is complicated by expected simultaneous peaks. The nature of the securities business causes maximum activity in both stocks and commodities between 10 and 11 a.m. This fact



Mr. van Gelder is project manager for the hardware complex referred to in this article. He joined The Teleregister Corp. in 1961, serving in several systems and project engineering capacities relating to on-line services for security exchanges and brokers. Prior to joining the firm, he was with Westinghouse Electric Corp.'s new products laboratories. He has a BSEE from MIT and an MSEE from the Univ. of Pittsburgh.

required that the system be designed to handle the maximum possible data flow on all lines.

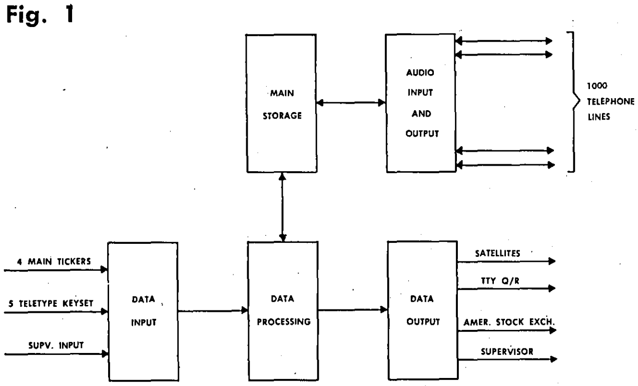
The expected input data rate is 540 messages per minute. This is divided into 200 messages from the NYSE, 120 from the ASE, and 220 messages from other trading centers. The interrogation services will handle at least 1,200 queries per minute via telephone, 75 via Teletype, and an unlimited number of queries and replies from the special keysets via the satellites. At the output, the system can transmit 720 messages per minute to the satellites, 1,200 messages per minute to the telephone query/reply network, 75 per minute to the Teletype query network, and outputs to the American Stock Exchange as required.

The system has excess input and output capacity to handle the necessary supervisory and clerical functions in addition to the above data capacities.

data flow

A block diagram (Fig. 1) shows the flow of data into, through, and out of the system. Briefly, a data message is received via the data input and brought into a processor. The processor then updates the main storage and initiates any immediately required output messages. Once the data is in storage, it is accessible to any querying network.

Fig. 1



A somewhat more detailed examination of the data flow generated by an input American Stock Exchange last sale message will serve as an example of all message handling routines. The message is received, via ticker, from the exchange. Before any further action is taken, the program examines the message to see that it is complete, that the security identifier is a valid code, and that the price change from the previous sale is within reasonable limits. The sale price is then entered as a new last price into storage and the old last price is removed. The total number of shares of this security traded is increased by the number of shares in this trade, and if this trade is a new high or low it is so noted in the main storage. Certain other items of interest to the industry are generated, such as net change and up or down trend since yesterday's close.

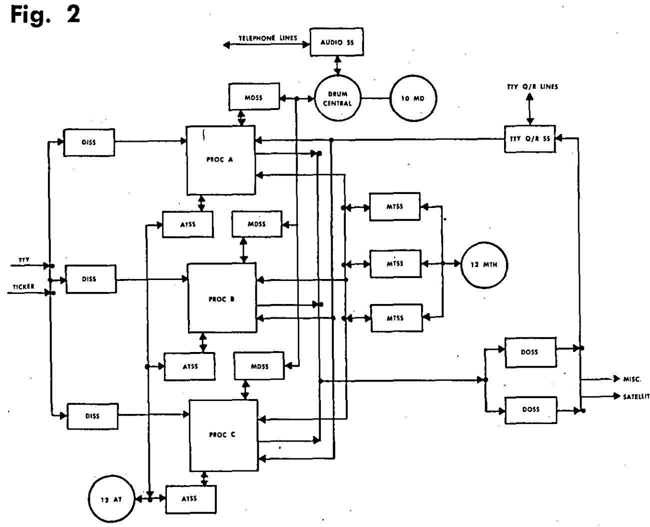
Once these operations have been performed, one or more satellite messages are generated. These fixed format messages are alphanumeric, but of different composition than the original input message. In certain circumstances fallback or supervisory messages are generated at the same time.

In all, this single input message will cause a change for up to eight items of storage and up to six output messages. Once these actions have been performed any subscriber can interrogate the records of this security and receive a comprehensive list of information which may be of use to his client. In the case of a telephone subscriber, he picks up a standard telephone, dials a four digit code number, and receives an audible reply in the earpiece. In the case of a Teletype subscriber, the procedure is somewhat more complicated, requiring the generation by the subscriber of a fixed format message. However, this method of querying allows multiple queries and provides hard copy of the replies. In the case of a Telequote III keyset subscriber, the query is made by using his keyboard and the reply is displayed on a CRT tube in the keyset, or is printed on a tape if desired. In the case of the boards, no action by the subscriber is required, since any new high, low or last price which is received into storage is automatically transmitted to every board which carries the item.

system hardware organization

Fig. 2 is a simplified block diagram of the system hardware. The flow of information, as explained in the previous sections, can also be traced on this diagram. Data enters from Teletype lines via a Data Input Subsystem (DISS) and flows to a processor (PROC). Programmatically, the processor has access to any magnetic storage drum (MD) via the drum control register (MDSS) and the drum central, to any magnetic tape handler (MTH) via a tape control register (MTSS), to any automatic typewriter (AT) via the AT control register (ATSS), and to output Teletype lines via an output control register (DOSS). Interrogations are handled via the Audio Subsystem and the Teletype Query-reply Subsystem (TTY Q/R SS).

Fig. 2



There are three data input subsystems, one assigned to each processor. The input Teletype lines can bid for any DISS. Each Teletype line is terminated in a reperforator-transmitter set, which provides what amounts to an infinite buffer.

The processor complex consists of three Telefile data processors operating in simplex. The expected maximum traffic will utilize less than two processors full time, thus providing a complete processor as fallback in case of failure. Each processor contains 16 priority levels to regulate subsystem bidding and has over 100 instructions available to the programs.

The magnetic drum subsystem consists of three drum control registers, a drum central, and 10 magnetic drums. Each drum control register is assigned to one processor and bids for any desired drum via the drum central. Each drum has 600,000 decimal digits of storage for a total capacity of six million digits. The access from the audio subsystem to the drums is via the same drum central.

There are two data output subsystems, distinct from the audio output, accessible on a seize and release basis from any processor. This permits the simultaneous output of two messages from any one processor. Each DOSS has access to any output Teletype line via reperforator-transmitter sets. The input transmitters and output reperforators, of the reperforator-transmitter sets, operate at 12 times line speed to reduce control register occupancy per message.

The other subsystems accessible from the processor are the magnetic tape subsystem, the automatic typewriter subsystem (used for programming and maintenance), the punch card subsystem (used for programming), and the real time clock subsystem (used by the interrogation networks). A processor, under program control, can control two tape handlers simultaneously and have access to any of 12 automatic typewriters. The punch card subsystem has access to only one processor at a time because of the small system use of this type of input-output device.

Of the three interrogation networks, only the TTY Q/R subsystem operates through the processors. The Teletype query/reply subsystem receives a bid from a remote station, sends a permission to query signal, assembles the query and bids for a processor's attention. The processor interrogates the main storage and generates a reply via the data output subsystem. This reply is switched to the proper interrogation station by the TTY Q/R subsystem.

The audio subsystem is a separate entity, a wired program computer, and is covered in the next section.

the audio subsystem

The audio subsystem deserves special attention because of several unique features in its organization. This subsystem is a wired program data processor with the capability of receiving telephone dial pulse interrogations at any rate from 1,000 lines and of transmitting audio replies at a rate exceeding 20 per second. Almost all American Stock Exchange member brokers' offices in the New York City area will have at least one of these direct lines. Through an arrangement with the American Stock Exchange, these lines are leased from the telephone company.

Compliance with these specifications resulted in a three unit subsystem: an input multiplexer, a reply control, and an output multiplexer. The input multiplexer receives the queries, assembles and stores them. The reply control takes each assembled query, interrogates the main storage, and stores the reply in digital form. The audio multiplexer translates the stored digital reply into an intelligible audio message and switches this reply to the proper outgoing line.

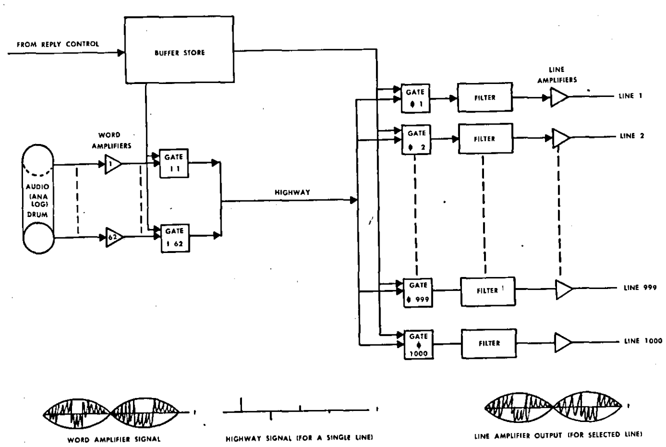
A query consists of a four digit numeric message in dial pulse code. This code provides one contact closure per unit of the digit, thus the higher the digit the more pulses and the longer the query. The input multiplexer is permanently connected to all 1,000 input lines. Each line is sampled every 12 milliseconds to detect a change of state in the line, which will correspond to a dial pulse. This sampling frequency is high enough to permit at least two identical samples for each change of line condition, thus minimizing the errors caused by line hits. Each dial pulse is stored in a location peculiar to its line. A shorted line condition, seven sample-lengths-long, indicates the inter-digit pause, and an open line for the same length of time indicates the caller has hung up. These digits are stored on a magnetic drum (the query-reply drum which is distinct from the magnetic storage drums previously referred to) which has a slot for each subscriber. A bit on this drum slot is marked whenever a complete query has been assembled.

The marked bit, from the assembled query, acts as a bid for the reply control. The reply control takes the query and translates it into the magnetic drum address where the information for the interrogated stock is stored. A bid is then initiated for the particular magnetic drum and the particular band that contains the required information. The magnetic drum logic and organization is designed so that there is very little chance of drum congestion due to interference between the audio subsystem and the processors. The information on the security, which was retrieved from the magnetic drum, is placed on the query-reply drum in a slot which corresponds to the requesting subscriber. There is one slot on this query-reply drum for each subscriber, and these slots each contain enough bits for a query and the digital form of the reply.

The audio multiplexer provides a continuous output to all 1,000 telephone lines. When the phone is hung up this output is a pause, or silence, character. When the receiver is picked up a dial tone is transmitted. During dialing, pauses are again transmitted. When a complete reply has been assembled on the query-reply drum the individual characters of the reply are taken from a third type of drum, the audio drum, in analog form and transmitted sequentially. Because of this scheme it does not matter if all 1,000 lines require different messages, since some character is being transmitted continuously on every line and the particular sound on any one line is dependent only on the code configuration in its query-reply drum storage slot.

Fig. 3 is a simplified block diagram of the audio multiplexer. The audible signals are stored in analog form on the audio drum. This drum is continually scanned by

Fig. 3



60 audio word amplifiers, so that the output of each amplifier consists of one word repeated every word time. Table I lists these words. The buffer store contains, in digital form, the information of which word (from the 62 available) is required on each output line. This buffer store is rewritten every word time. Each outgoing line is assigned a time slot. The gate associated with a particular line is opened during its time slot, and at the same time the gate blocking the desired word amplifier is opened. This procedure places a series of pulses on the highway. When these pulses reach the (low pass) filter, the analog signal is recreated. For perfect reproduction the sampling frequency for each line must be at least double the maximum frequency to be reproduced. An oscilloscope looking at the highway would see a train of pulses of varying amplitudes and polarity. If the same word were sent to all lines, the highway signal would be the word amplifier output after it had passed through a high frequency chopper.

The requirements of the audio vocabulary, as sent over the lines, are difficult to define. It was very easy to give the objective requirements because the limitation of the telephone lines are known. The subjective requirements were another matter, and the final requirements were the result of an intensive investigation.

The objective (measurable) requirements were that the audio frequency response of the system should be flat from 300 to 3,000 cycles, that the noise should be down 30 db from the signal, and that the output power should be from -8 to -5 VU. The subjective requirements arrived at were that a male voice should be used rather than a female, that a pleasant voice with flat pitch was preferable to a professional announcer's voice, and that the optimum word length was 350 milliseconds.

Table I: Spoken words in the Televox Vocabulary

A	U	15
B	V	OFFER
C	W	HIGH
D	X	LOW
E	Y	LAST
F	Z	VOLUME
G	1	NONE
H	2	OPEN
I	3	AND
J	4	SIXTEENTH
K	5	UP
L	6	OFF
M	7	EVEN
N	8	½
O	9	¼
P	0	¾
Q	(silent pause)	⅛
R	(dial tone)	⅜
S	11	⅝
T	13	⅞

Typical quotation:
"A B Z 9 and ½ offer ⅞ last 9 and ¾ up ⅛ volume 3 4 open 9 and ¼ high one zero low 9 and ⅛."
(Each underline represents one word time.)

This means that the particular stock, whose symbol is ABZ, is bid for at $9.50, and is being offered at $9.87½. The last trade was at $9.75, which was up 12½¢ from the previous day's closing price. The volume of trading for the current day up through the last trade is 3400 shares. The opening trade was at $9.25, the highest price for the current day was $10, and the lowest was $9.12½.

Smallest fractions enunciated are sixteenths. Only odd sixteenths exist, because the even sixteenths are reducible to lower numbers; i.e., 14/16 = ⅞. This accounts for the absence of twelve and fourteen in the vocabulary.

These subjective specifications led to one major problem, that of fitting drawn out words into the rather short word time. This was solved by breaking some words up into two parts, each part one word-time long. For example, the word sixteenth became the words six and teenth. It is possible to distinguish that these words are assembled but they do not sound unpleasant.

programming

The programs for this application total approximately 400,000 digits, divided equally between on-line and off-line applications. The programs are stored on a magnetic drum and are surged into core at the behest of an executive program. The programs are also stored on a stand-by magnetic tape unit to forestall the possibility of losing the drum stored programs.

The programmatic problems can be divided into two areas, one of identification of data, and the second of changes in the data to be processed due to causes outside of the system.

In the area of identification, the outstanding problem is the identification of a complete unit of information. A typical incoming string of messages reads:

ABC DEF Pr GH J.C
5s 17½ 4.5 21 14½ 103⅜

For such a string, the end of one message and the start of the next is hard to identify. Complicating the picture is the need to handle information from different exchanges in different manners, and the possibility of conflicting identification symbols between exchanges. The last problem is so serious that no solution other than manual editing has been found.

The problem area of changes has forced the programs to rely on a large number of tables. Changes are due to the actions of the exchanges (for example, in adding a new stock), to the action of time (for example, when a stock begins trading at a lower price after payment of a dividend), and to the requirements of the subscribers (who might want a stock added to the broadcast service). All securities are therefore entered into tables which list the various functions to be performed on any input information regarding the security. These tables are updated daily by supervisory personnel.

maintenance features

The system contains over 3,000 lights which indicate everything from the contents of the control registers to failures in the Teletype equipment. The equipment is broken down into groups, each clustered around one data processor, so that a failure will not shut down the entire system. All peripheral equipment is controlled from a systems console located next to the processor consoles so that the operator can substitute for defective equipment with a minimum of down time. The effectiveness of these maintenance features is demonstrated by historical records, on similar systems, showing that 90% of all service interruptions are rectified within one minute.

summary

Work on this project was started in 1959, restricted to the audio interrogation service. The scope was expanded late in 1962 to include the remaining services, and the equipment was installed in its present 20,000 square foot location starting in June of 1963. The audio interrogation service becomes operational in the first quarter of 1964 with the remaining services due in the second quarter.

The more than 35,000 transistors in the system are distributed among 65 racks of electronics. There are 12 magnetic drums, 15 racks of Teletype equipment, and 40 racks of audio line terminations. The remaining racks, of the over 150 rack total, consist of consoles, relay equipment, power supplies, etc. The three data processors are general purpose "Telefile" computers manufactured by Teleregister, which also designed and built the digital portion of the wired program audio processor. The analog portion of the audio subsystem was adapted from a military system by the North Electric Company.

It is the intention of Teleregister, which operates the system on a service center basis, to expand this system in the near future with two additional processors. These processors will be tape oriented to provide more off-line processing capacity, and will have access to the central storage via core to core transfers from the existing three general purpose processors. ■

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CIRCLE 19 ON READER CARD

THE MITRE CORPORATION

research for the federal government

by ROBERT B. FOREST, Editor

In Bedford, Mass., near Route 128 with its numerous electronics firms ringing Boston, is MITRE, a nonprofit research firm sponsored primarily by the Air Force. Its main effort is in command and control systems, its role ranging from occasional consultation to complete system design and technical direction of the acquisition phase.

Of the firm's 2,000 employees, nearly 800 are Technical Staff, 600 are technicians and lab personnel, the remainder in business support activities. Of the Technical Staff, more than 400 have advanced degrees. An IBM 7030 STRETCH is included in its complement of 10 computers.

MITRE also has facilities in Colorado Springs in support of NORAD, in Wiesbaden in support of a European Air Weapons Control System, in Paris in connection with work on European Air Defense for NATO, and offices in Arlington, Va., from which to implement work with the Defense Dept. on the National Military Command System and with the Federal Aviation Agency on the future National Airspace System.

DATAMATION: How did MITRE get started?

HALLIGAN: In the late 1950's the SAGE Air Defense System, which had been developed at Lincoln Laboratory, was getting into the implementation phase. The Air Force required a very large systems engineering effort to make it work. The Air Force did two things. They formed a military organization which was first called Air Defense Systems Integration Division and which was made up of R & D, Logistics, and Operating people put together in one organization. They also looked for appropriate technical support, and in their search for this support they talked to organizations in conventional industry and elsewhere. They finally decided to ask MIT for Lincoln Laboratory's support. MIT concluded that the system engineering job was not appropriate for a university laboratory, but offered to have Lincoln Laboratory give the support temporarily and to sponsor the formation of a nonprofit corporation to take on the permanent task. So, in August 1958, MITRE was incorporated. The Lincoln group which had been working on this effort transferred to the new corporation. For the remaining part of fiscal year 1959 MITRE operated as a subcontractor to MIT. Since July 1959, there has been no fiscal or organizational connection with MIT. Near the end of 1959, ADSID became the Command and Control Development Division and their scope was expanded to include not just SAGE, but the whole spectrum of Air Force command and control systems. CCDD then asked MITRE to expand its scope to take on the broader technical mission, and MITRE agreed. A little later the Air Force formed the Air Force Systems Command. CCDD became the Electronics Systems Division of this new Command. There was no significant change in its mission. Today MITRE is handling system engineering for Air Force command and control systems including related advanced planning and technology work. In addition, we have been doing air traffic control development work for the Federal Aviation Agency, since 1959, and we expect that we will continue to do so. In September we were assigned the technical support responsibility for the Defense Communications Agency's National Military Command System. We are now organizing a staff in Washington to work with DCA.

DATAMATION: I wonder if you could spell out in slightly more specific terms what the term systems engineering means in your work for ESD?

HALLIGAN: We use the term in a very broad sense. We include the early conceptual work, where we develop concepts for a new system. Sometimes this results from our own advance planning. Sometimes we are asked to design a system for a particular task. This is fundamental work. Initially, it's paper work, but as the concept develops certain features may be tried out in "breadboard" fashion. By that we mean simulating a condition on a computer, or otherwise creating a model which we can use to check critical factors. When Air Force approval to go further has been given, the next step is a system design detailed enough to permit the Air Force to ask contractors for proposals on system implementation. This is the stage where the basic system engineering gets done. Later, when the contractors become involved with detailed design, we may be required to coordinate with, and sometimes to direct, the contractors. Finally, we work with the contractors on test and evaluation. All of this effort is, in a broad sense, systems engineering.

Mr. Halligan became president of MITRE in 1958 after 32 years with AT&T's Development & Research Dept., Bell Labs, and Western Electric. Positions with Bell Labs included director of the Continental Air Defense Survey, director of military engineering, and head of development of the DEW line and the lab's part in the SAGE development work. He holds 12 patents in communication, and a BS (magna cum laude) and MS in EE from Bucknell.

DATAMATION: And do you help choose the contractor, or is that a unilateral ESD decision?

HALLIGAN: The choice is entirely an Air Force responsibility. When requested, we may evaluate the technical content of a contractor's proposal. The contractor selection process involves many other factors—his performance record, his experience in the area, and a great many other things. From industry's point of view it would be intolerable if we engaged in source selection. It would be extremely unwise from our point of view, too.

DATAMATION: When you work with a contractor who is installing and testing a system, do you evaluate his efforts?

HALLIGAN: We are often asked by the Air Force to evaluate contractor tests and sometimes to perform our own evaluation. There have been occasions when the Air Force has asked us for performance evaluations of jobs on which we had no initial system design responsibility. Usually these have involved systems that were well along before we came into the picture.

DATAMATION: Let's consider another angle now. Perhaps we can get another view of MITRE by asking you to distinguish it from: (a) a possible private enterprise counterpart and (b) other captive nonprofit organizations.

HALLIGAN: The most obvious difference between MITRE and a private enterprise firm is that we don't make a profit. We don't have stock or dividends. Another very important distinction is that we do not manufacture anything. We do some bread board and experimental work but we do not engage in production, as the profit-maker customarily does. There are many profit-making industries that have capabilities similar to those of MITRE. But, by constant application to our area of work, and because of our close relationship with the military establishment which specifies requirements, we can become more proficient in our area than profit-making industries. This is mainly a matter of continuity and focus. For these reasons, I think we are normally better able to do the basic design part of the job than conventional industry. Certainly we can be more objective because we don't have any inherent bias. We're not trying to sell anything nor trying to make money for share owners.

DATAMATION: Let's pursue this part of the question further. There are private enterprises which do not produce anything, management consultant firms for example. Such firms would seem to have a vested interest in objectivity too, although they don't deal with the military necessarily.

HALLIGAN: Consultant firms must be objective. Certainly one can envision such a company being set up to do the systems engineering job that MITRE does. NASA is using Bell COM, which is a profit-making company. As you know, there is a continuing discussion going on in Congress, DOD, and throughout industry, about the need for "nonprofits" and whether profit-making concerns can be used to do the same work. Personally, I think it's easier for the nonprofit to remain entirely objective, for the reasons I have already discussed.

DATAMATION: Now to the second part of the question. How is MITRE distinguished from other "captive" nonprofit organizations?

HALLIGAN: First, I don't like the word "captive." It is true that about 85% of our work is for the Air Force, but this does not make us "captive." As to how we compare with other similar organizations, let's consider a few. RAND is one example. Some of the work RAND does is quite like our early and conceptual or advanced planning, although RAND tends to look farther out in time. RAND does little experimental laboratory work nor do they design systems in the sense that we do.

System Development Corporation is another nonprofit. It has specialized mainly in the "software" areas—operational specifications and the follow-on computer programming effort. SDC does not do system design in the equipment sense—communications, sensors, displays, etc. MITRE must have a substantial capability in the software area in order to do its conceptual and basic design work, but it must also be competent in the appropriate equipment areas.

There are many other nonprofits. One category is university laboratories. They differ from MITRE in that they tend to be research-oriented rather than systems engineering-oriented.

DATAMATION: I'm interested in your research activity. What kind of basic or applied research goes on here and how is it funded?

HALLIGAN: It's funded in several ways. Some research work is covered by specific Air Force projects which are funded by the Air Force. Such work must be in areas that have a direct relation to Air Force command and control. We conduct work of this sort in the fields of radar, communications, and data processing.

We also conduct some research supported by our management fee. To date this has been a modest effort because most of our fee has gone into our building program. However, we have recently set up an independent research activity in which we pick our own projects, and pay for them out of our fee. Here we also stay in fields that support our basic work for the Air Force, DOD and FAA. We don't think it would make sense for us to do a medical research job, for example. The main difference is that we can pick our projects with greater freedom since we don't need Air Force approval for the projects we select.

DATAMATION: What percentage of your work is under Study contracts, rather than Systems contracts?

HALLIGAN: We operate under just one basic contract with the Air Force which covers all of their work. Systems work involves some 60% of our total Air Force budget. Our work in advanced planning is close to 20% and our work in technology, that is sponsored by the Air Force, is close to 20%.

DATAMATION: Might not some of these technology projects lend themselves to handling by a private industry?

HALLIGAN: Yes, and many projects of this sort are handled by private industry. The philosophy we share with the Air Force is that if we are to stay proficient in the systems engineering job, we must keep up-to-date in the technology we use. We must have some work actually going on in our organization to evaluate and understand what other organizations are doing and to make sure that we know what techniques are available or are soon to become available. There is bound to be some duplication, but I don't consider this kind of duplication harmful.

One last point before we leave this question. We are sometimes asked to do certain jobs for the Air Force which we feel industry could do perfectly well and in such cases we suggest the job be given to industry.

DATAMATION: The original MITRE charter calls for service "to or for the U.S. Government or any department or agency thereof." Yet, ESD has been noted as your sponsor. How does a nonprofit like this get a single or all-important sponsor?

HALLIGAN: We consider ESD our major sponsor because we were formed to do an air defense job for the Air Force. The Air Force is still our major sponsor, but we have two other sponsors—FAA and DCA. As pointed out earlier, about 85% of the budget comes from the Air Force, 10% is FAA and only 5% is DCA. Our charter permits us to work for any government agency, but not for any agency outside of the government.

DATAMATION: Outside the federal government.

HALLIGAN: Yes. We wouldn't work for a state or city government. We have always very carefully preserved the spirit of our charter. We feel that if the corporate talents are unique in some respects, they should be available to any agency of the federal government that can use them. While the Air Force is still our principal sponsor, we think it's entirely proper to do the FAA work which grew out of our original capability, and now the DCA work which developed in the same way.
DATAMATION: You have said that the designer cannot afford a bias for any command, any service or agency, or any line of equipment. You do most of your work for the Air Force. How do you achieve objectivity if you run into something that you think is technically wrong and the Air Force disagrees?
HALLIGAN: Our work for the Air Force is technical. When we conduct conceptual or system design work, we use all of the information that is available . . . operational requirements, cost limitations, technical requirements, etc. Our product—recommendations, specifications, evaluations, and so on—is the best technical answer we can make in view of all these factors. However, our sponsor may have any of a number of valid reasons for deciding to do the job in some other way. Final decision is a government responsibility, and we are not, and should not be, in a position to dictate the final decision. However, we try to make sure our recommendation, and the requirements on which it was based, become a matter of record. We are, accordingly, objective in a technical sense, no matter what decision is finally made.
DATAMATION: What you're saying in essence is that an oragnization like MITRE has to try and remain as aloof as possible from the political consideration which may be behind a particular project. Now what this tends to mean, I think, is that each major defense agency then is going to build up a team like yours which is going to take the original idea and pursue it as diligently as possible without questioning how it fits into some overall strategy. Is there a need for a nonprofit technical outfit at the level of DOD to supervise the work of all the other agency nonprofits?
HALLIGAN: First, we do make every possible effort to see that our design work "fits into some overall strategy." However, most of our information is secured through our sponsor, and it may be that his ideas of what is needed are in disagreement with those of other agencies in the defense establishment. This may result from an honest difference of opinion, from a service bias, from some "political" consideration, or from inadequate knowledge of overall strategy. I don't think that this problem could be solved by having a nonprofit at DOD level supervise nonprofits at, say, service level. The important thing is to make sure that the overall requirements are known to the implementing agency, and are followed by that agency. This is a government responsibility, and should be achieved through government channels. However, it may well be that nonprofits should be utilized at the higher levels to make certain that the overall requirements are sound, and I see nothing wrong with this. The command and control area is an especially good example. Conformance to national requirements is essential in all of these systems, whether they be for the Army, Navy, Air Force, or the Unified and Specified commands. Some central authority must make sure they fit together, and if this requires outside technical assistance it could well be secured by using a nonprofit organization. However, the final decisions, and the directives placed on the implementing agencies, should be through government channels.
DATAMATION: What would be the function of such an organization?
HALLIGAN: If a nonprofit were to be used to provide technical support at the DOD level it would probably deal with things such as national strategy, balance of offense and defense forces and facilities of all sorts, integration of all supporting systems . . . in other words, with the nation's overall requirements. It would specify these requirements broadly but with enough detail to give adequate direction to the agencies charged with providing the supporting systems.
DATAMATION: If nonprofits have some advantages, are there some inherent disadvantages?
HALLIGAN: Yes, there are. One disadvantage results from the nature of their work. Nonprofits should undertake work where the need for objectivity, for unique competence, for continuity, etc., is such that the task cannot well be given to industry. They should not do work that can be done as well, in the overall sense, by industry. Accordingly, the fields available are limited, and the opportunity to secure new work, if the nonprofit's budget is reduced, is correspondingly limited. This places an obligation on the part of government to avoid serious changes in budget level that might reduce the company's effectiveness to a serious degree.

Another disadvantage arises from the lack of benefits such as bonuses and stock options to use as an inducement in recruiting its staff. It isn't possible to make up for this lack, especially at the higher management levels, by salary ajdustment.
DATAMATION: It has been said that private enterprise has to be efficient by definition or else it's driven out of business, which is not necessarily true of nonprofits. Would you care to discuss that?
HALLIGAN: The nonprofits, by definition, lack the profit measure of efficiency. We and our sponsors are well aware of this and take all possible measures to make up for this lack. Actually, we wouldn't survive very long either if we failed to operate efficiently, and I believe that we are as efficient as profit-making industry.
DATAMATION: How do you do it?
HALLIGAN: To a considerable extent it is a matter of management philosophy. We have available to us all of the management techniques that are available to industry. In evaluating performance, a MITRE supervisor can judge his people just as accurately as he could with a similar group in industry. Further, our sponsors know our procedures and our people intimately, and they can and do compare us with their industrial contractors.

We are a high morale organization. Our people know that their work is important to the government, and have a patriotic motive for working effectively and efficiently.
DATAMATION: Doesn't it involve two different views of human nature? One view is that people only work well because of profit motivation, or fear, and the other one is that people work well because they love the work and want to do a good job.
HALLIGAN: These are the two extremes of motivation. I think most people's incentives are a mixture of the two. One of the disadvantages I mentioned earlier is that the nonprofit can't offer bonuses, stock options, and the like, and the satisfaction from doing important work helps to make up for this lack. We have people working with us now who can leave today and get a substantially higher salary somewhere else. Some do leave. On the other hand, we have people who came to work with us at a reduction in salary because they wanted satisfactions beyond those of income.
DATAMATION: What about the other intangibles affecting attitudes toward work, something as vague as the work environment?
HALLIGAN: Environment is important, especially for technical people, in any company. We must provide the

right working conditions or we won't hold the people. We do all we can to create a good working environment.

DATAMATION: You don't try to be more lenient in terms of attendance, or this sort of thing?

HALLIGAN: No, we don't. Having come from a technical job in an industry laboratory, I can say quite honestly that our rules here are much like those in industrial companies. People who do our kind of work—research people, development people, people with high technical talents generally—can't be regimented with time clocks, whether they are at MITRE or with a conventional firm. Of course, you don't let them make their own individual ground rules, either.

DATAMATION: Earlier this year a national publication reported that the Air Force was dissatisfied with MITRE performance. Was this true?

HALLIGAN: I recall the item, which came as a surprise to us and to our Air Force sponsors. We tried to find out what was back of it, and we found that the editor had written the item in good faith. The remark was made to him by somebody he felt was in a position to know. We talked to people who were in the best possible position to know of any dissatisfaction with our performance, but could not determine the source of the story, nor could we find any basis for it. It's apparently one of these things that we'll never run down.

DATAMATION: How does the Air Force evaluate or monitor your performance? If all of the work that they have in this area is done by your organization how can they compare it?

HALLIGAN: The Air Force can compare our work with other companies. It's possible to isolate any systems engineering job done here and find parallels in industry. We don't do all of this work for the Air Force by any means. It's not difficult to find other companies where a similar effort is underway. A comparison will reveal whether comparable efficiency exists. Of course, a quantitative evaluation, especially for creative conceptual work, is extremely difficult. We admit, as industry does, that numerical values can't be assigned to the performance of technical people. Management judgment, the experience of supervision, and the overall quality of the work form the best basis for assessing the work, qualitatively and quantitatively.

DATAMATION: Suppose all the contractors on a particular job complained that your system design specifications were poorly drawn up. Would this represent a significant commentary on your work?

HALLIGAN: Yes, it would.

DATAMATION: Has this ever happened?

HALLIGAN: Not in the way you put it. There has been criticism, sometimes justified, sometimes not. Technical people don't always have the same technical opinion. This we face all the time. I don't think there has ever been any such large-scale criticism. In one case the criticism involved the private interests of a contractor. Some criticism of this kind is to be expected.

DATAMATION: Some people, perhaps because they don't understand the role which you have outlined here, have complained about the technical validity of some of MITRE's system engineering.

HALLIGAN: There have been a few such complaints. Here again I have to say that technical people don't always agree. Furthermore, the information on which such criticism is based is not always adequate for making an evaluation.

DATAMATION: You have said about MITRE responsibility, "The company must not assume the responsibilities for decisions that belong to the government. It must make its position clear as a partner to the sponsor but final responsibility must be the government's." Does this sound like an evasion?

HALLIGAN: I hope not. What I meant was this. The government's decision must include matters of the budget, matters of international relations and intelligence, that we may not understand as fully as the government. The final decision must involve factors which may not be fully known to us. We give the government our technical opinions and/or recommendations, but the government may have sound reasons, other than technical, that will influence the decision.

DATAMATION: Suppose your sponsor over-rides one of your technical judgments on grounds which you consider within your province. Is it your responsibility to issue a minority report or to complain?

HALLIGAN: I have touched on this problem earlier. We must make it clear that we don't agree with the decision that came out, and why. We can't guarantee that our technical view will reach the top through the involved command levels but we do our best to get our technical opinion on the record. We can't insist on a hearing at the top in all cases. This is a problem that I don't see how you can get around, unless the technical opinion-giver reported to the President himself.

DATAMATION: One important function of an oragnization like MITRE is to provide technological advice to arms of the government which aren't staffed to provide their own expertise. Private citizens need this help too. As I see it, one critical problem facing this nation is to help our non-technical electorate make intelligent technical decisions. What are the checks and balances on the MITRE-type organizations? How does the sponsor evaluate them adequately and how can we citizens be certain you are spending our tax dollars wisely?

HALLIGAN: Organizations like MITRE are under constant evaluation by their immediate sponsors . . . in our case by ESD. They evaluate our management, our use of our budget, and our technical performance. Such evaluations are also made at successively higher levels in the Air Force, and in the Department of Defense itself, notably in the Research and Engineering group, which has some very competent technical people.

DATAMATION: This adds another dimension or another level. Who evaluates the evaluators?

HALLIGAN: If we assume that the final evaluation is done in a broad sense by the elected or appointed officials at the top of the government then in a sense it is the electorate, the voters, who in the long run make the final evaluation.

DATAMATION: Isn't one of the answers a continuing responsibility of the technical community to keep the lay world educated and informed within the bounds of security?

HALLIGAN: Yes, I think you are right. There is a responsibility here and we should give it more attention. Are you asking what MITRE people might do to meet this responsibility?

DATAMATION: Yes. I'm thinking about appearances before Congressional committee or subcommittee hearings on matters involving information processing, and publishing in the journals.

HALLIGAN: We do publish in the technical journals and we are trying to increase this activity. We participate in discussions at all levels in the Air Force and in DOD, and we testify before Congress when invited to do so.

Appropriate reports go to the Defense Documentation Center (formerly ASTIA). We also write technical papers; as many as we have time for. We have no reason to withhold information here because of the proprietary restrictions that apply to profit-making companies. We have no reason to withhold information about anything that we're doing, excepting of course security regulations.

Before leaving this discussion on responsibility, I'd like to make one more point. We believe that ideally most of the MITRE type of work should be done within the government, but for a number of reasons—salaries, organizational structure, and so on—this is not now possible. To help overcome this limitation we believe organizations like MITRE should help to improve the level of capability in government—in the military and the civil service—and we are currently setting up a technical institute, sponsored by ESD, to train government people. We believe this effort may turn out to be very valuable in the area with which you are concerned.

DATAMATION: You've mentioned earlier that there may be other alternatives to use of the nonprofit which are being investigated. Will you comment on them?

HALLIGAN: I understand that the government is trying to improve civil service salaries and organizational policy. Also underway is an attempt to make it more attractive for the military to stay in service. There is talk of setting up internal laboratories similar to nonprofits in organization, but functioning as an actual arm of the government. As to alternatives involving profit-making organizations, I think suitable exclusion clauses and rules of conduct that insure objectivity can be developed. Of course, the element of profit itself is a problem.

DATAMATION: As a systems engineering firm, you are interested in techniques of organization and using equipment to help organization flow. Have you applied any of these techniques within your own organization for improved management control or decision making?

HALLIGAN: We use computer equipment for some of our business operations as do other firms. If I understand your question properly, we haven't introduced data processing functions into our business any more than the industrial firms.

DATAMATION: What is your computer complement? How many computers do you have?

HALLIGAN: We have a number of 1401 computers, a 1410, and a 7090. We also have the XD-1, which was the SAGE prototype, and D825, which is the BUIC prototype. We have an analog computer, and a research computer that we have assembled ourselves. We also have a 7030 STRETCH, which is a very large IBM computer.

DATAMATION: What is the STRETCH used for?

HALLIGAN: STRETCH is currently being checked out in the new System Design Laboratory which MITRE will run for ESD. It will be used mainly for design experiments and for simulations. It's big enough so that it can be used to represent the interplay between command systems. In brief, STRETCH will be a developmental tool for future command and control systems.

DATAMATION: Do you know about how much use this gets or will get under this setup?

HALLIGAN: It will operate on a two-shift basis, at least.

DATAMATION: Is it rented?

HALLIGAN: We bought the STRETCH, with Air Force agreement, because a study of the lease cost over a period of three or four years revealed that it would be cheaper to buy it.

DATAMATION: When was it installed?

HALLIGAN: We took delivery of the 7030 in January 1963 in a temporary building so we could check it and the ancillary equipment out while the System Design Laboratory was under construction.

DATAMATION: You got it at the bargain price before IBM found out that it couldn't make money at that price. Is that right?

HALLIGAN: The 7030 didn't meet IBM's performance expectations. So, IBM cut the price on the few they had manufactured, and indicated no more would be produced. For us it is a very useful and powerful computer, and we were glad to be able to acquire it.

DATAMATION: Is it doing the job for you?

HALLIGAN: Yes, up to the degree we have been able to use it to date. As you know, it takes a long time to program a computer and get it fully operational. We see no reason why it won't fulfill our expectations.

DATAMATION: Have you developed your own software, in terms of programming?

HALLIGAN: Yes, we have.

DATAMATION: Do you maintain fairly strict controls over computer usage within MITRE?

HALLIGAN: Yes, the schedules for them are very carefully worked out. Time is allocated to the projects in accordance with priority of need. Every Air Force project that needs to use computer time is charged for it so that the cost is fairly prorated.

DATAMATION: Are these run as closed-shop installations with a fixed staff of people? Not people wandering in off the hall and pushing buttons.

HALLIGAN: They are run by their own staff. The unit that has a job brings it in and supervises the use of the computer when necessary.

DATAMATION: How flexible is the programming? Do MITRE people handle their own programming in FORTRAN or ALGOL, for example?

HALLIGAN: Yes, and we use other techniques including some that we have developed. We are doing a considerable amount of development work on programming as such.

DATAMATION: What is the turn-around time for an arrangement where a man produces a program deck and wants an immediate answer? How soon can he expect it back?

HALLIGAN: We try to keep the turn-around time less than two hours.

DATAMATION: MITRE has been described to me, by someone whose judgment I trust, as probably the most important single influence in the computing fraternity. If you agree, what made this true?

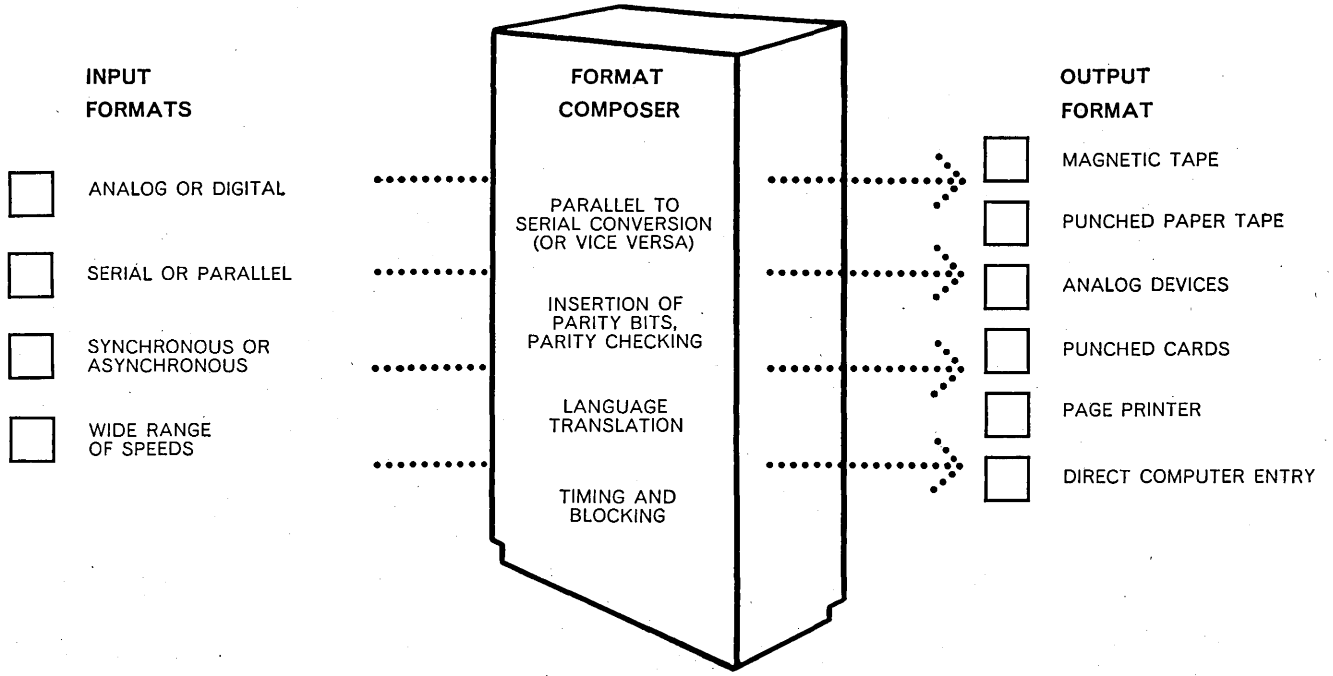
HALLIGAN: There is justification for such a statement. Our experience began with SAGE which was the first large computerized system ever designed and, as a matter of fact, is still by far the largest that has ever gone into the field.

DATAMATION: Physical size?

HALLIGAN: Physical size, total capacity, and investment. It really opened up the computer art. The design of the SAGE system pioneered the field of computerized command and control. The people who wrote that history are with us still. They understand this area thoroughly and they, and their recruited talent, have remained at the leading edge of the art. I think we are one of the most important influences in the field.

DATAMATION: One final question. As an organization that is on the frontier of this art, do the results of your work point to new concepts in computer organization or computer technology? If so, could you give us a hint as to what they might be?

HALLIGAN: There is of course the rapid improvement in the physical sense: smaller size, greater speed, etc. But our work deals more with improvement in the use of the computer, and especially with programming techniques. We have work going on which we believe will go a long way toward solving the problem of excessive programming cost and time. This was the most difficult problem in SAGE, and it's been a problem in almost every big computer job since then. These new techniques offer a way to solve these problems, and that is one of the most important areas of our work. ■



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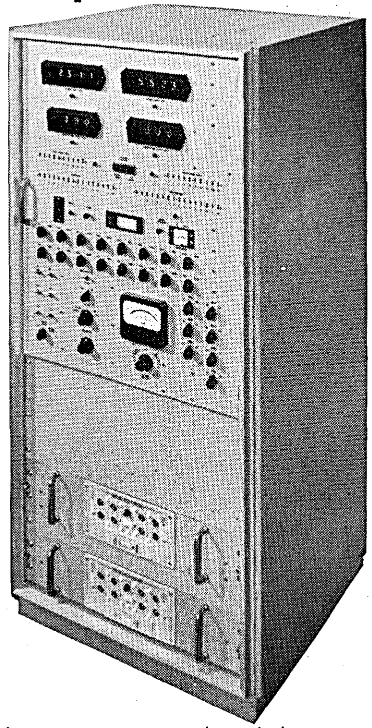

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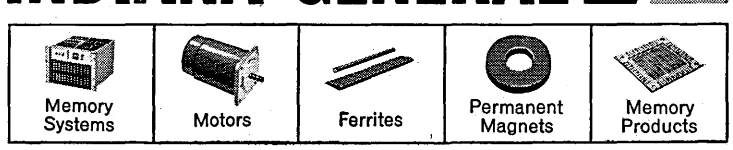


CIRCLE 26 ON READER CARD

USING DECISION STRUCTURE TABLES

part two: manufacturing applications

by D. T. SCHMIDT and T. F. KAVANAGH

This article emphasizes manufacturing applications because most of our experience is in this area. Decision structure tables coupled with computers are paying off because they:

- define and think through manufacturing problems, often providing new insights and understanding which have led to improved performance.
- formulate and record decision systems for subsequent use and communication.
- simplify computer implementation where mechanization is desirable.
- get manufacturing to using computers.

There is a wealth of potential computer applications in manufacturing. They offer great opportunity. Without structure tables, application costs would be exorbitantly high. It is easy to learn how to use decision structure tables, and, further, the user requires minimum computer knowledge and background. Later in this article a structure table application using computers is described—PRONTO.

benefits of decision structure tables

Experience in General Electric shows decision structure tables can reduce actual time spent in problem definition and coding. Users report up to 90% lower programming costs because detailed flow charting and coding are virtually eliminated. Other users report 50% lower application costs because of this, plus improved systems design and check-out efficiency.

Others have been attracted to structure tables because conventional flow charting and coding techniques proved unrealistic for their problems. Also, structure tables are easy to maintain and when used in conjunction with a computer, they offer a level of accuracy unequalled in manual systems.

Another benefit that recently came to the forefront is more efficient documentation. Engineers have long recognized the need for good documentation; for decades draftsmen have laboriously made detailed drawings of every part, assembly, and product. Dimensions, tolerances, materials, finishes are all carefully noted. Frequently, each drawing is given an identification number signed by the draftsman and approved by a supervisor. Precise records are made of all changes—who made them, when they take effect, whether the modification is interchangeable, etc. This defining of every part in a product—every nut, screw, and washer—is important. But is it less important than the decision logic used to manufacture the same parts, to pay the workers, or to bill the customer who purchases them?

In a very real sense, decision structure tables provide a natural "blueprint" for decision. In this simple analogy, the part itself becomes the elementary decision. A structure table is like a blueprint. Structure tables can delineate groups of decisions, as assembly drawings and outline drawings show groups of parts. Decision logic can be just as vital to a business as its engineering drawings. It should be just as easy to find out how detailed decisions are made as it is to locate the design of a part.

Structure tables also provide an opportunity to improve specialist-manager communication in both directions. On one hand, the specialist receives a much more precise definition of requirements from his manager—while the manager, in turn, receives feedback from the structure tables to assure himself that the detailed decision-making system implements his management objectives. The command and control aspects of decision structure tables offer great promise.

Some have asked if it isn't just as easy to forget a pertinent condition when making up a structure table as it is to overlook a test in flow charting. Quite the contrary, the rigid, uniform tabular format makes it more difficult to make mistakes. Each table entry requires individual attention. As discussed last month, the tables also contain some built-in reasonableness checks. But most important are the six rules outlined in the February issue. They provide a logical approach for writing tables one step at a time. The extensive preliminary specification of objectives and the determination of elementary decisions provide overall structure to the problem. The sequential, one at a time analysis of each elementary decision, developing decision parameters, their related tests and values, and results or outcomes with their values are all designed to minimize the chance for error.

Others have asked how useful decision structure tables will be to the informed senior programmer. Certainly one of the problems faced by senior programmers—indeed all programmers—are those who come with inconsistent and incomplete problem definition. Considerable time and effort must be spent trying to uncover and resolve these difficulties so that complete, consistent specifications can be written. But if the application came to the programmer defined with sets of decision structure tables in the first place, there would be substantially less emotion in computer applications work. Also, the informed senior programmer would have to spend much less time learning all there is to know about his prospective client's problem.

If the senior programmer is relieved from handling this applications work, he can then concentrate on making existing applications more computationally efficient. There are also integrated operator systems to be designed and programmed to make it easier for the computer to handle all these different problems. The programmer might even build a structure table processor. In fact, he might find tables very useful in structuring the logic of these applications.

Right now, many informed senior programmers are working as "general applications practitioners" when actually they should be working as computer specialists.

After the application has floundered and no one knows what's wrong, then the informed senior programmer must come in and remedy the situation. It would be a lot easier for him to handle the situation if decision structure tables were used.

The application described below illustrates these benefits. PRONTO is a program to automatically convert conventional, manual manufacturing planning to the considerably more elaborate and complex instructions required to operate numerically programmed machine tools.

development of "pronto"

The introduction of automatic electro-mechanical machine tools created demands for a new kind of planning data. Very detailed coded information was necessary to position a part in relation to a tool. Depth control and tool selection were also necessary. Tool motion patterns for operations such as tapping, drilling, and milling were required. Proper feeds and speeds had to be specified, and provision had to be made for auxiliary functions such as turning coolants on and off.

Instructions required for numerically controlled (NC) machine tools were far more precise. They varied greatly from the routine planning instructions used with conventionally-operated equipment. This preciseness was necessary because the NC machine tool replaced the control and judgment of the human operator.

Using the NC system presented formidable problems. Not only was a high degree of sophisticated planning needed, but a new and unfamiliar "language" was required. Also, standards did not exist and each machine tool required unique inputs. The number of routine, repetitive calculations was enormous and sometimes very complex; this meant the error potential was high and these errors could be very costly. Tape-preparation time was excessive; this resulted in long planning cycles and in idle time of expensive equipment.

Initial analysis showed that a three-fold program was needed:

1. A technique whereby a planner could effectively direct the operation of an NC machine tool in conventional planning terms with minimum translation of data from engineering drawings.
2. A device (probably a computer) to accurately perform the numerous, repetitive, routine calculations required to develop usable NC instructions. The device must also produce an operator's manuscript and punched paper tape for operating the machine tool.
3. A technique that would significantly reduce planning time and cost.

Initially, it appeared that the solution might exist in the development of a planning language and associated computer program. This would enable a planner to describe operation selection and sequences (the *creative* planning) while the computer did the routine calculation and decision-making (the *non-creative* tasks).

But this alone was not enough. Early PRONTO (PROgram for Numerical Tool Operation) programs were constantly undergoing revisions and modifications at considerable expense—to say nothing of the analysis, programming, and documentation problems.

Here was an opportunity for decision structure tables. They would provide a decision-making analysis technique, plus documentation, communication, and programming. Also, decision structure tables could be modified easily.

Thus, PRONTO was developed using decision structure tables. PRONTO is a generalized computer assist planning program for NC point-to-point machine tools. It also includes arcs, slopes and lines for milling operations. It is a "planner oriented" language, that greatly simplifies the planning job. It allows the parts planner to "verbally machine" a part in his everyday planning language. Yet the language allows the most complex parts to be described easily with minimum drawing translation and calculation.

To produce a part on an NC machine tool requires two kinds of data:

1. Part-oriented or process data that relate to the part being machined.
2. Machine-tool-and-control-oriented data related to the specific machine tool and control being used.

function of pronto main processor

Part-oriented data in the Main Processor include process description (drill, ream, tap, bore, etc.), dimensions, reference points, hole patterns, and tools. Basically, it is a geometric and machining description of the operations to be performed. It is these descriptions (locations, operations, and auxiliary functions) that will be converted into the information values and codes that will control the machining of the part.

Note that the part-oriented data is generally universal. The Main Processor, because it is process-oriented, can handle most parts as is. However, some modifications may be desired for special applictions.

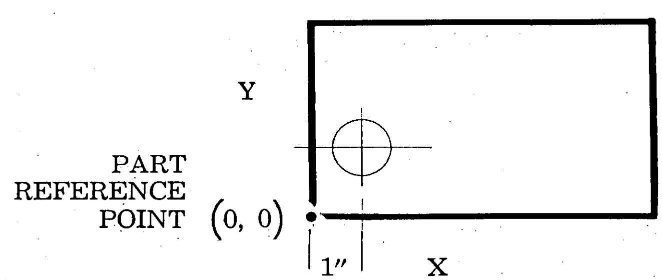
function of pronto post processor

Unfortunately, machine tool and control data is *not* universal from one machine to another. Although recently significant progress has been made in the development of NC standards, most machine tools now installed were not built to these standards. This means that different machines have different codes, tape formats, and unique machine capabilities.

Therefore, the PRONTO "Generalized" Post Processor was developed. It was not written for a specific machine tool or control—but was written to include functional logic packages applicable to most point-to-point NC systems. It can be adapted to specific machine tools by selecting the proper routines (logic) and by completing specific information (data) applicable to the machine tool and control. This normally is about 75-80% of the logic and data. The remaining 20-25% required to complete a specific post-processor must be developed for the specific application.

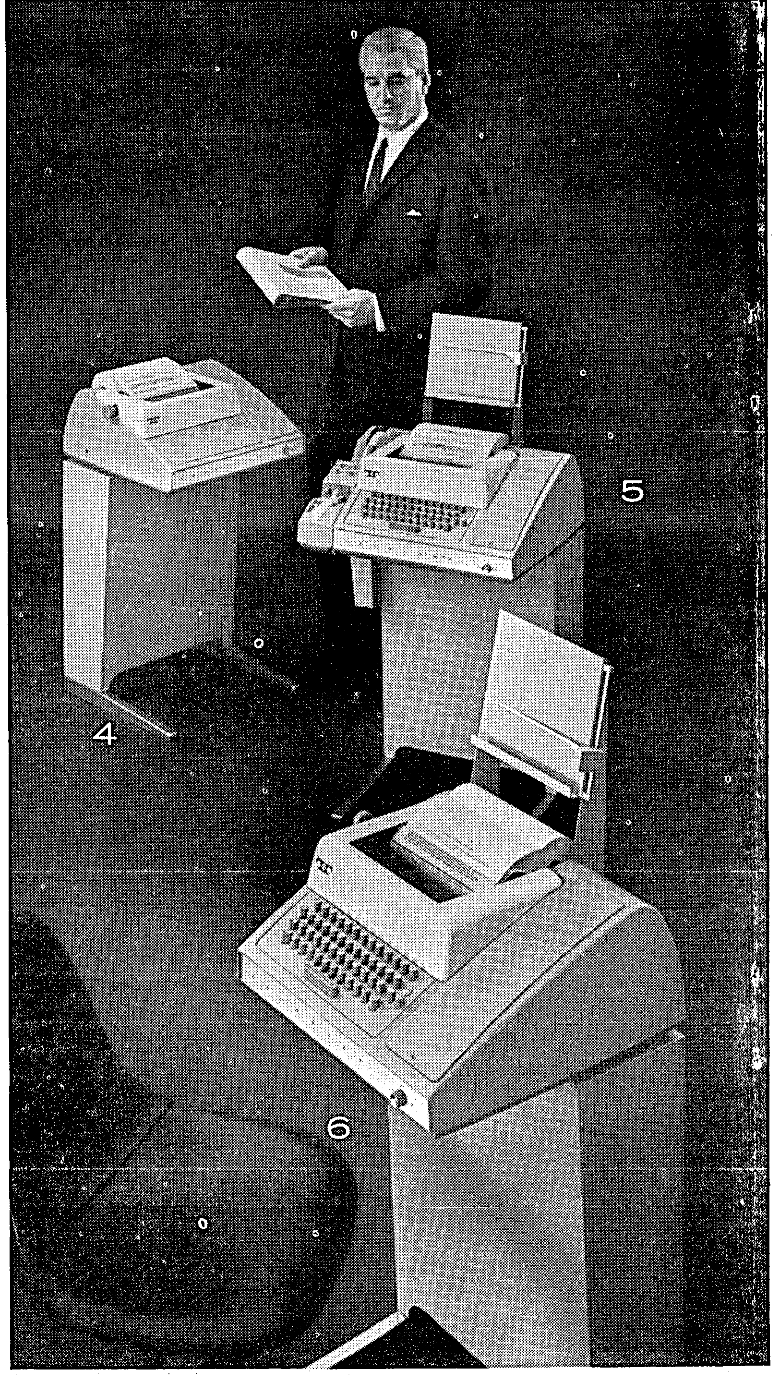
Typical Post Processor data include number of axes (X, Y and/or Z), part reference or location on machine tool, tool or turret selection, modes of operation, auxiliaries, available feeds and speeds, etc., all specific machine tool and control data.

The planner specifies the location of each operation by specifying the X and Y coordinates of the center of the operation. That is the position of the tool in relation to a basic part reference point (0, 0). For instance, the location of a drilled hole is defined by the X, Y coordinates of the center of the hole. In the sketch below, X = one inch.



The planner must also specify once for the part, the relation of the part reference to the machine tool refer-

MODEL 32 SERIES. This new low-cost series operates at 100 wpm. Has a 3-row keyboard with a 5-level code. Shown above: (1) RO Receive-Only Set. (2) KSR Send-Receive Set. (3) ASR Automatic Send-Receive Set.



MODEL 33 SERIES. This economical series has a new 4-row keyboard and operates at 100 wpm with an 8-level, 11-unit code. Shown above: (4) RO Receive-Only Set. (5) ASR Automatic Send-Receive Set. (6) KSR Send-Receive Set.

RELIABILITY COSTS LESS THAN

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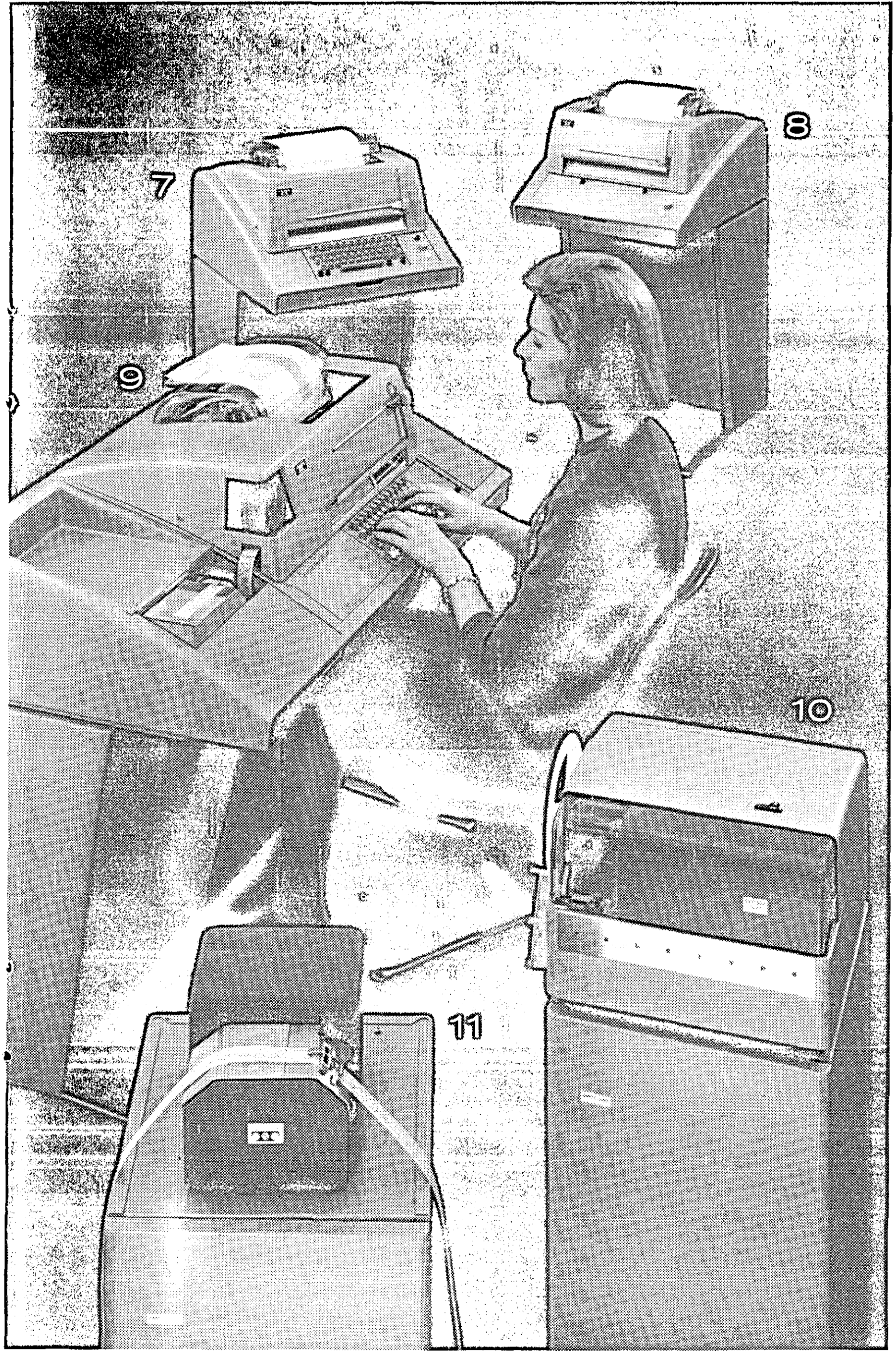
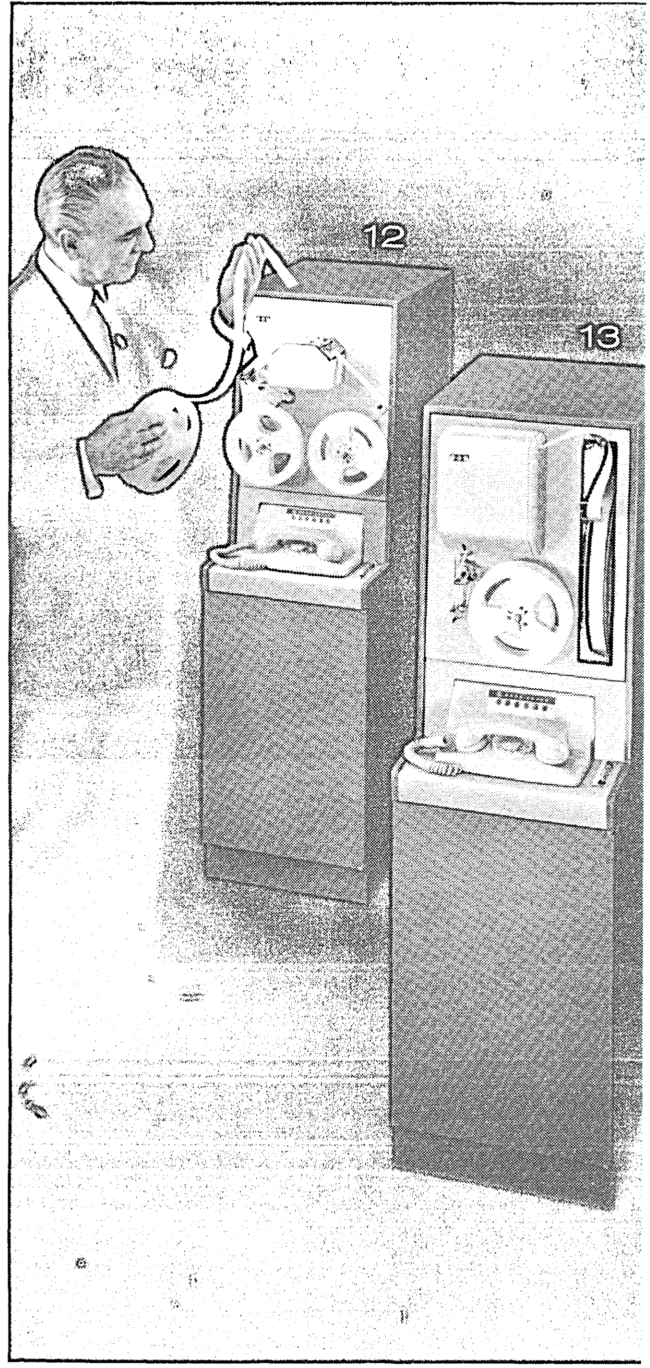
The new Teletype Model 33 and 35 series are made for the Bell System and others for operation on 8-level, 11-unit code. Both series can be used for direct communication with data processing equipment. This opens up many possibilities for their use with your systems—both on-line and off-line. The Model 33 and 35 series



MODEL 35 SERIES. A rugged, heavy-duty line that has a new 4-row keyboard and operates at 100 wpm with an 8-level, 11-unit code. Shown above: (7) KSR Send-Receive Set. (8) RO Receive-Only Set. (9) ASR Automatic Send-Receive Set. (10) Self-Contained Tape Punch. (11) Self-Contained Tape Reader.



HIGH-SPEED TAPE-TO-TAPE EQUIPMENT. Used with DATA-PHONE and other communication services over voice circuits, this equipment is capable of 1,050 wpm tape-to-tape transmission. Shown above: (12) Sending Set. (13) Receiving Set.

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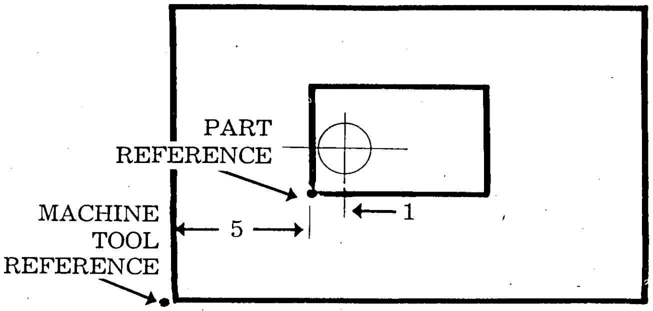
CIRCLE 22 ON READER CARD

ence. This is the location of the part on the machine tool table. Now all dimensions can be related to the machine reference.



Thus, the X hole location is now six inches from the table reference. The next step is referencing to the spindle or absolute position, usually a function of the control.

The computer can calculate these current absolute values for all dimensions, in this case C–X.

These values must then be formatted for the particular machine tool and control being used. Two major control variations are "Memory" and "System." Memory can be YES or NO depending on whether the control retains a value until it is replaced (YES), or if the value must be repeated each cycle (NO). System is ABS, meaning the dimension is the absolute position of the machine tool, or DEP, meaning departure if the next position is in relation to the last.

Two forms of output are obtained from the PRONTO Post Processor: Paper tape for the machine tool, and a printed output for the planners and operators. Here are additional definitions related to the output:

M-X The present adjusted absolute machine position in the X dimension.

PT-X The X value for the paper-tape output. (As you will see, this may vary from the manuscript values.)

O-X The X value for the manuscript.

Table X-OUT-1 of the program now prepares the X output values for the paper-tape (PT-X), and the manuscript (O-X). Table X-OUT-DEP develops the X manuscript value for a departure system—the output value may

TABLE X-OUT-1.

C-X	MEMORY	SYSTEM EQ	PT-X	O-X	GO TO
NEQ M-X	–	"ABS"	C-X	C-X	X-OUT-END
"	–	"DEP"	(C-X)-(M-X)	–	X-OUT-DEP
E Q M-X	EQ "YES"	"ABS"	SPACES	SPACES	X-OUT-END
"	EQ "NO"	"	C-X	C-X	"
"	–	"DEP"	O	–	X-OUT-DEP

be the absolute position or the departure value—depending on what information it is desired to give the operator. X-OUT-END is the end of the example.

The next example will involve tape output format. Tape output formatting has been a continuing major problem. Variations are practically unlimited as these examples show:

Prefix Variations: Prefixes are one-letter designations a machine tool control uses to identify an item of data. For instance, X12345 indicates the data 12345 is an X value. Some controls do not require prefixes; thus, the order of the data becomes significant. In this case, the items are usually separated by tabs (-). Successive tabs indicate no data for an item. The prefix variations of controls are numerous as shown by possible representations of the same value.

X12345
-12345-
A12345

Sequence Variations: The sequence in which the data is punched into the tape is another variable The tape is read in blocks or groups of items. Each block controls a machine tool action. It may be positioning in the X and Y dimensions or tool positioning in the Z or depth dimension. The sequence of data varies within blocks for different controls.

One control may accept all the information in one block, another may require several blocks. Each of the following represents a valid output format—some requiring multiple blocks.

XY (one block)
XYZ
XY (two blocks)
Z
XY (four blocks)
Z
Z
Z

Digit Variations: Still another variation is the number of digits and right or left justification of the digits required for any item. Some variations of the value X = 10.500 are shown (b = blank).

010500
0105bb
b10500
b1050b

The table at the end of this example is the master output table where the manufacturing engineer originally establishes the tape format, order, etc., for any PRONTO Post-Processor.

At this point, all the calculations, logic, etc., have been performed. It is now time to produce the tape. This table will determine the correct tape format for the machine tool, based on logic that the manufacturing engineer has supplied.

The following terms are used in the table:

LINE Some machine tool controls require several blocks of data to complete a motion or operation—each block represents a line of manuscript output—hence "LINE." LINE 1 might contain the X and Y values, LINE 2 might contain the Z dimension.

ORDER This is order within a "LINE"—the first item, second item, and so on. In LINE 1 above, X was order 1, Y order 2, etc.

ITEM This is the specific variable whose current value will be output for the corresponding LINE and ORDER. Here the manufacturing engineer determines the tape format. In this example, ITEMS being output are SEQ-NO, a consecutive sequence number; X, Y, and Z position values; TOOL, the current tool identification number; AUX-1 and AUX-2, auxiliary functions such as coolants; and MODE, the tool motion sequence, a function of the operation. The X dimension is the ITEM for LINE 1, ORDER 1; the Y dimension is the ITEM for LINE 1, ORDER 2, etc.

TAPE FORMAT This is the output format that is desired for the ITEM. The first digit represents the number of positions to the left of the decimal, the second digit the number of places to the right of the decimal. For example, X = 12.345 would be of the 23 format, X = 12.34 would be the 22 format, and so on.

LEAD-SUPP TRAIL-SUPP Indicates by "YES" or "NO" whether suppression of leading or trailing zeroes is desired. Leading or trailing zeros are not required by some controls, therefore tape punching and reading time can be reduced by their elimination.

Table OUTPUT-1

This table creates the output tape—the ITEMS are selected for proper LINE and ORDER. The TAPE-FORMAT and SUPPRESSION are determined next—the ITEM is then ready for tape output.

LINE	ORDER	ITEM	TAPE-FORMAT	LEAD-SUPP	TRAIL-SUPP
1	1	SEQ-NO	40	"NO"	"NO"
1	2	X	23	"YES"	"NO"
1	3	Y	23	"YES"	"NO"
1	4	TOOL	40	"NO"	"NO"
1	5	AUX-1	30	"NO"	"NO"
2	1	SEQ-NO	40	"NO"	"NO"
2	2	Z	23	"YES"	"NO"
2	3	MODE	40	"NO"	"NO"
2	4	AUX-2	30	"NO"	"NO"

In our opinion, the use of decision structure tables in PRONTO helped:

1. Provide for an excellent analysis of the problem and an approach to the generalized solution.

2. Introduce the concept of "skeleton tables" whereby logic and relationship are furnished, but specific values must be supplied by the user. Skeleton tables include the condition and action headings as developed in the rules for writing structure tables (Part I). The values for the parameters must be furnished. For instance, different machines have unique feeds and speeds; thus the speed skeleton table may look as follows:

SPEED	SPEED	SPEED-CODE	SPEED-RANGE
GR	NGR		
GR	NGR		
GR	NGR		
GR	NGR		

Here the given speed, SPEED, is converted to the specific SPEED-CODE and SPEED-RANGE for this machine tool. Other machine tools may have different break points for the speed, or different codes and ranges.

3. Provide source documentation for manufacturing engineers, planners and programmers.

4. Reduce programming time.

5. Minimize communications problems between users, specialists, and programmers.

6. Allow debugging at the source level (in English).

Thus the objectives of PRONTO were fulfilled—largely through the use of structure tables.

wider acceptance and use

Why isn't there wider acceptance and use of decision structure tables? There are three primary reasons.

The first is that structure tables are relatively new compared to flow charts. Most programmers began their training with flow charts and are understandably reluctant to make an abrupt change.

Second, there has been limited information available on how to do structuring. Earlier articles described what structure tables are without going into real "nut and bolt" explanations of how they are actually put together. Frankly, verbalizing the structure technique is difficult, as this article has demonstrated. Then too, relatively few persons have had actual experience with live problems.

Third, few structure table compilers are available today. Therefore, much of the benefit is lost because tables must then be coded. Experimenting with one of the existing processors probably isn't such a bad idea, since much of the advantage of structure tables certainly stems from the fact that they can be used directly to compile operating computer programs.

However, many benefits are not dependent on the computer. So, therefore, don't overlook the power of structure tables as a manual systems analysis and design tool. Indeed, this is where the principal benefits are claimed. Then too, if there is a mental or organization block about going someplace else to "compile" structure tables you can implement a simple structure table language of your own. They are remarkably effective and don't cost much. Simplified compilers ranging from $10,000-$25,000 have been built for a variety of machines. In comparison, regular full scale pseudo languages are complex and may take hundreds of thousands of dollars to implement.

The important point is, don't wait for the world to provide a slick structure table processor. If needed, you can make one to satisfy your own needs on your own computer.

In closing, the authors would like to acknowledge the contribution of their associates in Advanced Manufacturing Engineering Service, Production Control Service, Computer Dept., and X-Ray Dept. to the work reported in this article. Mention should also be made of the many contributions other General Electric departments have made to the development and application of decision structure tables. ■

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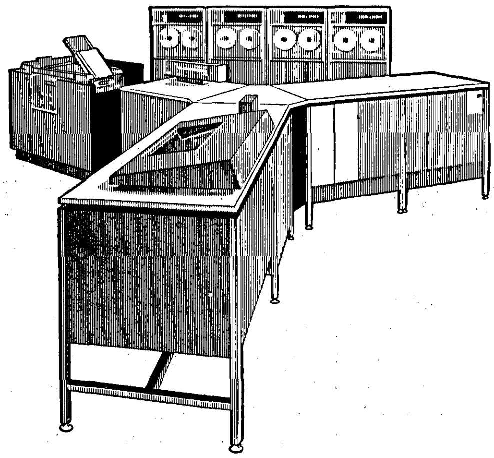

The new Honeywell 200 can print, punch, read and write at the same time it's computing

(No other low-cost computer can make that statement)

Two weeks after the Honeywell 200 came out, $50,000,000 worth of orders were in. That's a lot of orders. But, then, the 200 is a lot of computer. ▫ It's the first business computer that combines big-system performance with a low price tag. (As little as $3,160 a month.) ▫ The Honeywell 200 has up to eight input and eight output trunks, giving it real versatility for peripheral jobs. What other low-cost computer, for example, can print, punch, read and write at the same time it's computing? None. ▫ No other low-cost computer has such speeds, either. The H-200 has a two-microsecond memory cycle (that's three to five times faster than any other small system – even faster than some big ones). ▫ A powerhouse in its own right, it is also efficient as a satellite to other computers. And it's compatible. Chances are, you can switch over to a Honeywell 200 from your present system with little if any re-programming. ▫ For more information on the new H-200 computer, write: Honeywell EDP, Wellesley Hills, Mass. 02181. Or contact your local Honeywell EDP office.

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DATAMATION

NEWS BRIEFS

DIRECTIONAL LASER BEAM CONTROL REPORTED

Working toward the display, transmission or processing of light, rather than electrical signals, in computers, IBM engineers have developed an experimental device that electro-optically deflects a laser beam to locations on a surface. Deflection under mechanical control had been found to be too slow.

Described in the firm's *Journal of R&D*, the digital-indexed light deflector is reportedly capable of a one-usec random directing of letters, numbers or other images to about 1,000 binary addressed positions; the selection includes some code-converting logic. In time, deflections in the nanosecond range reportedly will be possible. The laser is used because of the loss of light intensity through absorption in the deflection process.

PARTS PRODUCTION SCHEDULER DEVISED BY SRI, LOCKHEED

A sort of PERT-for-parts system has been developed by Stanford Research Institute and Lockheed Missiles and Space Co. for production planning in the Navy's Polaris program. The PACER (Planning Automation and Control for Evaluating Requirements) system determines quantity and need dates for the hundreds of components that go into the missile, based on production schedule and system configuration changes.

Prepared for an IBM 7094, the software is being used by those in purchasing, subcontracting, production scheduling and budgeting. In progress is a study of its interfacing with other systems of management control.

FALL JOINT CONFERENCE ISSUES CALL FOR PAPERS

A call for papers has been issued for the Fall Joint Computer Conference which will be held on Oct. 27-29 at the San Francisco Civic Center. Deadline is May 1. Named conference chairman is Richard I. Tanaka of Lockheed Missiles & Space Co., and technical program chairman is David R. Brown of Stanford Research Institute, Menlo Park, Calif. 94025.

Five copies of the entire paper, not exceeding 10,000 words, should be sent to the latter, and should include a 100- to 150-word abstract.

RCA READIES INTERNATIONAL TELEGRAPH SWITCHING SYSTEM

A computerized international public telegraph system which will replace a torn-tape center has been demonstrated by RCA Communications Inc. It is scheduled to go on the air this spring. Central hardware is a computer similar to the 601 and capable of handling 2.5 million cps.

Capable of switching messages through 100 receiving and transmitting channels, the computer can also identify any of 7,000 cities, states and countries in three languages, and 12,000 internally registered coded addresses. It also examines messages for accounting and billing information.

IFIP CONGRESS 65 ISSUES A CALL FOR PAPERS

A call for papers for the IFIP Congress 65, international congress on the information processing sciences in New York City, May 24-29, 1965, has been issued. Deadline is Sept 1, 1964. The program will cover major advances in such areas as automata, language translation, information systems, communication, and artificial intelligence, as well as the design and programming of computers. The triennial meeting of the 23-nation organization is expected to draw more than 5,000 people from 50 countries.

Those interested in the detailed requirements pertaining to the submission of papers may obtain them from IFIP Congress 65, 345 East 47th St., New York 17, N.Y.

RECORD ATTENDANCE EXPECTED IN WASHINGTON FOR SPRING JOINT

More than 80 exhibitors and some 4,000 attendees are expected in the nation's capitol for the Spring Joint Computer Conference, April 21-23 at the Sheraton Park Hotel. Scheduled exhibitors include two foreign manufacturers, ICT of England and A. B. Atvidabergs Industrier of Stockholm, Sweden.

The conference is sponsored by the American Federation of Information Processing Societies. Registration fees are $8 for members of sponsoring societies (ACM, IEEE, SCI), $10 for non-members, and $2 for students. With the theme, "Computers '64: Problem-Solving in a Changing World," about 45 papers will be presented in 14 technical sessions: Information Retrieval (one technical, one tutorial); Business DP; Command & Control; Hybrid (technical and tutorial); Numerical Analysis; Logic, Layout & Associative Memories; Compilers; Artificial Intelligence; Multiprogramming; Social Implications of DP; Applications; and Evaluating Computing Systems. A cash prize of $500 is being awarded for the best paper.

Other activities include a special session on the computer education of the blind, an educational symposium, informal evening seminars and tutorials, and a ladies' program. Field trips to four computer sites are scheduled.

Conference chairman is Herbert R. Koller of the U. S. Patent Office, and Technical Program chairman is Jack Roseman of CEIR Inc.

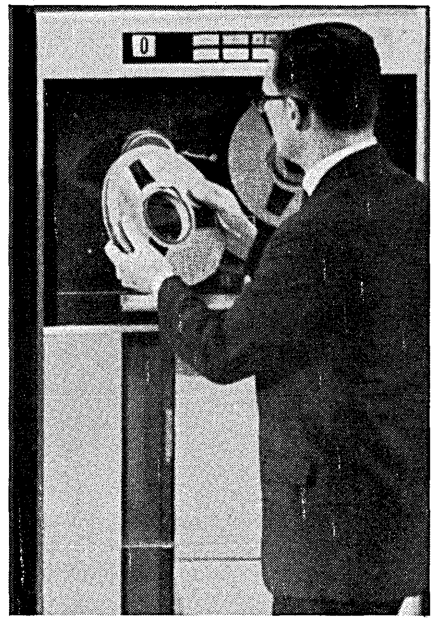
BANK ADDS HARDWARE TO CENTRALIZE BOOKKEEPING

Centralized statewide bookkeeping for its branch offices is being instituted by the United California Bank with the installation of a San Francisco-Los Angeles data communication system. Transactions at each branch bank are carried to San Francisco or Los Angeles for processing at the latter city each evening, and returned by the next morning. Starting with checking accounts, the next move is to savings accounts.

Communications hardware cost is $3K per month, plus $4K per month for the lines; being used is a broad band channel composed of 12 telephone circuits. An IBM 7710 Teleprocessor in Los Angeles is nestled amid five 1401's and one 7074. In San Francisco is one 1460.

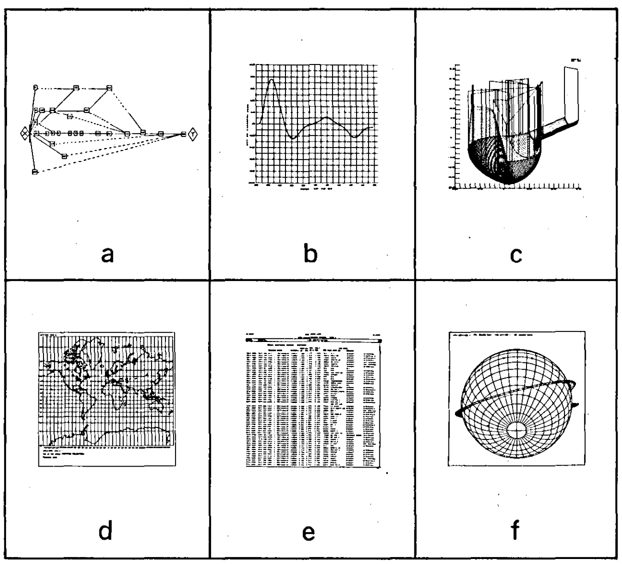
• Local high school seniors are attending a junior-level programming

Computer Output Questionnaire



Test your knowledge of the latest methods available for displaying and recording the output of large-scale digital computers.

Questions



1 How much time was required to record the above output sample "b" on film.

a. One hour ☐ b. One minute ☐
c. One second ☐ d. One-half second ☐

2 How much time was required to print all of the above samples from tape transport start to delivery of finished paper to the engineer?

a. Thirty seconds ☐ b. Six minutes ☐
c. Twenty-five minutes ☐ d. One hour ☐

3 How much time was required to write the computer program for producing sample "b"?

a. One minute ☐ b. Five minutes ☐
c. One hour ☐ d. Four hours ☐

4 How much large-scale computer time (IBM 7090 class) was required to prepare tape for output sample "b" shown above?

a. Less than three seconds ☐ b. One minute ☐
c. Five minutes ☐ d. Ten minutes ☐

5 How many of the following output types can be produced by one versatile computer recorder already in commercial operation? (1) 16mm microfilm for automatic storage and retrieval; (2) 35mm microfilm; (3) quick-look paper copy; (4) high-quality paper copy for reports and distribution; (5) vellums; (6) page-size film negatives; (7) animated motion picture strips.

a. (1) through (3) ☐ b. (1 through 4) ☐
c. All except (7) ☐ d. All of these ☐

6 Each of the six samples above represents a specific computer output application. Match correct letter code of above samples to each of the applications listed below.

Curve Plotting ______
PERT Charts ______
Tool Path Drawings ______
Orbital Plotting ______
Mapping ______
Alphanumeric Line Printing ______

7 What is the minimum number of hours of daily usage required to justify economically an output device capable of producing all of the above samples in a matter of seconds?

a. Sixteen hours ☐ b. Eight hours ☐
c. Three hours ☐ d. One hour ☐

(Answers may be found on following page)

course at the Univ. of Miami (Fla.) School of Engineering in a program financed by an anonymous member of the local chapter of the American Institute of Industrial Engineers and matching funds by the college. The 11 high schoolers last semester ranked among the top 10% of the more than 100 in the course.

● An 8K Telefunken TR 4 has been ordered by the Technical Univ. of Delft, in The Netherlands. Core memory is expandable to 28K. Being prepared is an on-line operation, the computer reportedly capable of running up to eight programs simultaneously. The language in the open shop operation is ALGOL 60. Another system is scheduled for the Univ. of Groningen.

● An effort to construct a metropolitan area databank for machine processing has been started by the Metropolitan Planning Comission of Portland, Ore. Accomplished to date: a 1401 output of a map which shows the condition of dwellings with census enumeration districts. Still lacking is a method of getting legal land descriptions into machinable form.

● A coaxial circuitry packaging technique that reportedly enables computers to operate up to 100 times faster than present speeds has been developed by Sylvania Electric. The technique is said to reduce by a factor of four the total circuit inductance attained by conventional construction. Used in locked pair tunnel diode logic circuits, it also makes feasible circuits with current gains of 20 at a phase rate of 800 mc, with four phases operating at a clock rate of 200 mc.

● A contract to study the acquisition and use of scientific and technical information by Defense Dept. scientists and engineers has been awarded to Auerbach Corp., Philadelphia, by DOD's Advanced Research Projects Agency. To be investigated are the kinds of information used, and its relationship to decision making and management functions. Under the direction of Walter M. Carlson, director of Technical Information, in the office of the director of Defense, Research and Engineering, the study will be completed this year at an estimated cost of $290K.

NEXT EXAM SLATED

dpma certificate program

A tentative date of Feb. 13, 1965. has been set for the next examination for the DPMA's Certificate Program in Data Processing. Deadline for applications is Dec. 1, 1964. Established by the five-man Certificate Advisory Council which controls the program, these dates were set to enable the various societies, colleges, and professional groups to present refresher courses for those preparing for the exam. This is the last exam which will not stipulate that applicants satisfy an academic requirement.

Since its start in 1962, a total of 2,534 certificates has been awarded. There were 2,445 applicants for last November's exam, of whom 1,136 were members of the Data Processing Management Assn., 217 were members of the Assn. for Computing Machinery, and 1,092 were not affiliated with either. Among them, 1,596 received certificates. Investment to date in the exam is estimated at $40K.

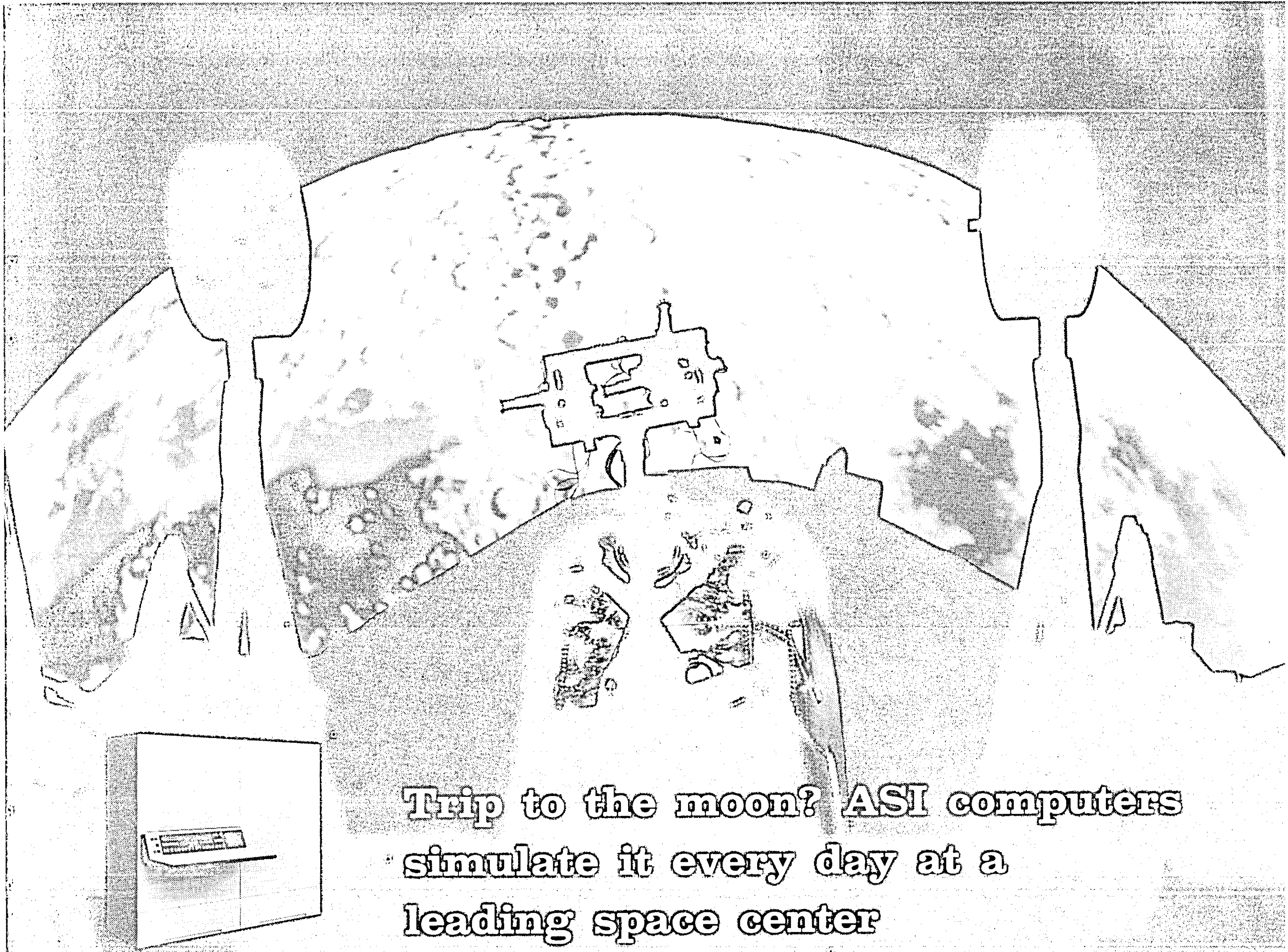
Reportedly emerging is a pattern in the format of the exam. Seven parts of the test and their approximate contribution to total score are as follows:

Computer	30
Punched Cards	15
Systems	20
Equipment	5
Accounting	10
Math	10
Statistics	10
	100

Viewing this, the council decided that five sub-tests, as they are called, appear to be statistically dependable, whereas two require additional work.

In addition to administrative problems dealing with the present examination, and mechanical problems concerned with the scoring and grading, the council discussed extensions to the examination which cover the professional areas of scientific and engineering programming. It was felt that the first four sub-tests should apply equally well to both fields, whereas additional sub-tests could be devised and administered in lieu of the tests in accounting, math, and statistics. If the test was so split, a certificate could be awarded in Data Processing, Scientific Processing, or for those qualified for a combination, a certificate in Information Sciences. In the face of rumors that ACM and SHARE were both considering some sort of a certificate program, the council chairman, R. S. Gilmore, expressed a willingness to discuss extensions to the present program with any duly constituted representative of either body.

A study guide and additional information on the 1965 exam is available from DPMA International Headquarters, 524 Busse Highway, Park Ridge, Ill. ■



Trip to the moon? ASI computers simulate it every day at a leading space center

Ask Ling-Temco-Vought! Advanced Scientific Instruments digital computers are a vital component of the LTV-Dallas moving base simulator presently being used for manned aerospace flight training. This simulator is one of the most realistic comprehensive simulators in existence. This simulator and associated ASI computers have already logged thousands of hours in solving problems for aerospace and low-altitude vehicles.

The new ASI 2100 is ideal for this application. Why? Because real-time simulators such as the LTV unit must exchange data with the computer at highest rates to assure simulator reactions that closely approach actual vehicle behavior. The 2100 input/output rate has large scale computer speeds of 500,000 words per second. At this rate even the most complex simulator does not strain the 2100's capacity to accept data.

True simulation demands instantaneous reaction to emergency situations. ASI's 2100 has 64 individual addresses for external interrupts, any one of which can be addressed by up to 16,000 external devices. As many interrupt locations as desired can have priority and various priority levels can be assigned to external devices to give them recognition over lower priority interrupts. This powerful priority interrupt structure enhances simulator flexibility in allowing external events such as emergencies to transfer operation into an entirely new mode.

Simulator systems must be adaptable to current problem demands at low cost. The basic 2100 is available for $2,590 per month or a purchase price of $87,800.

ASI's 2100 has modular compatibility both upward and downward. A change in the scope of any program will not render the existing hardware or software useless. An entire system can be radically modified (reduced or enlarged) and be back in operation immediately. Hidden costs such as having to write new programs simply do not exist. ASI programming software is standard; it is written in only one way to accommodate all possible external hardware configurations, special or otherwise.

Some other outstanding 2100 features are:

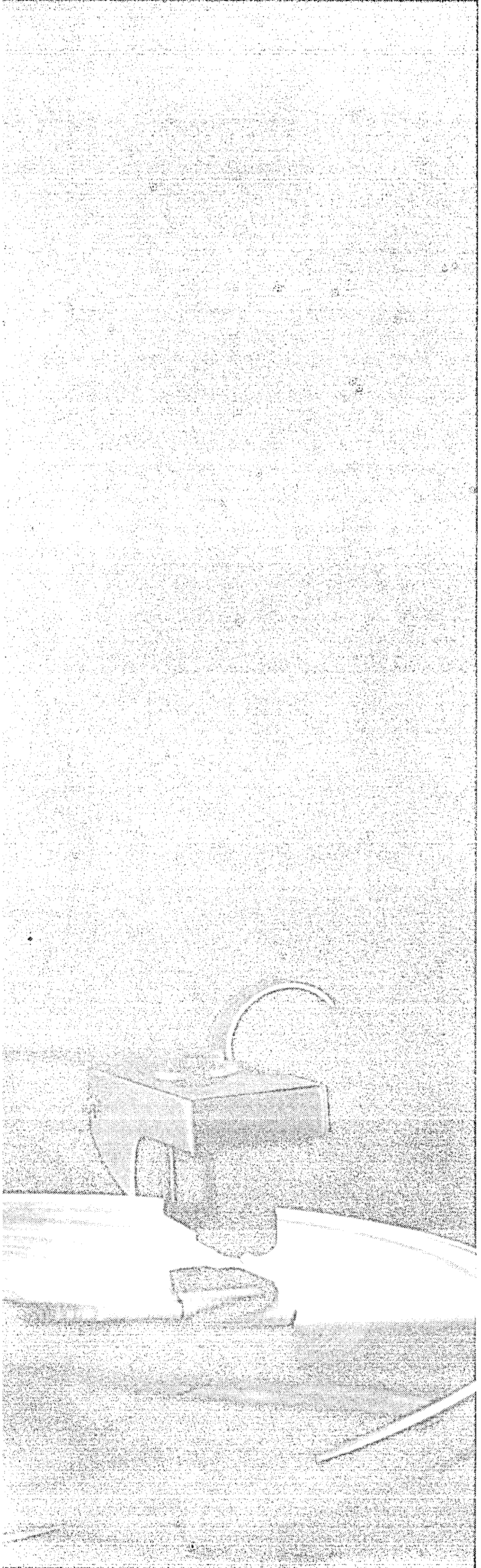
2 usec memory cycle time
4 usec add time
Three index registers

For full information ask us for a descriptive brochure.

ASI

ADVANCED SCIENTIFIC INSTRUMENTS / DIVISION OF ELECTRO-MECHANICAL RESEARCH, INC.

8001 Bloomington Freeway, Minneapolis, Minnesota 55420



One of a series briefly describing GM's research in depth

When will it wear out?

Most things we know about—and this includes biological systems—begin to wear out as soon as they go into service. Survival rates do not follow a Gaussian distribution. Life is not symmetrical. For the person concerned with reliability, the problem is to find a realistic mathematical representation of the wear-out phase of components.

In a break from classical reliability statistics, GM Research mathematicians were among the first to use the relatively little known Weibull distribution function . . . a remarkable generalized way of handling skewed distributions by one family of straight lines. To demonstrate its appropriateness, they've developed a number of easy-to-use graphical techniques for planning and interpreting life tests, fatigue experiments, and even incomplete field service data. Among their pioneering contributions:

A new method using median ranks for graphically describing experimental main effects and interactions;

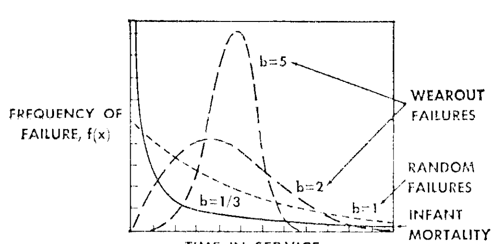
New ways of slashing test times and optimizing experimental designs;

A new method (theory of suspended items) for analyzing endurance data in which some items have failed and some are still running.

Now an accepted standard in the bearing industry, their graphic Weibull techniques have filled numerous papers and two books now on press. It's one of the ways GM researchers and engineers are working to bring improved reliability to both space and earth-bound hardware.

General Motors Research Laboratories

Warren, Michigan



Varying one parameter (b) in the Weibull distribution function allows the characterization of many types of reliability phenomena.

people IN DATAMATION

■ Arnold K. Weber, who had been Operations vp of RCA-EDP, has been elected corporate vp. He remains responsible for the division's overall direction. Wesley J. Gallagher has been named division vp for Government Marketing.

■ Dr. Norman E. Friedmann has been named president of ITT Data and Information Systems Div., Paramus, N.J. He had been vp-California operations of ITT Federal Labs.

■ Dr. Richard F. Clippinger, former associate director of product planning, has been named assistant to the vp for planning and engineering at Honeywell EDP, Wellesley Hills, Mass. He continues as director of standards.

■ Erwin H. Warshawsky, former chief of Computer Technology for Douglas Aircraft, has joined Mesa Scientific Corp., Inglewood, Calif. He will head the firm's consulting services in design automation.

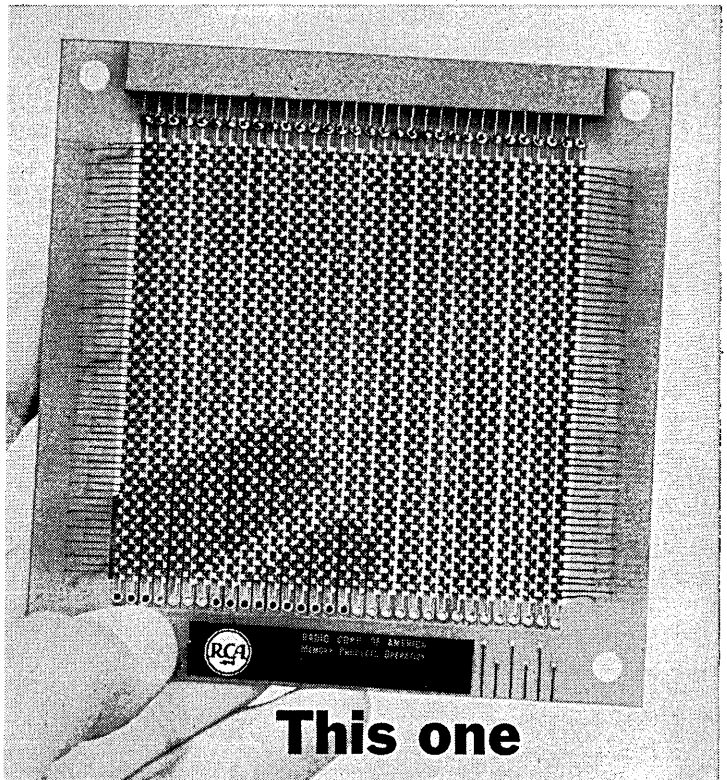
■ William R. Hoover has been appointed manager of the Los Angeles division of Computer Sciences Corp. He was formerly chief of the Computer Applications and Data Systems Section of the California Institute of Technology's Jet Propulsion Laboratory.

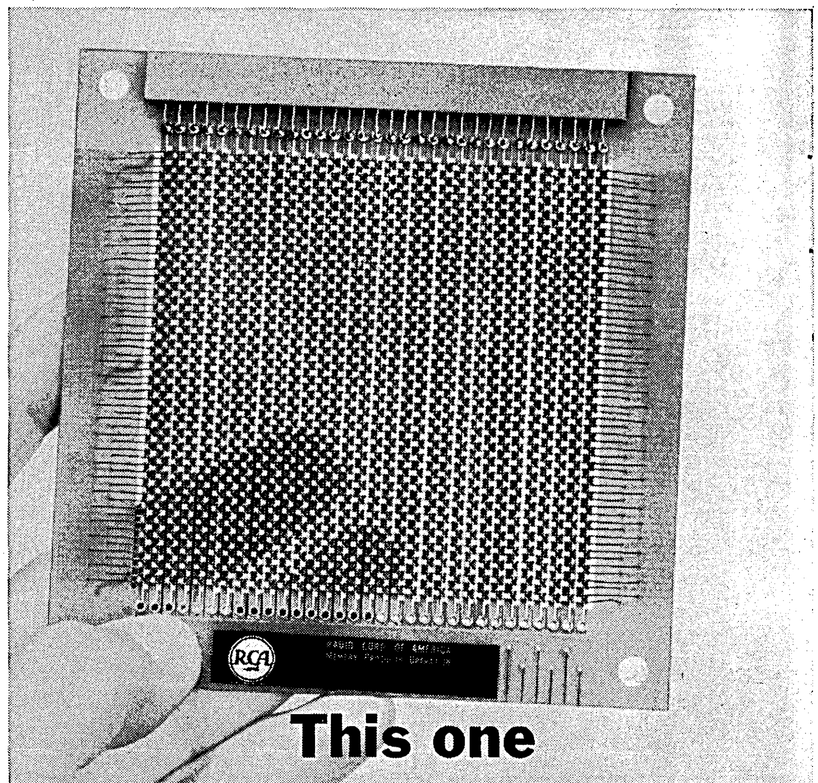
■ Joseph B. Rice, Jr., has been named to the post of corporate director of manufacturing for the Burroughs Corp., Detroit. He is currently serving as manager of the company's ElectroData Manufacturing and Engineering Div., Pasadena, Calif.

■ Edward Leyman has been named director, Information Systems Div. of Herner and Co., Washington, D.C. The firm specializes in information systems design and consultation.

■ Frederick W. Howells has been appointed director, Washington Research Center of Technical Operations Research, Burlington, Mass. He was formerly with Lundy Electronics & Systems Inc. and MITRE.

What's the difference between these two microferrite memory arrays?





This one remembers 1024 bits

This one remembers twice as much!

New RCA ONE-CORE-PER-BIT Microferrite Memory Array cuts space requirements in half...cuts array costs by 40%!

You're looking at still another major RCA contribution to ultra-high-speed memory systems: a one-core-per-bit array with a complete read/write cycle of 300 nanoseconds at drive-current levels below 400 ma and bit outputs of 140 mv.

It permits the highest information-packing density yet attained in a commercial high-speed word-address system: 2,000 to 4,000 bits per cubic inch! Plus the quality features you take for granted in RCA Microferrite Memory Components:

- *Superior Stability and Ruggedness*... Printed wiring assures positive, rigid contact to each core. Planes designed to meet military mechanical and environmental specifications.
- *Precision Uniformity*...Mechanized fabrication eliminates many hand-assembly variables.
- *Outstanding Reliability*... Mechanized production techniques permit more precise control of each fabrication step—produce a rugged, high-reliability structure.
- *Broad Capacity Range*...Available in 32 word x 32 bit size, and in any multiple of this size.
- *Plug-In Convenience*...Each stack incorporates standard plug connections for fast, easy installation.

TENTATIVE DATA

Typical Drive Requirements at 25°C

	Amplitude (ma)	Rise Time (nsec)	Duration (nsec)
Read Pulse	400	30	100
Partial Write Pulse	230	30	65
Digit Pulse	80	30	80

Typical Bit Output (One Core/Bit Word-Address)
Undisturbed "1": 140 mv
Disturbed "0": 30 mv
Bit Switching Time: 75 nsec

Whatever your memory requirements, your local RCA Representative is prepared to provide a coordinated application service. Call him today at your nearby RCA Field Office.

For complete technical information on new RCA Microferrites, write RCA Electronic Components and Devices, Memory Products Operation, Section F-D-3, 64 "A" Street, Needham Heights 94, Mass.

RCA The Most Trusted Name in Electronics

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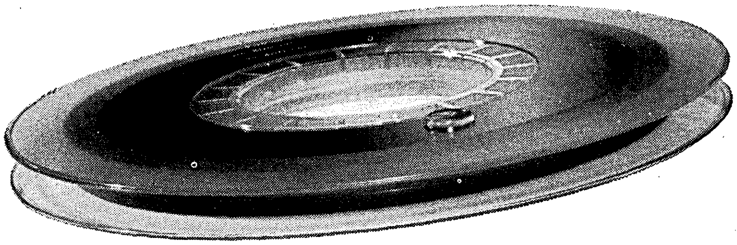
CIRCLE 35 ON READER CARD



NEW PRODUCTS

hybrid linkage

The Adage 770 is a modular system with a number of standard options which provides A-D and D-A conversion channels, performs multiplexing, distribution and timing functions necessary for linking analog and digital computers. Provisions for manual control permit system checkout independent of the digital computer. ADAGE INC., 292 Main St., Cambridge 42, Mass. For information:
CIRCLE 200 ON READER CARD

information access

MIMO (man-in, machine-out) is an I/O device which allows interrogation of an on-line storage unit. Input can be by handwriting with a stylus or with prepared message tabs, and output is by non-impact strip printer. DATA TRENDS INC., 1259 Route 46, Parsippany, N.J. For information:
CIRCLE 201 ON READER CARD

random access memory

RCA's new RACE (Random Access Computer Equipment) has a maximum capacity of "some 5.4-billion characters," stored on 16 x 4.5-inch magnetic cards, each with a capacity of 166K characters stored on 128 channels. A removable magazine contains 256 cards. The notched cards are selected by the computer and fed to a drum for read/write. A read/write station will handle up to 16 magazines; up to eight RACE units can be incorporated into the system. No specific access times were quoted. RCA, 30 Rockefeller Plaza, New York 20, N.Y. For information:
CIRCLE 202 ON READER CARD

data transmission

This system consists of Dial-o-verter paper tape terminals D508S and D508R which are able to transmit data over the regular dial telephone network at a speed of 750 words per minute from any number of remote locations to a central point. DIGITRONICS CORP., Albertson, N.Y. For information:
CIRCLE 203 ON READER CARD

computer speakout unit

A device that provides verbal replies to inquiries about the contents of a computer-controlled file has been

designed. The 7770, which can be linked to a 1401/40/60/10 and 7010, stores a vocabulary of 32-127 words and has from four to 48 communications lines. Telephone inquiries, with verbal responses, are handled with a 1001 data transmission unit. IBM, DP DIV., 112 E. Post Rd., White Plains, N.Y. For information:

CIRCLE 204 ON READER CARD

automatic film reader

The PFR-1 reads data on photographic film at 5,000 points per second and records it on mag tape or outputs on a printer. The system includes a PDP-1 with CRT, and has applications in reading data from

radars, theodolites, spark and bubble chambers, and oceanographic and biologic labs. It reads 16, 35, and 70 mm film. INFORMATION INTERNATIONAL INC., P.O. Box 106, Maynard, Mass. For information:

CIRCLE 205 ON READER CARD

intercoupler

This teletype-keypunch intercoupler, designed for communications in decentralized industrial or business operations, converts data from teletype code directly into standard Hollerith code, or the reverse, at rates from 60-100 wpm. NAVIGATION COMPUTER CORP., Valley Forge Industrial Park, Norristown, Penna. For information:

CIRCLE 206 ON READER CARD

data line terminal

Type 2 enables the 1004 card processor to communicate over conventional telephone lines with local or remote mag tape terminals. All information on full 80-column cards can be transmitted, received and processed at rates up to 140 cpm. UNIVAC, The Sperry Rand Building, New York 19, N.Y. For information:

CIRCLE 207 ON READER CARD

modularized edp system

Nanologic 100 is able to operate at repetition rates to 100 megapulses per second with coincidence resolving times of 1.2 nanoseconds. Ten func-

NEW PRODUCTS . . .

tional modules include: pulse height discrimination, coincidence detection and resolution, pulse shaping, pulse amplification to 100 Mp/sec, prescaling, logic functions (AND, NOR, OR), pulse shaping and standardizing, fan-in and fan-out, time to pulse height conversion, scaler driving and power driving. CHRONETICS, INC., 965 Nepperhan Ave., Yonkers, N.Y. For information:

CIRCLE 208 ON READER CARD

desk-size computer

Zuse Z 25 features 18-bit word, basic 38-instruction repertoire, up to 1024 index locations. Fixed store is 4K; working core can range from 256 words, and an auxiliary drum contains 17,664 words. Maximum operating speed is quoted as 11,765 operations/second. Software includes ALGOL and COBOL; FORTRAN is being developed. ZUSE KG, Bad Hersfeld, Germany. For information:

CIRCLE 209 ON READER CARD

data acquisition

Model 24373 can accurately make 2000 voltage measurements per second and record them on mag tape for direct entry into a digital computer or recorder. A sample and hold feature permits the voltage measurement displayed to represent the instantaneous value that the voltage had within 0.5 microseconds after the command. NON-LINEAR SYSTEMS, INC., Del Mar Airport, Del Mar, Calif. For information:

CIRCLE 210 ON READER CARD

direct accounting

The E2100 is a sophisticated accounting machine, available with 40 or 100 words of magnetic core memory. Printing speed on a 220 alphanumeric character line averages 20-40 cps. Features in five models include the ability to read and write alphanumeric data on mag stripped ledgers, and a choice of punched card or paper tape output. BURROUGHS CORP., Detroit, Mich. For information:

CIRCLE 211 ON READER CARD

translator

The CT-58 has been designed for connecting punched tape data to a five-level telegraph line. The device features 5-level serial telegraph code output to the line from either 8-level, or 5-level punched tape information. CANADIAN AVIATION ELECTRONICS LTD., Box 2030, "St. Laurent," Montreal 9, Quebec, Canda. For information:

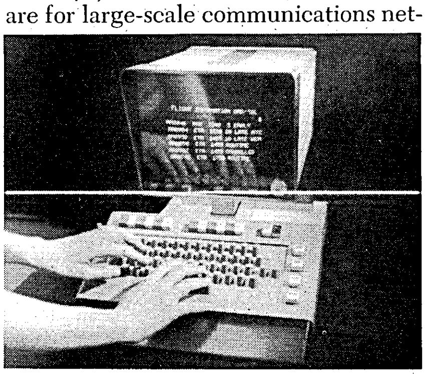
CIRCLE 212 ON READER CARD

telemetry-computer interface
Model 1201 digitizes, multiplexes, and stores up to 16 asynchronous serial PAM, PDM, PCM and time-multiplexed FM telemetry data inputs for computer interrogation. At the heart of the system is an asynchronous digital scanner which accommodates 160,000 samples/second from up to 16 sources. MONITOR SYSTEMS, INC., Fort Washington Industrial Park, Dept. 1282, Fort Washington, Pa. For information:
CIRCLE 213 ON READER CARD

buffer core memory
The KD-5030 is a compact printed-circuit unit that accepts parallel digital data at up to 10,000 bits per second. The unit features fault-isolation and storage detection circuits, clock-rate storage and demand-rate unloading. ITT, 320 Park Ave., New York 22, N.Y. For information:
CIRCLE 214 ON READER CARD

terrain data translator
Measuring and digitizing X, Y, and Z distances on a three-dimensional stereoptic model, this device is used with projection-type stereo plotters for such applications as highway design, cartography and photo recon data analysis. Available as standard outputs are cards or paper tape. Tracing table travel is 20 inches horizontal, five inches vertical. BENSON-LEHNER CORP., 14761 Califa, Van Nuys, Calif. For information:
CIRCLE 215 ON READER CARD

terminal devices
Series 100 and 200 are buffered CRT inquiry stations with numeric or alphanumeric keyboards, procedure sequencing and program identifier control keys, and "erasure" keys. The 100's are for large-scale communications net-



works with high concentrations of remote I/0 devices, and the 200's are general purpose units. The CRT's can display from 128-768 characters, and the codes conform with the ASCII standard. THE TELEREGISTER CORP., 445 Fairfield Ave., Stamford, Conn. For information:
CIRCLE 216 ON READER CARD

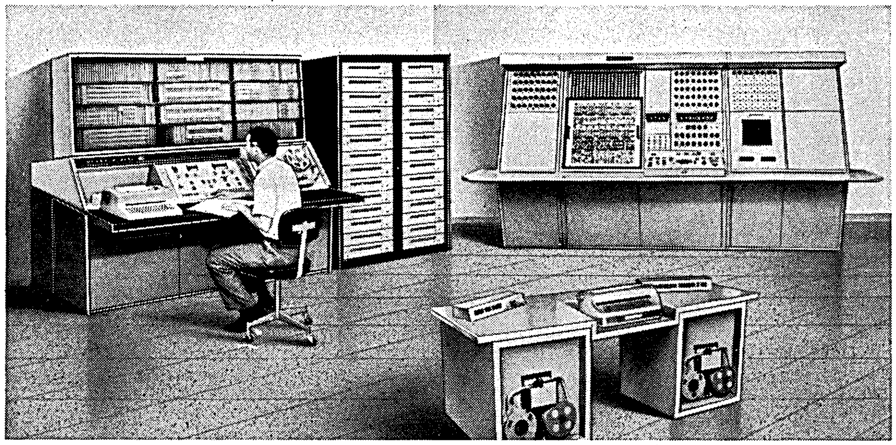
CONSIDERING A

HYBRID ?

6 good reasons to consider

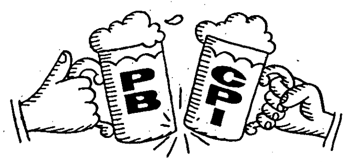
HYCOMP©

from PACKARD BELL and COMPUTER PRODUCTS, Inc.



Here is HYCOMP, a hybrid Analog/Digital Computing System for aerospace and bioastronautical simulation, design of sampled data systems, optimization of multiparameter systems, man-machine systems.

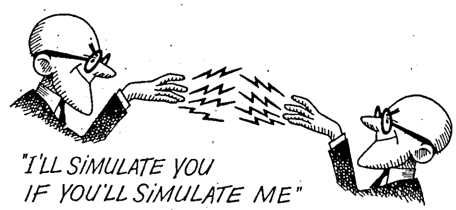
1. IT MAKES BETTER BUSINESS SENSE (We never underestimate the influence of the man who signs the check)... Under a working agreement between Packard Bell and Computer Products, Inc., com-



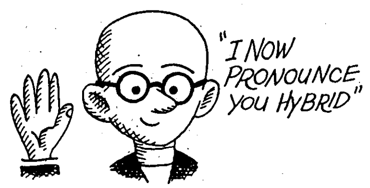
plete hybrid computer system responsibility is offered under one contract with either company. System checkout and proof of performance are provided at the manufacturer's plant before installation and checkout at your site. You have only one procurement and one contract for an operational system; not three separate procurements for an analog computer, a digital computer and a linkage system, leaving you to put them together. Cost is lower because joint design effort eliminates contingency cost factors usually needed to cover buy-outs; extra overhead profit is eliminated because neither firm must buy the other's computer to offer a complete system. You don't pay for custom engineering since standard system design spreads costs over several projects.

2. A BETTER ANALOG COMPUTER... The Mark III Analog Computer is capable of faster operation than any other real time general purpose analog computer available. Solid-state electronic mode control provides integrator switching to "operate", "reset" and "hold" functions in 500 nanoseconds. Wideband (80KC) operational amplifiers are used... Didac desk provides solid-state input/output and increased speed and reliability over mechanical selection systems... all control signals are binary logic directly compatible with digital computer control and sense lines... each computing component has identifying four-digit address providing virtually unlimited equipment expansion...optimum amount of patchable digital logic is provided—logic that can be handled easily by the analog programmer who may not be a logical designer.

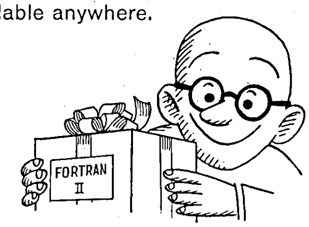
3. A BETTER DIGITAL COMPUTER... Dual Memory Stored Logic design makes the PB440 ideal for hybrid computation. Microprogramming flexibility means programs are designed with exact characteristics needed for combined analog-digital problem solution. These include rapid input/output to analog computer; floating point operations at speeds which allow use in fastest real-time applications; all arithmetic operations plus logarithms, powers, roots and transcendental functions as commands; simulation of other digital computers on command format and word length basis (imagine how useful this would be in simulating



a control system digital computer); direct memory access independent of program, useful in large scale simulation. Operating and display features which make the PB440 more useful to the engineer-programmer include console memory and register display and entry in octal form, manual control of single-step program advance and display of all arithmetic and control unit flip-flop states by indicator lights.



4. BETTER LINKAGE SYSTEMS... Packard Bell has designed and manufactured more successful linkage systems connecting analog and digital computers than any other company. There are more than a dozen such linkage systems operating today (one connects two computers 2500 feet apart). Packard Bell has been making A to D and D to A converters since 1957. The Hycomp linkage system includes our newest, the ADC20, an 0.01% 15-bit converter operating at 30KC and the ADC21, a 70KC12-bit unit —fastest and most accurate converters available anywhere.



5. BETTER SOFTWARE... Hycomp software includes diagnostic routines for automatic checkout of Mark III and PB440 computers; automated problem static check; input/output program providing all scaling computation and analog computer input/output in engineering units; Fortran statements for hybrid system operation (part of compatible Fortran II package already available for hybrid computing).

6. A DIGITAL DIFFERENTIAL ANALYZER OPTION... A unique type of hybrid system can be supplied by adding Packard Bell's TRICE* parallel DDA for high accuracy real-time integration and implicit function generation. Several Trice-PB250-analog computer combinations are highly successful in real-time simulation. Trice computation is parallel and continuous like an analog computer, so the analog programmer can handle a Trice-Mark III combination with minimal training.

WE'RE NOT OUT OF REASONS, but now that you know why Hycomp is the hybrid computing system that can solve more of your scientific and engineering problems, why not call or write today for the rest of the story. Write Dept. C-20-7.

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SEE US AT BOOTH 3308, IEEE,—AND AT DIGITAL DESIGN CLINIC, HENRY HUDSON HOTEL

CIRCLE 44 ON READER CARD

Continued from page 21 . . .

chasing as an overall DOD policy. Several, in fact, are positively gleeful over the prospect of quick cash for their goods.

POST OFFICE CUTS ADP CENTERS FROM 14 TO SIX

The Post Office Dept., feeling the heat from President Johnson's economy drive, will reduce its ADP centers from 14 to six in the next 14 months. Consolidated sites will be located in Dallas, St. Louis, San Francisco, Minneapolis, New York and Atlanta. Savings will consist of a hefty $3.7 million annually in manpower but only $300K in machine costs (surviving centers will double up on 1401's to handle the administrative overflow).

The cutback, however, does not indicate a slackened interest by the PO in plans for extended automation and computerization of its services, according to a department spokesman. "Process control" is still considered the key to the PO's future, replete with optical scanners reading zip code numbers, automatic counters, weighers and sorters. Eventually the PO visualizes its automated mail handling processes tied in with computer systems in perhaps 50 major post offices. These computing complexes in turn would be tied in with the regional ADP centers by data phone or some similar communications device. Finally, the whole operation would be linked with the overall government communications network.

How far away is this Orwellian concept from realization? The technology exists now to make the system go, says the Post Office. All that's needed is funding, trained personnel and Congressional approval. Optical scanners are expected to be in operational use within three years. By 1969, five years hence, the complete system should be in operation. Then heaven help the man who tries to make a four-cent stamp do the work of a five-cent stamp.

BUREAUCRATS FORESEE EXPANDED SERVICE BUREAU OPERATIONS

The pilot service bureau at the Bureau of Standards has yet to encounter a rush of new business, despite a pointed BOB suggestion that government agencies "should" use the BuSt 7094/1401 for their fringe dp needs. The $1 million annual volume of outside dp work remains little changed from pre-directive time.

Plans are afoot, though, for a greater government emphasis on internal service bureau activities. The GSA, at the behest of BuBudget, is reportedly establishing a new group on its organization chart which would take all government service bureaus under its wing and expand them into a much larger enterprise.

CONGRESSMAN ATTACKS HYPER-ACTIVE PRINTERS

Nursing a grudge against increased federal paperwork and blaming it partly on edp is Rep. Arnold Olsen (D., Mont.), chairman of the House's Census & Government Statistics subcommittee. Olsen charges that computers, instead of taming the paper tiger, are creating a greater paperwork burden. Case in point: the 500 million forms pumped out annually by the Internal Revenue and Social Security people in operating their new taxpayer numbering system, which depends wholly on edp.

DATAMATION

NEW LITERATURE

REAL TIME SYSTEM: Brochure explains real time dp for business applications and defines much of the terminology associated with data communication. Capabilities of the 1400 are detailed. HONEYWELL EDP, 60 Walnut St., Wellesley Hills, Mass. For copy:
CIRCLE 130 ON READER CARD

MANPOWER REPORTS: Reports 6 & 7 deal with automatic data processing in the federal government and reading machines for dp. U. S. DEPT. OF LABOR, MANPOWER ADMINISTRATION, OFFICE OF MANPOWER, AUTOMATION AND TRAINING, Washington, D.C. 20210. For copy:
CIRCLE 131 ON READER CARD

DP ACCESSORIES: 80-page brochure details company's complete line of data processing accessory equipment. MONARCH METAL PRODUCTS, INC., New Windsor (Newburgh) N.Y. For copy:
CIRCLE 132 ON READER CARD

KEYSORT: Outlined are the methods and machines which make up the Keysort punched card system for code-punching and tabulating original records. ROYAL MCBEE CORP., 850 3rd Ave., New York, N. Y. For copy:
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DIGITAL MODULES: Data sheets describe power supply, amplifiers, converters, drivers, other units. DIGITAL EQUIPMENT CORP., Maynard, Mass. For copy:
CIRCLE 134 ON READER CARD

GLOSSARY: 177-item glossary defines and explains the more fundamental terms common in magnetic recording applications. MEMOREX CORP., 1180 Shulman Avenue, Santa Clara, Calif. For copy:
CIRCLE 135 ON READER CARD

RECORDER/REPRODUCER: Brochure includes applications, tape transport, magnetic heads, electronics and capstan drive power on the GL-2810 continuous loop recorder/reproducer. CONSOLIDATED ELECTRODYNAMICS CORP., 360 Sierra Madre Villa, Pasadena, Calif. For copy:
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INCREMENTAL RECORDERS: Illustrated bulletin gives features and complete specifications for the DSR 1400 series. DIGI-DATA CORP., 4908 46th Ave., Hyattsville, Md. For copy:
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MACRO SYSTEM: "A Macro-Programming System for Scientific Computation" describes the BOUMAC macro system for using high-speed computers. (National Bureau of Standards

NEW LITERATURE . . .

Technical Note 203). Detailed instructions and illustrations are given. Price is 30¢, SUPERINTENDENT OF DOCUMENTS, U. S. GOVERNMENT PRINTING OFFICE, Washington, D. C.

PROGRAMMED DATA PROCESSOR-6: Brochure discusses processing, memory, and I/0 subsystems, instructions, peripheral equipment and software for this system. DIGITAL EQUIPMENT CORP., 146 Main St., Maynard, Mass. For copy:
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MESSAGE & DATA SWITCHING: System features, applications and equipment features of the PCP-150 are offered. PHILCO, COMMUNICATIONS & ELECTRONICS DIV., Blue Bell, Penna. For copy:
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USED EDP EQUIPMENT: Brochure describes company's new services as a broker in used edp systems. INFORMATION PROCESSING SYSTEMS, INC., 200 W. 57th St., New York, N. Y. For copy:
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420 SYSTEMS COMPUTER: Bulletin gives detailed description of the computer's applications, specifications, command list and theory of operation, including a block diagram illustrating computer organization. BECKMAN INSTRUMENTS, INC., SYSTEMS DIV., 2400 Harbor Blvd., Fullerton, Calif. For copy:
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MAGNETIC MEMORY DRUMS: Brochure offers complete physical data on company's line of magnetic memory drums. Tables show variable access times, cost per bit, and all other pertinent factors for specification. HOUSTON FEARLESS CORP., WESTWOOD DIV., 11801 Olympic Blvd., Los Angeles, Calif. For copy:
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BUILDING BLOCKS: Data sheets provide information on six standardized digital logic building blocks which feature individual plug-in logical elements. AVRON, INC., P.O. Box 223, Huntington, N.Y. For copy:
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ENGINEERS & SCIENTISTS

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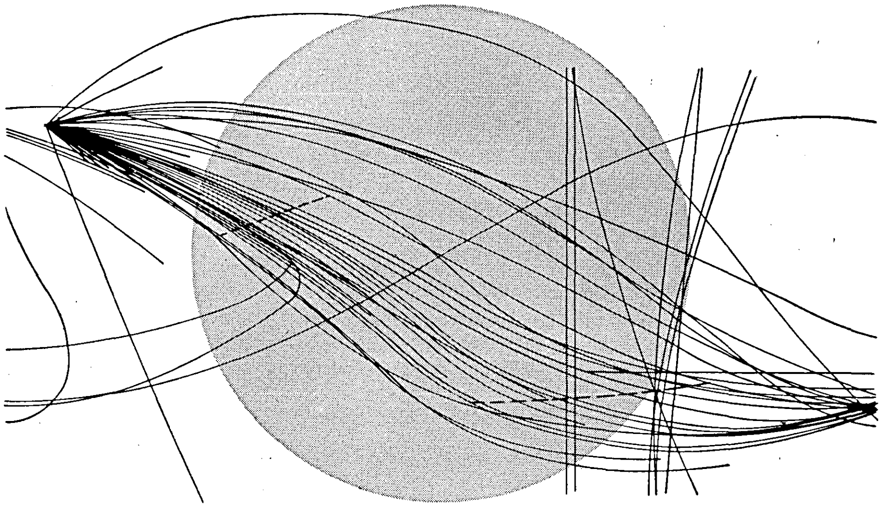

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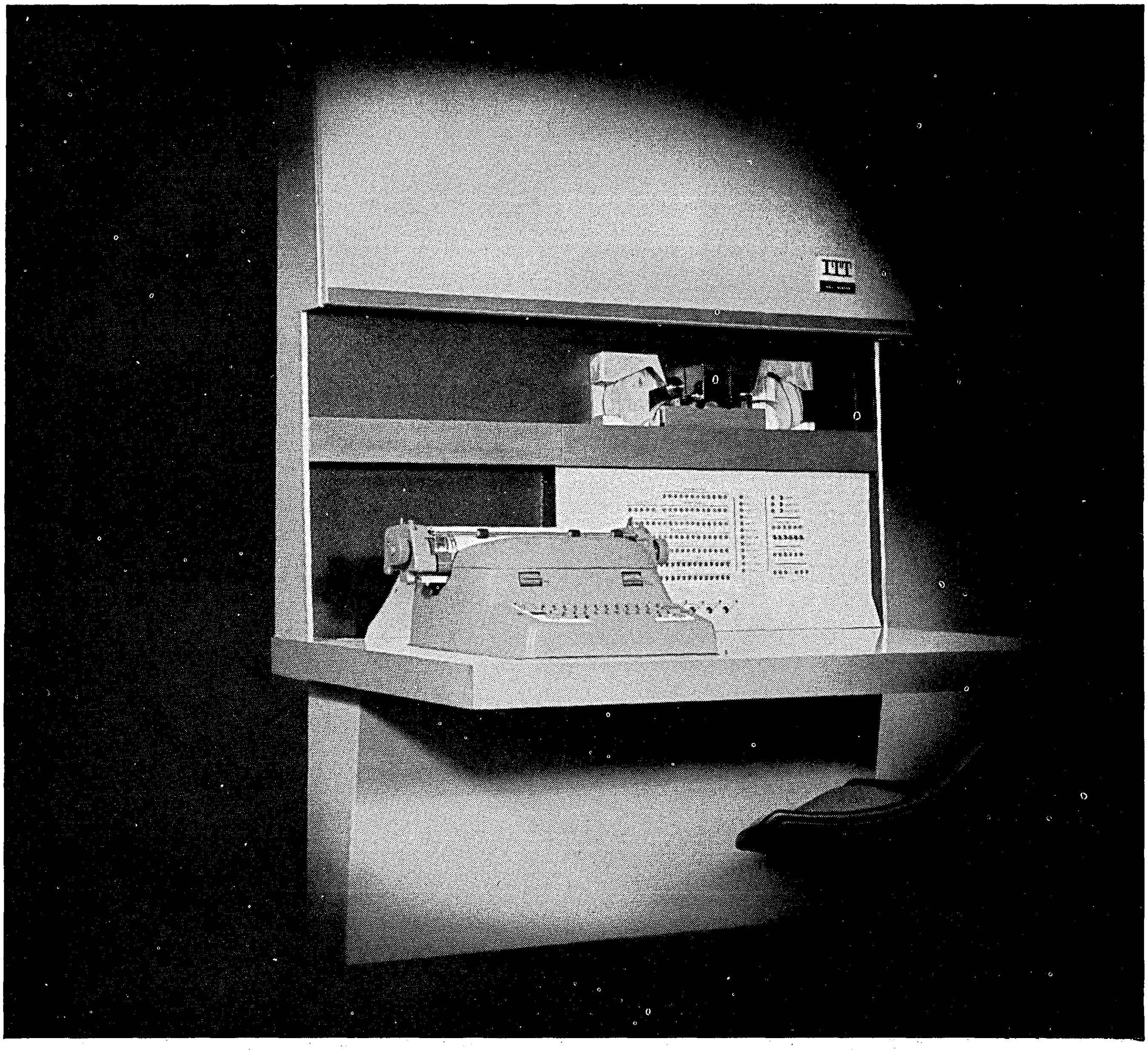

THIS MACHINE IS IMPORTANT TO SYSTEMS MEN WHO "COULDN'T CARE LESS" ABOUT HARDWARE

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More than a half dozen of these systems have already been installed, including a major complex accepted by NASA in September 1963, at the Marshall Space Flight Center. In addition to switching huge amounts of data between the many computers *within* the Huntsville operation, this ADX system will eventually handle the switching of traffic to and from NASA installations at Cape Kennedy and others in a number of states.

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ITT DATA AND INFORMATION SYSTEMS DIVISION

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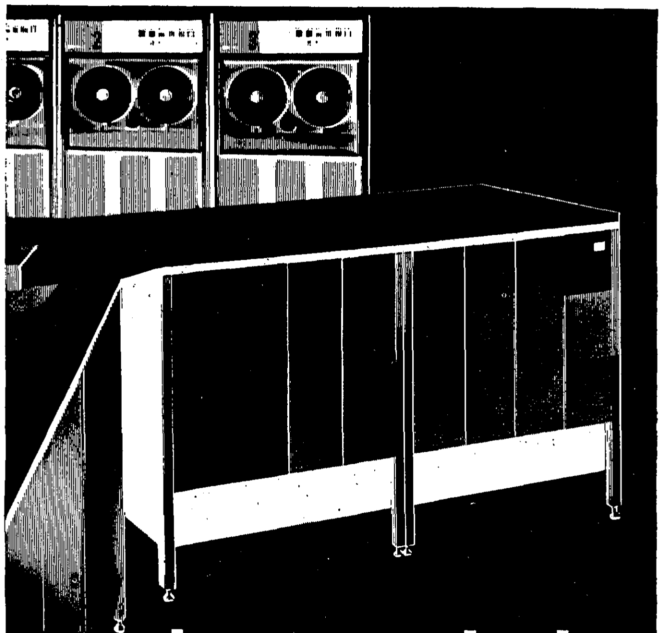
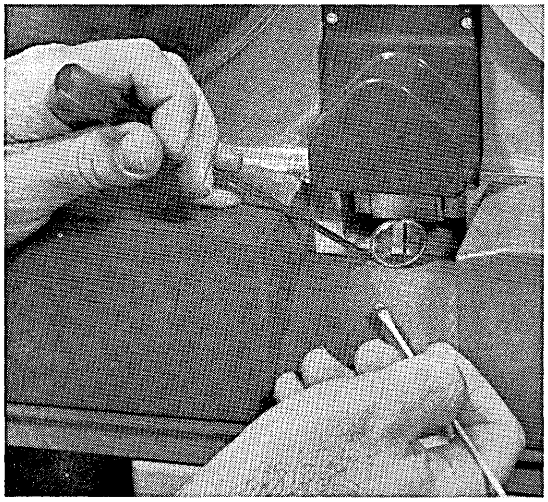


ADVERTISERS' INDEX

4 REASONS FOR BUYING ONLY PREMIUM TAPE

(Memorex, of course!)

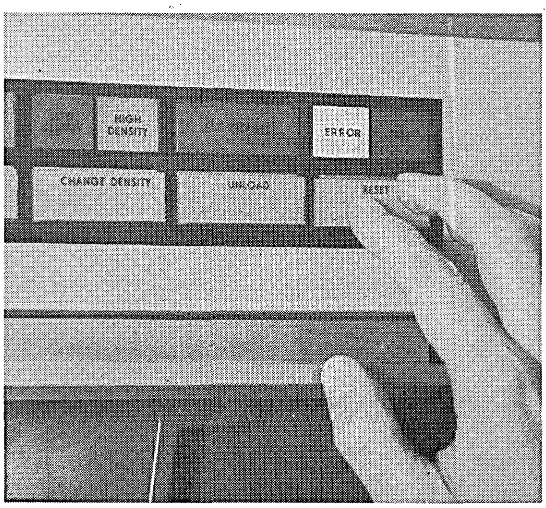


Reduced maintenance down-time. Premium tape increases head life and reduces head replacement. Its better adhesion of oxide coating and tougher, smoother coating surface minimize operating interruptions resulting from oxide build-up on heads and guides.

Memorex magnetic tape is premium tape.

Longer life. Premium tape minimizes tape stripping. It assures error-free performance long after inferior tape breaks down and becomes loaded with dropouts. The more severe the use, the more the economies afforded by premium tape's tougher, smoother coating.

Memorex magnetic tape is premium tape.



Greater reliability. Premium tape remains error free — pass after pass, reel after reel — and provides greater security of data in demanding routines. Despite the somewhat higher price of premium tape, few users can afford to miss the economy inherent in its greater reliability.

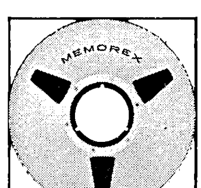
Memorex magnetic tape is premium tape.

No rejects. Premium tape provides freedom from rejects because it is always read-pass perfect — reel after reel. Its price is higher, perhaps. But its effective cost is less because premium tape delivers machine-time savings by eliminating pre-testing and maximizing error-free operation.

Memorex magnetic tape is premium tape.

Memorex tape is premium tape. No need to pre-check it. You can place Memorex computer tape directly in service — reel after reel.

Memorex certification means what it says: Memorex computer tape <u>is</u> error-free. Extra care, extra steps and scrupulous attention to every detail make it that way. We know the importance to you of having a tape you can depend on.



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