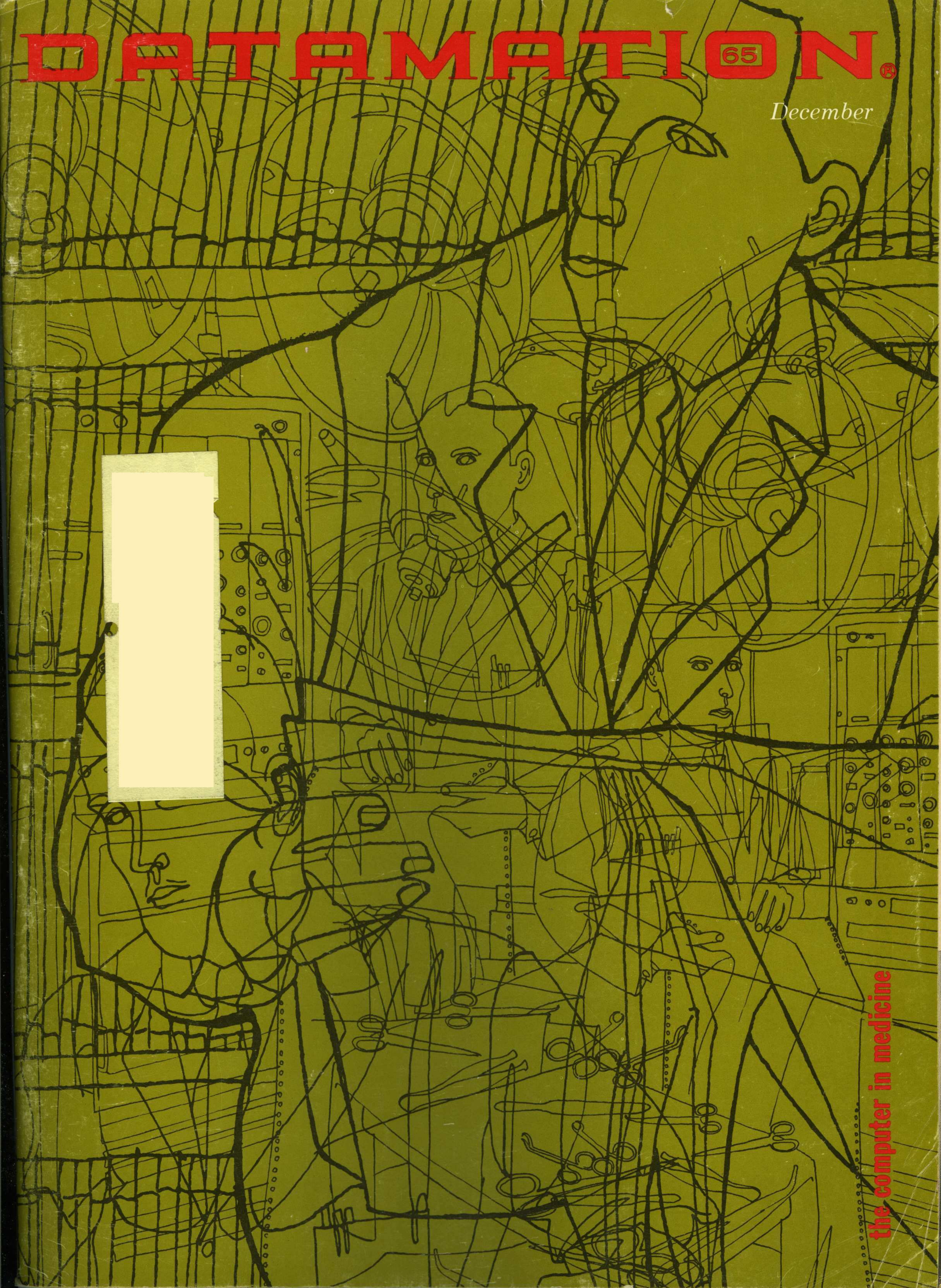
# DATAMATION

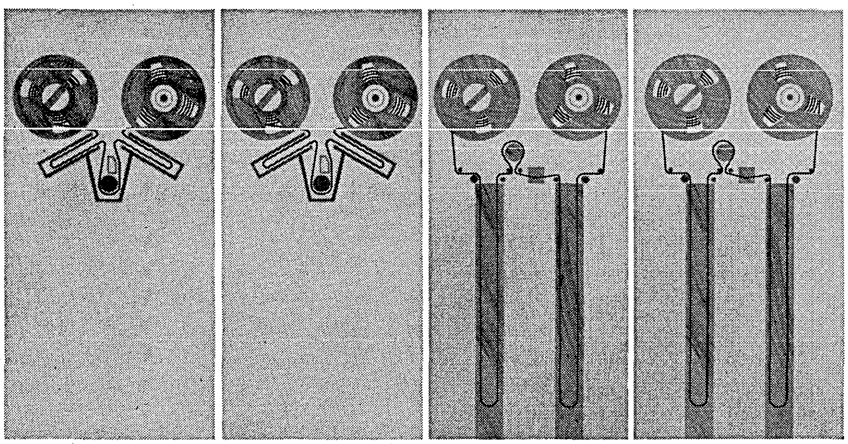
65

December



the computer in medicine

# Only Ampex gives you a complete family of interface interchangeable single-capstan tape transports.



*What are your EDP system needs?*

*TM-7* for up to 45 ips, 36 KC
*TM-9* up to 75 ips, 60 KC
*TM-11* up to 120 ips, 96 KC
*TM-12* up to 150 ips, 120 KC.

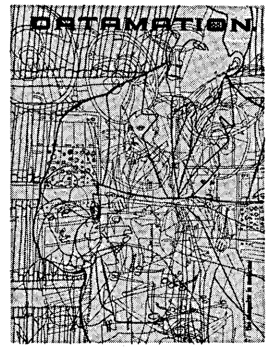
All with servo-driven single-capstan drives.

All generating tapes up to 800 cpi, fully IBM/ASCII compatible.

*Now one source meets all your data transfer requirements:* Ampex. Only Ampex gives you a family of servo-driven single-capstan digital transports with a complete range of drive speeds and data transfer rates—from 0 to 120 KC. *All units are interface interchangeable.* This allows you to easily pick the drive to match the requirements, and change the drive if requirements change. Also, you can select exactly what you need: just a transport, or the transport with electronics and control, or a system comprising several transports with time-shared data electronics and control.

*Ampex transports meet or exceed the reliability of the equipment they serve.* You get at least 2,000 hours mean-time-between-failure and at least one billion start/stop operations before start/stop mechanism replacement parts may be needed. Also, the single-capstan design eliminates problem parts and tape path adjustments. Result: more uptime, greater accuracy, performance to specification, all at lower cost.
Write for complete details.
Ampex Corporation,
Redwood City, California.

**AMPEX**




# december 1965

volume 11 number 12

| | |
|---|---|
| *President* | **FRANK D. THOMPSON** |
| *Publisher* | **GARDNER F. LANDON** |

| | |
|---|---|
| *Editor* | ROBERT B. FOREST |
| *Managing Editor & Art Director* | CLEVE MARIE BOUTELL |
| *Associate Editors* | EDWARD K. YASAKI |
| | WILLIAM J. ROLPH |
| *Assistant Editor* | HEIDE E. HESS |
| *Eastern Editor* | ANGELINE PANTAGES |
| *European Editor* | CHARLES WHITE |
| *Contributing Editors* | HOWARD BROMBERG |
| | ROBERT V. HEAD |
| *Washington Reporter* | JAMES McCROHAN |
| *Editorial Adviser* | ROBERT L. PATRICK |
| *Technical Consultants* | DANIEL D. McCRACKEN |
| | LOWELL AMDAHL |
| *Production Manager* | MARILEE PITMAN |
| *Circulation Mgr.* | ALGENE TRAINA |

| | |
|---|---|
| *Eastern District Managers* | JAMES M. MORRIS<br>WARREN A. TIBBETTS<br>FELIX CHARNEY<br>141 E. 44th St., New York N.Y. 10017<br>[212] MUrray Hill 7-5180 |
| *New England District Manager & Vice President* | WARREN A. TIBBETTS<br>112 West Haven Rd., Manchester, N.H., [603] NAtional 5-9498 |
| *Midwest District Manager* | JOHN BRENNAN<br>205 West Wacker Drive, Chicago, Ill. 60606<br>[312] Financial 6-1026 |
| *Western District Manager & Vice President* | HAMILTON S. STYRON<br>1830 W. Olympic Blvd., Los Angeles, Cal., 90006<br>[213] 385-0474 |

EDITORIAL OFFICES
1830 WEST OLYMPIC BLVD.
LOS ANGELES, CALIF. 90006

BPA

Circulation audited by Business Publications Audit

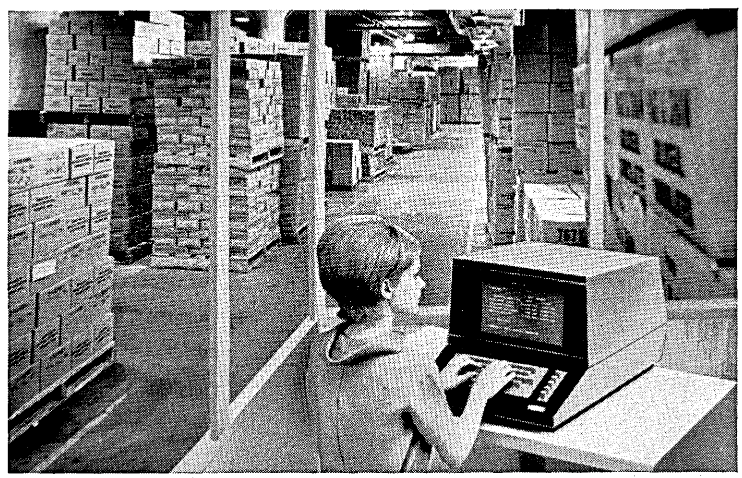
ABP

Member, American Business Press, Inc.

Microfilm copies of **DATAMATION** may be obtained from University Microfilms, Inc., 313 No. First St., Ann Arbor, Michigan. DATAMATION is published monthly on or about the tenth day of every month by F. D. Thompson Publications, Inc., Frank D. Thompson, President. Executive, Circulation and Advertising offices, 141 East 44th Street, New York, New York 10017 (MUrray Hill 7-5180). Editorial offices, 1830 W. Olympic Blvd., Los Angeles, California 90006. Published at Chicago, Ill. DATAMATION is circulated without charge by name and title to individuals who qualify by our standards and are employed by manufacturers or users of automatic information-handling equipment in all branches of business, industry, government and the military. Available to others by subscription at the rate of $15.00 annually; single issues (when available) $1.50. Annual rate for students: $7.50. Foreign subscriptions are on a paid basis only at a rate of $25.00 annually. No subscription agency is authorized by us to solicit or take orders for subscriptions. Controlled circulation paid at Columbus, O. Form 3579 to be sent to F. D. Thompson Publications, Inc., 205 W. Wacker Dr., Chicago, Ill. 60606. Copyright 1965, F. D. Thompson Publications, Inc.
Printed by Beslow Associates, Inc.

This issue 58,902 copies

# New from Raytheon... the first self-contained remote display console available at an economical price...$6000*



It's no longer necessary to buy — or rent — expensive multi-display control units to serve locations that only need 1 or 2 remote display stations.

The Raytheon Display Console, model 402, is the only low-cost equipment with its own control unit combined into the *same* package. And, because the 402 connects directly to a telephone dataset, there's no need for a separate interfacing console. Character generator, buffer memory, keyboard, telephone interface and power supply are all combined in one desk-top sized package which can be remotely connected to any general purpose digital computer.

The 402 can be easily moved from one location to another. Connect, and it's ready for quick-response, on-line communication with regional offices, warehouses, or ticket offices. Ideally suited for remote computer time sharing applications.

If your problem is one of providing real-time access to computer-stored information from remote locations, send today for information about the new model 402 Display Console and other units in Raytheon's DIDS (Digital Information Display System) family. Write: *Manager of Industrial Sales, Dept. D 125, Raytheon Company, Wayland, Massachusetts 01778. Or phone: (617) 358-2721 ext. 2911.*

*Rental prices available on request

RAYTHEON

CIRCLE 7 ON READER CARD

DATAMATION®

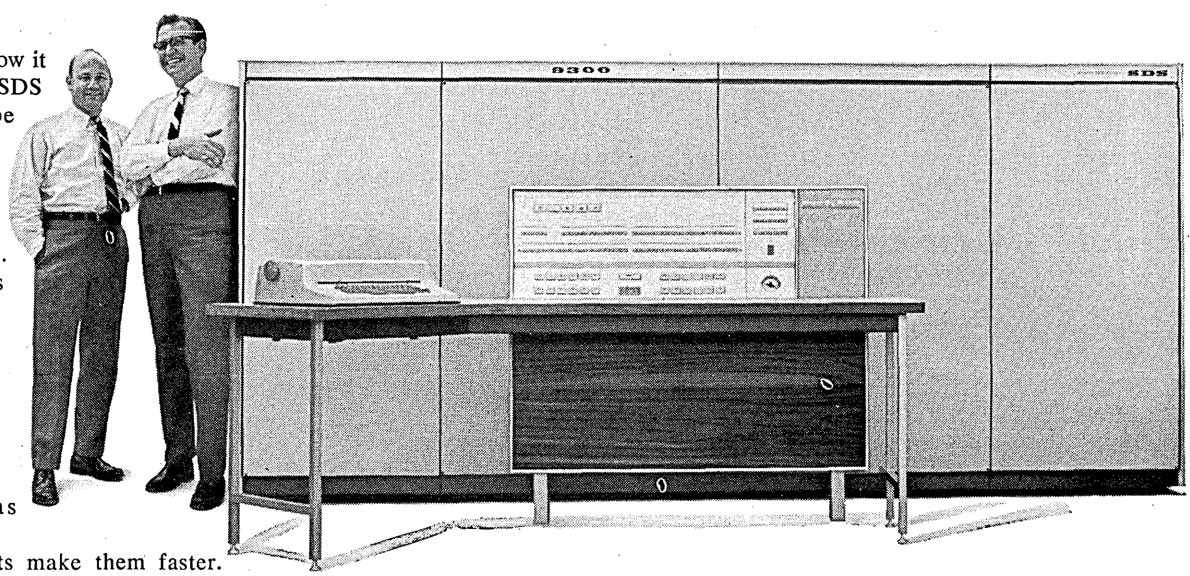
december 1965

volume 11 number 12



automatic information processing for business industry & science

# To make computers as good as these you've got to be simple-minded.




People ask us how it is possible for SDS computers to be faster, more reliable, and cheaper than other companies' machines.

The answer is simple.

SDS computers are simpler than other people's. They do the job with fewer circuits. Not nearly as many parts.

Fewer circuits make them faster. Fewer parts make them more reliable. Both make them cheaper.

It's hard to design simple computers. Much harder than designing complicated ones.

It's so hard that nobody will try to do it without a strong incentive.

Our incentive is greed. We believe that if we can make better machines than anybody else, and sell them for a lot less money, we can get rich in the computer business.

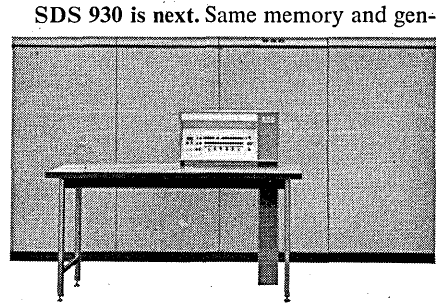
So far we're doing very well.

We've found a lot of people who are willing to pay less money for computers that do more work.

We make these six real-time computers and a lot of stuff to go with them:

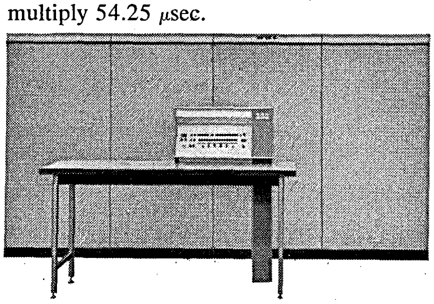
**SDS 9300 is our biggest.** It has a basic core memory of 4096 words, expandable to 32,768 words, all directly addressable. One standard and any number of optional buffered input/output channels with rates to 572,000 words per second. Input/output simultaneous with computation up to 1024 levels of priority interrupt. Memory cycle time 1.75 μsec. Execution times, including all addressing and indexing: Fixed point (24 bits plus a parity bit): add 1.75 μsec, double precision add 3.5 μsec, multiply 7.0 μsec, shift (24 positions) 5.25 μsec. Floating point (39-bit frac., 9-bit exp.): add 14.0 μsec, multiply 12.25 μsec.

**SDS 930 is next.** Same memory and gen-

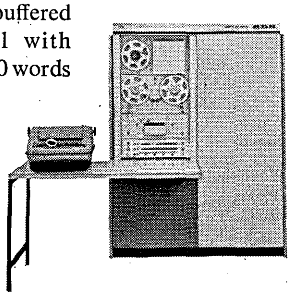


eral description as the 9300. Only the execution times are different: Fixed point (24 bits plus a parity bit): add 3.5 μsec, multiply 7.0 μsec.

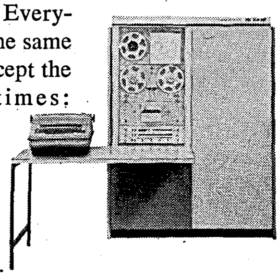
**SDS 925's** basic core memory of 4096 words is expandable to 16,384. From there on the specs are the same as the 9300 and 930, except the execution times: Fixed point (24 bits plus a parity bit): add 3.5 μsec, multiply 54.25 μsec.



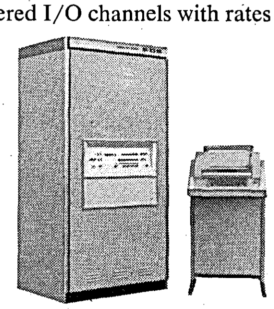
**SDS 920** has the same memory capacity and priority interrupt as the 925. One standard and one buffered I/O channel with rates to 62,500 words per second. Memory cycle time 8.0 μsec. Execution times: Fixed point (24 bits plus a parity bit): add 16.0 μsec, multiply 32.0 μsec.



**SDS 910** has a basic core memory of 2048 words, expandable to 16,384, all directly addressable. Everything else is the same as the 920 except the execution times: Fixed point (24 bits plus a parity bit): add 16.0 μsec, multiply 248.0 μsec.



**SDS 92 is our integrated circuit baby.** It has a basic core memory of 2048 words, expandable to 32,768, all directly addressable. Memory "scratch pad" reduces both program size and execution time. Hardware index register; indexing requires no additional time. One standard and any number of optional buffered I/O channels with rates to 572,000 words per second. Up to 256 levels of priority interrupt. Memory cycle time 1.75 μsec. Execution times, including all accesses and indexing: Fixed point (12 bits plus a parity bit): add 3.5 μsec, multiply 8.75 μsec, divide 22.75 μsec.



And here's some of the stuff that goes with them:

**Fortran IV for all SDS computers** (it's ASA Fortran IV, and then some).

**SDS Rapid Access Disc Files** (we call them RAD Files) which store from 528,000 to 8,000,000 characters, with access times as low as 500 μsec and transfer rates as high as 480,000 characters per second. RAD Files give the speed and capacity of drums at the price of discs.

**SDS new high-reliability magnetic tape drive.** Single capstan and full-vacuum columns eliminate tape wear and skew, maintain uniform tension. IBM-identical tape format and guide path assures compatibility.

**SDS Business Programming Package** permits SDS computers to perform decimal and character operations with the same ease as standard arithmetic.

---

Scientists and engineers have snapped these machines up. We have more computers working on line in real-time systems than any other company.

Some of them use their leisure to run payrolls. It's a nice change of pace after the hard work of real time.

How much do SDS computers cost?

If you ask us we'll tell you.

**Scientific Data Systems**

1649 Seventeenth Street, Santa Monica, California
Offices in principal cities throughout the world.

SDS

## DATAMATION calendar

● The American Univ. is sponsoring courses: "Managerial Implications of Electronics in Publishing," Jan. 17-20, International Inn, Washington, D.C.; "The Challenge of Cybernetics to Education," Jan. 26-28, Twin Bridges Marriott Motor Hotel, Washington, D. C.; "Eighth Annual Institute on Information Storage and Retrieval," Twin Bridges Marriott, Feb. 14-17. Fees: $150-175.

● Seminar on the economics and basic technology of integrated circuits, sponsored by Integrated Circuit Engineering Corp., will meet Jan. 17-21, Los Angeles, Calif. Fees: $175-500.

● Symposium on simulation languages will be held in March 1966, Univ. of Pennsylvania, Philadelphia. Application deadline is Feb. 1, 1966.

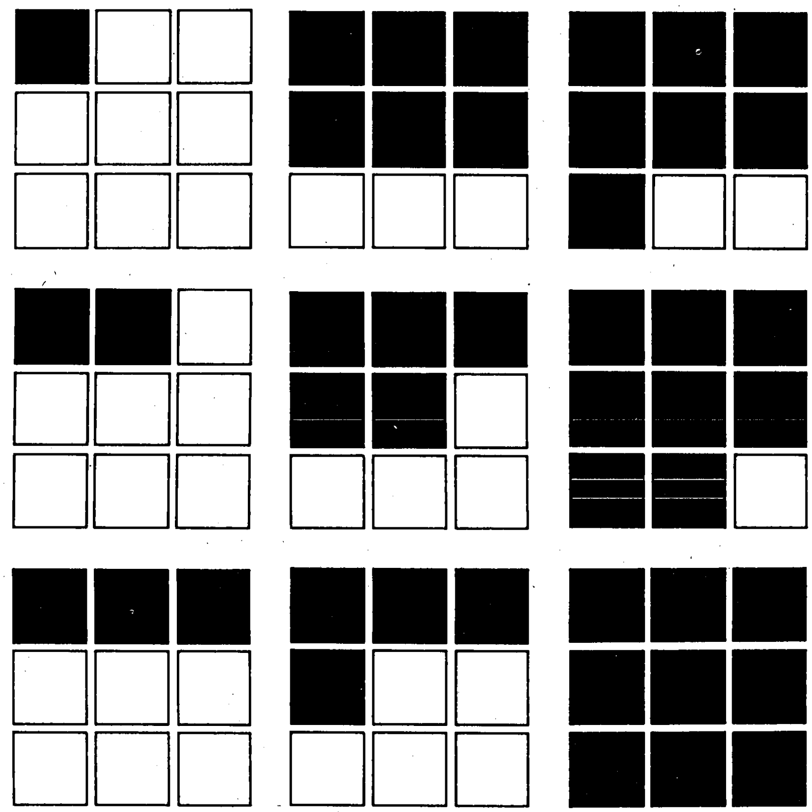
● Business show and midwest management seminar is scheduled for Feb. 8-11, Conrad Hilton Hotel, Chicago. Co-sponsors are the Administrative Management Society, Chicago Chapter and Northwestern Univ.

● SHARE XXVI will meet Feb. 28-Mar. 4, El Cortez Hotel, San Diego, Calif.

● Lomond Systems, Inc. and Chevy Chase Travel, Inc., Bethesda, Md. will sponsor a group seminar tour for adp executives in eight European countries, March 21-April 7.

● The Div. of Continuing Education, Univ. of Texas Graduate School of Biomedical Science is sponsoring a symposium: "Biomathematics and Computer Science in Life Sciences," Mar. 24-26, Shamrock Hilton Hotel, Houston, Tex.

● ACM symposium on symbolic and algebraic manipulation will be held on Mar. 29-31, Washington, D.C.



Your production.

# letters

## u. k. service bureau

*Sir:*

Your September "World Report" (p. 75) includes a reference to Centre-File Ltd., a new real-time service bureau in London, for which my company has technical responsibility. I would like to correct two mistakes in your report. The complete 360 system will cost about $1.7 million (not $7.5 million) when on-line testing starts in January 1967. The eventual configuration, to handle about 40 (not 25) medium-size firms of brokers, will cost about $4 million.

A. E. L. de Watteville
*John Hoskyns & Co., Ltd.*
*London, England*

## shoot the programmer

*Sir:*

The Editor's Readout in the October issue (p. 23) titled "Big Brother" reminded me again of a continually recurring thought. If a person uses a .38-caliber pistol to shoot his neighbor, we do not electrocute the gun. Why then do we attribute all the wonderful and frightening accomplishments of computers to the machines?

There are many contributors to the output of a computer—be it an equation describing a nuclear reaction or a marriage arrangement: the manufacturer and his employees, the power company that supplies the electricity, the operators, and of course the programmer. Is it not the programmer who actually pulls the trigger? Or is it pulled by the physicist or psychologist who developed the theories that were coded by the programmer? In any case, the computer itself is not to blame, nor should it get all the credit. Even computers that "learn" were programmed to do so according to a specific learning theory. So let us give credit or blame where it is rightfully due. Of course, the scientists and programmers could not produce the fantastic results that are presently obtained without the high-speed computers of today, just as Big Brother will not be able to regulate and keep watch over our lives of tomorrow without tomorrow's computers, but can he do it without a programmer?

This dependence on programmers and/or those who develop the methods is obvious to anyone in the computer sciences when mention is made of the "all-powerful" computer. However, the layman (for instance a viewer of the panel discussion described in your Readout) often does not understand that the "machines" do not truly make independent decisions. That is why I suggest we all make an effort to inform the layman as to what really makes the computers "hum." I'm reminded of the uninformed person who is delighted with eight-place results obtained from the computer even though his input was only good to three places. Would an informed public passively accept marriage arrangements from Big Brother's computer even if it matched brother and sister? I think not. They would realize that his programmer must have forgotten to consider certain basic relationships.

In conclusion, I beg to differ with Mr. Grosch (you quoted him as saying, "Big Brother is going to be a computer.") Big Brother will not be a computer. Big Brother will simply use a computer.

Lyle B. Smith
*Stanford, California*

## operating systems

*Sir:*

. . . It is apparent that the author ("Operating Systems: One Installation's Experience," by R. F. Brockish, Oct., p. 64) is so enveloped in his IBM world the mere existence of other manufacturers' software has escaped him. Awake, Mr. Brockish, to the world of high-speed language translators, parallel processing and efficient operating systems. But, alas, the eyes of Big Brother are upon you.

Paul V. Gravelle
*Compiler Development Group*
*Honeywell EDP*
*Wellesley Hills, Massachusetts*

**The author replies:** The article was intended to be what the title implies and not a survey of all the fine and maybe not so fine operating systems available or on the drawing boards. I know other systems exist because the salesmen have told me so. But, alas, I have no experience with them so I leave the writing of articles about them to the people who have actually used the systems. Perhaps in all due respect I should have included a lead sentence that the article was about systems on two IBM computers so that readers not interested in that sphere of the industry could immediately "trap," "branch," "jump" or "go" to the next article.

**software copyrights**

*Sir:*

I notice an error in the October Business & Science. On page 19, in discussing proprietary programs and copyrights, is the remark "New listings came from Burroughs—with a version of FORTRAN II for the B5500 developed at the U. of Indiana . . ." Indiana Univ. has done no programming for Burroughs or for a B5500. However, the Indiana Univ. Research Computing Center *did* produce a copyrighted FORTRAN II compiler called FASTRAN for the IBM 7090 series.

FASTRAN was developed in 1963-64 by Stanley Hagstrom, Stephen Young, and myself. It compiles 10-20 times faster than IBM's FORTRAN II, producing object decks that execute at about the same speed as IBM's. The only incompatibilities worth mentioning with IBM FORTRAN II are FASTRAN's detection of undefined variables, and the happy absence of relative constants. FASTRAN is presently used in about 20 computer installations; communications and distributions are handled through a recently formed FASTRAN Interest Group in SHARE.

DR. FRANKLIN PROSSER
*Indiana University*
*Bloomington, Indiana*

**fortran 4**

*Sir:*

Re: "How to Tell If It's FORTRAN IV," by Daniel D. McCracken (Oct., p. 38). . . At least one insidiously variable characteristic was omitted from his table. This is the matter of testing or not testing the first value assigned to the DO variable in a DO statement. Significantly different results are often obtained when a program is moved from one system to another where DO statements are treated in the opposite way.

Most of the inconsistencies between various FORTRANS are either obvious or quickly become obvious (thanks to compiler diagnostics) but this one is both obscure and serious.

DONALD H. THURNAU
*Marathon Oil Company*
*Littleton, Colorado*


From ASI's continuing program of new product development

# It's all in a day's work....for ASI's 6020

What is extra output from your computer worth to you? . . . completion of projects on or ahead of schedule? . . . cutting down engineer's overtime? . . . reducing waiting time between problems? All this is our way of saying that you get more machine productivity per dollar when you get an *ADVANCE* Series 6020. Compared with competitive machines in the same cost range, the 6020 turns out 50% more work.

It begins with *ADVANCE* 6020 features such as high speed computation, a versatile input/output system, completely modular expansion both within the central processor and with peripheral equipment. In addition the software system features the fastest FORTRAN compiler in its class. At 1500 statements per minute your problem is entered in record time . . . as much as four times faster than other computers. This combination assures that your 6020 will return 12 hours work in an 8 hour day.

This extra workload capability already is working, or very soon will be installed, at facilities such as Chemstrand, Division of Monsanto Chemical; Gulf Oil; University of Chicago; Sun Oil Company, and others.

Contact ASI today for further information. We invite you to put a stop watch on us with your problem.

ASI

**ADVANCED SCIENTIFIC INSTRUMENTS**
DIVISION OF ELECTRO-MECHANICAL RESEARCH, INC.
8001 Bloomington Freeway, Minneapolis, Minn. 55420



CIRCLE 15 ON READER CARD

# BUSINESS & SCIENCE

## IBM HARDWARE, SOFTWARE COMPATIBLY DELAYED

There's no clear pattern visible yet in the effects of the recent 360 hardware and software slippages, but it looks as if IBM has pulled the whole thing off with its usual savoir faire. Astonishingly, the reaction of many to hardware delays was, "That's okay, the software is tardy anyway." But a lot of people don't know yet how far deliveries will slip. Just about every installation gets a different story.

IBM will pay L.A. City an estimated $20-30K penalty for a three-month delivery delay of third level software on the 360/30F, due in mid-December. With $300K invested, the city didn't feel justified in reopening bids to other vendors, will accept $17K plus $100 a day until everything is in, with no rent until it's all working.

The competition hasn't assessed the impact of the slow-down yet, warily claiming only that it's opening some doors for them. One view: the move is IBM's means of taking back the reduced rental (10%) offered earlier on old machines during three-four months the 360 and its predecessor are both still in. Meanwhile, rumbles about 1401 and 7094 emulator troubles keep popping up.

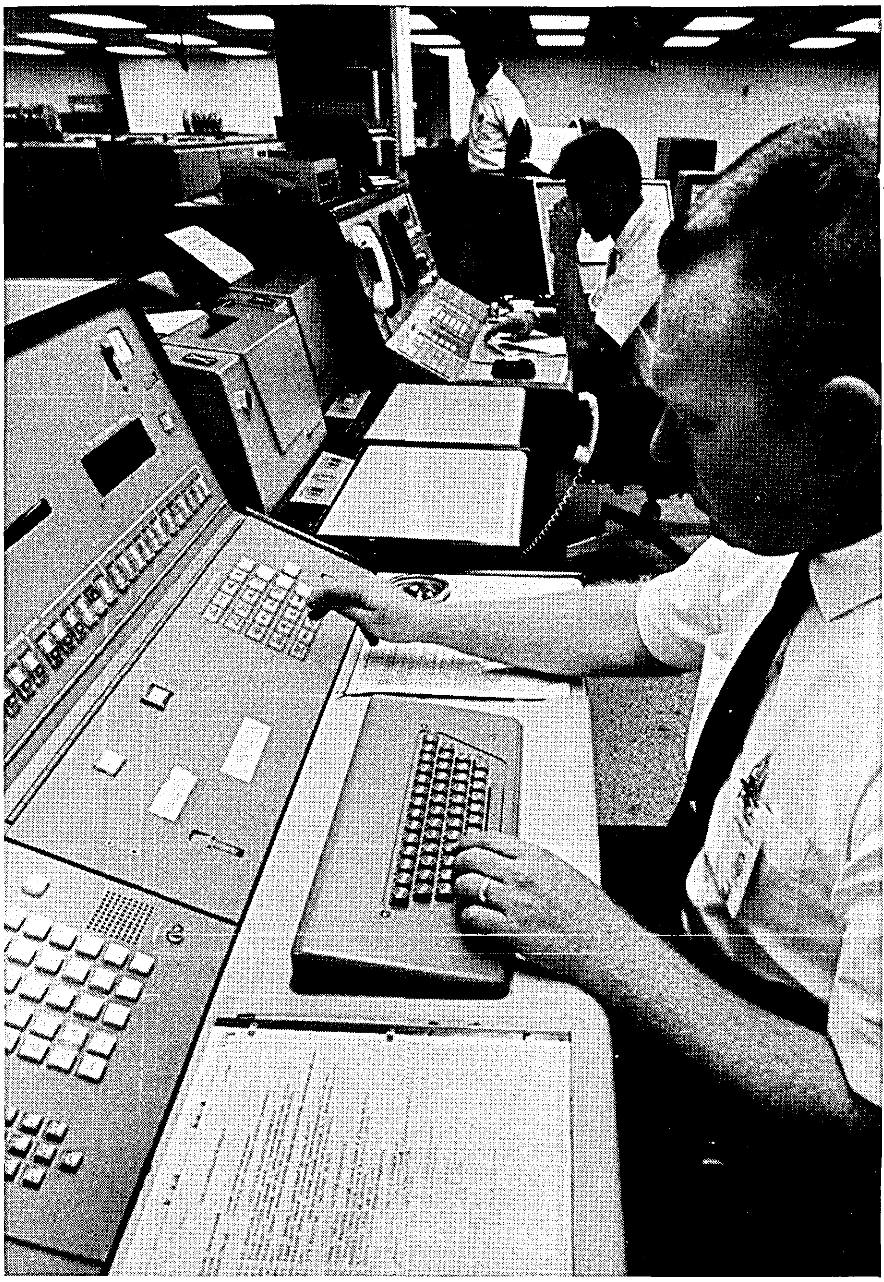
## FAST 1108, SLOW TERMINAL HYPO UNIVAC HOPES

Univac is elated over performance of its 1108, some 50% better than anticipated, says for engineering job shops the system is six times as fast as a 94 mod II, somewhat faster than the 6600 on a throughput basis. The company is readying for announcement in Dec. or early '66 a Remote Communications Terminal which will offer on-line aficionados 80 cpm and 240 lpm speeds. Cost for an 80-character print line will be around $500, with higher prices for extra goodies.

## L.A. SERVICE BUREAUS ABHOR A VACUUM

L.A. service bureaus are scrambling to fill the vacuum they hope will appear when the 1107 at Computer Sciences comes out. University Computing, which already has a 1604 in L.A., has ordered an 1108. Meanwhile, Matrix will run a 635 for GE, Fairchild and TRW. Allen Babcock Computing's time-shared 360/50G is scheduled to go on the air in April or May, and ITT plans to open shop in '66 with 360/30, /50 and /67. Western Union will probably get into the act next year too, and CEIR will beef up their operation.

Newest face on the L.A. service bureau scene is Abacus Electronic Computing Corp., headed by Al Gravitt, formerly of Signal Oil, first remote users of CSC's machine. AECC will open shop with a B 5500 in April or May, offering a B 5500 version of Joss,



# When you need a 'conversation piece' for fast-talk with busy computers...

Consider an "interpreter" from Tasker. Like this versatile, modular input/out console–one of the vital units used in programming, checking out, and monitoring such delicate unmanned space flights as the Mariner mission to Mars.

Human-engineered for fast, fatigue-free operation, this multiple-input console works through a data communications channel to four main computers. Its operator can alter programs, call out subroutines, make preflight checks, run tests and observe the status of all computers and peripheral equipment. Among the principal features: a single-line, 72-character CRT readout that lets the operator verify entire alphanumeric messages before transmission.

The modular, easily modified console and its proven, long-life circuitry (estimated: above 82,000 consecutive hours) typify a Tasker talent: "quick reaction" ability to solve special problems and customize as needed. If you have problems in display, computer control, or radar and tracking . . . try Tasker for good solutions.

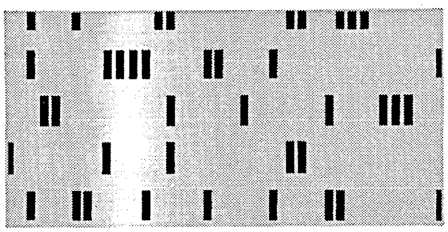
## look to Tasker

Tasker Instruments Corp. / 7838 Orion Ave. / Van Nuys, Calif. 91409 / (213) 781-3150

CIRCLE 16 ON READER CARD

# if

## Cobol and PL-1 are "romance languages" to you



## then you're the kind of Programmer we're looking for at Douglas.

service to remote 1004's, TTY, IBM 1974, etc. The system will include 24K core, six tapes, two 9.6-megacharacter discs, will simultaneously handle up to eight remote terminals at first.

Gravitt plans to charge for cpu time, plus charges for cards fed in, pages printed out. Customers will be able to store their programs on the disc for another fee per 1000 words.

## BURROUGHS CUTS PRICES, PUSHES OFF-LINE SORTING

Burroughs has cut prices on its 300 series: memory prices are slashed in half, a 1400 cpm card reader goes from $600 to $500, cpu costs for a three-year contract is 60% of old. Fast disc sort times — a fraction of 360 tape sorts — are encouraging the Big B to push a B300 costing less than $6K/month as an off-line sorter.

## FOR ON-LINE WHISTLERS, AN EXTENDED UMBILICAL CORD

On-line enthusiasts who get nervous when they're away from their computer will be glad to know that the umbilical cord is being lengthened. Carnegie Tech has been experimenting with a prototype "portable" Mod 33 Teletype terminal. Housed in a 100-pound trunk, the unit cradles a phone, translating keyboard entries into acoustical signals; it literally whistles.

Pleased with prototype results, Carnegie Tech has ordered 16 more from a firm set up by Jesse Quantse, who developed the first one as CT's manager of engineering development. Other universities and firms are interested too. The Pittsburgh firm, Electronic Systems, Inc., is working on new packaging: two suitcases weighing 65 pounds, with lighter cases in sight. Other development plans include an automatic dialer, an answering device, and units which will accept any data source.

Quantse views portability as the way to go, notes the convenience to low-demand sites such as labs and classrooms which can avoid expensive set-ups and long rentals. Costs are expected to be about $2600. Initial indications are that the phone company won't be able to stop Quantse and his customers from whistling in the light.

## LINCOLN LABS LINKS WITH OUTSIDE WORLD

Plans are underway for linking Lincoln Labs' experimental time-sharing system — TX-2, MIT's MAC, and SDC's system. The purpose: to allow programs of one facility to make use of programs of another, with early emphasis on sharing of graphics software. A young Cambridge research and consulting firm, Computer Corp. of America, is doing a preliminary study on it for the Labs, due by the end of the year.

Harvard Computing Center will also tie into TX-2 via a satellite computer and is now adapting its syntactic analysis programs to the system and its graphic capabilities. Among other new Lincoln Lab developments for the commercial world to note are a paging system, SPAT, which uses a fast film memory to transform page address, a compiler-compiler called VITAL, and a time-sharing exec called APEX. Coming up is a Graphical Service System which will allow a user to define his own graphical language.

*(Continued on page 115)*

DATAMATION

# WASHINGTON REPORT

## MARKETEERS PONDER BROOKS BILL SIGNIFICANCE

The full significance of the Brooks Bill, newly passed and signed, is being assayed carefully by Washington's dp marketing corps. The initial consensus of opinion seems to be that while the GSA might be able to force lower per-unit computer costs through centralized purchasing, savings will fall far short of the $250 million to $300 million annually claimed by the bill's proponents. And all disclaimers to the contrary, it's also considered likely that GSA will become intimately involved in the selection of computers, not just the negotiation for their procurement.

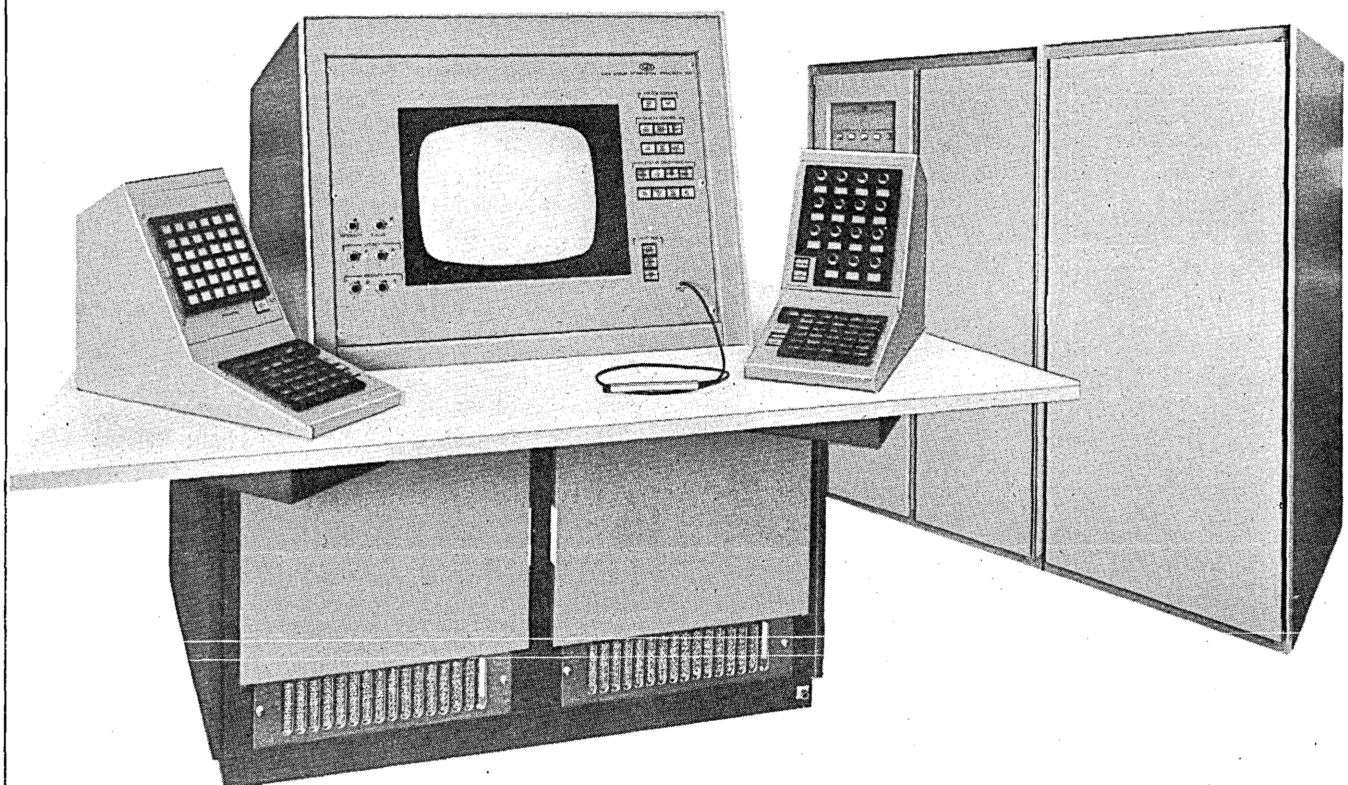
An immediate concern is the amount and make of equipment presently on lease by government agencies that might be purchased right off the bat through the revolving fund to be set up. "Even if such a purchase freezes agencies into obsolete computer and tab equipment, GSA is going to go after that big discount," warned one sales manager, "and that's going to seriously contract our new equipment market." He also opined that the very large manufacturers, which could sustain large discounts on volume purchases, would benefit most from the new situation. Others, however, believe that the GSA involvement will favor the smaller companies because marketing efforts can be focused on one set of agency officials, not diffused throughout the government.

Other questions raised, but not resolved, by the Brooks Bill include the distinction to be made between programming/support services and hardware proper, cost evaluation, and the extent to which the research-oriented agencies — NSF, NIH, ONR, ARPA, etc. — will have to stand tall before GSA in accounting for funds expended on dp equipment.

Answers to most of these questions will be largely determined by the as-yet unnamed executive who will run the dp show for GSA. It's considered likely that he will report directly to GSA chief Knott, with a title to match that eminence.

## AIR FORCE PLUMPS FOR STAUNCHER COBOL

The Air Force, revving up for a large-scale procurement to replace the fleet of "interim" computers ordered last year, has passed the word along to manufacturers to get on the Cobol bandwagon, AF style, if they want favorable consideration for the plum. Stimulus for the AF action was the proposed ASA Cobol specs circulated to users last spring for comments. The AF's detailed response, which expressed considerable dismay over the lack of mandatory tusks and fangs in the proposed specs, was returned in September to the X3, 3.4 and 3.4.4 committees. This response, and those of other users, will be considered by the X3 committee at a meeting in Washington in mid-December.



Picture above shows display console with its associated scanner and control cabinets.
Link Waveform Display/Analyzer is used on line with 7040/7094 computer at Ballistics Systems Division, USAF.

# New LINK Waveform Display/Analyzer— precision film reading and recording with one machine.

Here is a new graphic input/output device that can help reduce computer time and programming costs significantly.

The Waveform Display/Analyzer allows real-time access to information and immediate updating and analysis.

You can change the display with a light pen and keyboard and request further action from the computer without the assistance of a programmer.

The light pen lets you alter, add and delete data. You can move, enlarge and reduce images, plot graphs, and label displayed information. Problems can be altered for further analysis. It is not only a problem-solving tool—it's a system for producing new designs.

The light pen saves time and cost by eliminating the need for an output record, thereby cutting down on equipment and producing answers more quickly.

AND THESE OTHER FEATURES—

- Scan a film image or waveform and digitize the data.
- Display data and images on a high-resolution CRT.
- Store computer output data on film in black-and-white or a 16-level gray scale.
- Handle large amounts of information by film scanning—(1024x1024-bit matrix with 16,380x16,380 also available).
- Buffer system storage capacity 1024 words, 36 bits each.
- All solid-state circuitry.
- Utilizes interchangeable film transports making it possible to use 16mm, 35mm and 70mm film in both the read and record mode.

The Waveform Display/Analyzer can operate as a single unit with one small binary computer or as one of several time-shared units on a large host machine.

For an informative brochure, write to Advanced Product Sales, General Precision, Inc., Link Group, 1451 California Ave., Palo Alto, Cal.

GENERAL PRECISION INC
LINK GROUP

# EDITOR'S READOUT

## TRADITION AND TECHNOLOGY: THE DILEMMA IN GREAT BRITAIN

The London Hilton rises with less than majesty above the main plane of London's skyline, scorning and mocking the lovely old, short, quaint buildings crouched beneath it. From the 14th floor, you can watch a thin rain slant down on the multiple ant-like columns of autos and double-deck busses inching along Park Lane between the Hilton and marvelously green Hyde Park. From a side street slowly streams a steady procession of the black high taxis, tall enough by decree to allow a gentleman to sit in them with his tophat on.

From another window, you can see Big Ben loftily dominating *its* skyline of Parliament and Westminster Abbey, haughtily staring out at the scattered towers of modern glass and steel impudently challenging Big Ben's dominance. Outside the windows the wind howls and moans, like a modern echo of the savage sounds which open *Macbeth*.

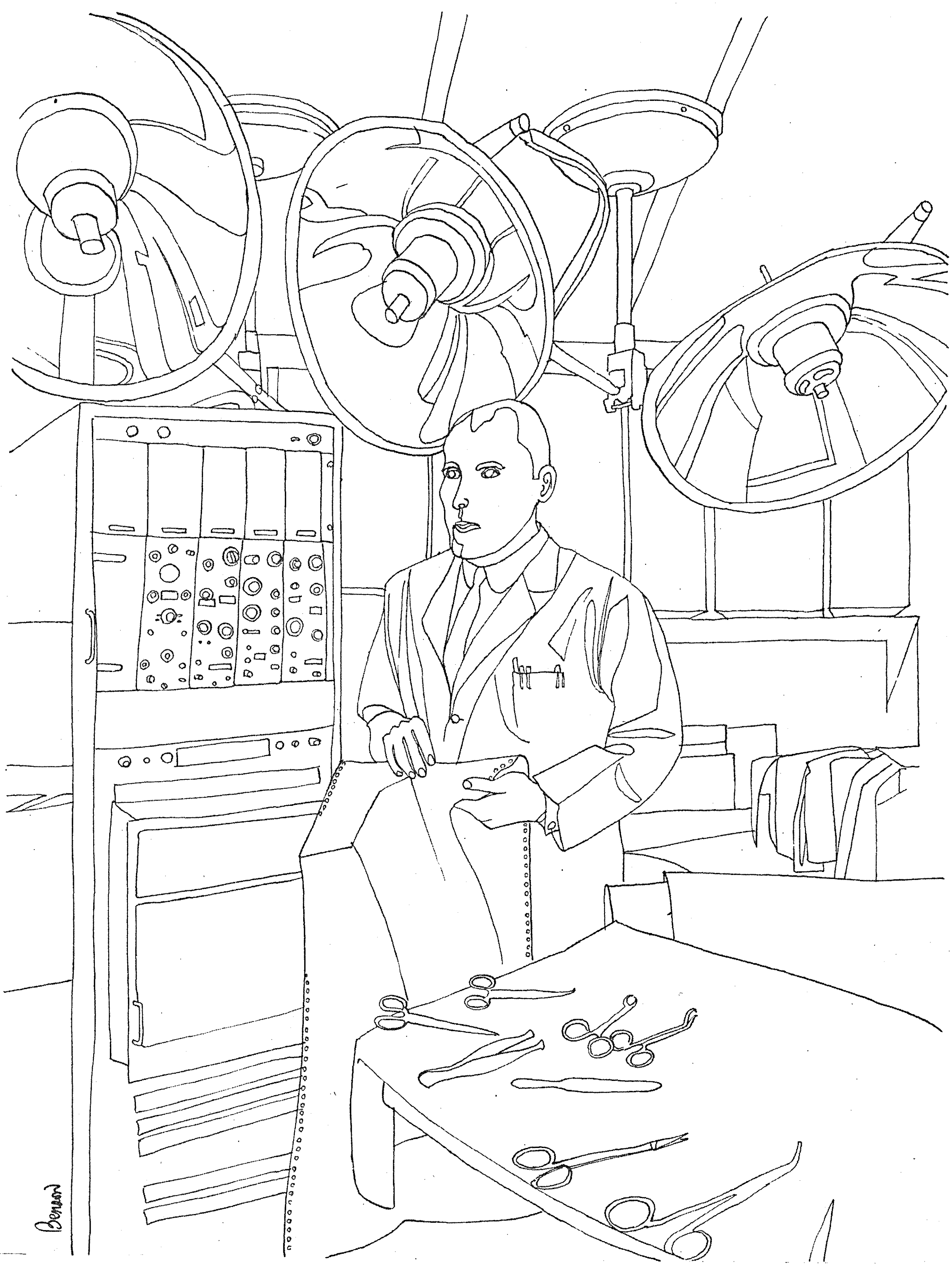
The scene symbolically reflects all too vividly the current computing scene in the U.K.: the heavy burden of tradition which slows progress in the only remaining indigenous industry in Europe; the rising spectre of increased competition from aggressive U.S. firms for whom the U.K. market is only an extension of the big, big American market, providing a production (and profit) base unavailable to U.K. firms. The wind may be howling a dirge for British computer technology. The industry has come to the brink of the agonizing question posed in Hamlet's soliloquy.

There are some slivers of light in the dark picture: the Wilson government-created Ministry of Technology is pushing computers as a key to revitalized industrial effort, has established a department of Computer Services, which advises on the choice and use of computers in the public sector, parcels out pounds for research, is reviewing the needs of university and research councils, and is considering setting up a national computer programming center.

So far, the organization's principle act has been the loan of five million pounds to ICT, which shares about equally with IBM some 75-80% of the U.K. computer market. It may not be enough to save the last major European manufacturer trying to fight IBM with its own equipment.

The basic problem underlying the British computer dilemma is that of education, for which no quick solution appears available. Steeped—if not drowning—in tradition, British universities are not likely to rapidly revise their methods and curricula to meet the nation's pressing technological personnel needs. It's a necessity, nevertheless.

If, as Wilson's government has evidently decided, a strong indigenous computer industry is vital to Great Britain's economic revival, the country had better get cracking. We hope they will. We like to believe that a healthy national computer industry would benefit not only the U.K., but accelerate the progress of computer development everywhere. What we'd *like* to see is a Volkswagen-like computer invasion of the U.S., helping to keep American manufacturers on their toes. A healthy U.K. computer industry offers the only hope of such a dream.



# THE COMPUTER IN MEDICINE

*an overview*

by EVON C. GREANIAS

The role of the computer in medicine is expanding at an impressive rate. Electronic data processing equipment can be found in hospital management information systems and in many areas of biomedical research. Applications range from conventional accounting to integrated management information systems that include administrative, service and some patient care functions.

Impressive as the variety of applications may be, the medical and EDP professions have only begun to demonstrate what the computer can do. There are 7,000 hospitals in the United States, 1,200 with at least 300 beds, but less than 10% of these larger institutions have gone beyond punched card accounting equipment. On the other hand, advanced computer systems that can handle a broad spectrum of applications can be found in many types of institutions.

There are few areas of hospital administration, patient care or biomedical research in which members of the medical profession and the computer industry are not working together to develop better information handling methods. The primary function of the physician, whether general practitioner or specialist, is to gather and evaluate information and make decisions regarding the treatment of patients. Hospital service departments are better equipped for effective patient care when timely, accurate information is available. Biomedical research has vast requirements for information storage, retrieval and dissemination.

The advent of Medicare next year is expected to put greater emphasis on detailed reports of medical activities and hospital performance. With more agencies participating in the funding of medical care, the need for accurate, timely information about many hospital activities will become even greater and more mechanized data processing will become indispensible.

In the past few years, the practice of medicine has required more and more information, while professional personnel have had less and less time to process it. The physician and nurse spend a large portion of their time recording medical data about the patient's history, condition, treatment and progress. It has been estimated, for example, that medical technologists in clinical laboratories spend 30% of their time on routine clerical work associated with the evaluation and reporting of test results.

While the number of professionals or college-trained workers has increased six times since 1900, the U.S. still suffers a chronic shortage in all categories of health personnel. With our continuing population growth, 330,000 physicians will be needed by 1975, to maintain our present ratio of 140 physicians for every 100,000 persons. The present medical school graduation rate cannot meet this demand. In addition to the 87 medical schools that are presently accredited, 12 new schools have opened or are

***Mr. Greanias is manager of the Medical Information Systems Program, IBM Advanced Systems Development Division, where he has been associated with the development of pattern recognition methods. He holds a BS in engineering physics from the Univ. of Illinois and an MS in physics from the Univ. of Chicago.***

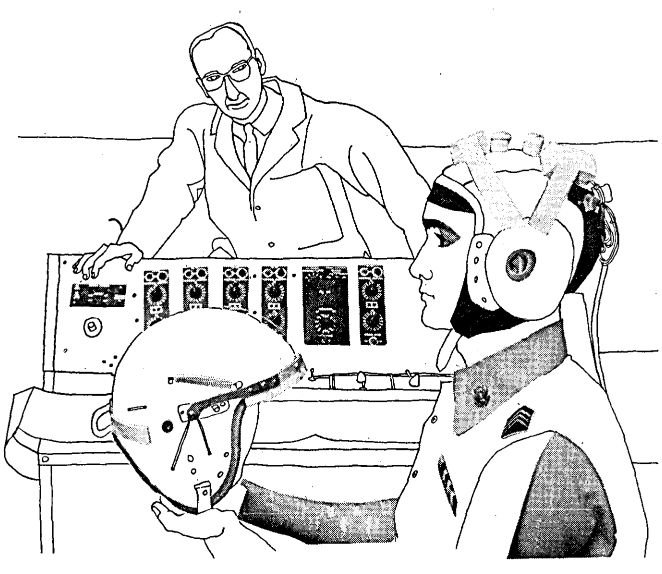
in the planning stage. Yet the shortage can only be met in part by this planned expansion of medical education facilities. Other means must be found to increase the efficiency of physicians and other medical personnel.

### current applications

Current application of mechanized data processing in hospitals and medical institutions is for the most part confined to administrative and budgetary functions. An information system generates financial information to help department heads measure and control their operations. At the same time, hospital administration is given reliable information for evaluating overall cost performance of each department in relation to its budgetary goals. In such a system, department managers are given monthly budget reports covering expenses for payrolls, materials and equipment for the preceding month. Actual and budgeted costs for each department are given side-by-side for both the current month and the year-to-date. The sum of total outstanding purchase orders can be easily included since those data are already stored in the data processing equipment.

Although not nearly as advanced as financial information systems, data processing equipment is gradually being applied in handling medical data. The first operating systems have been developed for recording test schedules and results in clinical laboratories.

The need for mechanized data processing in the clinical laboratory is demonstrated by the fact that in a typical 250-bed hospital today more than 700 tests are conducted daily—and each must be scheduled, recorded and reported in various forms. Dr. A. E. Rappoport, Director of Laboratories of the Youngstown, Ohio Hospital Association, expects that the number of tests will double again in seven years, as it has in the past.[1] While automated test procedures have helped laboratories speed up the analytical tests, no broadly applied mechanized systems have been developed to reduce the amount of clerical work. Recently,



numerous clinical laboratories have designed mechanized information handling procedures to answer their own special needs.

Although there has been intensive activity lately in the mechanization of clinical procedures, there is still considerable room for improvement. A computer-based information system can be applied in clinical laboratories, with punched cards used by floor nurses to order laboratory tests which physicians have requested. They replace the 8½ x 11 inch forms now used and provide machine-readable input for data processing equipment. Information on a card, some pre-punched and some recorded by punching out prescored sections, is transmitted to a central computer. After the tests have been ordered, the computer is programmed to print out a schedule, prepared for each ward, with the names of patients along with the type of test ordered and other data. As specimens are collected, pre-numbered labels on the right-hand edge of the order card are placed on the specimen containers for positive patient identification.

With this system, one computer-produced test card is also prepared for each test ordered. The technologist uses the same card to report test results to the computer after the specimen has been analyzed. Two test reports are printed and relayed to the ward nursing station. The first is a ward summary report, which is produced at intervals—usually every two hours. This lists the progress of testing up to that time and is used by the nursing station to report results to physicians during the day and to answer inquiries. The other report, the patient summary report, is prepared at the end of the day for every patient tested that day. This report shows on a single document the chronological results of all tests performed during a patient's hospitalization, with abnormal results flagged for the physicians.

### current trends

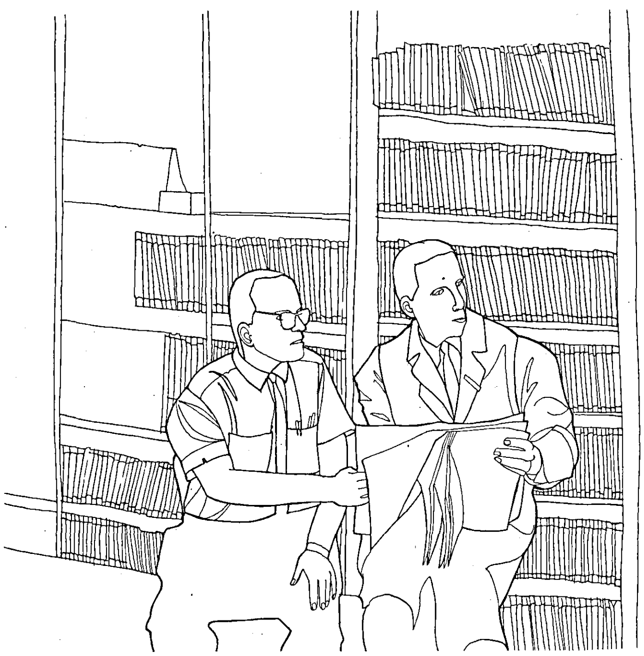
It can be seen that current data processing procedures, although quite useful for the hospital administrator and laboratory director, are only indirectly connected with the patient. Countless other studies are now underway to apply special mechanized systems in virtually all phases of patient care where data is recorded, transmitted, retrieved or evaluated in some way. Particular interest has been shown in direct patient monitoring, medical record mechanization, ECG analysis, and physiological modeling.

*Direct Patient Monitoring*—Primary data from the patient himself may be processed by the computer either off-line or on-line. The off-line data can be recorded by the physician or nurse on special cards or forms (or at appropriate terminals) and then fed into computer storage as part of the basic patient record. The on-line data, such as electrocardiograms and respiration rates, can be automatically monitored by the computer and directly fed into storage without human intervention. As might be expected, on-line (real-time) computer applications have not progressed as far in medicine as have off-line applications.

One of the earliest projects to develop an on-line system for direct patient monitoring is being carried out in the Shock Research Unit of the University of Southern California's School of Medicine and the Los Angeles County Hospital under the direction of Dr. Max H. Weil.[2, 3] An automatic digital monitoring system has been assembled that monitors 24 variables including blood pressure, respiration rate, heart rate, body temperature and other clinical parameters such as cardiac output, venous pressure and urine output. Two patients can be monitored simultaneously 24 hours a day, entirely under the control of ward medical personnel. The primary measurements are processed by a remote computer, and the measured and derived variables are printed out on an output typewriter in the ward, and displayed on a screen at the patient's bedside. In addition, cards are punched for off-line analysis of data for research use. The purpose of this effort is to improve efficiency in the care of the seriously ill and explore basic physiological factors relating to shock and circulatory failure.

*Medical Records*—A developmental computerized medical records system is now in operation at Roswell Park Memorial Institute in Buffalo, N. Y.[4] Dr. Robert Ausman of Roswell Park has looked upon the medical record as all information recorded on the patient's chart during his hospitalization, as well as the documents which are conventionally in the care of the medical records librarian. The system makes no attempt to replace the paper records stored in the medical records department, since many of the signed and dated documents must be retained for legal purposes. Although the system is presently entirely off-line in operations, it keeps pace with day-to-day activities in the institution. Much of the emphasis is on retrospective searching among records of all patients in the service of research to generate clues and evaluate hypotheses in the diagnosis and treatment of future patients.

The three key documents in Roswell Park's experimental records system are a daily information sheet, daily patient profile, and coded nurse's note form. The daily information sheet is prepared by the computer and filled in by



the nurses. The data are keyed onto tape and fed into the computer the next morning for use in the preparation of the daily patient profile. The coded nurse's note form is filled out by the nurse and the data is entered into the patient's chart by the computer. With these documents, Roswell Park expects to improve the quality and ease of collection and presentation of patient data.

*ECG Analysis*—Experimental computer programs are now analyzing electrocardiograms at numerous medical research institutions.[5,6,7] Computer measurements on ECGs with normal rhythm have been found to agree with manual measurements made by cardiologists. ECGs with abnormal rhythms are still under study.

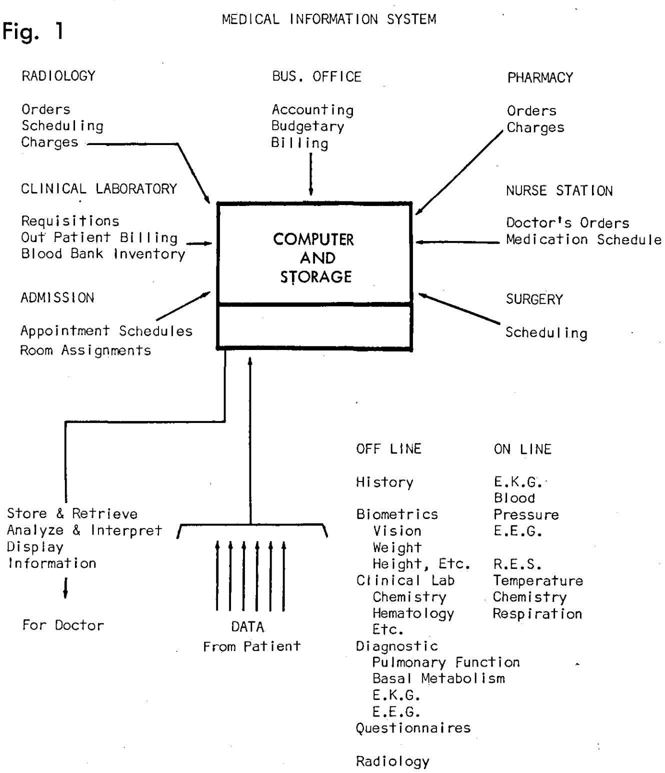
*Physiological Modeling*—The development of realistic models of physiological systems offers real help in both research and therapy. Researchers at several universities have developed advanced mathematical models which enable computers to simulate the human lung, heart, cardiovascular system and blood chemistry.

An experimental lung model,[8] which is expected to be useful both in improving understanding of pulmonary diseases and as a teaching aid, presents a dynamic picture of gas exchange and blood flow in the lungs. A three-compartment lung construction has been developed and verified with data obtained from several patients with various pulmonary disorders. The operation of the lung is described by 31 mathematical equations. The model is expected to be helpful, for example, in a type of therapy in which patients breathe different gas mixtures. Physicians may be able to predict the patient's reaction to these gas mixtures and their effect on the oxygenation of his arterial blood.

*Diagnostic Assistance*—Diagnostic assistance by computers is an attractive potential application in which the system provides a ready storehouse of possibly relevant information for use by the physician in diagnosis. In such a system, physicians sitting at typewriter-like consoles in a number of separate locations might direct questions to a large computer and receive medical information that can be helpful in making diagnostic judgments.

In a typical exchange with the computer, a physician might type in a few symptoms, and the computer would respond by printing out a list of possible diseases. The physician might then ask why a particular disease appears on the list, and the computer would supply a number of possible cause-and-effect relationships. The physician could then ask for more information about a particular causal path, examine the logic, and agree or disagree with the computer's response. Searching in this way, the doctor could make a logical examination of all the reference possibilities stored in the machine. In one experi-

Fig. 1




mental program of this kind,[3] information from medical text books on malformations of the heart have been stored in a computer and can be retrieved at a terminal in accordance with a physician's logical inquiries.

## the medical information system concept

The medical information system concept described schematically in Fig. 1 would integrate all special data processing systems—financial, clinical, research and patient care—in a given medical institution. To do so, it would embrace all information processing and flow both within and between professional, service and research functions.

Such a system, which in fact does not yet exist anywhere, requires precisely defined information flow structures and various types of EDP equipment to receive, store, manipulate and present information. A formal structure based on the types of activities and needs of all departments is vitally needed to insure processing of data in the quantity, form and frequency that is truly useful.

The special data processing systems that are being introduced to perform one or more critical information handling tasks in medical institutions can ultimately become part of complete information systems. The introduction of a medical information system can evolve gradually —without serious disruption of facilities or hasty retraining of personnel. Essentially all of the medical institutions now using computers in some manner are preparing for expanded application into new departments and for other functions, many with full medical information systems as their ultimate objective.

## role of the computer in patient treatment

The most important joint challenge to the medical and EDP professions today is the wider application of information retrieval and logical analysis in the treatment of patients. As indicated at the lower left of Fig. 1, most information processing in diagnosis and treatment is in the hands of the physician.

Just what is the information handling job of the physician, and how much further can computer systems go in giving him more time for his primary skills? Dr. F. J. Moore of IBM's Advanced Systems Development Division has analyzed the physician's fundamental decision-making process from the time of patient admission to discharge. It can be summarized as follows:

A. *Acquire patient data*—a physician interviews the patient, his family and perhaps others to obtain routine data for the patient's medical record and symptomatic information normally required in treating his apparent condition.

B. *Process data*—the data are combined and transformed, perhaps by being related to relevant information in the medical library.

C. *More data needed*—data are reviewed to determine whether or not adequate information in useful form is available. If not, the physician must decide what data are needed and go to the patient to repeat the preceding steps.

D. *Diagnosis, prognosis, therapeusis*—the physician reviews the data in the light of relevant information on both what is already known in medicine about the condition itself and on what choices and decisions he and other physicians have made in the past.

E. *Action*—the physician decides what must be done. If no action is called for, the patient is discharged. Otherwise the action is taken.

A vitally important characteristic of this information handling process, of course, is that the entire cycle begins over again once action is taken and repeats until no further action is called for. The results of each action must be observed, recorded, evaluated, augmented, and usually further action, major or minor in nature, is needed.

The significant fact is that most of the physician's time in this decision-making process is involved in gathering information that is already known and from it making clear-cut choices that he and others have made many times before. This information-gathering part of the process—an estimated 90% of the physician's time—is the kind of task that can then be programmed in a computer. Conversely, less than 10% of the process requires decisions based on human value judgments, calling on the physician's special training and experience.

## in the future

The role of the computer is then clear—to perform the 90% of the job that is programmable. In doing so, the data processing system must not alter the physician's qualitative decision-making process in the slightest and must be available at an acceptable cost. Through time-shared computer usage, it may be expected that the cost will be shared with various other subsystems. In any case, the cost of computer time must be related to both reduced clerical costs and the increased productivity of the physician in making human value judgments. An improvement in the quality of the physician's decisions may also occur because he has more information available to him sooner. This is certainly a significant benefit beyond measure in dollars.

While numerous special information systems are seen to be already in operation, and many experimental programs are exploring computer-aided diagnosis, there are several areas where further development is needed before the computer can play its full role in medicine. First, there must be improved primary instrumentation to provide better input data for medical information systems. Second, there must be improvement in the tools and techniques for other forms of data acquisition, such as health questionnaires and observational notes. The Minnesota Multiphasic Personality Inventory (MMPI)[10] and the Kaiser Foundation's Multiphasic Screening and Diagnosis System[11] have already made significant advances in this area.

The rate at which the computer takes its place in medicine depends on increased cooperation and interdisciplinary understanding between the medical profession and the EDP industry. With continued application of computers, it may be expected that medical information systems will spread beyond the individual medical institution to regional health care centers. Central computer systems with massive information storage capacity that can be shared by many medical institutions for the improvement of patient care and the advancement of medical research can be expected to become the way of the future in medicine. □

## REFERENCES


1 *Computer-Assisted Pathology*, proceedings of symposium sponsored by the College of American Pathologists, October 1965.
2 *On-Line Monitoring of Critically Ill Patients* by M. H. Weil and others. To be published in a future issue of "Medical Electronics and Biological Engineering."
3 *Patients On-Line* by R. L. Patrick and M. A. Rockwell. Paper published in Datamation, September 1965.
4 *Clinical Data Management* by R. K. Ausman and others. Paper presented at the Conference on Advances in Biomedical Computer Applications sponsored by the New York Academy of Sciences, June 1965.
5 *Electrocardiographic Analysis by a Computer System* by C. A. Caceres. "Archives of Internal Medicine," Volume III, February 1963.
6 "*Computer Analysis of the Electrocardiogram* by H. V. Pipberger. Chapter 16 of "Computers in Biomedical Research, Volume I," edited by R. W. Stacy and B. D. Waxman, Academic Press, 1965.
7 *A Hybrid Computer System for the Measurement and Interpretation of Electrocardiograms* by D. Wortzman and others. Paper presented at the conference cited in Reference 4.
8 *Possible Distribution of Ventilation and Perfusion in the Human Lung as Related to Arterial Nitrogen Tensions* by F. Wiener and others. Paper presented at the Fall Meeting of the American Physiological Society, August 1965.
9 *DAP — A Diagnostic Assistance Program* by R. E. Bonner and others. Paper presented at the 6th IBM Medical Symposium, October 1964.
10 *Automatic Personality Assessment* by H. P. Rome and others. Chapter 21 of book cited in Reference 7.
11 *Computers in Multiphasic Screening* by M. F. Collen and others. Chapter 14 of book cited in Reference 7.

# JOINT VENTURE AT MASSACHUSETTS GENERAL

*bolt beranek and newman at the hospital*

**by DR. JORDAN J. BARUCH and G. OCTO BARNETT, M.D.**

**Q:** Dr. Baruch, what are the objectives of the BBN-MGH Hospital Computer Project?

**Dr. Baruch:** Basically, what we're trying to provide is a computer environment which will foster the growth of medicine. We're interested in applying computation to the fields of patient care, research and administration. Some of these can be subdivided. Patient care, for example, can be the routine activities such as keeping track of drugs and doctors' orders or more extended activity where, say, a psychiatrist may be using the computer to help analyze test scores.

The project began about three years ago with a small time-shared computer. It started with a heavily administrative emphasis. We built a "little hospital system" (Fig. 1) which permitted us to assemble parts of the medical record on an experimental basis—very small sets of data, for a few mock patients actually—and to do many of the operations which we felt would be necessary in an actual hospital environment. When it became clear that the principles were valid enough to warrant further investigation and the capacity of the equipment was too small to permit such further investigation, we increased our facility size and went on to build what we fondly call the "big hospital system." In this system we have the capacity, at least insofar as machines and concepts are concerned, to amass the medical records of many patients, interrogate these records through the machine from many terminals and hopefully analyze the results of the interrogation. The system is large and has these capabilities, as I say, only in concept and hardware.

**Q:** Dr. Barnett, what problems do you see from the hospital's point of view in getting a system of this kind operating?

**Dr. Barnett:** I would say the first problem is that of specifying exactly what information we want to collect; this requires the explicit identification of the actual problems

*Dr. G. Octo Barnett is director, Laboratory of Computer Science, Massachusetts General Hospital in Cambridge, where he is responsible for the development of user program specifications and the use and evaluation of the running system. He received his BA in chemistry and math from Vanderbilt Univ. and his MD from Harvard Medical School. Dr. Jordan J. Baruch is vice president of Bolt Beranek and Newman Inc., Cambridge and initiated the hospital computer project where he is responsible for the overall system design and programming. Author of numerous papers, he has been with BBN since 1949. He holds a BS, MS and ScD from MIT.*

of medical practice in a hospital. It is probably true that many of the record keeping methods we use are somewhat archaic and represent the carry-over of practices developed 30 to 50 years ago. Much of medical practice can be described as forms of information processing and communication. It is clear, therefore, that we should at-

Fig. 1

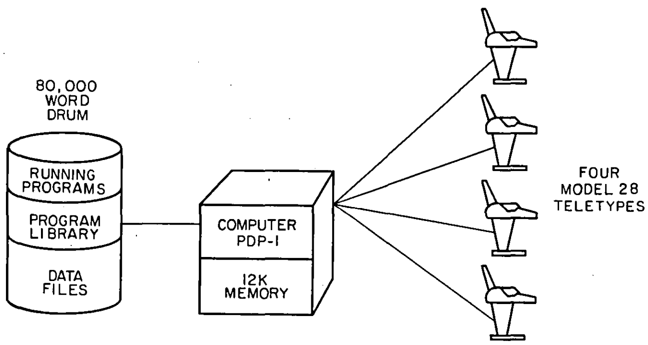



Fig. 2

```
LABORATORY REPORT  4:08 PM 10/14/1965
1  PATIENT? .12005   NORMAND,SUSAN
2  DATE?  10/2/1965
3  N DAYS?  7
PLEASE WAIT...
ADJUST PAGE; TYPE "ENTER".

LABORATORY REPORTS                                   NORMAND,SUSAN
7  DAYS BEGINNING OCT 2, 1965 - SHEET 1               123-54-89

                          DATE SPECIMEN COLLECTED
                          OCT    OCT    OCT    OCT    OCT    OCT    OCT
                            2      3      4      5      6      7      8

              *   *   HEMATOLOGY REPORTS   *   *

HEMOGLOBIN                13.6                 14.0
    GM./%
HEMATOCRIT                45.    40.           34.                  42.
    %
WBC COUNT               12500. 11700.         8700.  7500.         7500.
    /CU.MM.

WBC DIFF IN %
    POLYS                 82.                  82.
    BANDS
    LYMPHS                 8.                  11.
    MONOS                 10.                   7.
    EOS
    BASOS
    PLATELETS              N                    N
   OCT 2  -  +- VAR SIZE RBC'S.
   OCT 5  -  +- VAR SIZE RBC'S.

                 *   *   URINE ANALYSIS   *

ROUTINE  VOL (ML)
   COLOR                  AMB
   PH                     6.0                                   7      8
   SP. GRAV.              1.015                                 CONTINUED
   ALB

LABORATORY REPORTS CONTINUED                         NORMAND,SUSAN
7 DAYS BEGINNING OCT 2, 1965 - SHEET 2               123-54-89

                          DATE SPECIMEN COLLECTED
                          OCT    OCT    OCT    OCT    OCT    OCT    OCT
                            2      3      4      5      6      7      8

LIVER FUNCTION REPORTS CONT'D

BSP RETENTION                                              15.
    % AT 45 MIN.
CHOLESTEROL                                                         152
    MG.%

          *   *   REPORTS ON BLOOD OR SERUM METABOLITES   *   *

UREA NITROGEN              9      8           13                    15
    (BUN)  MG.%

                                              END OF LABORATORY REPORTS
```

tempt to take advantage of the advances in this scientific area that are being applied in other disciplines.

**Q:** How do you correlate this information?

**Dr. Barnett:** A good example is in the presentation of the laboratory reports. Laboratory tests are ordered by specific names on specific dates. However, in the presentation to the physician, it is very important that the tests be displayed in a chronological order and by logical groups, such as serum electrolytes, liver function tests, tests of urine function, etc. Some tests, of course, having relevance to different groups may well appear twice in the listing (Fig. 2).

**Q:** Do you find that you get better quality input because of the system's ability to validity check information as it's coming in?

**Dr. Barnett:** Yes indeed. This is one of the more powerful features of the on-line system we are developing. For example, one of the difficulties we have in the hospital is that many of the drugs have rather complicated spellings. To make sure that drug orders are correctly entered, we check drug name against a formulary. If no exact match is found, the person operating the Teletype is presented with a list of drugs having similar sounding names and requested to choose the desired one. In addition, we take advantage of the fact that many drugs have a dose limit which is rarely exceeded, and check all orders against dose limit. If, because of error in interpretation of an order, or because of error in remembering the proper dosage, a quantity of drug larger than this limit is specified, the computer returns with the information that this is an unusually large dose and requests a specific confirmation of the order. Also, many drugs can be given only by a specific route, such as intravenously, or by mouth. By checking the route of each prescription item the program assures that the order is valid in this regard.

I would like to point out, however, the individual physician still has ultimate responsibility for a given prescription order. The program allows the operator to override the formulary limits. However, when this formulary override feature is used on any given prescription item, notification is printed out on a Teletype in the Pharmacy Office so that the Formulary Committee can collect information about the actual utilization of drugs in the hospital and thus make sure that the formulary items reflect actual common practice.

**Q:** Does the system provide any support for doctors doing statistical research into records?

**Dr. Barnett:** Yes. There are two classes of problems for which the present computer system has proven to be extremely useful. The first has to do with the entry, manipulation and retrieval of data in large files, such as the pathology records, the file of all of the records of demographic data on patient admissions, the file on various subgroups of disease populations. A number of physicians have found the system to be extremely useful in creating and updating these on-line and in retrieving the information with a very free and flexible control language. This has been done using batch processing methods but the availability of on-line techniques allows a much more useful manipulation of these files.

**Q:** Could you give us a description, Dr. Barnett, of how a doctor actually uses this information storage and retrieval and statistical research system?

**Dr. Barnett:** A program is available that allows the physician or the research worker to describe the structure of the file. There are also programs which are used to enter data into this file either from punched cards or directly from the Teletype. This latter method has this advantage: the on-line system can be used to check the syntax and the content of the data as to its acceptability at the time it is entered. This type of on-line checking seems very useful in that it allows relatively untrained operators to enter data. The data then can be manipulated in a variety of fashions: new fields being created, simple mathematical operations performed on the data, and subpopulations of the data extracted by inputting specific descriptors concerning the characteristics of the subpopulation. Finally, these data can be displayed in tabular form and various statistical manipulations carried out, such as chi-square testing for significance, etc.

**Q:** Have you had any reaction from your nursing staff to the way that user programs look from the Teletypes? Do the user programs help the nurses, or are they merely an impediment to the practice of medicine as they see them?

**Dr. Barnett:** We have had only limited experience with use of the programs in the Patient Care areas. For the most part the programs have been used by nurses of our own laboratory staff, but these individuals are not typical. In the development and specification of the programs we have been quite concerned with the problem of acceptability and usefulness of these programs to persons who are neither trained in the art of programming nor particularly motivated to use a computer. Therefore, we have been concerned with the external appearance of the programs, with adding self-teaching features, with making variations of programs available to fit the relative sophistication and experience of users. The input programs are set up to carry on a dialogue where the computer system controls to a major extent the type and form of the input and where the operator is mainly concerned with answering correctly a given question from the computer. We have provided a technique whereby the operator can request information about the form of answer that is required. In addition, the programs are set up so that the operator can change the questions from either a very short abbreviated form to a longer form depending upon the experience of the operator (Fig. 3).

**Q:** What about the response time?

**Dr. Barnett:** We actually have little quantitative data on any sort of consumer usage of the system. It is clear that even with a very slowly responding computer system we can perform many of these tasks orders of magnitude faster than present techniques, so even a very slowly responding

Fig. 3

```
3:31 PM 10/14/1965  BUB'S(06)  RR1
CALL MEDX  EAG
MEDICATION ORDER

1  T  T    (Program starts in short form. T for time, T=now)
2  D  T    (D means Date?  T=today)
3  DR  ←/  (Change to long form)
3  DOCTOR  JECKYLL, W
4  PATIENT  CASTLEMAN, LOKI  FIX (Patient is specified by room space)
4  PATIENT  ←HOW  E.G. 150-1  152-1 CASTLEMAN, LOKI     F  000-02-00
5  ORDER
  5.1     RX,ASPERIN,3MG\\00MG,PO,TID,I    (Backslash means cross-out)
...DO YOU MEAN...
   1    ASPIRIN GUM
   2    ASPIRIN EC
   3    ASPIRIN SUPP
   4    ASPIRIN COMP
   5    ASPIRIN BUFFERED
   6    ASPIRIN

  SELECT N...  6
  5.2
6  INITIALS  ←/   (Change to short form)
6  INIT  ←LIST    (Give a clean listing of the entry)


MEDICATION ORDER

1  T  T
2  D  T
3  DR  JECKYLL, W
4  PT  152-1 CASTLEMAN, LOKI     F  000-02-00
5  ORDER
  5.1     RX,ASPIRIN,300MG,PO,TID,I
  5.2
6  INIT  EAG

-THANK YOU-
```

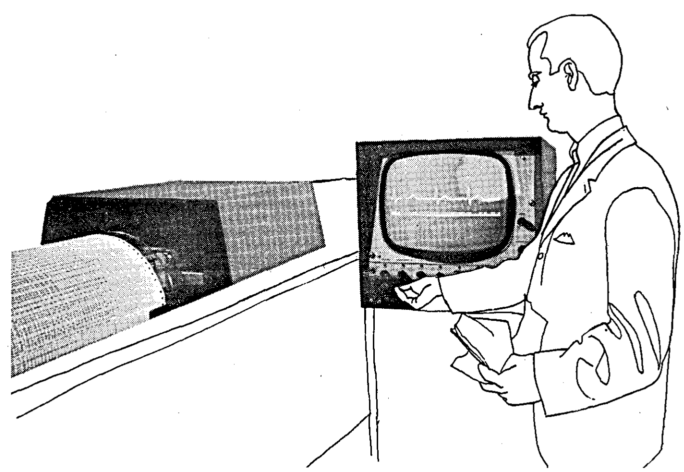
system could be quite acceptable. However, we have also noted that after a person becomes familiar with using the system and discovers that its speed depends on the total load on the system, a certain intolerance to slow response develops. In other words, when the user becomes experienced he also becomes less tolerant and would like to have fast response time on all occasions.

**Q:** Can you give me some idea of what response times you do get? If, for example, a nurse is typing in a medication order and this takes place as a series of questions by the computer and responses by her, how long does it take for the computer to come back with the next question?

**Dr. Barnett:** In a typical instance under the present load of the system, the time lag is so short as to be hardly detectable. Even in the worst case this lag will be only a few seconds. However, there are some programs which require extensive manipulation of the data internally before typing out a response, and in some cases the time lag can be as long as a minute or two, which then becomes rather unacceptable to the experienced user.

**Dr. Baruch:** Those delays arise from the queueing to use the big drum storage. We are modifying the exec so that the delays will be avoided for those user programs that interact with users at the expense of those that are of lower priority.

**Q:** Whenever I talk to the hospital people, I get the impression that, next to getting the patients well, getting the bills out is the most important thing to them. Are you



programming to get out patient bills as a part of this system?

**Dr. Baruch:** Because there is in general such a simple transform between an accurate record of what has happened to the patient and the patient bill, we haven't bothered with the actual billing programming. We feel that that is a relatively easy extension of the work we are doing.

**Q:** Dr. Barnett, what do you have to say about the rather casual attitude toward bringing the money in?

**Dr. Barnett:** Well, I think I would be thrown out of the hospital by my administrator if I adopted quite so casual an attitude. However, I certainly would agree with Dr. Baruch that our primary emphasis has been on the development of a system which will improve our ability to give medical care with only a very secondary interest in the billing problem. I think that this emphasis of ours, however, is an important one, and that in the long run it will lead to development of a much more powerful and sophisticated system than if we started out with an accounting-type system and tried to extend it in some fashion to a medical communication or information-retrieval system. I think the latter function is so important and so much more complicated that it should be the one that should be emphasized primarily.

**Q:** Getting back to the hospital computer center. What equipment are you using?

**Dr. Baruch:** The central processor is a modified PDP-1 manufactured by Digital Equipment Corp. (Fig. 4). The modifications include instructions to facilitate 6-bit character handling, memory protection to cause trapping to the exec program when a user program tries to perform an instruction that addresses outside its own core, a trapped-instruction buffer to help the exec handle trapped instructions, and a 16-channel sequence break system and a crystal controlled real-time clock which provides 32 ms interrupts for time slicing and 1-min. interrupts for time-of-day. There are three independent banks of memory, each with its own memory address register and memory buffer. The 12K bank is used for storage of the exec and common routines and the two 4K memories hold user programs. Two other "processor like" devices, once started by the central processor, can operate independently and simultaneously: the high-speed swapping drum stores up to 32 programs in the time-sharing queue; the data channel handles transfers between memory and the Univac FASTRAND and tapes. The FASTRAND gives us 50 million characters of random access storage. The interconnections between the three memories and the three processors are controlled by an electronic crossbar switch which is controlled by the central processor. The Teletype interface has a 1-character transmitter buffer and a 1-character receiver buffer for each of 64 lines. The exec does the rest of the buffering internally.

**Q:** That seems like an awful lot of stuff to keep running all at once. What happens when lightning strikes and power fails? How do you safeguard the running of the system to make sure that the hospital doesn't get harmed by a power failure?

**Dr. Baruch:** We have assumed throughout our development work (and incidentally, please remember that we are a research project and not as yet a data repository for the hospital) that data can be destroyed by a power failure. We have assumed in the worst case, for example, that the power will change just one instruction which will cause the system to ingest its own tail and rapidly swallow itself, wiping itself clear at the same time. One could conceivably reduce the probability of having this happen by having two systems, or reduce it still further by having three. I think when you get up past three, rather than reducing the probability of serious failure you start increasing it.

We have taken a somewhat different tack, however. We say we have one system; and the hospital, no matter how much the backup, must be able to run without it. The hospital cannot be made completely dependent upon its system. We, therefore, are very careful in our programs to produce hard copy at the Patient Care Unit and other locations which will be sufficient to permit the hospital to carry on its activities without the system's help. Naturally, as time passes these pieces of paper can be thrown away since the state of the system is preserved every 24 hours. So we need no more than 24 hours' worth of such hard copy.

**Q:** Do you have any impression, even at this early date, of the frequency of detected errors which arise from hardware or program malfunction as compared with those from human malfunction?

**Dr. Barnett:** We have some quantitative data on a very small subset of the programs now functioning. For instance, in the transmission of test results from the laboratory to Patient Care areas, over a two-month period involving some 3,000 laboratory reports there was no case of any computer loss of data or erroneous manipulation of data. There was an error rate of .7% in input of the data by the operator, but this error rate compares very favorably with the hand transcription techniques in present use. In those programming areas where we are still in the very early stages of implementation there is a much higher error rate than this, but we expect to be able to identify the causes of these errors and correct them.

**Q:** When you spoke of an error rate of .7% what did you include?

**Dr. Barnett:** That is a total of errors in the identification of the test, the identification of the patient, and in the data for a given test. In all of these cases, over three-fourths of the errors were detected when they were entered or shortly thereafter and were corrected in the laboratory itself. The actual error rate of results appearing on the floor was less than .3%.

**Q:** Getting back to the hardware, how about communications?

**Dr. Baruch:** I was coming to that. The central processor has access to dedicated telegraph lines through a communications interface (DEC Mod. 630) which can handle up to 64 lines. The lines end in the user terminals.

Our terminals are general purpose keyboard printing telegraph instruments, rather than dense coded keyboard instruments which limit you to a fairly poor vocabulary. Specifically, we use model 33 Teletypes. Several are located at various places in the hospital, others are in our offices for the use of the programmers, and five are in schools around Boston. The system is configured by the programmers for the use of the medical people at the moment, with the schools as paying guests.

**Q:** Why did you refer to the Teletypes as keyboard printing telegraph?

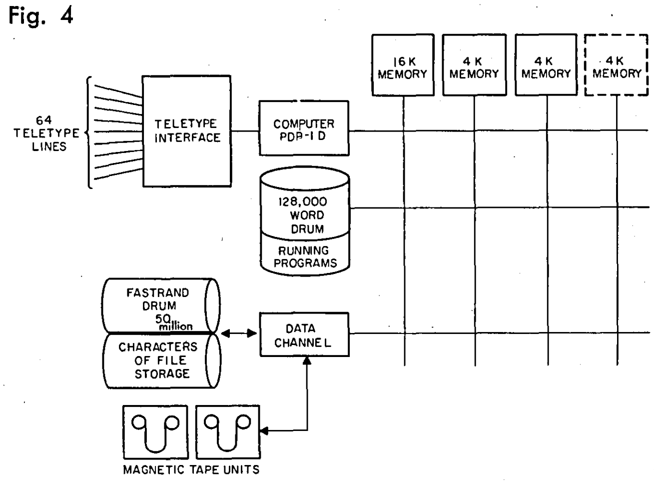
**Dr. Baruch:** Because the important characteristic of the terminal is not its manufacturer but the fact that it is a machine which converts alphabetic and numeric characters to code, which means the user then assembles the word rather than having little words printed on buttons, like "Stop," "Go," "Aspirin," "BUN" and so forth.

**Q:** Don't you find Teletypes awfully noisy for use in a hospital?

**Dr. Baruch:** We sure do! That's why we designed and built quieting enclosures for them (Fig. 5).

**Q:** You commented a moment ago that dense-coded keyboards "limit you to a fairly poor vocabulary." On the other hand they provide efficiencies by taking advantage of the redundancies in the material they communicate. Don't you find clear text inefficient?

Fig. 4




**Dr. Baruch:** Yes, as a matter of fact. It was to meet that problem that we designed an input device that we call a Datacoder (Fig. 6). It works in conjunction with a Teletype so we have the best of both worlds. When you position its pointer and push the send button, the Teletype sends two characters to the computer representing eight bits of X and eight bits of Y, coordinately. It is a simple matter to write a program that can decode (by table lookup) the resulting dense-coded input.

**Q:** Is the densely coded input then stored in its densely-coded form for economy of storage or is it translated back into its full-blown text meaning in the system?

**Dr. Baruch:** From long experience, we're devout believers in Murphy's Law which states, "If anything can go wrong, it will!" As a result, we neither assume that the right button was pushed nor that the communications lines transmitted the right signal. Rather, when we get densely coded information it's transformed into an English string or the equivalent and printed back at the user for his further verification. And that's done immediately. The form of internal storage is an independent decision that we make for each case. Input data verification is one of the necessities of any real-time system.

**Q:** Oscilloscope output is well known to be fast and well-coupled to people who read fast. How come you don't propose to use it?

**Dr. Baruch:** Well, the maintenance of the display on a scope requires either local memory or a broad-band line to the computer. We are, at the moment, particularly conscious of the cost of the task we are undertaking. As engineers, we do not feel that it really accomplishes anything to transfer information around in the hospital in some sterile atmosphere devoid of cost considerations.

**Q:** You mentioned some terminals in schools.

**Dr. Baruch:** Yes, by agreement with the hospital and the National Institutes of Health, another project under the Dept. of Health, Education and Welfare involves the use by the Massachusetts State Dept. of Education of remote terminals in the teaching of mathematics. Several schools—interestingly enough, ranging as low as the third grade—are experimenting with the use of a simple mathematical manipulation program TELCOMP as an aid to teaching mathematics in the classroom.

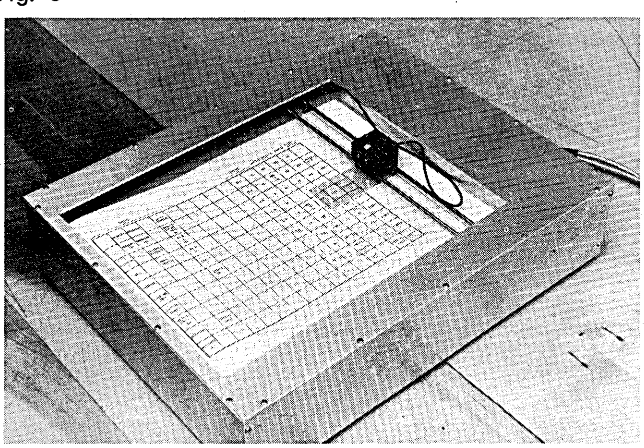
**Q:** I understand BBN is also offering a commercial on-line computation service for engineers. Is that on this machine?

**Dr. Baruch:** No, that's a separate machine which is also a modified PDP-1. Some confusion has arisen because we have used the name TELCOMP for both of our versions of the JOSS language, which was originally developed by Cliff Shaw at RAND Corp.

**Q:** Was the programming of that system done under the hospital project?

**Dr. Baruch:** No. The commercial version was programmed entirely separately because that's quite a different machine and has neither the time-sharing facilities of this machine nor the memory capacity, nor many other features. As a matter of fact, we hope that we will be able to "borrow" much of the coding that they have done for use by the hospital researchers when they want to do mathematical manipulation.

Fig. 6



**Q:** Has TELCOMP proved to be useful in the medical field?

**Dr. Barnett:** Yes indeed. The MGH is a very large research institution; our research budget from the National Institutes of Health is over $10 million this year. We have a large number of investigators who have a variety of relatively simple mathematical routines that are carried out every day. The availability of an on-line system of the power of JOSS has proven to be an extremely useful and very desirable feature of a computer within a hospital medical research institution. Examples of the use of this system are in the processing of data from a scintillation counter, from amino acid analyzer, from an ultracentrifuge, etc. In each of these cases an investigator collects a set of data of about 20 to 200 points and then performs relatively well-prescribed manipulations on these data in a routine fashion day after day.

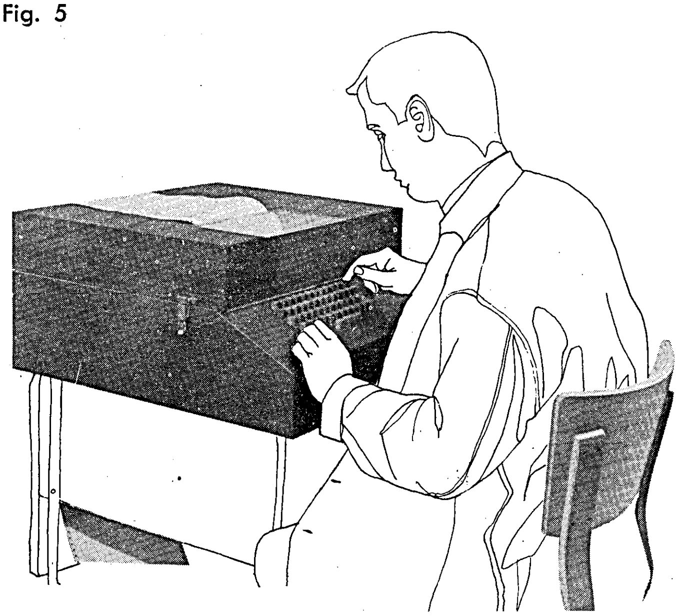
**Q:** Does the TELCOMP language enable a research doctor to write his own programs for performing transforms on measurements?

**Dr. Barnett:** The language is quite straightforward. Many of the individual research workers have written their own programs to carry out their work with very little difficulty.

**Q:** Suppose I'm a hospital administrator planning a new hospital and I want to know what effect the prospect of systems of this kind should have on the architecture of the hospital. What provision should I make for this revolution in medical information handling?

**Dr. Baruch:** This is a very pertinent question. At a minimum, one needs room for terminals in almost all areas of the hospital and provision for easy running of communi-

Fig. 5



cations lines. The American Hospital Assn. is currently preparing a book, *Data Processing in the Hospital,* which is meant for use specifically by administrators and boards of trustees who are planning new facilities, expansions of old facilities, remodeling or just a continual updating that's so characteristic of the hospital community.

I am hoping further that as the information handling becomes more of a natural process within the hospitals, the Hospital Engineers Group of the AHA will take the information processing systems as part of their responsibility and provide the professional leadership for it within the hospital community.

**Q:** If a hospital administrator came to you today and asked for service, could you provide it on this machine?

**Dr. Baruch:** No, this machine is dedicated to a research project and is, as yet, not available for service to hospitals in general. □

# COMPUTER ANALYSIS OF MEDICAL SIGNALS

*public health service activity*

by CESAR A. CACERES, M.D.

Results of several feasibility and prototype projects of the Instrumentation Field Station, Heart Disease Control Program, U. S. Public Health Service, have shown that a computer can be of tangible assistance to physicians in diagnosing and screening for heart disease. These projects have demonstrated the feasibility of automatically extracting, by pattern recognition, all necessary pertinent data from medical signals so that the extracted data may be properly interpreted for clinical purposes.

The Field Station has set up a processing system to demonstrate the practical application of its efforts, i.e., to develop a model for a practical, economic, and clinically useful computer system of electro-medical signal analysis.

Medical signals are used by all physicians as part of their routine diagnostic efforts in patient care. The signals must be interpreted by a physician. Interpretation requires a specialist with many years of training because of the complexity of the signals and the myriad nature of the patterns that are seen. These signals are generally recorded from different body locations by appropriate placement of electrodes and appropriate circuitry to tell us about heart function, brain function, lung function, muscle function, etc. Correct medical interpretation is necessary to help in arriving at correct patient diagnosis, defining the causes of disease, identifying what progress the patient is making and prescribing appropriate therapeutic procedures. As medicine has progressed, more and more medical signals have become indispensable in diagnosis and care.

## overall objectives

The program has six readily definable aims:

1. To provide, as a diagnostic aid, fully automated interpretation of medical signals. For this, routine signals need to be transmitted or recorded on magnetic tape, analyzed by computer, and the results made available to the hospital, physician or nursing home within hours of recording. In emergencies immediate results within seconds might be had.
2. To study methods to classify data according to biological variables which affect medical signals and to utilize these findings to refine diagnosis. To develop statistical routines a) to categorize, b) to combine computer processed signal values with anthopometric and physiologic data, history and laboratory test values for more complete diagnosis, and use this data as input for multivariate statistical discrimination programs, c) to study correlations between single or combinations of parameters and disease to develop new or more accurate diagnostic criteria, and d) to develop probability figures for a diagnostic statement.
3. To develop computer programs for patient monitoring under stress situations and for studying time changes of serial tracings as a means of developing predictive procedures.

---

*Author or co-author of some 60 papers, Dr. Caceres is now Chief, Instrumentation Field Station, Heart Disease Control Program, Division of Chronic Diseases, U.S. Public Health Service, HEW. He received his MD from Georgetown Univ. and has been affiliated with George Washington Univ. as an associate professor of medicine and special lecturer in biomedical engineering. His memberships include both medical and computer organizations.*

4. To develop for general clinical use diagnostic criteria which utilize objectively computed data.
5. To instruct medical and para-medical personnel in machine analysis of the medical signals so that medical use of computers may be better understood.
6. To provide consultation and assistance in refinement of computer programs for diagnosis.

## computer analysis of electrocardiograms

The reading and interpretation of large numbers of electrocardiograms is a routine and time-consuming task for the physician. A completely automated system has been developed to aid the physician in this task.

A CDC-160A digital computer has been programmed to determine the amplitudes and durations of all the waveforms of a heart cycle as well as the heart rate. These measurements are then automatically analyzed by an interpretive program which produces electrocardiographic diagnoses.

As a demonstration of practical use, electrocardiograms have been routinely recorded at the George Washington University Hospital for over two years. Electrocardiograms are obtained on FM magnetic tape with a special recorder which allows coding of such additional information as

Fig. 1

GEORGE WASHINGTON UNIVERSITY HOSPITAL HEART STATION
COMPUTER ANALYSIS OF ELECTROCARDIOGRAM BY
INSTRUMENTATION FIELD STATION HEART DISEASE CONTROL PROGRAM

NAME......................AGE....SEX...RECORDING DATE.........RECORDING TIME........

ROOM........HOSPITAL NO..........HEART STATION NO.........PHYSICIAN................

DIGITALIS..QUINIDINE..OTHER DRUGS............HT....WT....BP...........BED FLAT......

CLINICAL DIAGNOSIS........................................................BED RAISED....

A= AMPLITUDE IN MILLIVOLTS; D= DURATION IN SECONDS; O= ONSET; M= MIDPOINT; E= END

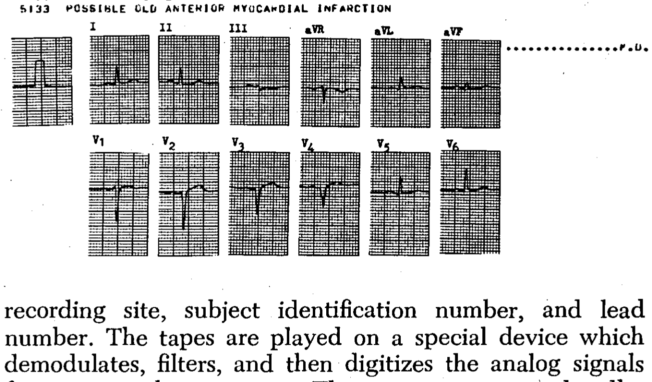
PROCESSING DATE 12-23-64 ECG 0066--0567

| | I | II | III | AVR | AVL | AVF | V1 | V2 | V3 | V4 | V5 | V6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PA | .05 | .13 | .09 | -.06 | .04 | .03 | .04* | .05 | .06 | .04 | .08 | .06 | PA |
| PD | .06 | .10 | .11 | .05 | .04 | .10 | .06 | .05 | .07 | .04 | .08 | .07 | PD |
| P'A | .00 | .00 | .03 | .00 | .00 | .03 | -.03 | .00 | .00 | .00 | .00 | .00 | P'A |
| P'D | .00 | .00 | .00 | .00 | .00 | .00 | .08 | .00 | .00 | .00 | .00 | .00 | P'D |
| QA | -.04 | .00 | .03 | .00 | -.06 | .00 | .00 | .00 | .03 | .00 | -.08 | .00 | QA |
| QD | .02 | .00 | .00 | .00 | .02 | .00 | .00 | .00 | .00 | .00 | .02 | .00 | QD |
| RA | .72 | .60 | .05 | .05 | .52 | .00 | .11 | .06 | .00 | .00 | .69 | .95 | RA |
| RD | .07 | .05 | .02 | .02 | .08* | .00 | .03 | .01 | .00 | .00 | .04 | .07 | RD |
| SA | .00 | -.09 | -.23 | -.64 | .10 | -.12 | -1.34 | -1.34 | -1.10 | -.79 | -.06 | .00 | SA |
| SD | .00 | .02 | .07 | .06 | .00 | .02 | .07 | .08 | .10 | .09 | .02 | .00 | SD |
| ST | .12 | .12 | .09 | .12 | .12 | .12 | .12 | .09 | .11 | .10 | .12 | .12 | ST |
| STO | -.01 | -.06 | -.06 | .01 | .05 | -.03 | .06 | .09 | .08 | -.03 | .01 | -.02 | STO |
| STM | .05 | -.08 | -.07 | .03 | .07 | -.06 | .10 | .17* | .16* | .08 | -.01 | -.05 | STM |
| STE | .13 | -.05 | -.07 | -.02 | .09 | -.03 | .08 | .20* | .23* | .13 | .01 | .02 | STE |
| TA | .12 | .10 | -.05* | -.12 | .13 | .06* | .00* | .16 | .09* | .09* | .07* | .06* | TA |
| TD | | | .13 | | | | .00 | .15 | .10 | .10 | | | TD |
| PR | .13 | .15 | .16 | .12 | .11* | .21* | .15 | .13 | .15 | .12 | .14 | .12* | PR |
| QRS | .09 | .07 | .03 | .08 | .10 | .02 | .10 | .09 | .10 | .09 | .08 | .07 | QRS |
| QT | .30 | .33 | .31 | .34 | .33 | .28 | .00 | .33 | .31 | .29 | .36 | .32 | QT |
| RATE | 78 | 79 | 75 | 76 | 74 | 78 | 69 | 76 | 72 | 80 | 75 | 77 | RATE |
| CODE | | | L | | | L | | C | C | C | | | |

| AXIS IN DEGREES | P | QRS | T | Q | R | S | STO | ST-T | QRS-T | ANGLE IN DEGREES |
|---|---|---|---|---|---|---|---|---|---|---|
| | 72 | 16 | -05 | | 20 | -56 | | | 21 | |

INTERPRETATION DATE 02-16-65

6631 MINOR ST DEPRESSION
5133 POSSIBLE OLD ANTERIOR MYOCARDIAL INFARCTION




recording site, subject identification number, and lead number. The tapes are played on a special device which demodulates, filters, and then digitizes the analog signals for input to the computer. The computer system handles the day's recordings during the evening so that they are available for the Heart Station electrocardiographer the next morning.

The computer has been programmed with two 16,000 12-bit-word programs written in machine language. The first is a pattern recognition program that recognizes, identifies and measures each waveform of the medical signal. Automatic pattern recognition programs are difficult but particularly so in medicine because each pattern differs from subject to subject and varies with time and activity of each individual. The second program inter-relates the results according to criteria used in the physician's logic. The computer results liberate the physician from routine work, speed the task and insure against observer error due to fatigue. The results of a typical analysis are shown in Fig. 1, along with photographs of the signals analyzed.

Electrocardiograms from other locations have also been processed. The system has analyzed over 30,000 electrocardiograms recorded in San Francisco; Columbia, Missouri; Framingham, Massachusetts; and Pensacola, Florida, and as far away as Israel. The electrocardiographic measurements from these studies are being automatically analyzed for the distribution pattern of the variables in normal and diseased categories. The computer is also being used to perform multivariate analyses and for other tedious statistical techniques which should improve electrocardiographic diagnosis as a result.

## statistical analysis of electrocardiographic data

Diagnostic accuracy of the electrocardiogram to differentiate between normal and abnormal conditions currently rests on the empiric analysis of the distribution of electrocardiographic characteristics in normal and diseased populations. The computer analysis provides data that is more objective so that sources of variability can be studied to improve the diagnostic value of the electrocardiogram. Electrocardiogram measurements derived from the automated electrocardiographic computer programs are being collected and tabulated in reference to specific characteristics such as age, weight, height, skinfold, blood pressure, cholesterol, arm circumference, or grouped as diseased or clinically normal. These will be used to advance research in use of electrocardiographic data.

Tables of normal limits in adult population are being studied to determine sources of variability, biological and constitutional. Multivariate computer analysis to separate normal from abnormal subjects is being done in addition to obtaining new techniques for detection of electrocardiographic variables which contribute to the identification of disease.

## computer monitoring of dynamic electrocardiograms

Visual electrocardiographic monitoring during stress, exercise and post surgical states and during daily activities produces important clinical information. It has been used in all space flights. In constant monitoring, information is often obscured by electrical noise produced by deep breathing, muscle movement, and electrode movement. The noise makes automatic recognition of wave changes difficult.

Computer programs have been developed to scan such recordings, to sift out noise, and to measure pertinent changes. Techniques of digital smoothing and signal averaging may be employed with each where indicated, but are not always necessary. The alterations from the subject's resting cardiograms can be ascertained in real time and an appropriate diagnostic classification can then be appended.

Automatic measurements of such tracings exclude bias and produce detailed wave description. Data storage and recall for *immediate use* in any situation is thus possible.

Consider the patient in an intensive care unit. The job of the watchful nurse is made easier by the assurance that she will know immediately of any change of the patient's heart signal, with sufficient time to call in specialists or to take emergency measures.

For the researcher, constant analysis of electrocardiograms can provide data to evaluate the effects of everyday stress and to evaluate the effects of exercise on heart muscle. For the physician, there is the future possibility of being able to constantly observe by a telemetry system any patient who has had a heart attack in the past and to be aware of any changes that might occur in the patient even though the physician is still in the hospital or at the office miles away.

## telephone transmission of electrocardiograms

One goal of the Instrumentation Field Station is to increase the utility of the computer. One way to do this is to make the computer more accessible to outlying locations by using the telephone to transmit data.

In this way anyone who has access to a telephone will also have access to a computer. The telephone has been used to send electrocardiograms to the computer from several locations. The computer provides the complete analysis of the data, which is returned by teletype to the originating station ready for clinical use.

When a call is received at the computer site, the telephone is answered automatically, and a tape recorder turned on. When the call is finished, the sending technician hangs up; this action disconnects the line and turns off the equipment at the computer. It is thus possible to transmit directly from a patient to the computer for "on-line" diagnosis.

To transmit electrocardiograms over telephone lines, frequency modulation (FM) is used. FM converts the low frequency electrocardiographic waves to high frequency tones. These tones are transmitted by telephone just as the voice is. At the receiving end, a specially designed telephone set converts the tones back to the electrocardiogram. FM is used because it is free from noise and inexpensive. The Instrumentation Field Station has cooperated with the developers of telephone telemetry sytems in the design of new equipment and the evaluation of experimental sets.

As the Honorable John E. Fogarty stated at the October 19, 1965 meeting of the American Public Health Association, "Medical research combined with advanced physics and engineering has now brought us the capability for automating many of the steps in a standard medical examination, for screening of electrocardiograms by a computer a thousand miles away at the end of a regular telephone line, even for compiling a usable nationwide system for medical records. The economics in precious professional time and resulting expansion of professional service, made possible through the use of such twentieth century methods, thrill the imagination. How long will it be before these things help, not a few of the lucky ones but the millions of health consumers?"

## electrocardiogram analysis as a service

One of the most significant contributions of a medical computer system will be the aid it can provide to a community health service. Such a system can offer low cost, accurate medical signal interpretation, which should improve the capability of a health department, clinic or hospital in mass screening and early disease detection. Smaller hospitals, or single physicians, can have quick access to interpretations that are the equivalent of those of a highly trained specialist. Those hospitals with highly trained personnel can offer them less routine work and thus better make use of their time and talents. Easy recall and statistical analysis of the measurements is a further advantage.

To demonstrate the feasibility of such a system, the Field Station has cooperated with local community health departments in three endeavors. These included taking electrocardiograms of patients in their homes, taking 2000 electrocardiograms in a two-week mass screening effort, and currently taking recordings in a health department clinic on a daily ongoing basis. In each of these efforts, analog dataphone facilities have provided an electronic link from the electrocardiographic machine to the computer. Current work in this field includes evaluation of what leads and what other tests are of most value to the community health department.

In one project at Hartford Hospital Outpatient Clinic in Hartford, Conn., tracings are being recorded daily and transmitted to Washington for analysis. This is a test to link, in 1966, the emergency room for analysis of problem cases. The computer system from Washington, D.C., will provide *immediate returns* of the electrocardiographic analysis at any time. In the emergency room action can thus be taken not heretofore possible due to lack of rapid availability of the analysis of an electrocardiogram.

Continuing the philosophy exemplified in computer analysis of the electrocardiogram, automatic recognition of physiologic signals must be extended. These include those useful to determine the output of blood that the heart puts out every stroke (cardiac dye dilution curves) or signals which allow us to determine whether the blood vessels are adequately supplying blood to the various body parts (plethysmograms). There are other signals such as tonograms that tell us whether the eye pressure is too great and might be leading to glaucoma which can lead to blindness. There are signals in laboratories such as electrophoretic curves that permit us to study composition of certain body constituents and there are signals such as spirograms that emanate from respiration and can allow us to detect disease which obstructs or restricts lung function in any way. Some research procedures such as harmonic analysis, spectral analysis, etc. must be programmed for investigation of signal content. Some of these projects have already begun.

## the computer in indicator dilution studies

As a tool for the cardiologist doing dilution studies, the digital computer can offer several benefits. In these a dye is injected into the blood stream and its output measured after passage through the heart. If coupled with appropriate medical equipment, the computer can provide answers such as the blood volume output of the heart for each of its strokes within seconds. Thus, with a cardiac catheter still in place, the cardiologist may decide to do other studies; having answers as the procedure is in progress will lead to more complete studies with fewer indications for repeat studies.

With proper programming, a computer can provide accurate results. The error inherent in hand measuring the dye dilution curves from which data heart output is determined is well-known; the combination of accurate measuring capabilities with "high-fidelity" recording equipment will allow indicator dilution procedures to provide all the answers they are theoretically capable of; and relieving the technicians from the tedious task of measuring and calculating curves is a further benefit.

## phonocardiogram analysis

Heart sounds and murmurs are obtained with a microphone and are displayed on oscilloscopes and oscillographs for medical analysis of their acoustic pressure waveforms. Phonocardiography, as this technique is called, allows physicians to make various sound measurements pertaining to frequency, timing and intensity of these sounds and to correlate these measurements with cardiac abnormalities. The acoustic pressure waveforms, when recorded in an electrical analog form, are also amenable to analysis by a computer, which can be programmed to recognize and measure the various acoustic patterns just as the physician does. In fact, there is reason to believe that the computer can be programmed to analyze the phonocardiogram signals in a manner superior to conventional clinical methods. This superiority is due to the ability of the computer to be consistent in its performance and to perform vast numbers of computations and correlations which are normally beyond the scope of clinical practice.

The task of processing the phonocardiogram by computer presents a two-fold problem: (1) devising instrumentation for high quality detection, recording, and conversion of acoustic signal into digital form, and (2) developing a computer program which recognizes and measures the parameters of interest. The timing and relative amplitudes of heart sounds are displayed in a printed form along with the onset, duration, relative amplitudes, and relative frequency information of any systolic or diastolic murmurs which have been detected.

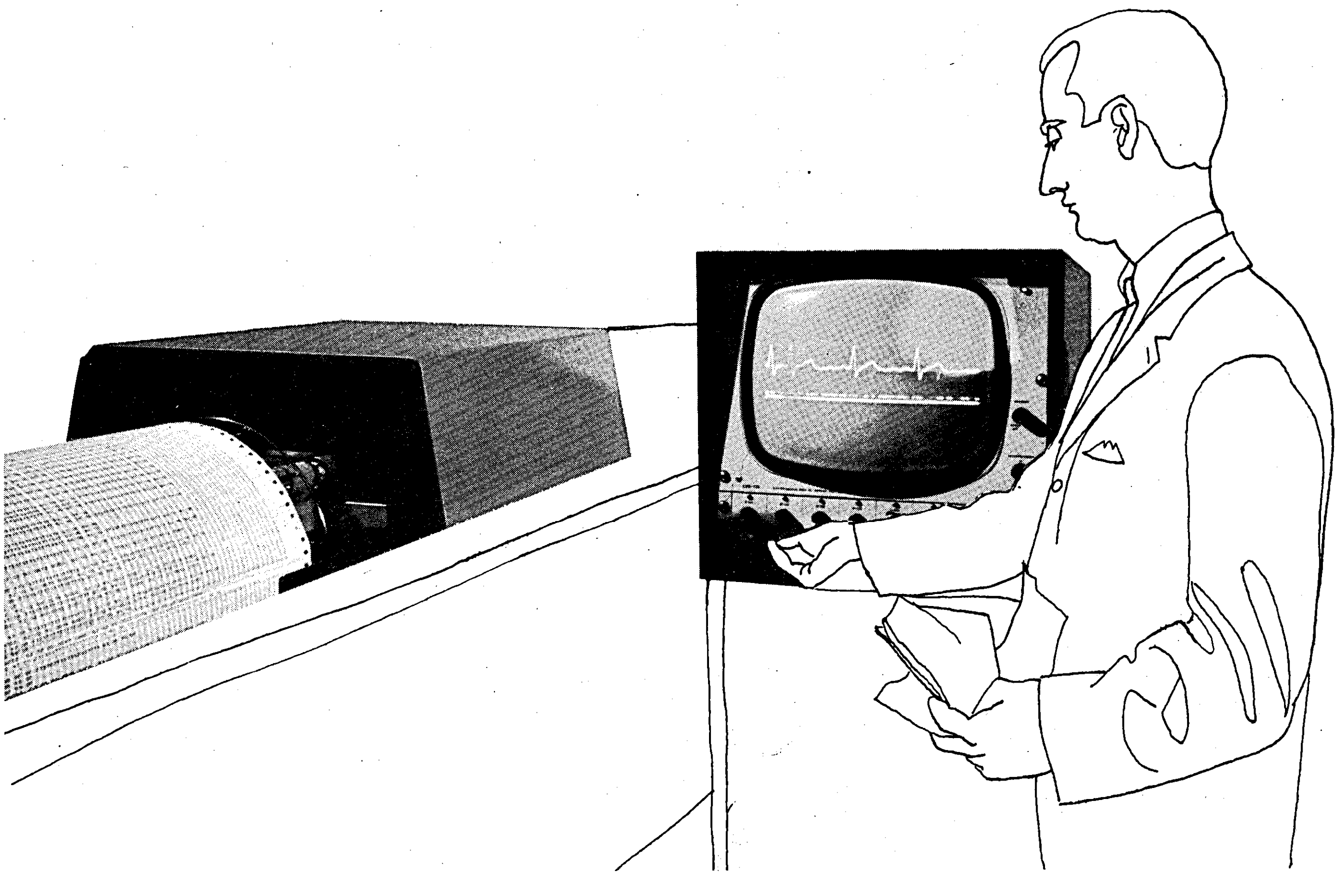
## lung function analysis

The instruments (spirometers) used to determine physiologic and clinical characteristics of pulmonary function have been used to provide a varying voltage corresponding to a changing volume. This analog signal is suitable for computer analysis. Additional information, coded for computer use, includes the subject's age, sex, height, weight, and a calibration constant.

Our computer has been programmed to recognize and measure the (spirogram) respiratory waveform; it can produce an analysis on the basis of the data, and print the results in 40 seconds. The results, among other items, include the total volume, time of occurrence, the volumes at one, two and three seconds, and various flow rates of clinical importance. An interpretation of "within normal limits" is produced if all predicted normal values are achieved. An interpretation of "restrictive" or "obstructive" disease or both is produced when any measured parameter falls below the predicted values.

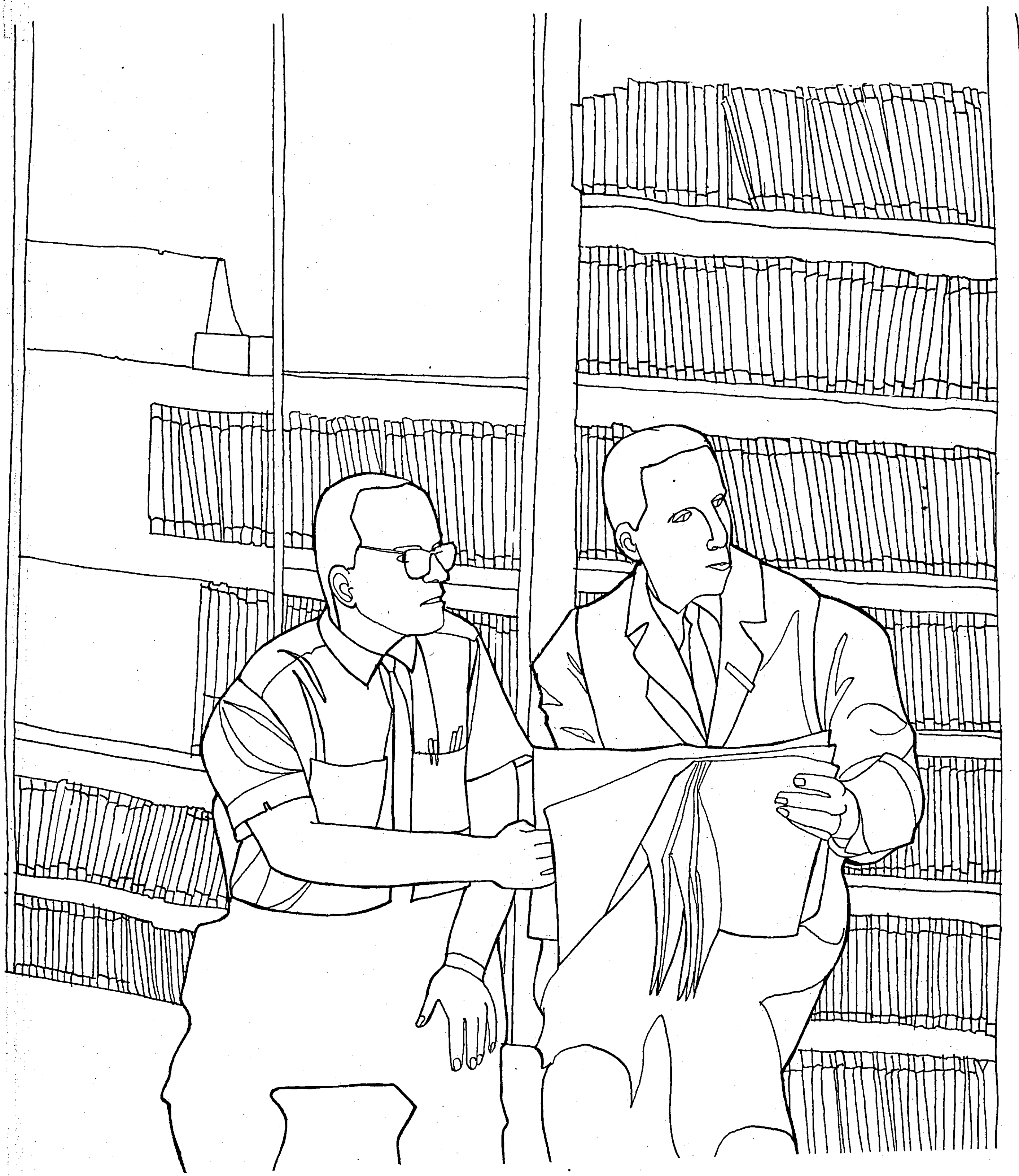
## electroencephalogram analysis

An electroencephalographic program has been written as a pattern recognition program to separate out and measure the rising and falling wave forms seen in a brain wave recording. The program classifies each wave as an amplitude and a frequency. Frequency is determined as the reciprocal of the period between minimums. Each four-second time interval has its waves classified as above and printed out. Such quantitative measurements will allow determination of a normal range of values and quantitative ranges of disease entities from clinical populations.



## conclusions

Only a few examples of computer usage in analysis of medical signals are given. We are only at the beginning. With automation, any number of medical signals can be surveyed rapidly. This can diminish and simplify the workload of the physician. With an accessible computer system, the services of a physician can be better used. What is more important, such a system can provide what physicians since, and before, Hippocrates have searched for—means to improve basic data to improve diagnostic acumen and increase the quality of patient care. □



# CLINICAL INFORMATION PROCESSING

*problem solving strategies*

by BENJAMIN KLEINMUNTZ

A minor legend of the old country doctor was that he could smell a disease the moment he entered the room of his patient. Some lesser physicians were reputed to have diagnostic dogs as traveling companions and presumably these dogs would bark a certain number of times when the presence of various types of diseases. Such folklore must have been invented in order to account for the mysterious and sometimes miraculously intuitive powers of these specially trained healers.

Present day diagnosticians still earn formidable reputations because of their repeatedly demonstrated ability for coming up with the correct diagnosis on the basis of what seems to be minimal pathognomonic cues. Clearly there are individual differences among diagnosticians in their problem solving abilities and some of these differences can probably be accounted for on the basis of differential intelligence, aptitude or training; but the fact of the matter is that not much more is known today about the way clinical information is processed by the diagnostician than was the case during the time of the old country doctor. Moreover, with the ever increasing amounts of medical information that have been made available as a result of major breakthroughs in all branches of the health related sciences, the present day physician must process much more data before he arrives at a diagnosis than did his predecessors. Since the amounts of data to be processed are extremely large, and the speed with which these data must be coordinated and compiled is great, it has been said that the field of medicine invites high speed data processing techniques. In this article several of these techniques will be described briefly, and my own work, which attempts to shed some light on human clinical information processing by closely examining the diagnostic problem solving strategies of clinicians in a specific branch of medicine, will be presented.

In order to aid the clinician, several methods have been proposed for making diagnoses by electronic computers. One of these approaches uses an analog, or some-

***The author is associate professor of psychology at Carnegie Institute of Technology. His current research focuses on the study of the diagnostician as a clinical instrument. He holds a BA from Brooklyn College and a PhD in psychology from the Univ. of Minnesota and his research has been supported since 1962 by grants from the National Institutes of Health.***

[1] This paper was prepared while the author was under partial support by a National Institutes of Health research grant (GM 11734-02), and grateful acknowledgement is hereby expressed.

times an analog-to-digital conversion procedure, in order to process and interpret electrophysiological input data. The types of data that such a procedure could process include electrocardiogram readings, electroencephalographs, basal metabolism rate measures and such other physiological measures that yield identifiable electronic signals. The physician is then provided with an output that is an interpretive summary of large amounts of information that would otherwise take many hours to compile and interpret. Such data could even be processed and interpreted on a round-the-clock basis as is the case in our man-in-space situations. Of course there is a good deal more information than just electrophysiological data that a physician needs at his disposal before arriving at a diagnosis, and hence such other schemes have been proposed as are discussed below.

## diagnostic approaches

Several reports in the research literature have proposed diagnostic systems in which the brute force arithmetic speed of the computer is used for the processing of physiological signs, symptoms and laboratory results. These procedures require that an encyclopedic amount of medical information be stored in the computer's memory, and that when the machine is challenged to provide a diagnosis for a hypothetical patient who presumably has a particular set of symptoms, a table look-up program is executed so that the appropriate symptoms are correlated with the correct diagnostic classification.

Such a system fails to take into account the probabilistic occurrence of signs, symptoms and their associated diseases; and simply assumes that a sign or symptom is either present or not in a particular disease. Furthermore, it is a fact that different patients who have a particular disease almost never present an identical configuration of symptoms. Therefore the symptom-disease combinations that are stored in computer memory represent text book cases that hardly ever appear in clinics.

A more sophisticated approach to medical diagnosis by computer has been suggested by Ledley and Lusted. These researchers have proposed a scheme in which symptoms and diseases are formalized in terms of symbolic logic, probability theory and value theory so that a computer can be programmed to represent this formal process and to carry it through step by step. Essentially their system proposes to process combinations of symptoms and signs that are associated with certain specific diseases and when their computer is challenged with a particular patient's symptoms and signs, it prints out several diseases that are "most likely" associated with the patient's specific set of symptoms. The treatment that their computer program prescribes is likewise designed to maximize the chances of curing the patient. Their computer program is innovative in that probabilistic values are assigned to symptom-disease occurrences and because symptoms, signs and laboratory tests are weighted as to relative significance for various diseases.

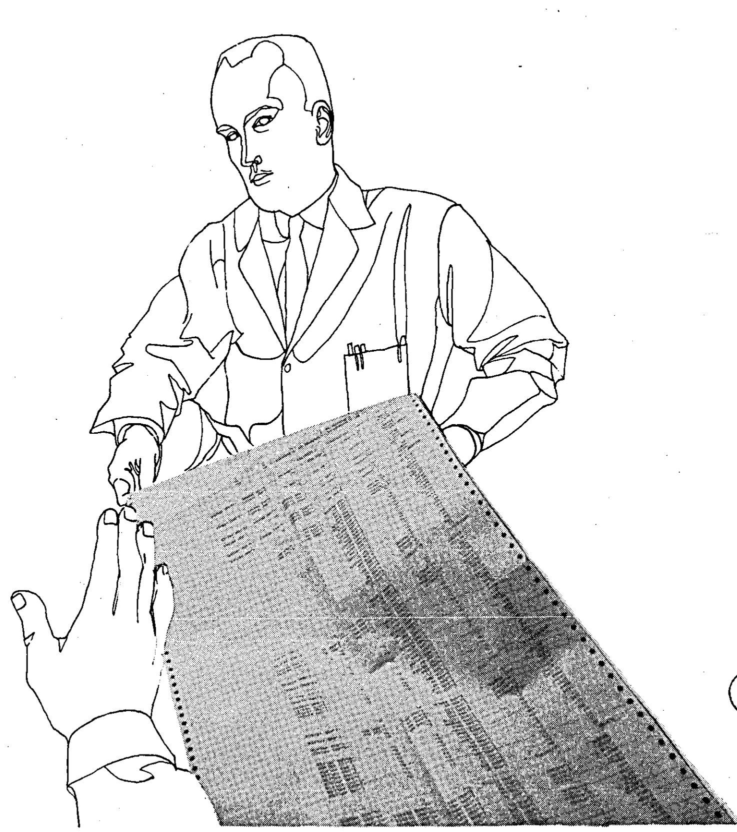
## a different tack

My own work at Carnegie Institute of Technology has been a radical departure from any of the above mentioned computer processing techniques. I make no attempt to hook the patient up directly to the computer and I do not stuff the computer's memory drum with symptoms, laboratory test results, signs and their associated diseases. Nor do I attempt to formalize the decision processes of the diagnostician in mathematical terms. But rather, it has been my purpose to demonstrate that the clinical judgment process of the human diagnostician can be simulated on a computer.

As an initial task—perhaps because of its relatively simple structure—I chose to study the thought processes of an experienced psychologist interpreting the results of a personality test. The test chosen was the Minnesota Multiphasic Personality Inventory (MMPI). A great deal is known about the properties of that test, and conveniently for my purposes, it yields a patterned profile. The test was designed to classify most of the known pyschiatric diagnostic categories along about 13 dimensions or scales; and it is the correct interpretation of the configuration of these scales that is essential in arriving at a correct diagnosis. The task of test interpretation would be immeasurably simpler if it were merely a question of basing one's diagnosis on the elevation of a single scale; but because this is not the case, profile interpretation can be a rather subjective business.

In order to get a glimpse of the way a test interpreter processes MMPI profile configural information, it was necessary to devise a scheme that enabled and even forced him to "think aloud" and give us a running commentary of his thought processes as he solved the MMPI profile problem. An experienced MMPI user was therefore instructed to sort into separate piles the profiles of emotionally maladjusted and adjusted students. While he was making his decisions to place the profile in one pile or the other, he was encouraged to think aloud and was instructed to give his reasons for placing a particular profile where he did. It was essential not to allow him to make any decisions without giving his rationale. Typically, a statement would be made such as the following: "Now I'm going to divide these into two piles . . . on the left (least adjusted) I'm throwing MMPI's with at least four scales elevated above the score of 70 . . ."

These "thinking aloud" sessions were tape recorded, and the protocols of this expert were studied inten-



sively. The information which was obtained from this test interpreter after about 30 hours of profile sorting was edited, compiled and then programmed into computer language so that a digital computer could make decisions about profiles similar to those made by him. In other words, the computer was given the sorter's information and rules of thumb for processing MMPI profiles. The success rate of the programmed decision rules was quite similar to that of the MMPI expert: They both achieved an 80% hit rate in classifying correctly the profiles of persons who were maladjusted; and they had about a 70% hit rate in the correct classification of the adjusted persons.

Perhaps the most important lesson learned from this project was that the clinician can be forced to make public and explicit his problem solving strategies. As a matter of fact the test interpreter gave sufficient information to enable me to program his decisions. However, it must be noted that although the programmed sequential decision rules were surprisingly similar to those of the MMPI expert, there were departures in the computer program from the expert's taped protocol. Interpretive rules of thumb and procedural tricks of the trade were borrowed from the expert, and were used in the computer program only if they maximized the success rate of the MMPI decision rules. In other words, due to a focus at that time on the pragmatic problem of devising a set of "best" rules for performing the profile analytic job, I decided to depart from perfect simulation.

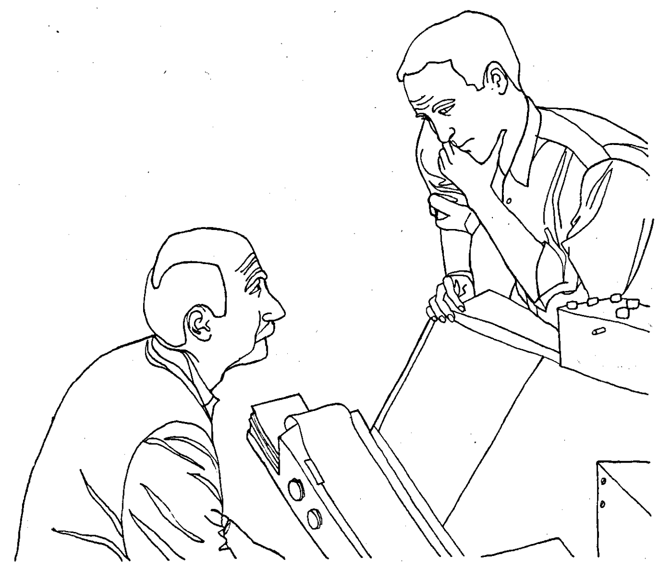
Mathematicians call these short cut solutions *heuristics*. An approach which would have aimed at reproducing the MMPI expert's every decision, down to its minutest detail, would have been a *simulation* of profile analytic decision making. Such an approach, although impractical from the point of view of yielding a set of workable interpretive rules, would have permitted us to obtain an explanation, and perhaps even the beginning of a theory, of the pattern analytic behavior of the clinical decision maker. It should also be noted that the method I used to study profile analysis of MMPI's could be extended to include computer programming of such other pattern yielding measures as the electroencephalogram (EEG), electrocardiogram (EKG) and so forth. But instead of using the pattern recognition computer programs that rely heavily on probability density function analysis, my approach has been to ask the human to tell us what rules he uses. Whether or not he is telling us these rules with any degree of reliability can be put to a simple test: Does the computer program process the data correctly? If the answer to this question is in the affirmative, then the expert probably was accurate in this description of his thought processes.

The major problem in this particular approach to studying the person at work, is that very often the expert in a particular specialty such as MMPI, EEG and EKG interpretation actually thinks that he is using some special subliminal cues in arriving at his profile decisions. I had to convince my specialist that if the cues were subliminal, then he probably couldn't perceive them; and if he couldn't perceive them, maybe they were not worth worrying about. If the expert buys that explanation, you still have the additional problem of getting him to report continually about the supraliminal cues to which he is reacting. This takes persistent coaxing and nudging—which was not so bad because it served to keep both the expert and me awake.

## the next step

The next study—the work currently in progress at Carnegie Institute of Technology—had as its main objective the direct simulation of the diagnostic judgment process. I chose to focus on the cognitive activities of diagnosticians within the medical specialty of clinical neurology. This was not an arbitrary choice: The highly structured nature of clinical data within that specialty, and the emphasis among neurologists on coming up with the correct diagnosis, made that area a tempting one for scientific study.

In order to force the neurologist to "think aloud" during his diagnostic searching, a scheme had to be devised which was similar to the sorting procedure described earlier, and which would be more appropriate than profile sorting for the clinical neurology situation. For this purpose it was found that a variant of the childhood game of "Twenty Questions" could be a technique which lends itself to the systematic study of a number of decision making variables. The game is played by having one player, called the experimenter, think of a disease while the other player, or subject, tries to diagnose the disease the experimenter has in mind. The experimenter can assume any of a number of roles; for example, he could pretend that he is a patient suffering with symptoms a, b, and c; or he could assume the role of the omniscient



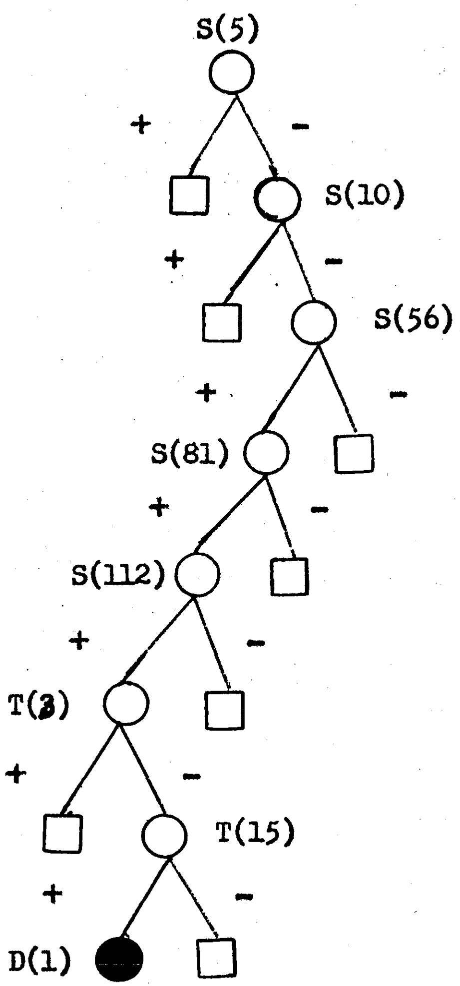
neurologist who is thinking of a cerebral disorder which is characterized by symptoms a, b, and c.

The subject's task as diagnostician is to ask about the presence or absence of other symptoms, signs or biographical data, and he may call for certain laboratory tests and inquire about their results. Obviously if this game is to be played meaningfully and is to yield usable neurology data, the experimenter must be a highly experienced neurologist because, in answering the subject's questions, he must be able to recognize the appropriateness of certain laboratory tests and he will have to have mastered his neurological symptom-disease complexes. Again as in the case of the MMPI decision rule study, the subject's questions and the experimenter's answers are tape recorded.

The end product of our diagnostic game can be considered to resemble a tree structure. The way the game was described above, we obtain binary trees in which each point or node in the tree has exactly one connection to a point closer to the root of the tree. The starting point or the root of the tree is the subject's first question; all subsequent questions are the tests that are performed at the various nodes of the tree. Unless a node is an endpoint—that is, unless a diagnosis has been made on the basis of the questions asked (i.e., tests performed up to that point)—it is connected to two lower nodes, and through them, to any number of still lower nodes. A test is associated with each nonterminal node, and depending on the result of the test, a particular branch to a lower node is taken. A path is a collection of lines from the root of the tree to an endpoint or terminal node; and the path is the representation of the search strategy that the clinician used in arriving at the diagnostic solution.

For illustrative purposes, consider the game represented in Fig. 1 in which the experimenter asserts that he has a disease in mind, let us call it D(1), and the subject, inquiring about the presence or absence of a number of symptoms, asks whether a certain symptom is present in that disease. The subject's first question is whether S(5) is present in the particular disease the experimenter has in mind. He receives a negative reply. Then the subject asks whether S(10) is a symptom of the disease. Again he receives a negative reply. His next question, presumably based on information he obtained from his prior questions, concerns the presence of S(56). An affirmative reply to that question leads him to ask about the presence of S(81) and S(112). Confirmation of the presence of these symptoms then leads the subject to call for laboratory tests T(3) and T(15). The experimenter in our example replied that the results of the first test were negative, but that T(15) yielded positive results. The subject then ventures a diagnosis, D(1), which in our example happens to be a correct diagnosis, and the game is terminated. Since the game was tape recorded, the tree structure is ready for computer programming.

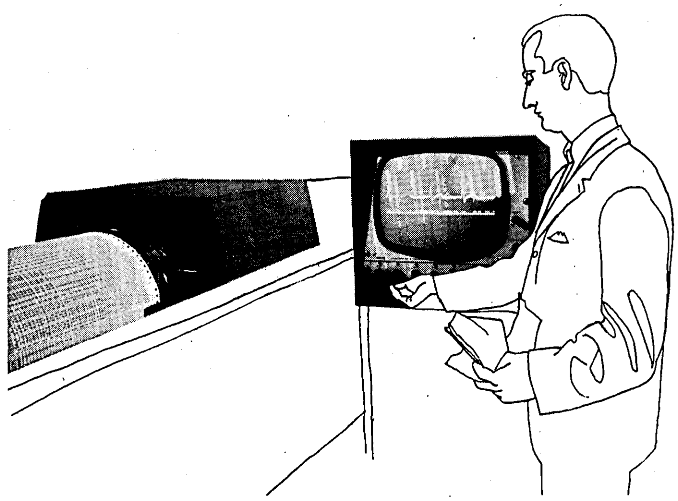
Fig. 1. A binary tree structure for representing the search strategy of a diagnostician.




From inspection of this tree we can readily see the number and types of questions that the subject had to ask to arrive at a diagnosis. In the game represented in Fig. 1, the binary tree which begins with the root S(5) has exactly 8 nodes, all except the last of which are test nodes. The path from S(5) to D(1) has seven branches, of which 3 are negative and all the rest are positive.

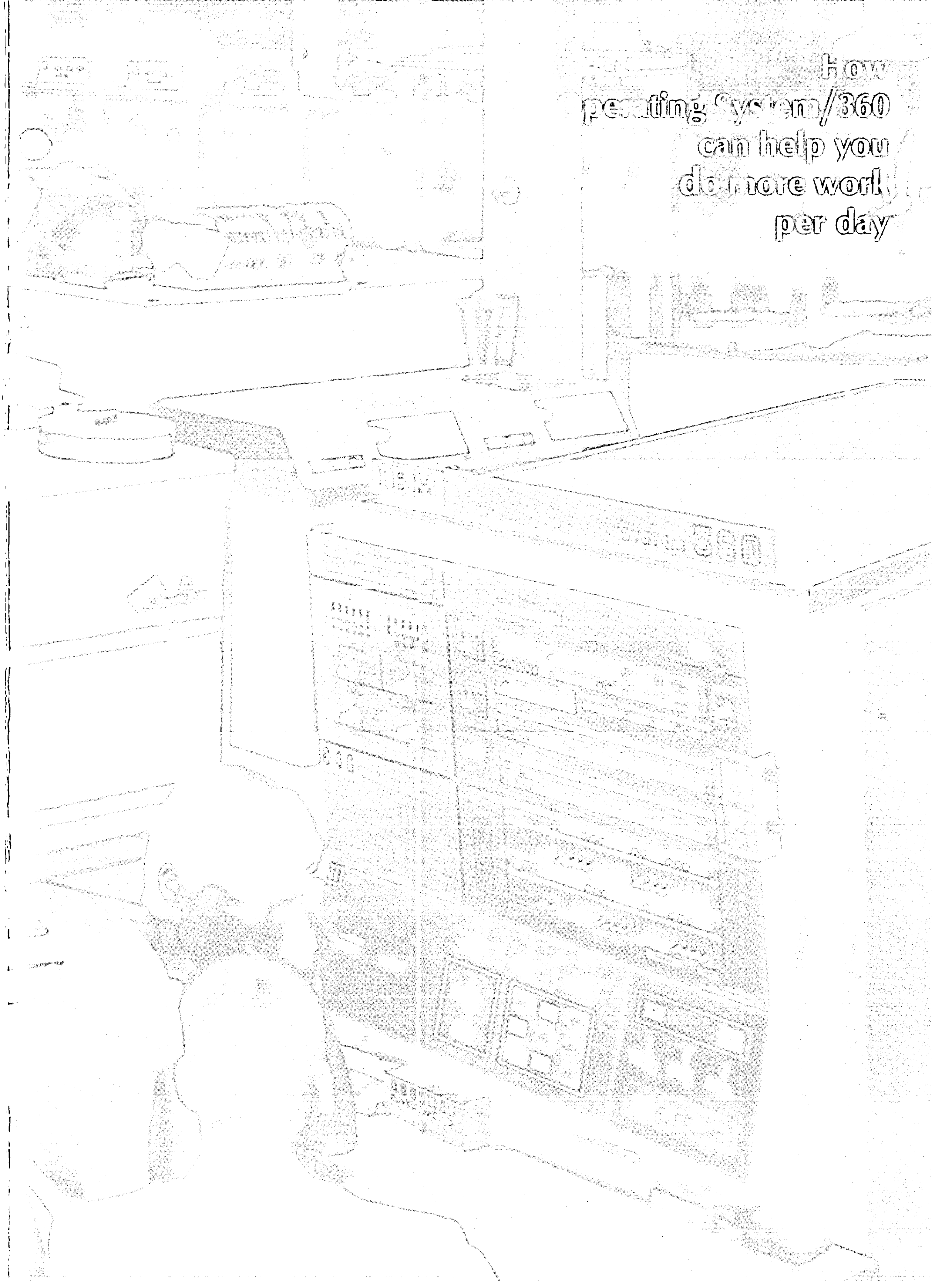
## enter the computer

Now what does the computer have to do with all this? So far, not very much. Mainly the storage capacity of the machine has been used to accumulate our tree structure information. This information allows us a glimpse of the manner in which a clinician (or several different ones) utilizes cues and combines diagnostic information before arriving at a decision. The tree structure approach facilitates the testing of hypotheses about methods of combination, individual differences between diagnosticians in judgment ability, effects of misleading cues on a diagnosis, and many other variables yet to be specified. But for all of this, no computer was really necessary. We might very well have stored our information on a large revolving blackboard; or perhaps we could have left it on the magnetic tapes of our recording machine. Analyses of the tree structures would have been possible in those forms. However, the computer is a more convenient storage bin because it allows us ready access to the information; and more importantly, the rigors of computer programming forced me to devise a scheme that compelled the careful spelling-out of the thought processes under study.



Additionally the digital computer allowed a refinement not mentioned above; and I must admit that this refinement was the really intriguing one which has helped to motivate the direction and the course of this work: The computer enabled me to construct a model of the clinical decision maker which, if the model is a good one, functions in precisely the same manner as the human decision maker. In other words, once we have a collection of one subject's tree structures, it should be possible to write programs that will enable the machine to utilize diagnostic search strategies in much the same manner as did the human. In principal, if a large enough collection of trees is tape recorded from one subject or diagnostician, and if this collection includes most of what he knows about clinical neurology, then we can challenge the machine in much the same way as we might challenge him by confronting it with a set of symptoms; and we would expect that the computer and the human neurologist

# How Operating System/360 can help you do more work per day



# Operations Managers—More throughput at no extra cost.

Operating System/360 will release the full power of your computer to handle, efficiently, both scientific and commercial processing.

It will increase your work throughput measurably... and give you full time computing.

It will release your top-flight programmers from time-consuming trivia—let them use the full run of their ability—create more productive programs, by virtually eliminating the need for them to design "systems" functions.

Operating System/360 provides five versatile high-level languages. It minimizes concern about input/output device assignments—they're all done by the computer.

It reduces testing and debugging of new programs through built-in test features... releases your people from preparing often-used routines by providing a host of IBM created service and utilities programs, providing standard conventions that pave the way for standard communications that eliminate many human errors often caused by a lack of these standards.

Your company's programs will "live" longer because they can be easily updated, modified and tested.

Your computers will run continuously—thanks to automatic job scheduling.

Your computer will offer rapid job turn-around. You will get more jobs through per day.

You will be able to run many jobs concurrently with each job sharing the system's total resources.

You can run concurrent peripheral operations too. You can print on-line without tying up your precious central processor or carrying tapes to and from off-line systems.

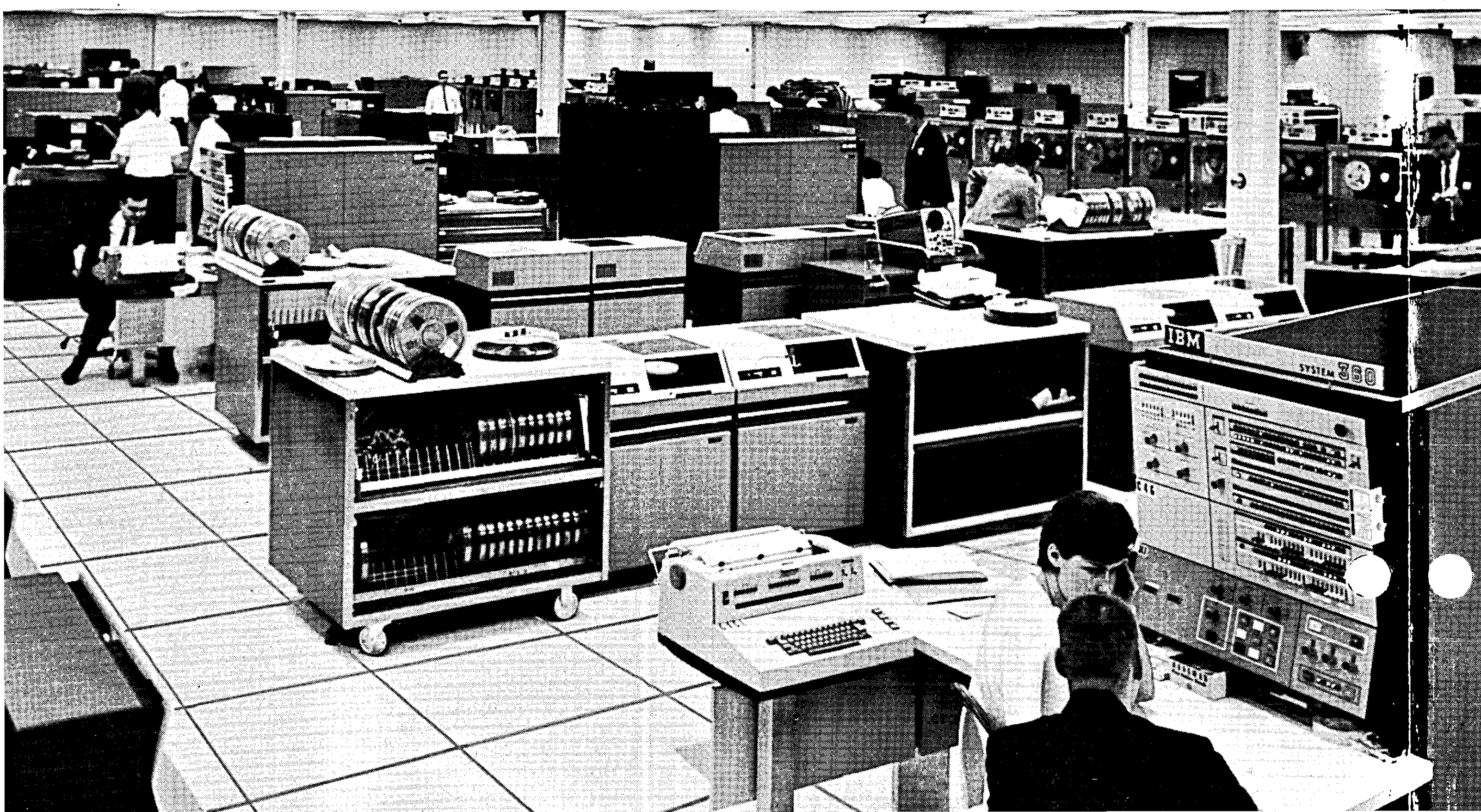
Your special jobs can be run at any time through a high priority coding that enables them to go to the top of the work input queue—and the interrupt can be a simple query or a big, complex processing job.

Programming maintainence, which may take 15% to 25% of your best people's time, is greatly simplified and takes less time because of system conventions—even when one person maintains programs written by someone else.

Your large programs can be divided into smaller sections, then overlayed to conserve valuable main storage space. This allows complex jobs to be done in a small machine.

And because of these and many other features of Operating System/360, all your jobs get rapid turn around—you get increased system throughput, you process more jobs per day, more efficiently.

**Operating System/360 was born in this half acre room.** This is one of the largest concentrations of computing power in the world—two SYSTEM/360 Model 30's, ten Model 40's, one Model 50, one Model 60, three IBM 1710's, four 1401's and a 7094. Eventually there will be close to 300 input/output units as well as special equipment.



# Installation Managers—Process more jobs with faster job turn-around.

Operating System/360 will help you make full use of your computer and the people that run it. You'll be able to provide better service to more people in your company with the fastest job turn-around possible.

You'll be able to stack your jobs, have them run one after the other with immediate job-to-job transition—automatically.

Multitask control will enable you to get many jobs on the system at one time, even unrelated jobs. You'll have real efficient use of big-system ability.

Machine operators won't be bothered with time consuming bookkeeping—this manual job accounting is done automatically.

Computer idle-time will be greatly minimized: you'll have fewer setups and program loadings... standard operator methods and standard formula for job instructions... less human intervention, fewer errors.

You'll have a standard way to store and recall programs from the systems library.

You'll get much needed help in keeping track of data on tape reels and disk packs.

And with rapid test results, you'll save valuable programming time. You'll be able to add new applications without changing existing programs.

Now, you'll take full advantage of device independence. A single program can use card, tape, disk, or drum storage without rewriting.

You'll realize a rock-bottom minimum of personnel retraining and study time in order to meet demands of new applications or new system configurations.

And for the future you can grow right along with your installation expansion without rewriting programs.

# Programmers—Create your best programs.

You'll have the benefit of five highly versatile languages to work with—FORTRAN, COBOL, PL/I (Programming Language/One), Assembler, and RPG (Report Program Generator). Now you'll have the right language for the right job.

There's a complete list of Service Programs like Sort/Merge, for fixed or variable length records in ascending or descending order, while using one or more storage devices... Linkage Editor for combining individual segments of programs that were individually compiled or assembled... Utilities for transferring data from one storage medium to another, editing and updating the system library, changing the indexing structure of the system library catalog.

You'll be free from scheduling input/output devices. Job control statements will call data and programs, and the computer will do scheduling and sequencing, automatically.

Operating System/360 will let you place data in the system library without a detailed location reference. Retrieval is accomplished by the system, automatically, through a simple symbolic notation.

You'll get test results back sooner, correct errors sooner, be on the air sooner.

Segmenting large programs for greater handling flexibility can help you by letting you divide large programs among two or more programmers.

System and installation growth will find your proved and tested programs still applicable.

**SYSTEM/360—The Computer with a Future** IBM®

# Full time computing with these Operating System/360 programs

**Control Programs**
Supervisor,
scheduler
and data management
functions

**Processing Programs**
FORTRAN
COBOL
ASSEMBLER
PL/I
RPG

**Service Programs**
Linkage Editor
Sort/Merge
Testran

**Graphic Programming Services**

who served as a model would come up with very similar diagnoses.

There are two practical applications that could result from this simulation work. In the first place, it is entirely possible to construct models of the ways in which various types of proficient and nonproficient neurologists process medical information. With the aid of such models, which in a sense could be teaching programs, medical students can be taught to sharpen their diagnostic search strategies. This can be accomplished either by having medical students study the static structure of the various diagnostic models, or by having them interact with computer programs that represent the diagnostic strategies. In the instance of medical student-computer interaction, the machine would print out the diagnostic problem to the student and he would "read in" his probing and searching questions. When the student's questions lead him too far astray, the machine, acting much the same way as our expert neurologist often did during the game of Twenty Questions, might inform (i.e., print out to) the student that he is lost or that his patient died as a result of the last procedure that was prescribed.

The second possible application that could result from the simulation of neurological decision making is a completely operational neurology diagnostician. Such a diagnostician would of course not replace the human decision maker because it is entirely unlikely to expect the machine to elicit a Babinski toe reflex or to perform a spinal fluid tap. However, with the assistance of human neurologists who would elicit signs, symptoms, biographical data and other important clinical information, then transmit these data to the machine, the computer could serve as a valuable aid in the diagnostic process. For example the computer, once it is given access to some limited clinical information, could print out to the human a number of relevant and perhaps optimal tests at a specific point in time. Or the machine could print out a number of working diagnostic hypotheses that the human just happened not to think about. When both the human neurologist and the machine have access to all the clinical signs, symptoms, and cues then the human decision maker can double check his own diagnostic and treatment decisions against those of the computer. Since neither the human nor the machine is infallible such cross-checking could only serve to increase both of their diagnostic success rates.

## some problems

Of course there are a number of technical problems that must be resolved in order to make a system operational as either a teacher of medicine or as a diagnostician. The medical-student/teaching-machine interaction is much easier to implement than the computer diagnostic scheme. The student can communicate with the machine either by the conventional typewriter keyboard or by pointing with a "light gun" at a display on a cathode ray tube. Likewise on the output side the student can be given feedback by some typewriter-like device or by an image display on a tube. Considering the large number of potential questions that the student diagnostician may want to ask and their responses, present day computer storage capacities possibly might be inadequate.

The computer as a diagnostic aid presents somewhat different problems. Perhaps the most important consideration is one of human relations; all participating physicians must be highly motivated to cooperate in such a venture if it is to become a success. In the first place, their note-taking habits during their diagnostic examinations must be altered in order to insure absolute precision. Physicians must be encouraged to notate every observation, by making a proper marking on a prepared symptom checklist, and in turn some device must be developed for allowing the physician to communicate this checklist information to the machine quickly and without having to give up this information. Additionally there is the problem of having to communicate tentative diagnostic information from the machine back to the physician. Likewise the machine must be able to print out its final diagnostic statements and treatment recommendations to the physician. Again this calls for larger memory storage capacities and greater speed of access to these memories than is possible in present day computers. Communication between computer and human must also be made more convenient than is presently possible.

Recent developments in dynamic analysis of speech and sound mechanisms may solve both the communication problem and may eliminate the need for extensive note-taking during the diagnostic interview. Such a system would permit the diagnostician to address the computer vocally and through appropriate encoding procedures he could receive replies audibly.

There are a number of other technical problems that our particular diagnostic computer shares with other hospital-based automated systems and these include considerations of central hardware location, an adequate number of remote teletype stations, cable ducts from the remotes to a central computer location and the multitude of other hardware accessories that accompany such a system. However, my own preoccupation has been with software problems and it may very well be the case that these may be the most difficult ones to resolve in the long run. □

# DATA TRANSMISSION SYSTEMS

The following charts supplement those published in the September 1965 issue (Data Transmission Systems, Data Acquisition Systems, and Data Transmission Common Carrier Subsets). A degree of selectivity has been exercised in assembling the charts. Certain types of data transmission and acquisition equipments are not included (e.g., facsimile, analog, etc.).

Approximately 150 firms were sent questionnaires to develop data for these charts. Equipment is listed in the charts only if the manufacturer returned the questionnaire properly filled in, and if equipment is scheduled for production and installation in 1965. As a result, the charts are not exhaustive. All information has been furnished by the manufacturer, and cannot be guaranteed by Datamation.

Among the replies received to the questionnaires were many descriptions of equipment which did not match Datamation's ground rules for inclusion in the charts. Since some of these devices may be of further interest to readers, a brief list is shown among the footnotes at the end of the chart.

An interesting addition to the Data Acquisition Systems chart published in September has been submitted by Data Pathing Inc. of Palo Alto, California:

SOLAR (serialized on-line automatic recorder)

INPUT:

Fixed input of plastic badge (10 col), punched card (80, 51, 22 col), edge punched (102 col). Various combinations available.

Insertion is vertical slot for badge, flat bed for cards.

Variable input is via 10-key keyboard. The variable field is displayed as it is entered.

TRANSMISSION:

Speed is 240 characters/sec.

2-conductor cabling is used, with in-plant range of 12,000 ft.; or unlimited range via telephone (with subset).

OUTPUT:

Options are 8-channel 16mm sprocketed mag tape (for subsequent off-line conversion at 300 characters/sec), and direct to computer.

Feedback: Each remote unit capable of receiving and displaying up to 10 numeric digits. There is also a 40-bit parallel feedback output available.

GENERAL:

Format control on input via eight transaction codes. In addition to parity checking (character and longitudinal) there are programmed checks of message format and length. All messages are recorded and identified as valid or invalid.

The transmission speed used allows 15 remote terminals per line, or 15 remote terminals per small central station, 45 remote terminals per large (3-line) central station.

Special capabilities include: selective pickup of data from input documents (under program control); special 40-bit parallel input is available, either for electrical levels or contact closures; each central station is equipped with a 40 character per second off-line monitor printer.

Pricing: Complete standard remote terminal (with badge reader, and either punched card or edge punched reader, plus variable input):

| | | |
|---|---|---|
| | $88/mo. | $ 4,190 purchase |

Central station (no concentrating or additional switching equipment required):

| | | |
|---|---|---|
| 1-line | $ 585/mo. | $15,000 purchase |
| 3-line | $1050/mo. | $27,000 purchase |

Total system with 10 remote stations:

| | | |
|---|---|---|
| | $1,465/mo. | $56,900 purchase |

## column legends

*Function* — Most of the devices listed in this chart have many applications. The terminology used here is general, and is not meant to exclude additional uses. For example, a teller console could be used in a management information display system, etc. Where "on-line" is stated, this normally indicates that the device allows a message to be composed off-line, stored in its own buffer, and then transmitted directly to the computer.

*Input/Output* — I means input; F, feedback; O, output. "Feedback" indicates an output at a remote terminal (normally the input terminal).

*Speed* — Speed shown is maximum over the most capable transmission medium; c/s indicates characters per second; b/s means bits per second.

*Error Prevention* — The word "Prevention" has been used to cover the range of detection through correction schemes. Entries in this column cover error prevention provided by the specific equipment listed (not the error prevention capability offered by associated equipment, such as a computer). "Parity" implies a character (or vertical) parity check only. "Parity C, L" indicates character parity plus longitudinal parity checking. "Retransmission" shows automatic retransmission of data when an error is detected; it is sometimes an optional feature.

*Transmission Medium* — Tp means telephone line; Tt, Teletype or telegraph line.

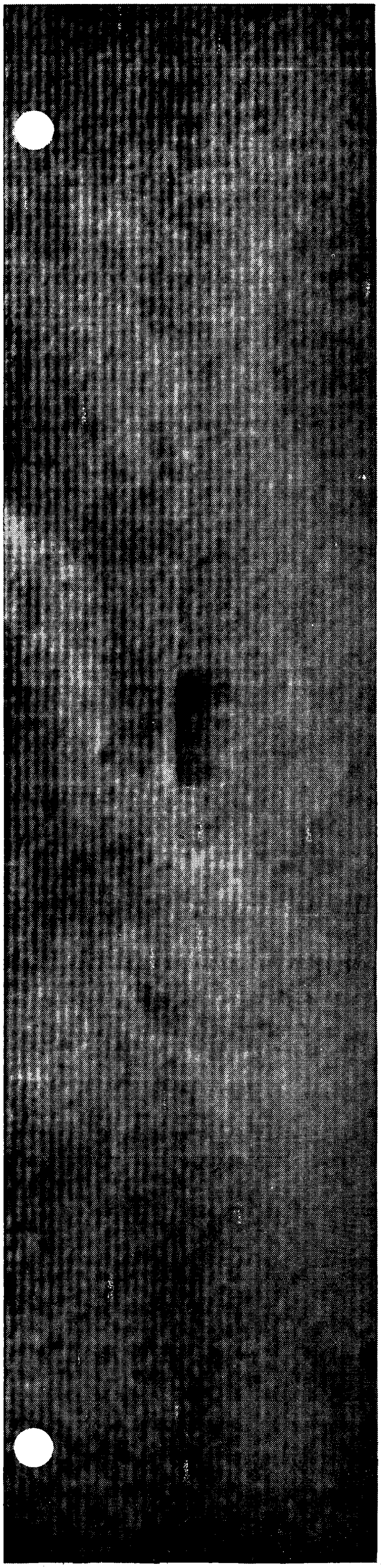
*Pricing* — Approximate pricing is shown both for a stripped version and for one with all optional features. The symbol "L" is used for the monthly charge on a lease (or the monthly rental figure); "p" indicates purchase price.

a. Pricing shown is function of quantity purchased.
b. Pricing of remote station includes adding machine input and ¼" mag tape cartridge recorder. Pricing of switching and central equipment includes mag tape, card, or paper tape receiving terminal.
c. Pricing of receiver.
d. Selected additional equipment not listed in chart:
Addressograph-Multigraph reader for embossed plastic cards.
Alden facsimile scanners and recorders.
Hancock "Telecontrol" production-machine utilization recorder.
Mohawk keyed data recorder.
SCAM "Data-Mate" programmer for controlling IBM Selectric.
Victor "Electrowriter" handwriting transmission system.
Analog data acquisition, recording, and conversion equipment manufactured by:
EECO
Fairchild Instruments
Hewlett-Packard (Dymec)
Moore Associates
Radiation Inc.
Towson Laboratories

| | FUNCTION | INPUT / OUTPUT | SPEED | ERROR PREVENTION | TRANSMISSION MEDIUM |
|---|---|---|---|---|---|
| Burroughs B606 | Teller console, on-line | I: Keyboard<br>F: Word printer (word is 10 digits plus 4 transaction codes of up to 12 levels each) | 167 c/s | L parity per word (fixed); retransmission | Tp w/subset (202D) |
| Burroughs Cer 1130 | Remote on-line card reader, printer | I: Punched card<br>F: Printer | 40,800 b/s | Parity, validity | Telpak |
| Bunker-Ramo 200 | Inquiry, on-line | I: Keyboard<br>F: Visual display, printer | 2400 b/s | Parity C, L | Tp w/subset (201,202) |
| Colorado Instruments C-Dek | Data entry keyboard | I: Programmed storage keyboard, card and badge reader, counters, remote contact closures, etc.<br>O: Mag tape, paper tape, card, on-line | 150 c/s | Parity C, L; keyboard lockout logic | 14-conductor |
| Cook Electric 150 | Output terminal: mag tape | I: BCD data on seven pairs of lines<br>O: ½" mag tape | 300 c/s | Parity, C, L | 20-conductor |
| Control Data 8092 | Buffered programmer for family of transmission terminals | F: Adding machine or typewriter monitor<br>I/O: Most of CDC standard peripheral devices | up to 2.5 megabits/sec | Cyclic encoding; parity C, L | Tp w/subset; Telpak |
| Data Trends MIMO | Inquiry, on-line; data entry keyboard | I: Stylus-contact keyboard<br>F: Electronic strip printer | 60 b/s | Echo-back verification | Tt, Tp w/subset (103) |
| Data Trends DTI-100 | Communications line controller | I: Digital data on 2-wire line; teletype | 2400 b/s | Parity, retransmission | Tp w/subset |
| Data Trends 600 | Data entry card reader | I: Punched card | 12 c/s | Length of message, start and end of message | Tt, Tp w/subset |
| Digital Equipment 630 | Data entry | I: Paper tape, teletype, IBM 1050<br>F: Paper tape, teletype, IBM 1050, Calcomp plotter | 12,500 b/s | | Tt, Tp w/subset; Telpak |
| Digitronics D401 | Output terminal: printer | O: 120/132 column printer | 300 lines/min | Parity C, L block count control character; retransmission | Tp w/subset (201B, 202C) |
| Digitronics D507 | Paper tape transmitter | I: Paper tape | 300 c/s | Parity C, L block count control character; retransmission | Tp w/subset (201B, 202C) |
| Digitronics D509 | Output terminal: Paper tape | O: Paper tape | 100 c/s | Parity C, L block count control character; retransmission | Tp w/subset (201B, 202C) |
| Digitronics D512 | Data entry card reader | I: Punched card | 300 c/s | Parity C, L block count control character; retransmission | Tp w/subset (201B, 202C) |
| Digitronics Dataverter | Transmission modem with family of input modules | I: ¼" mag tape cartridge from special input recorders (adding machine, reader for special cards, typewriter) | 36 c/s | | Tp, subset not required |
| Electric Information 303 | Data entry keyboard, portable | I: Thumb wheels<br>O: ¼" mag tape | | Read after write | |
| Electric Information 404 | Data entry | I: Plastic badge, keyboard<br>O: ¼" mag tape | | | |
| General Electric Datanet 15 | Communications line controller | I/O: Digital data on 2-wire line; teletype | 2400 b/s | Parity, end of message | Tt, Tp w/subset |
| General Electric Datanet 20, 21 | Communications line controller | I/O: Digital data on 2-wire line; teletype | 40,800 b/s | Parity C, L | Tt, Tp w/subset, Telpak |
| General Electric Datanet 30 | Communications line controller | I/O: Digital data on 2 or 4-wire line; teletype | 2400 b/s | Parity C, L | Tt, Tp w/subset |
| General Electric Datanet 70 | Communications line controller | I/O: Digital data on 2 or 4-wire line; teletype | 40,800 b/s | Parity | Tt, Tp w/subset, Telpak |
| General Electric Datanet 760 | Inquiry, on-line; data entry | I: Keyboard<br>F: Visual display, teletype | 2400 b/s | Parity C, L | Tp w/subset |
| IBM 1009 | Computer-to-computer transmission | I/O: Computer | 300 c/s | Parity | Tp w/subset |
| I B M 1026 | Communications line controller | I: Digital data on 2 or 4-wire line | 600 b/s | Parity C, L; retransmission | Tt, Tp w/subset |
| I B M 1092, 1093 | Data entry | I: Programmed keyboard | 12 c/s | Invalid character, field definition | Tt, Tp w/subset |
| I B M 1448 | Communications line controller | I: Digital data on 2 or 4-wire line | 600 b/s | Parity C, L; retransmission | Tt, Tp w/subset |
| I B M 2260 | Inquiry, on-line; data entry | I: Keyboard<br>F: Visual display, typewriter | 2400 b/s | Parity C, L; retransmission | Tp w/subset |
| I B M 2701 | Communications line controller | I: Digital data on 2 or 4-wire line | 40,800 b/s | Parity C, L; retransmission | Tt, Tp w/subset, Telpak |
| I B M 2702 | Communications line controller | I: Digital data on 2 or 4-wire line | 600 b/s | Parity C, L; retransmission | Tt, Tp w/subset |
| I B M 2703 | Communications line controller | I: Digital data on 2 or 4-wire line | 600 b/s | Parity C, L; retransmission | Tt, Tp w/subset |
| I B M 2740, 2741 | Data entry typewriter | I/F: Typewriter | 133 b/s | Parity C, L | Tt, Tp w/subset |
| I B M 7710 | Computer-to-computer transmission | I/O: Computer | 28,800 c/s | 4 out of 8; parity L | Tp w/subset, Telpak |
| I B M 7770, 7772 | Inquiry, on-line (with audio response) | I: Telephone, special keyboard, IBM 1001<br>O: Audio | | | Tp w/subset |
| NCR 42-500 | Teller console, on-line | I: Keyboard<br>F: Printer | 1200 b/s | Parity C, L | Tp w/subset (202B) |
| Philco Card & Badge Reader | Data entry | I: Badge, punched card | 100 c/s | Parity; end of message | Tp w/subset |
| Philco READ | Inquiry, on-line; data entry | I: Keyboard, light pen<br>F: Visual display, microfilm | | Parity C, L | Telpak |
| RCA 6050 | Inquiry, on-line; data entry | I: Keyboard<br>F: Visual display | 1800 b/s | Parity | Tt, Tp w/subset (103,202) |
| Raytheon DIDS-400 | Inquiry, on-line; data entry | I: Keyboard<br>F: Visual display, printout | 40,000 c/s | Parity | Tp w/subset, Telpak |
| Teletype 33 ASR, 35 ASR | Teletype | I: Keyboard, paper tape<br>O: Printer, paper tape | 10 c/s | Parity | Tp w/subset |
| Teletype Telespeed 750 | Paper tape transmission | I/O: Paper tape | 75 c/s | | Tp |
| Teletype Telespeed 1050 | Paper tape transmission | I/O: Paper tape | 105 c/s | | Tp |
| UGC Instruments SODA | Data entry; family of off-line recorders, including portables | I: Dials, adding machine, keyboard<br>O: ¼" mag tape | | | |

# MISSION-ORIENTED DEVICES

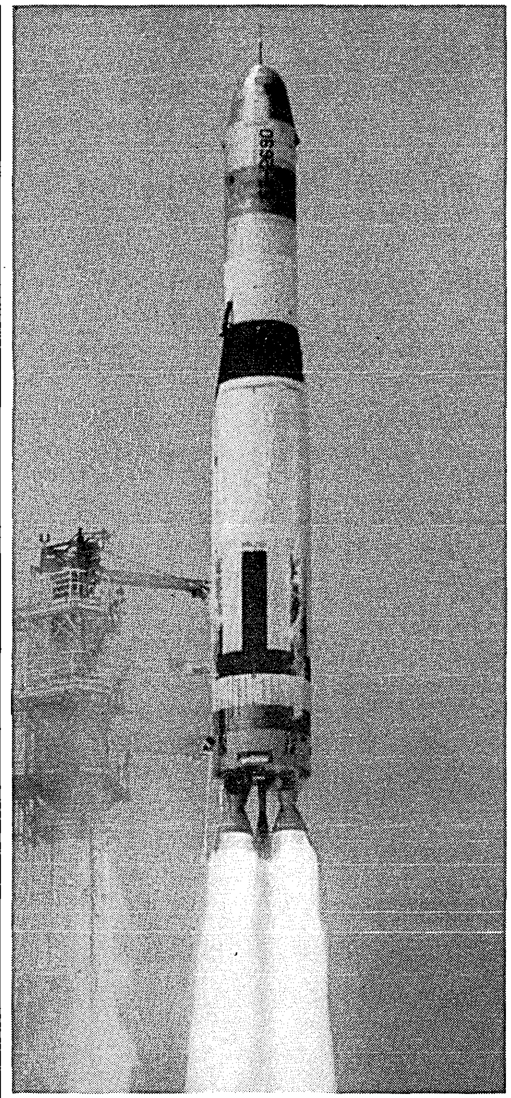
| SPECIAL CAPABILITIES AND COMMENTS | | PRICING: Remote Input Station | | Switching and Central Equipment | |
|---|---|---|---|---|---|
| Currently used as on-line window-posting machine in Savings & Loan applications. Works with B-300, B-5500 and other Burroughs computers. Max of 1440 units to one B-300. | Stripped: | 205 L | 8,100 P | | |
| | W/all: | 215 L | 8,300 P | 1,255 L | 55,675 P |
| Works with Burroughs B-5500 computer. | Stripped: | 1,860 L | 99,900 P | | |
| | W/all: | | | | |
| Works with "any" computer having a communications interface. | Stripped: | 35 L | 1,000 P | 280 L | 12,320 P |
| | W/all: | 50 L | 1,775 P | 335 L | 15,700 P |
| Standard modular components can be combined to provide unique solution to each application. Output code format easily changed. Significant logic capability present in each input station. | Stripped: | | 1,200 P | | 8,000 P |
| | W/all: | | 6,000 P | | 16,000 P |
| Incremental mag tape recorder, ½", IBM. | Stripped: | | 4,350 P | | |
| | W/all | | 6,200 P | | |
| Terminals are programmable as small free-standing data processing systems. When peripherals added to model 8092, transmission system designated as model 8030. | Stripped: | | | | |
| | W/all: | | | | |
| Works with any computer having a communications interface. Optional buffer available. | Stripped: | | 800 P[a] | | |
| | W/all: | | 1,590 P[a] | | |
| Used with Data Trends MIMO or other input devices. Handles up to 100 lines. | Stripped: | | | | 36,500 P |
| | W/all: | | | | 54,700 P |
| Unit is a card reader with accessories such as keyboard, 350-card input hopper, etc. available. Output via optional equipment can be paper tape, card, printer, or direct to computer. | Stripped: | | | | |
| | W/all: | | | | |
| Works with most DEC computers | Stripped: | | 900 P | | 9,689 P |
| | W/all: | | | | |
| Works with Digitronics paper tape, punched card, or mag tape terminals. | Stripped: | 750 L | 28,125 P | | |
| | W/all: | | | | |
| Works with Digitronics mag tape or printer terminals, or paper tape receiver. | Stripped: | 145 L | 5,440 P | | |
| | W/all: | | | | |
| Works with Digitronics mag tape, punched card, or paper tape transmitters. | Stripped: | 180 L | 6,750 P | | |
| | W/all: | | | | |
| Serial card reader. 1500 card input hopper and stacker. Works with Digitronics mag tape, paper tape, or printer terminals. | Stripped: | 425 L | 18,975 P | | |
| | W/all: | | | | |
| Input is acoustically coupled via telephone handset. Output terminal needs 202C subset. Works with Digitronics mag tape, card, or paper tape terminals. | Stripped: | | 1,195 P[b] | 250 L[b] | 6,885 P[b] |
| | W/all: | | 1,605 P[b] | 1,885 L[b] | 58,470 P[b] |
| Useful in meter reading, inventory reporting, etc. Powered by rechargeable battery. Conversion units provide direct input of ¼" magnetic tape into several computers (27,000 character cartridge in 70 sec.). | Stripped: | 27 L | 995 P | 112 L | 4,500 P |
| | W/all: | | 1,045 P | 285 L | 12,500 P |
| Used as point-of-sale recorder. Conversion units provide direct input of ¼" mag tape into several computers (27,000-character cartridge in 70 sec.). Other input units include an adding machine recorder, a production-machine utilization recorder, etc. | Stripped: | | | 112 L | 4,500 P |
| | W/all: | | | 285 L | 12,500 P |
| Works with GE 200-series computers to control up to 15 lines. | Stripped: | | | 690 L | 30,000 P |
| Works with GE 400, 600-series computers. Automatic calling and answering. Data transfer from remote terminal, or computer to computer. | Stripped: | | | 200 L | 9,600 P |
| Works with GE 200, 400, 600-series computers. Controls up to 100 lines. With optional features added can be operated as independent processor. | Stripped: | | | | 75,000 P |
| | W/all: | | | | 150,000 P |
| Works with GE 400-series. Controls up to 248 lines. | Stripped: | | | 1,000 L | 45,300 P |
| Works with GE 400, 600-series computers. Switching and central equipment can handle 8 display units, expandable to 32. | Stripped: | 60 L | 2,400 P | 550 L | 23,000 P |
| | W/all: | | | 695 L | 28,800 P |
| Works with IBM 1400-series computers, also with IBM communication systems. | Stripped: | | | 500 L | 26,400 P |
| | W/all: | | | | |
| Works with IBM 1400-series computers and IBM data collection and communication systems. Automatic calling and answering. | Stripped: | | | 270 L | 10,000 P |
| | W/all: | | | 330 L | 12,000 P |
| Works with IBM 1050, etc. | Stripped: | 30 L | 1,200 P | | |
| | W/all: | 75 L | 3,000 P | | |
| Works with IBM 1400-series computers and IBM data collection and communication systems. Automatic calling and answering. Handles up to 40 lines. | Stripped: | | | 1,150 L | 56,700 P |
| Works with IBM 360-series computers. Switching and central equipment can handle 24 display units. | Stripped: | 30 L | 1,000 P | 400 L | 18,000 P |
| | W/all: | 50 L | 1,600 P | 600 L | 27,000 P |
| Works with IBM 360-series computers and IBM data collection and communication systems. Automatic calling and answering. Handles up to 4 lines. | Stripped: | | | 300 L | 13,500 P |
| | W/all: | | | 800 L | 36,000 P |
| Works with IBM 360-series computers and IBM data collection and communication systems. Automatic calling and answering. Handles up to 31 lines. | Stripped: | | | 850 L | 40,800 P |
| | W/all: | | | 1,500 L | 70,000 P |
| Works with IBM 360-series computers and IBM data collection and communication systems. Automatic calling and answering. Handles up to 176 lines. | Stripped: | | | 1,500 L | 70,000 P |
| | W/all: | | | 2,100 L | 95,000 P |
| Works with IBM 360-series computers or other 2740's. Uses selectric typewriter with stroke-storage feature. Can be used as normal electric typewriter. | Stripped: | 80 L | 3,200 P | | |
| Works with IBM 1401 computers, also with IBM communication systems. | Stripped: | | | 1,575 L | 83,000 P |
| | W/all: | | | 1,735 L | 88,600 P |
| Works with IBM 1400-series, 7070, 360-series computers. 128-word vocabulary. Handles up to 48 lines. | Stripped: | | | 625 L | 30,000 P |
| | W/all: | | | 4,400 L | 211,000 P |
| Used in Savings & Loan and other applications. Works with NCR 315-series computers. | Stripped: | | | | |
| | W/all: | 160 L | 7,600 P | 1,185 L | 50,200 P |
| Photoelectric reader is part of driveshaft. If transmission error detected, will automatically reread. | Stripped: | | 1,800 P | | |
| | W/all: | | 3,000 P | | |
| | Stripped: | | 10,000 P | | |
| | W/all: | | | | |
| Works with RCA 301, 3301, Spectra 70 computers. | Stripped: | 250 L | 10,600 P | | |
| | W/all: | 275 L | 11,600 P | | |
| Works with "any" computer. | Stripped: | | 4,000 P | | |
| | W/all: | | 6,000 P | | 5,100 P |
| [illegible] work with other equipment using the ASCII code. The model 33 does not have paper tape [illegible]ut capability. | Stripped: | | 650 P | | |
| | W/all: | | 2,525 P | | |
| [illegible]dles 5, 6, 7 or 8-level code except advance feed hole punched tape. | Stripped: | | 785 P | | |
| | W/all: | | 1,214 P | | 2,300 P[c] |
| Handles 5, 6, 7 or 8-level code except advance feed hole punched tape. | Stripped: | | 1,800 P | | 2,425 P[c] |
| | W/all: | | | | |
| Portable "Metercorder" used for meter reading, inventory recording, etc. Interfaces also available for cash registers, calculators, etc. Recording of all units is 4-channel BCD, 16 cpi. Conversion units to ½" computer-compatible mag tape (converted at 960 c/s), or direct to computer. | Stripped: | | | | |
| | W/all: | | | | |



# EAI® software is the difference

EAI 8400 Scientific Computing System

The development of a software system for simulation is among the most challenging tasks presented to the computer industry. Not only must it include conventional scientific software, but it must be capable of performing under on-line, real-time constraints. With a heritage of over 15 years as both a supplier and user of scientific computing systems, EAI has produced the EAI 8400 operating system—the first software system to meet the demands of today's simulation laboratories.



The EAI 8400 operating system delivers a new high level of man/machine communication throughout all phases of program preparation, debug and program execution. Its time-sharing mode offers efficient throughput, by permitting a background of batch-processing to continue during man/machine communication or on-line dead-time. Error-free recovery from real-time, multi-level interrupts is provided during any phase of system operation—and the entire operating system—from monitor, through language processors, debug, and run time controllers, is operational over the spectrum of EAI 8400 expansion and peripheral configurations starting with the basic system.

EAI is setting the software standard in the field of simulation. How about your field... does a real-time, on-line system with batch processing capability sound interesting? If so, write for details.

EAI®

CIRCLE 24 ON READER CARD

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

FOR CONTROL DATA CIRCLE 25 ON READER CARD→

# COMPARING THE COMPACTS

**a careful dissection**

by EDWARD O. BOUTWELL, JR.

Computer word length has become an important parameter to designers, users, and others interested in evaluating computer performance. To the manufacturer, word length has a direct bearing on cost and indirectly determines the programming features of the machine. The specific user is additionally interested in comparing word length to the characteristics of his data and is concerned with computational accuracies, efficiencies, and the frequency of double precision operations.

From a chronological viewpoint, one might make the following generalizations about fixed word length machines:

1. Prior to 1961, the most common word lengths were 36 and 48 bits.
2. During the period 1961-1963 many computers having word lengths ranging from 18 to 30 bits were introduced, including several 24-bit machines.
3. Since 1963, a significant number of 12 to 18-bit word length "small" computers have been successfully marketed, many of these machines having been announced only within the past year.

It might seem curious at first that the computer industry developed the relatively complex, longer word length machines in its infancy and waited until maturity (?) to produce the shorter word length machines with simpler instruction sets. There are at least three reasons for this seeming anomoly.

1. Early computers were largely devoted to scientific problem solving which required the greater accuracy provided by longer words.
2. The long memory access times associated with early memories made it important to accomplish as much with each instruction and to bring as much data from memory with each operand access as possible.
3. Development experience, large volume production economies and advancing component technology have recently made low-cost, high-performance computers possible and there are an increasing number of applications requiring such computers.

A sub-set of the most recent category, those machines with random access memories and characterized by parallel, binary internal organization, form an important class of computers. This class has attracted considerable interest and is receiving growing customer acceptance because of the economy and performance of its members and because its machines are finding use in new application areas which are themselves interesting and profitable.

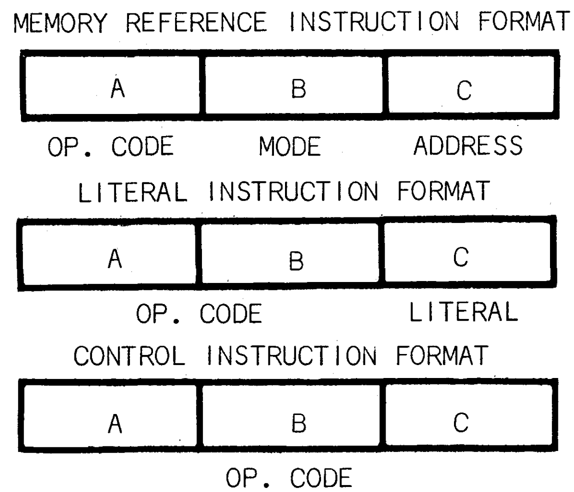
These application areas include: data acquisition, as encountered in the operation of wind tunnels, static test stands and general research instrumentation; industrial control, in which set-points may be computed for analog loop controllers or the process devices may be directly controlled by the computer (direct digital control); and other forms of on-line real-time processing, such as automatic checkout, telemetry data reduction, and communications control.

The following discussion considers those programming characteristics which are imposed by a short word length, their effect on use, and identifies some of the newer features which have begun to appear in computers of this class.

### effects of short word length on instruction format

A generalized instruction word format for a typical "single address" machine includes an A-field, which identifies the operation to be performed; a B-field, which specifies indexing, indirect, relative, or other forms of address modification, and a C-field, which contains address information, a literal, or an extension of the operation code. Instruction word formats for three basic categories of instructions are presented in Fig. 1. From the standpoint of control simplicity the machine designer would normally

Fig. 1. Instruction word formats for three basic classes of instructions.



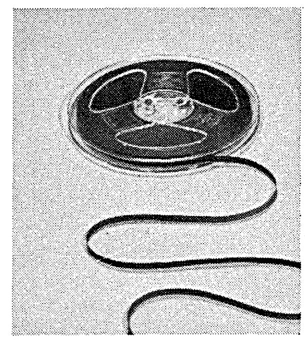

prefer that fields A, B, and C always have the meaning ascribed to them above, that is, all instructions having the format of memory reference instructions. The effect of decreasing computer word length, however, is to place a greater premium on encoding efficiency and to force the recognition of the two remaining categories.

To illustrate this problem, consider the allocation of instruction word bits in an 18-bit machine, at the upper end of our short word length class. If as few as four bits are assigned to specify the operation code (field A) and only a single bit to designate some form of address modification

*Mr. Boutwell is vice president of Compata, Inc., consultants in design and application of computer systems. Active in machine organization, logic design, and programming for the last nine years, he has been affiliated with NCR, Aeronutronic, and Packard Bell. He holds BS and MS degrees in engineering from UCLA.*

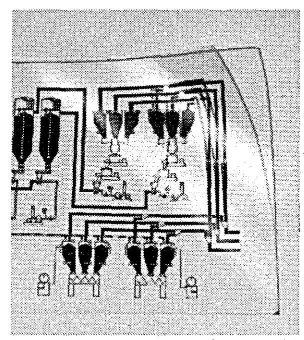
# Break the Red Tape Habit

You can sum up the difference between new Celanar polyester film and the other product in two words: *meaningful service.* Which means you get answers—and action—fast. There's no red tape with Celanar film.



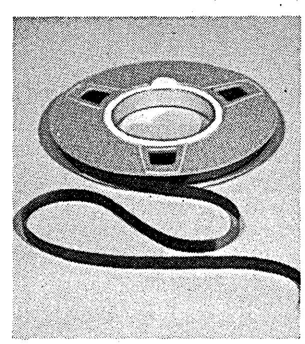
That's why so many manufacturers are now switching to Celanar polyester film by Celanese. For magnetic tape. Packaging. Engineering reproduction. Metalizing. Stationery and office supplies. And electrical applications.

Case in point: The cleaner the polyester film, the better it processes. To ensure maximum cleanliness, Celanese produces Celanar film in a sealed-off "White Room" clean enough for surgery. It's by far the most modern in the industry.



Another case in point: When essential, Celanar polyester film is shipped with temperature recording flags, to alert you to any harmful environmental changes suffered in shipment—before you put it on the processing line.

Other unique advantages that make Celanar polyester film your best buy include the fact that Celanar film is *protected against dust contamination* by use of non-fibrous plastic cores. That for critical applications it may be *shipped with Impact Recorders* to protect you against accepting film jolted and damaged in transit. That its splice-free roll lengths are *tailored to its customers' specifications.*



This is the kind of meaningful service you would expect from Celanese Plastics—whose operating philosophy is that the customer, not the supplier, is always right. Celanese Plastics Company, 744 Broad Street, Newark 2, N. J.

Celanese® Celanar®

# Celanar® Polyester Film

Celanese

Cutting through red tape to bring you answers and action *fast* is a specialty at Celanese. And it's just one of six meaningful service advantages you get when you switch to new Celanar polyester film.

CIRCLE 26 ON READER CARD

(field B), the remaining 13-bit C field is sufficient to directly address a maximum of 8192 memory locations. Thus, not only will indexing or indirect techniques be required to address typically larger memories, but if more than 16 instructions are to be provided, bit positions outside of the A field must be used to extend the operation code. This difficulty becomes more severe as instruction word length approaches 12 bits, the lower limit of the class. To meet the addressing problem, a variety of addressing modes have been conceived by computer designers. At the same time, the availability of and reliance on two-word instructions is noticeable in several of the 12- and 16-bit machines. In summary, the machine characteristics dictated by short word length are:

1. Inability to directly address total memory
2. Use of special addressing modes to obtain fast access to operands
3. Occasional reliance on two-word instructions
4. Small number of index registers
5. Use of address field as a secondary or extended operation code

In (*see p. 70*) a number of the short word length class computers are characterized by their addressing techniques, I/O methods, and special features. The significance and utility of these characteristics is discussed below.

## direct addressing

The principal classifying features of the short word length computers are those which describe available addressing modes. Because the short address field of a memory reference instruction usually does not contain enough bits to uniquely describe a general memory location, some form of relative addressing must be used. Three approaches are employed by the machines of Fig. 2:

1. The short address is added to the contents of the instruction location counter (A,E,G,H).[1]
2. The more significant bits are supplied by the location counter, that is, the short address is relative to the beginning of the memory "sector" from which instructions are currently being executed (B,D,F,K).
3. The more significant bits are supplied by an address extension register whose contents are program alterable (A).

Both the first and second approaches require that constants and working storage used at each point in the program be located within the short address "span" of the associated instruction sequence. In the first case, they always lie "in front" of the program counter up to a certain maximum distance; in the second case, they can be placed either above or below the instruction sequence. In both cases the program must periodically jump around these areas. The second method is simpler from an implementation standpoint, however, in that no addition is called for in forming the direct address.

The provision of a common scratchpad region in several machines avoids the need to duplicate this function in each program sector. On some of the 16-bit machines the scratchpad region is simply the first sector of memory (E,F,G,K). It is frequently large enough to permit direct addressing of limited data tables.

The third approach, in which a program alterable address extension register supplies the more significant bits of the address, appeared in a restricted form in one of the early short word length machines (A). Storage bank control registers indicated which memory modules were to be referenced by the short address, according to the addressing mode specified in the instruction.

An additional form of direct addressing is available on two machines by setting the short address field to all 0's (C,E). This mode, often referred to as "immediate addressing," implies that the operand is located immediately following the instruction.

## indirect addressing

Most of the short word length machines provide an indirect addressing capability. In indirect addressing, the effective address is used to locate not the operand but the address of the operand. If the address found by this means is itself provided with an indirect indicator, the process may be continued through several levels. Indirect addressing is useful in picking up main program parameters or tables of data by subroutines, and for use where program relocation or operation on multi-dimension data is involved.

Usually an instruction word bit or combination of mode bits signals the indirect mode. In one instance the indirect mode must be established by a previous instruction prior to each use (L). The memory location containing the operand address is typically accessed by one of the direct addressing means provided on the particular machine (i.e., relative, scratchpad, or address extension), adding one memory cycle to the execution time of indirect mode instructions.

In one 16-bit computer, indirect addressing may be specified only by using a two-word instruction word format (H). In another machine, with a 12-bit word length, the indirect word (operand address) itself occupies two successive memory locations (C). Indirect addressing in these machines carries a two-memory-cycle penalty.

The machines of Fig. 2 differ considerably in the number of levels of indirect permitted and in the ability to combine indexing with indirect addressing. If both are allowed, indexing usually precedes multiple level indirect and follows single level indirect.

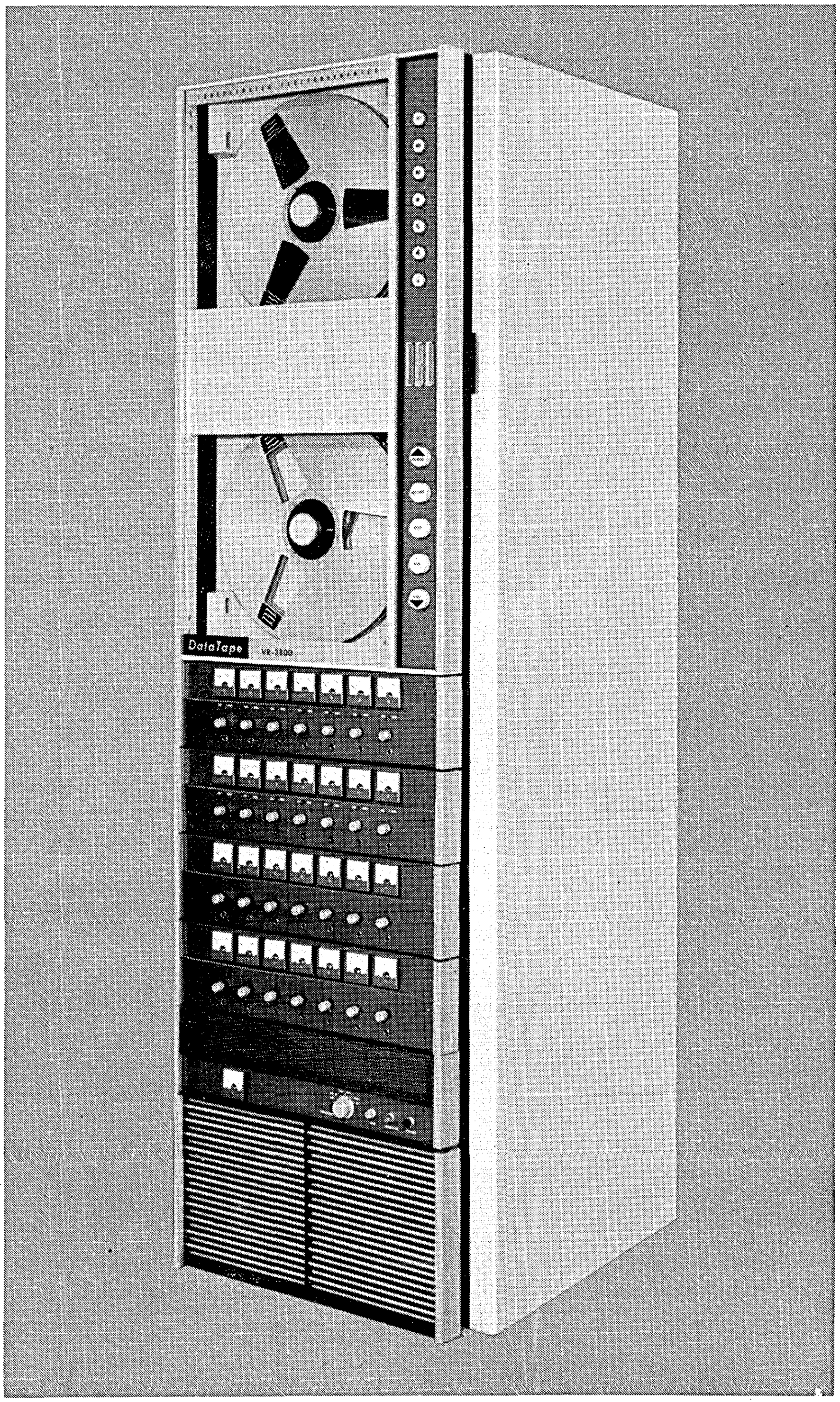
## indexing

The use of index registers in address modification and in counting program iterations has become common in larger computers and their availability is generally taken for granted. The necessity for cost consciousness in the short word length class, however, has resulted in index registers being completely eliminated in some instances and has produced interesting "implementations" of the indexing concept in several others.

Three of the machines considered in Fig. 2 have hardware index registers which may be used for this purpose alone (G,H,L). In three other machines, the accumulator extension register performs this function when indexing is indicated (C,E,K). This approach requires some "housekeeping" operations to preserve and re-establish the index register contents when indexing is interspersed with MULTIPLY or other "double length" instructions. For moderately long sequences of single length manipulative and control instructions, however, it provides indexing with no time penalty and at little hardware cost.

In another group of the short word length class, one or more memory locations are set aside by the designer for use as index registers, to be read automatically when indexing is indicated by the current instruction. A one-memory-cycle time penalty is incurred for each use but there is no program overhead as in the time-shared-register approach described above. One of the machines of this class offers two index registers, one in memory and the second an arithmetic register (E). With the dedicated memory location approach, one is limited in the number of

[1] Alphabetic characters enclosed in parentheses refer to specific computers in Fig. 2 as examples of the characteristic being described.


DataTape
VR-3800

# LIMITATION: 186,000

**The speed** with which electricity "flows" in a wire is rapidly becoming the limiting factor of computer memory performance, cost, and reliability. In a nutshell, here's why.

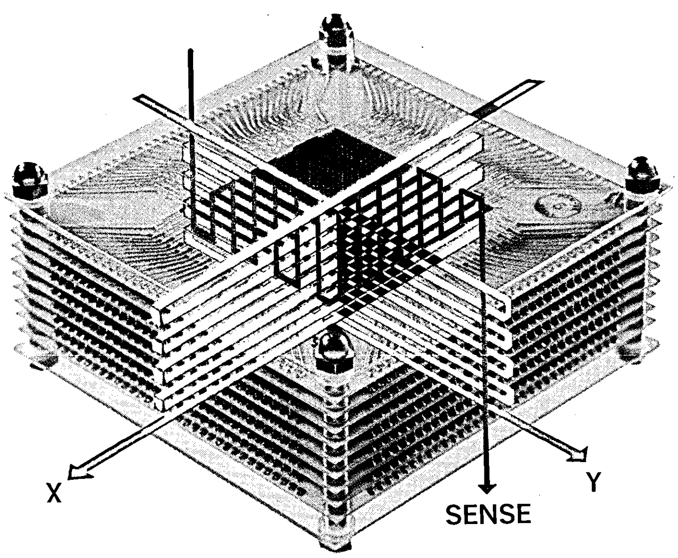
**In a typical** 16,384-word by 25-bit memory stack, using modern 20-mil diameter cores, the X and Y drive wires are about 10 feet long. A current pulse takes 40-millionths of a second to travel from one end of such a wire to the other. This delay is produced by the self-inductance of the wire, the capacity due to adjacent wires, and to core loading. It is directly proportional to the $\sqrt{LC}$ of the transmission line.

**This delay** cuts into the access time of the memory. In a high-speed system, an extra 10-billionths of a second delay-per-bit can mean twice the amount of circuitry in certain areas to achieve the required performance. With the memory engineer trying to glean every bit of available time for such reasons as recovery from noise, delays must be kept to absolute minimums for reliable operation at high speeds.

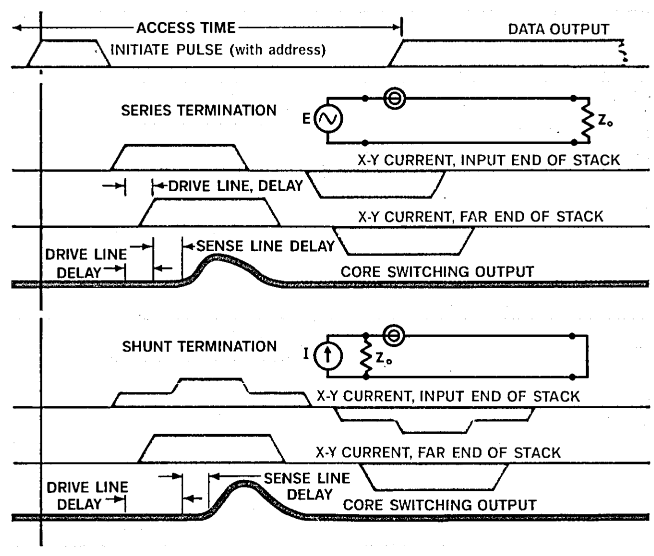
**The delay problem** can be approached by paralleling circuits, but this adds considerably to cost. One way to help the situation is to cut down lead lengths by using closer core spacing, by eliminating excess terminal lengths and by keeping the associated memory circuits as close to the stack as possible.

**Better cores** with shorter switching times and better transistors with faster rise times have made today's very high-speed systems possible. But, these component improvements have also made the delay-per-bit problem more pressing. Less delay-per-bit means: Fewer costly drivers and sense amplifiers to do the same job at the same speed, faster possible access time, and wider operating margins in each cycle for greater reliability.

**This is just one** of the many problems a memory engineer must face when he designs the "heart" of a computer, but it is a vital one. The primary factor confronting him in the improvement of speed and performance is the speed of light (and electricity) itself.



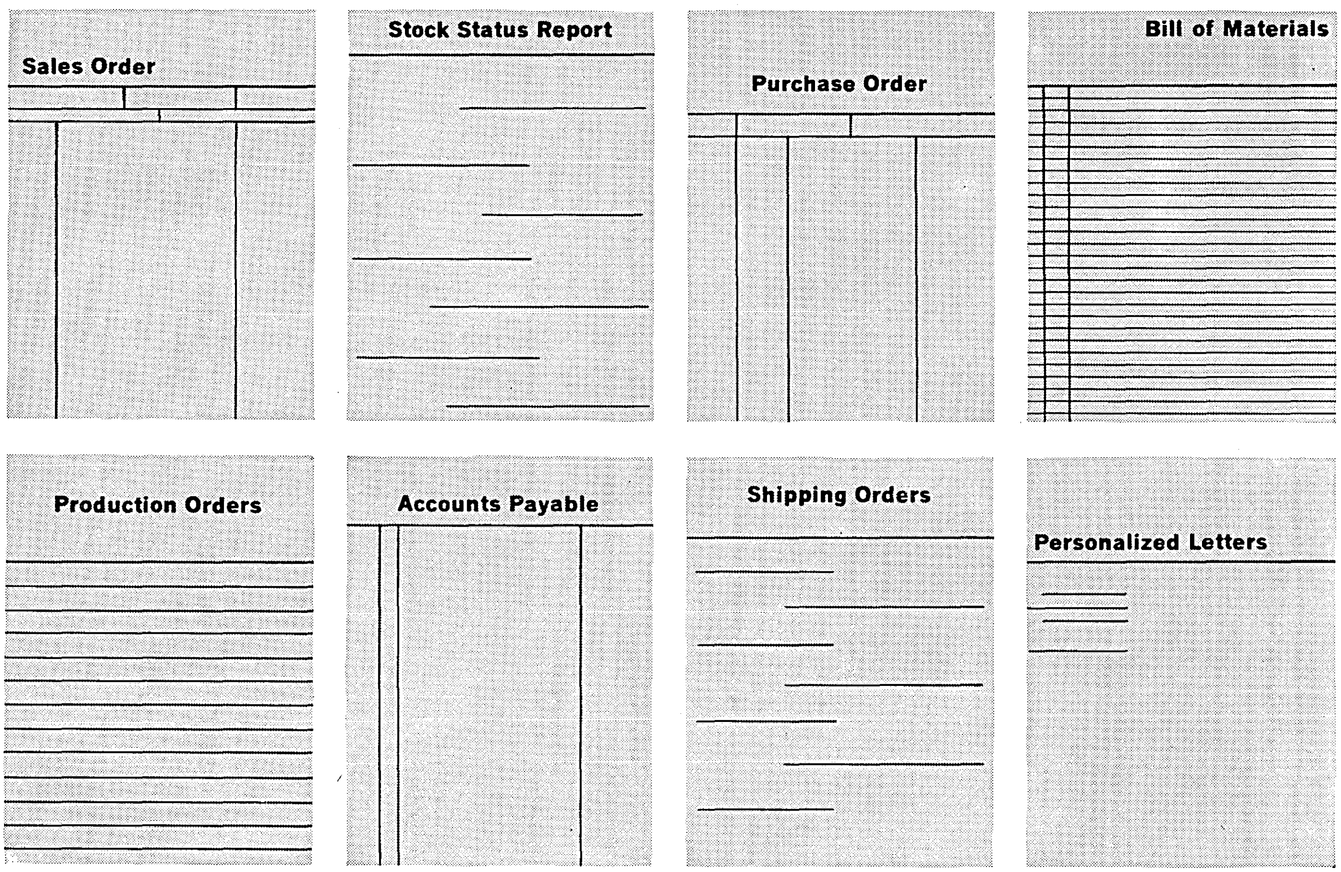

The memory designer must pay for delay in two ways. In a coincident-current memory, the X and Y currents must travel through the entire stack to select all cores. Breaking up the stack into smaller modules increases circuitry costs. Also, the sense line has a definite length which contributes to the delay.




This exaggerated waveform chart shows the delays encountered in using series and shunt terminations of X and Y drive lines. The series termination results in only one transmission delay, but it has built-in economic and physical disadvantages... large, bulky, expensive, and heat-producing resistors adjacent to the stack. The shunt termination avoids these disadvantages, but a two-way delay (down & back) results before full current amplitude is developed. This can necessitate a longer access time.

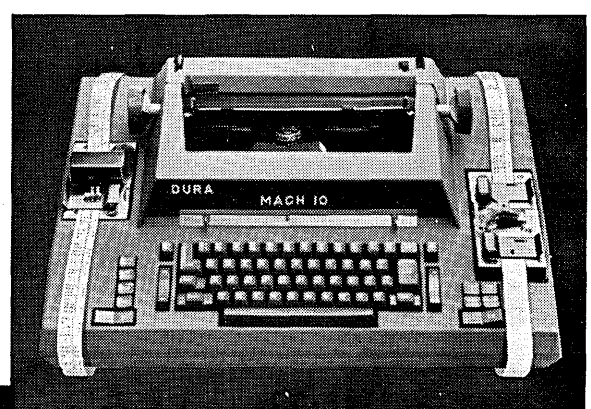
**This is the third of a series of six brief discussions on the basic principles of core memories. If you would like the complete series in booklet form, please circle 59 on the reader card.**

# Check the office forms you'd like prepared automatically...




# Now read about this one machine that automates them all

The Dura® MACH 10®. It automates sales orders, invoices, inventory reports—virtually any business application. Data is read, punched, and typed automatically at up to 175 words per minute. Edge-punch cards or punched paper tape are used to capture repetitive data—accurate data to produce documents. By-product tapes provide information for management decisions before the data is old history. Check into the Dura MACH 10 today. Call your local Dura representative. Or write your name and address on this advertisement and mail to: Dept. D21-125, Dura Business Machines, 32200 Stephenson Highway, Madison Heights, Michigan 48071.




**DURA** BUSINESS MACHINES

*Division of* DC* *dura corporation*

*Trademark Dura Corporation

CIRCLE 28 ON READER CARD

index registers principally by the number of instruction word bits available for register specification. A further benefit which derives from locating index registers in memory is the ability to initialize and modify their contents by using the ordinary LOAD and STORE memory instructions. Thus, the necessity to assign some of the limited number of instruction codes to special index register instructions is avoided. A related instruction, INCREMENT (DECREMENT) MEMORY-CONDITIONAL JUMP, has often been included, however, to facilitate the iteration counting function and, in fact, lessens the need for a large number of formal index registers.

An interesting variation on the above use of memory located index registers, referred to as "auto-indexing," has been employed by one manufacturer and appears in two machines of Fig. 2 (B,M). In auto-indexing, no instruction bits are allocated for index register control. An indirect reference to one of a number of predetermined memory locations, however, causes the contents of that location to be incremented, replaced, and the result taken as the effective address. This may be viewed as a form of indirect addressing with automatic incrementing of the indirect word, or as a combination base register-index register. In any case, each auto-indexing location is dedicated to a particular data table and a somewhat larger number of them is required to compensate for this fact. Although an arbitrarily large number of locations could be assigned to function in the auto-indexing mode without contributing to instruction encoding problems, the principal drawback to this method is the two-memory-cycle penalty incurred for each auto-indexing operation.

## general addressing

An important insight into the utility of the machines of the short word length class can be gained by noting the ease with which a general (or arbitrary) memory location may be referenced. Because of the typically small size of the program sector and any scratchpad region, it will be necessary in many applications to operate on data stored outside of these areas. This requirement presents no great difficulty in the machines with good direct addressing facilities (e.g., with 13-bit short address fields or address extension registers) and serves only to introduce a one-cycle time penalty for machines which provide two-word instructions for full memory addressing.

On those machines lacking both the above facilities and indexing, indirect addressing offers the only means for accessing generally located data. If data from several tables are involved in the processing, a corresponding number of indirect words may be established with their contents being periodically incremented under program control. Machines equipped with several full-address-length index registers can access as many data tables as there are registers by dedicating each register to a data table so that it becomes, in effect, an incrementable base register (cf. pseudo-indexing). For the several machines which offer combined indirect and indexing, the contents of a single index register may be used to modify a number of indirect words, without suffering the program overhead of the straight indirect approach, but with more economy than the multiple index register approach.

## new features and trends

In addition to somewhat unusual addressing characteristics, a number of new or novel features are discernible among the machines of the short word length class. Some of these are more or less peculiar to the small machines and are attributable to the specialized requirements of particular applications. Others are expressions of what seem to be trends (or perhaps vogues) in the internal organization of digital computers in general.

*Arithmetic and CPU Features.* An interesting general trend towards multiple accumulators and a companion feature, inter-register operations has evidenced itself in several machines of this class. In programming a typical single accumulator machine it is found that a number of the LOAD and STORE instructions arise from the periodic need to preserve intermediate results while some related, intervening series of operations is performed, then temporarily store those results and reload the previous result in order to proceed with the next phase of the problem, etc. (as in the evaluation of a general polynomial).

The availability of multiple accumulators, and instructions to combine their contents logically and arithmetically, reduces the number of superfluous memory access instructions otherwise required. An analysis performed by one manufacturer indicated that about 30% of the LOAD and STORE operations occurring in representative code were redundant in the above sense.[2] It was further observed that approximately 80% of these redundancies could be eliminated by the provision of as few as three accumulators, with the value of additional accumulators diminishing rapidly.

Although none of the short word length machines contains a complete implementation of features described above, a number of them are equipped with some of the desirable elements. Two of the machines considered exhibit dual, single length accumulators with many of the arithmetic and logical instructions being applicable to either register (C,K). In both cases the second register also functions as the accumulator extension for double-length operations and is time-shared as a hardware index register. The machines thus benefit from the ability to apply the general arithmetic operations to the index

[2] G. M. Amdahl, "The Structure of the System 360 — Processing Unit Design Considerations," *IBM Systems Journal*, Vol. 3, Nos. 2, 3.

# FIG. 2 SUMMARY OF FEATURES OF SHORT WORD LENGTH COMPUTERS

| | CHARACTERISTIC | A CDC 8090 | B PDP 8 | C SDS 92 | D PRODAC 50 | E CDC 1700 | F DDP 116 | G DMI 620 | H IBM 1801 | J MARK I | K SEL 810 | L H 22 | M PDP 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INSTRUCTION WORD | LENGTH (Bits) | 1. 12<br>2. 24 | 12 | 1. 12<br>2. 24 | 14 | 1. 16<br>2. 32 | 16 | 1. 16<br>2. 32 | 1. 16<br>2. 32 | 16 | 16 | 18 | 18 |
| | OP. CODE FIELD (Nominal) (Bits) | 6 | 3 | 5 | 5 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 4 |
| | ADDRESS FIELD (Bits) | 1. 6<br>2. 12 | 7 | 1. 3<br>2. 15 | 8 | 1. 8<br>2. 16 | 9 | 9 | 1. 8<br>2. 16 | 11 | 9 | 13 | 13 |
| MEMORY | WORD LENGTH (Bits) | 12 | 12 | 12 | 14 | 18 | 16 | 16 | 18 | 16 | 16 | 20 | 18 |
| | CYCLE TIME ($\mu$ sec.) | 6.4 | 1.6 | 1.75 | 4.5 | 1.1 | 1.7 | 1.8 | 2 | 3 | 1.75 | 1.75 | 1.75 |
| | CAPACITY (Words) | 8-32K | 4-32K | 2-32K | 4-16K | 4-32K | 4-32K | 2-32K | 4-32K | 2-16K | 4-32K | 2-16K | 4-32K |
| | PARITY CHECK | No | Optional | Optional | No | Yes | Optional | Optional | Yes | No | Optional | Yes | Optional |
| | PROTECTION FEATURE | No | No | No | No | Yes (Prog. Estab.) | No | No | Yes (Manual Estab.) | No | No | Yes (Prog. Estab.) | No |
| ADDRESSING FEATURES | INDEX REGISTERS | None | 8 "Auto-Index" Loc. In Mem. | 1, Accum. | None | 2, Accum. Ext. Reg., Mem. Loc. | 1 (Mem. Loc. 0) | 2, One is Accum. Ext. | 3 | 1 for each of 8 Memory-Stored Processors | 1, Accum. Ext. Reg. | 1 | 8 "Auto-Index" Loc. in Mem. |
| | INDIRECT | Single Level to One of 8K Loc. | Single Level | Multi-Level, Indexable at Any Level | Single Level | Multi-Level, Indexable at First Level Only | Multi-Level | Multi-Level | Single Level, Indexable, Two Word Inst. Format Only | No | Multi-Level, Indexable at Any Level | Single Level, Indexable, Req. Set-Up Inst. | Single Level |
| | SCRATCHPAD (Words) | 64 | 128 | 31 | No | 256 | 512 | 2048 | No | No | 512 | No | No |
| | EFFECTIVE ADDRESS | 1. Rel. to P.C.<br>2. Direct to 8K Bank | 1. Rel. to Sector Loc. 0 | 1. Scratchpad<br>2. Direct to 32K | Rel. to Sector Loc. 0 | 1. Rel. to P.C.<br>2. Direct | Rel. to Sector Loc. 0 | Rel. to P.C. | 1. Rel. to P.C.<br>2. Direct | Direct within 2K Basic Mem. | Rel. to Sector Loc. 0 | Direct within 8K P.C. Sector | Direct within Basic 8K |
| | ACCESS TO GENERAL LOCATION | 1. Indirect<br>2. Two Word Inst. | Indirect, Auto-Index | 1. Indirect<br>2. Two Word Inst. | Indirect | Indirect, Two Word Inst., Index | Indirect, Index | Indirect, Index | 1. Index Reg.<br>2. Two Word Inst. | Index Reg. | Indirect Indexing | Indirect Index | Direct |
| ARITHMETIC FEATURES | NO. ACCUMULATORS | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 per Processor (In Memory) | 2 | 1 | 1 |
| | REGISTER OPERATIONS | No | No | No | No | No | No | Yes | No | Yes | Yes | Yes | No |
| | ADD TIME ($\mu$ sec.) | 1. 12.8<br>2. 19.2 | 3.2 | 3.5 | 18 | 2.4 | 3.4 | 3.6 | 1. 4.5<br>2. 6.25 | 15 | 3.5 | 4.9 | 3.5 |
| | MULTIPLY TIME ($\mu$ sec.) | Subroutine | 15.2 Optional | 7.0 Optional | Subroutine $\sim$ 1 ms. | 7.0 | Subroutine 9.5 Opt. | 18 Optional | 1. 14.25 Std.<br>2. 17.0 Std. | Subroutine | 17.5 | 25.6 | 6.1 (Avg.) Optional |
| | DATA REPRESENTATION | 1's Comp. | 2's Comp. | 2's Comp. | 1's Comp. | 1's Comp. | 2's Comp. | 2's Comp. | 2's Comp. | 2's Comp. | 2's Comp. | 2's Comp. | 2's Comp. |
| I/O FEATURES | WIDTH OF DATA PATH (Bits) | 12 | 12 | 6<br>12 Opt. | 14 | 16 | 16 | 16 | 16 | 16 | 8, 16 | 18 | 18 |
| | PARITY TRANSMITTED? | Yes | No | Yes | Yes | No | No | No | No | No | Optional | Yes | No |
| | MAX. DEVICES | 64 | 64 | 30 | 64 | 8 Prog. Contr.<br>8 Buffered | 64 | 64 | 32 | 128 | 128 | 4096 | 64 |
| | BASIC I/O DATA PATH | CPU, Single Word & Block Transfer Inst. | CPU Accum. | Mem. Buffer Reg. | CPU Accum. | CPU Regs. | CPU Accum. | 1. CPU Reg.<br>2. Mem. Buffer | Memory via CPU Reg. | CPU Regs. | 1. CPU Reg.<br>2. Mem. Buffer | Mem. Buffer Reg. | CPU Accum. |
| | DIRECT MEMORY ACCESS WORD RATE | 70 KC | 625 KC | 114 KC Single Word, 572 KC Burst | N.A. | 900 KC | 145 KC Single Word, 580 KC Burst | 550 KC | 500 KC | Prog. Block Transfer 100 KC | 570 KC | 568 KC | 570 KC |

## FIG. 2. SUMMARY OF FEATURES OF SHORT WORD LENGTH COMPUTERS

| CHARACTERISTIC | A CDC 8090 | B PDP 8 | C SDS 92 | D PRODAC 50 | E CDC 1700 | F DDP 116 | G DMI 620 | H IBM 1801 | J MARK I | K SEL 810 | L H 22 | M PDP 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DMA CONTROL WORD LOC. | Channel Hdwe. | I/O Device Hdwe. | A. Memory B. Channel Hdwe. | N.A. | Channel Hdwe. | A. Memory B. Channel Hdwe. | Channel Hdwe. | Channel Hdwe. | Index | Channel Hdwe. | Channel Hdwe. | I/O Device Hdwe. |
| MAX. BLOCK LENGTH (Words) | 8K | Limited by Mem. Size | 512 | N.A. | Limited by Mem. Size | 16K | Limited by Mem. Size | 16K | Limited by Mem. Size | Limited by Mem. Size | 4K | Limited by Mem. Size |
| COMMAND, DATA CHAINING? | No | No | 2 Blocks Max. | No | No | No | No | Data Chaining | No | No | No | No |
| PRIORITY INTERRUPT LEVELS | 4 | 1 Common Int. Line | 256 Opt. | 14 Basic 50 Opt. | 2 Basic 13 Opt. | 1 Common Int. Line, 256 Opt. | 1 Common Int. Line 256 Opt. | 12 Priority Levels, up to 16 Lines Each | 7 | 1 Common Int. Line Basic, 96 Opt. | 32 Levels, up to 144 Lines Each | 1 Common Int. Line, 16 Opt. |
| UNIQUE MEM. LOC. FOR EACH INT. SOURCE? | Yes | No | Yes | Yes | Yes | Optional | Yes | 1 Loc./Level, Subroutine Ident. Line | Yes | Yes | Yes | Yes |
| ASCII COMPATIBLE? | No | Yes | No | ? | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| APPROX. PRICE: CPU, TYPEWRITER, P.T.R., P.T.P., 4K Words MEMORY | 35K | 18K | 35.5K | 27.5K | 28K | 28K | 30K | 54.3K | 23K | 29.5K | 32K | 45K |
| IMPLEMENTATION | Discrete | Integrated | Flip Flops Integrated | Discrete | Discrete | Discrete | Discrete | Discrete | Integrated | Integrated | Hybrid | Integrated |

register. These machines are not equipped, however, with extensive sets of inter-register operations. Unfortunately, one machine which has been equipped with a commendable set of inter-register operations does not permit the registers to function as independent accumulators.

Three of the machines considered contain some type of microprogramming facility (B,G,M). This takes the form of a non-memory-reference type of instruction in which all bit positions outside of the primary operation code are each used to control some simple CPU or I/O function (e.g., clear, complement, increment). The functions are typically independent and more than one may be specified in a given instruction. A microprogramming capability generally simplifies the programming of those larger functions which are not provided as instructions. In a sense it compensates for a limited instruction repertoire at little increase in control complexity or cost.

*Memory Features.* In addition to demonstrating generally improved memory cycle times (as low as 1.1 usec.), a number of the short word length machines are distinguished by memory features which are related to their size or intended application. Memory capacity is an example of the former. Maximum capacities typically range to 16K or 32K words. Because the cost of even 4K words of random access memory may represent a significant part of a computer's total cost, however, the basic configuration of several machines contains less than this amount. For a similar reason, incremental expansion of the memory system using modules as small as 1024 and 2048 words is offered in some cases (C,F,J,L). As another example of extreme cost consciousness, parity checking is frequently offered as an extra cost option. Here, the opportunity to reduce the cost of the memory by $\frac{1}{13}$ to $\frac{1}{17}$ in a 12-bit to 16-bit unit is a principal motivation. Memory reliability is also cited as justification for this approach.

The use of short word length computers in real-time applications involving relatively high I/O data rates and in industrial control applications has led to the inclusion of two additional important memory features.

The first, direct memory access, is available as an option on most of the computers in the class. This permits program initiated data transmissions to proceed concurrent with program execution at rates approaching the maximum memory transfer rate.

A second relatively new feature protects certain regions of memory against inadvertent alteration due to machine fault or operator error. Coupled with a safeguard against loss of memory information during power transients, memory protection guarantees the integrity of control programs in critical on-line industrial applications. In each of the computers offering this feature, protection is on a word-by-word basis and involves the use of an additional bit per memory word for this purpose. In one instance, the state of the protection bit is established under operator supervision and may not be altered by the program during subsequent unsupervised operation (H). In two other cases, protected words may be altered by instructions which are themselves protected (E,L). Thus, protection bits may be used to identify monitor or executive programs as well as the operating programs. With this provision, the computer may be used for program debugging from the console concurrent with the operation of an on-line control program.

*Input/Output and Special Features.* A number of classifying I/O features are listed in Fig. 2 for the computers of the "compact" class. As was the case in the previous consideration of arithmetic capabilities, some of these features are characteristic of the short word computers and others represent more general trends.

The width of the I/O data path typically corresponds to the word length of the central processing unit, although some of the computers also offer a half-word mode for communicating with character-oriented devices. In at least four cases, manufacturers have seen a need for including parity information in the I/O data channel. One of these manufacturers, however, offers memory parity only as an option. The number of devices or controllers which can be attached to the typical short word length computer is generally limited by the structure of its I/O command and in most cases exceeds a practical number (e.g. 128, 4096).

A significant characteristic of the computers under consideration is their widespread use of the accumulator in the I/O data transfer path. Although this practice was motivated earlier by reasons of economy, the need to inspect and process input data in real-time in on-line applications is probably equally responsible for this approach in recent computers. Nearly all of the computers of Fig. 2 also offer a direct memory access (DMA) option to permit simultaneous I/O transmissions and processing. Thus, word rates of 500KC to 1MC are possible using today's one-plus microsecond memories.

In most instances the registers holding current storage address and block length count information are contained within the DMA channel hardware. Two manufacturers offer lower cost versions of DMA, however, in which the channel control words are stored in pre-assigned memory locations (C,F). The number of additional memory cycles devoted to reading, modifying and restoring these words for each data word transmitted degrades performance but permits a large number of data transmissions to be buffered at rates well above those possible using the straight programmed approach. The length of the data block which can be DMA buffered varies from a few hundred words to a complete memory module, and in some instances includes the maximum size memory.

A fairly powerful approach to controlling a series of data transmissions where only short intervals or response times are permitted, involves the concepts of command or data chaining. In data chaining, each buffer region of memory points to another (perhaps non-contiguous) region for storing or unloading the subsequent block. With this feature, data block rates which preclude program intervention can be handled comfortably. In the more complex notion of command chaining, each channel is equipped to call from memory and decode subsequent instructions which may perform certain status tests or remedial actions before proceeding with the sequence of transmissions.

A program interrupt capability with some method for establishing priorities among several interrupt request lines has become a necessity in many of the small computer applications. In the machines of Fig. 2, interrupt facilities range from a common interrupt line, with programmed determination of the source and cause of the interruption, to many individual interrupt lines. A variation groups a number of lines into several levels having established priorities. A common method for handling program interruptions is to provide a unique memory location for each interrupt source where the initial instruction or the starting address of the desired program may be found.

Two further characteristics tabulated in Fig. 2 are compatibility with the American Standard Code for Information Interchange (ASCII), which is growing in importance, and the use of integrated circuits in implementing the computer. Although several of the machines listed use integrated circuits in some form, a few of the more recently introduced models still use discrete component circuit modules. In at least one instance this is due to the manufacturer's desire to use an existing high speed line of circuits previously designed for a larger model. In other cases the decision was based on the conclusion that the required performance was not yet available in commercial integrated circuit form at competitive prices.

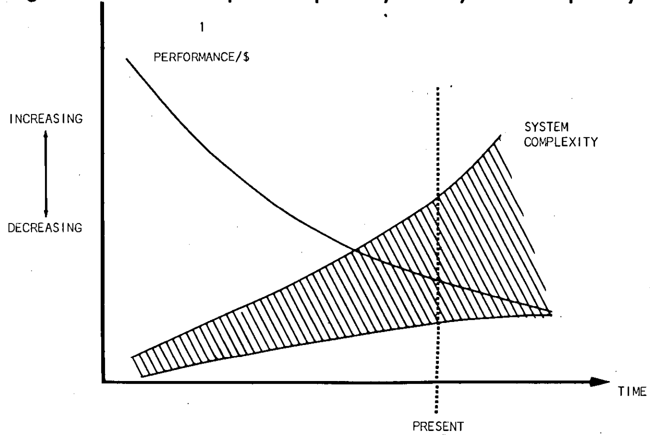
Additional features that are required to qualify for some areas of application are a real-time clock or interval timer and an automatic shut-down/restart capability where power transients must be accommodated. Each of these features is typically connected to a high priority interrupt request line.

Also included in Fig. 2 for each computer is the approximate price of a "basic" system which usually contains the CPU, typewriter, paper tape reader, paper tape punch and 4K words of memory. These figures should be taken as guides or indications only because of the difficulty in finding a "common denominator" configuration. Many of the features discussed above are standard on some machines and are options (or not available) on others. Furthermore, since the memory may contribute almost half of the cost of a small machine, differences in word length produce significant effects. For example, the 18-bit memories of the larger machines provide 50% greater storage capacity than those of the 12-bit smaller machines with a less than proportionate increase in price. Similarly, the information presented on memory cycle and instruction execution times should be considered only as a general indication of machine performance.

## impact on industry

Because of their low cost and flexibility the "compact" computers are being used in a large number of special purpose applications where the previous generation of fast but large or small but slow machines was inadequate. This point is illustrated in Fig. 3, which shows concurrent trends in the performance/dollar of system computers and in the complexity of special purpose systems. On the one hand system complexity has appeared to increase with time because of man's desire to undertake

Fig. 3. Trends in computer capability and system complexity.




larger tasks, because an expanding technology has provided the means to solve the related problems, and because succeeding "generations" of system designers have developed confidence in their ability to solve such problems and have learned how to use the available technological tools. At the same time, the cost of computers with the necessary performance and real-time features has been decreasing because of improvements in memory and component technologies and because of larger volume production efficiencies.

Some time ago, it became economically feasible to use the then available digital computers in lieu of special purpose digital designs in the larger, more complex systems. A continuation of the trends noted has resulted in a situation where a majority of the medium to large electronic systems specified today contain one or more digital computers. It is to be expected, however, that there will always remain some relatively small number of system requirements which can be best met by a special purpose design.

The "compact" class of computers has had an undeniable impact on industry. This impact can be measured by the number of small computer manufacturers who have risen to meet the occasion—between one and two dozen, by the annual sales volume of this class of computers—currently in excess of $25 million, and by the variety of tasks to which these computers are being applied. It is in this latter area, with an as yet unrealized potential of computers in industrial applications, that the "compact" computers promise to outlive their four-wheeled counterparts and to have a lasting impact upon industry and society. ■

**preview of a new book**

# SYSTEM/360 ASSEMBLY LANGUAGE

by MARTIN E. HOPKINS

*The following article is to be chapter 2 of a book titled "Programming the IBM System/360," being published by John Wiley & Sons. At the time of its inception, each of the 20 authors—all on the staff of Computer Usage Company—had already had one full year of experience with the machine. This book represents an effort to capture the early experience of these programmers and to disseminate it in printed form. It is aimed at experienced application programmers who wish to program System/360 routines in assembly language. Naturally, all who will be working with the machine will find much helpful material in the book.*

Ascher Opler, Editor

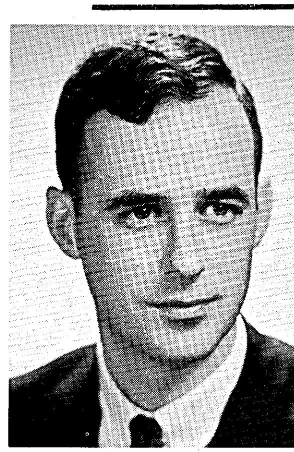
This chapter is intended only to familiarize the reader with the Assembly Language so that coding examples written in it can be understood. The Macro Language is not discussed.

The Assembly Language of IBM System/360 is similar to those used by other computers. Typical assembly languages are: "Operating System/360 Assembler Language," Form No. C28-6514; "IBM System/360 Special Support Basic Assembler Language," Form No. C28-6503; and "IBM System/360 Basic Programming Support Assembler," Form No. C24-3355. The last two are declared to be a subset of the first. More limited language versions are desirable for efficiency of assembly programs on smaller machines. In general, the examples in this book use Operating System/360 Assembly Language.

Input to the assembly program is called a source language program and is usually punched on 80-column cards. The assembler translates this source language to object code, which executes on System/360.

Source language statements may be punched in a relatively free format subject to certain restrictions. The statement itself may use columns 1-71. When column 72 is not blank, the next card is a continuation of the current statement. Continuation cards do not use columns 1-15; they begin with column 16. Columns 73-80 are the identification field and may be used for identification-sequence numbers or left blank. This basic framework can be varied by a special assembly control instruction, ICTL (input control).

A statement consists of name, operation, operand, and comments fields separated from each other by at least one blank. The name field may contain any legal symbol (to be described later) beginning in column 1. A blank in column 1 indicates the absence of a name field. The operation field contains a mnemonic, representing either a machine instruction or an assembler instruction. The operand field consists of one or more subfields or operands that supply whatever information, symbolic or absolute, is needed by the assembler to assemble the machine instruction or to act on the assembly control instruction.



***Mr. Hopkins is a senior analyst with Computer Usage Company. For the last two years he has supervised the design and implementation of various compilers, operating systems, and other software for the IBM System/360 and 9020. He has also designed RCA Spectra 70 systems and is a consultant on problems associated with new computers.***

The first blank after the operand field indicates the beginning of the comments field. This permits descriptive information about the program to appear on the listing. Furthermore, when an asterisk (*) is put in column 1, the whole card becomes a comment. In practice, many programmers write programs in the following format: the name field begins in column 1, the operation in column 10, and the operand in column 16.

Names may be assigned to most statements. They may represent memory locations, registers, or any arbitrary value of use to the programmer. These names, or symbols as they are called, must begin with a letter, contain only letters or the numerics 0-9, and be one through eight characters long. The following are legal symbols:

```
JOE    X1234567
X      TAXRATE
R15    TAPE2IN
```

Associated with each symbol are two attributes developed by the assembler. The *value* attribute is either the location of the instruction where this name appears or an arbitrary value assigned by an assembler control instruction. A symbol whose value is a location is said to be relocatable. This means that the loader will alter the value attribute if it is necessary to load the program at a location other than the one at which it was assigned by the assembler. An arbitrarily assigned value is said to be absolute and will never be altered by the loader. The length attribute is the size (in bytes) of the field associated with the symbol. This attribute can be used by the assembler to construct machine instructions that require an operand that specifies field size. The asterisk (*) may be used in the operand field to denote the location of the instruction in which it appears. Absolute values may also appear as decimal integers in the operand field. This is termed a self-defining value. In addition, the assembler will accept self-defining values in base 16 and base 256 character notations. Hexadecimal notation uses the integers 0-9 and the letters A-F to express the values $0_{10}$ to $15_{10}$. The value must be preceded by an X and enclosed in single quotation marks. The following are examples of hexadecimal values with their decimal equivalents:

```
X'01'     1
X'F'      15
X'1FFF'   8191
X'B8C'    2956
X'150'    320
```

Base 256 numbers are written as one to three EBCDIC characters enclosed in quotation marks. It may be preceded by the letter C. Any one of the 256 EBCDIC characters may be used. Each character in the string is assembled as its binary value in the character set.

```
57943   X'E261'   C'S/'
   91   X'5B'     C'$'
   64   X'40'     C'b'
```

The character quote (") is expressed in base 256 arithmetic by two consecutive single quotation marks.

Hexadecimal self-defining values are useful for expressing bit patterns. Character self-defining values are often used for immediate operands in SI instructions.

Symbols and self-defining values may be combined to form expressions using the algebraic operators +,—,*,/, which denote addition, subtraction, multiplication, and division, respectively. Some valid expressions are:

```
TABLE+C'S'
251
X
325—BOX3+X'A3F'
C'$.C'
ARRAY+'*'
64*JOE—X
*+6
```

Note that in the last three lines the asterisk has different meanings: first a self-defining character constant, then multiplication, and then the current location.

Just as symbols are relocatable or absolute, so are expressions. An absolute value added to or subtracted from a relocatable value will leave the expression relocatable. Two absolute values combined in any way form an absolute expression, as does the difference between two relocatable symbols. Relocatable symbols may not enter into a multiply or a divide, and the sum of two relocatable symbols is not usually legal. The rules for expressions with more than two terms are somewhat more complex, but they follow the above pattern.

## machine language instructions

There is a mnemonic operation code for each machine language instruction. The operand field has a different format for each of the instruction types; the exact formats are shown in Appendix B. A few examples will show the general pattern.

Register addresses, masks, immediate operands, and counts may all be coded using absolute values. Memory addresses are normally coded as relocatable symbols. The assembler will asign the correct base and displacement by a method to be described later. If the programmer desires he may specify an absolute displacement less than 4096 and a register address enclosed in parentheses.

Here are some examples of various operand formats:

```
L      6,PSUM
```

The contents of PSUM will be loaded into register 6.

```
AR     R6,X'F'
```

Register 15 (i.e.,X'F') will be added to the contents of the register defined as R6.

```
SLA    12,2
```

Register 12 will be shifted left algebraically 2 bits.

```
L      13,12(5)
```

Register 13 will be loaded from the effective address computed by adding displacement 12 to the contents of register 5.

```
MVI    SUGAR,C'A'
```

The character A will be moved to the memory location SUGAR.

For indexable instructions, a general register designated to serve as an index register may be specified in one of two ways:

```
S      10,25(3,6)
A      9,TABLE(6)
```

In the first example, register 3 is a base, 6 an index, and 25 the displacement. In the second, TABLE is a memory location for which the assembler will compute a base and displacement. Register 6 will be the index.

In addition to the regular instruction operation mnemonics there is a set of extended mnemonics, so that the programmer need not set up the condition code for each branch on condition instruction. Instead of writing branch on condition equal as

```
BC     8,EXIT
```

where 8 is the condition indicator, the programmer can write:

```
BE     EXIT
```

A complete list of allowable extended mnemonics is provided in Appendix B.

The define constant (DC) instruction allows the programmer to enter data in many different formats. To use this instruction, the programmer writes DC in the operation field. A symbol in the name field is optional. The format of the operand field provides many options and can be very complex. In its most basic form it consists of a letter which designates the type of constant followed by the constant itself enclosed in single quotation marks.

The following are the most important:
F fixed-point binary full word
H fixed-point binary half word
E single-precision floating-point
D double-precision floating-point
Z zoned decimal
P packed decimal
C character — 8-bit code in EBCDIC
X hexadecimal
A full address constant

Here are some examples of their use in actual DC statements:

```
DC     F'-329'
DC     H'167'
DC     E'3.14'
DC     D'314E-2'
DC     P'+202'
DC     Z'126'
DC     C'$AB*'
DC     X'0123456789ABCDEF'
DC     A(SAM+JOE)
```

It should be noted that the last constant is surrounded by parentheses. A-type address constants must use parentheses because an expression with character or hexadecimal self-defining values would be ambiguous. The following might be ambiguous if parentheses were not used.

```
DC     A(RESTART+X'2B')
```

DC instructions also allow a duplication factor which indicates how many times the constant is to be repeated. This may be written as an integer or as an expression enclosed in parentheses. To fill an area with zeros,

```
DC     (TBLSIZ)F'0'
```

or

```
DC     120F'0'
```

A series of modifiers is also permitted after the type. In general the need for these is limited, and their use will be explained as they occur.

Another means of defining an area is to use the define symbol (DS) assembly control instruction. This may be written exactly as one would write the DC. The difference is that the assembly program will not create a constant; it merely reserves space. Hence no value is required. Alternate means of reserving 6 bytes are

```
DS     6C
DS     C'123456'
```

The '123456' in the second example will not be assembled.

Another option allowed in both the DC and DS instructions is to have several value fields.

```
DC     H'100,200,300,400'
```

In this example, four half words will be assembled with the constants 100,200,300, and 400. This is also allowed with other types of constants.

```
DC     E(6.2,3.25E6,-10.)
DC     A(SAVE,INPUT-3,OUTPUT)
```

In all cases of DC and DS instructions, the name, when present, refers to the left-hand or lowest byte address of the constant or area.

The assembler allows the programmer to use literals—constants written as in a DC preceded by an equal sign. Some examples are

```
L      6,=F'128'
AE     4,=E'32.8'
LM     5,7,=A(TBLX,TBLY,TBLZ)
MVC    PRINT(132),=132C'b'
```

The assembler will generate a pool of these constants, eliminating duplicates.

The System/360 is oriented toward programs that are assembled separately and then loaded and executed together. In order to combine programs at load time, the loader must know which symbols are defined in one program but used in another. The instructions EXTRN and ENTRY are provided for this purpose. EXTRN declares that the symbols it specifies are not defined in this program. ENTRY declares that the symbols it specifies are to appear in the EXTRN list of another program or programs. The following are examples of these instructions:

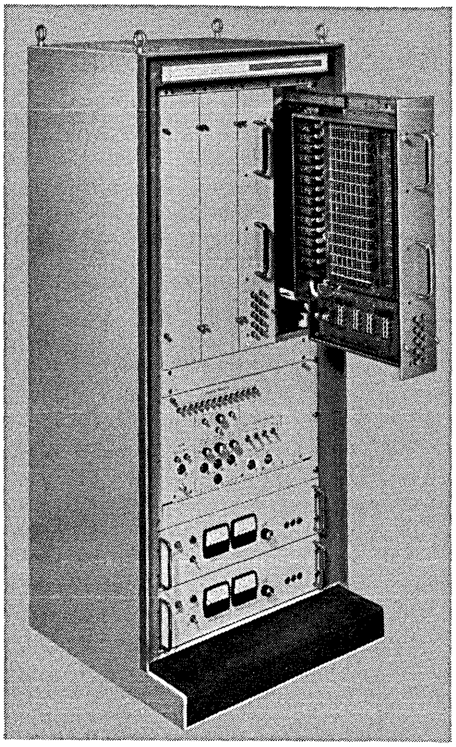
```
EXTRN  A,COS,TABLE28
ENTRY  NEXT,X
```

The programmer defines the beginning of his program with a START instruction. If there is a name, it is always treated as if it had appeared in an ENTRY statement. The operand field may contain a self-defining value. This will be used by the assembler as the initial location (i.e., origin) of the program. This is called the tentative load location. The loader will attempt to honor the request. The loader may have to load the program at a different location, but if it does not, the listing and dump will match exactly. Here is an example of a START instruction.

```
FLOW      START      X'10000'
```

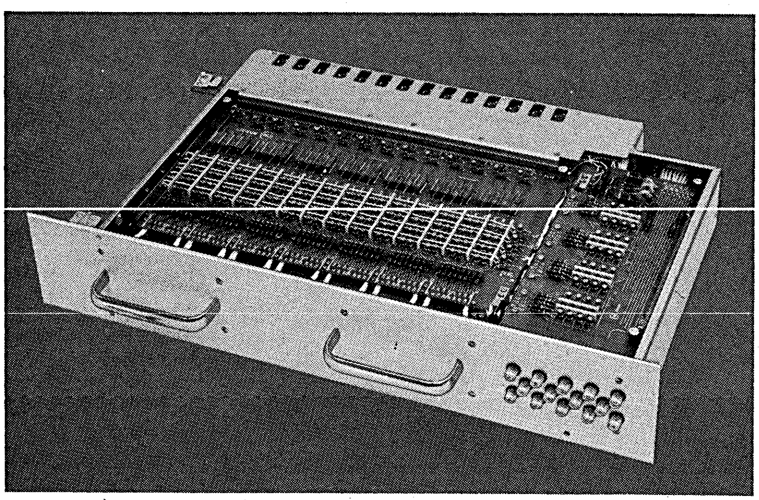
Programs may be divided into a number of "control sections." These are assembled together and can make symbolic reference among one another without using EXTRNs and ENTRYs. Each control section will be separately relocated by the loader which will also resolve inter-control section references. The programmer identifies the beginning of a control section by writing a CSECT instruction. The name of the control section, if any, is written in the name field. The instructions within one control section need not be physically contiguous in the card deck, because the assembler maintains separate location counters for each section. Any CSECT with the same name as a previous one is considered to be a resumption of that control section, and the assignment of locations begins at the next byte of this control section. All cards between one CSECT and the next are a part of the control section.

# You can buy the whole megabit nanosecond shebang. Or just the bits and pieces.



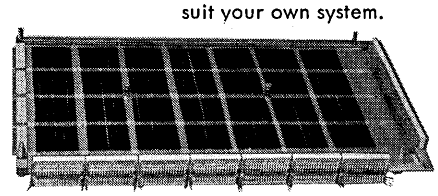
If you don't want to buy the fastest megabit memory system complete, we suggest that you build it yourself. Because of the unique modular construction of Nanomemory you can buy the complete memory system, the digitized stack only, or just the core stack assembly. In each case you get nanosecond cycle times, 2½ D organization, and highly competitive prices.

The whole shebang: Everything included from power supply to interface circuitry. Self-contained. Just plug into mainframe, peripheral system, or what-have-you.



If you'd rather build: Buy the digitized stack only. This includes low level decode, sense amplifiers and drivers. But you have to add your own interface, timing, control, power supply and box.

Stack only: If you really want to build from the ground up, buy just the Nanostak (magnetics plus decode diodes). You still get nanosecond cycles, and the benefit of our design and memory construction experience. But you build drivers, decoders, sense amplifiers, control, interface, etc. to suit your own system.



**Nanomemory Specifications:**

**Speed:** 900 nsec. cycle (30 mil cores) 350 nsec. access. 650 nsec. cycle (20 mil cores) 300 nsec. access.

**Capacity:** 4, 8, or 16K 8 to 84 bits per word.

**Temperature:** +10°C to +40°C operating ambient.

**Power requirements:** 115 VAC ±10%, 60 cycle, 1600W (16K words of 70 bits)

**Size:** 19" RETMA rack-mounted (8-70 bit word length) 24" RETMA rack-mounted (8-84 bit word length) 16" rack depth 38" rack height (excluding power supply)

For full details write to: Dean Knutson

**electronic memories inc.**

Memory Cores, Stacks and Systems for Industry and Aerospace, 12621 Chadron Ave., Hawthorne, Calif.

As with START, the name associated with a CSECT is treated as if it had appeared in an ENTRY instruction. Unlike START, a CSECT must not have a value in the operand field. Each control section is assembled immediately after the previous one.

In a machine such as System/360, where it is common to have data remote from the instructions that operate on them, a means of defining relationships between data without specifying their actual location or reserving storage is needed. The instruction DSECT is provided to define a dummy control section. Each DSECT may be given a name, but no operand is permitted. Each one begins assembling at location zero. In practice most statements that appear in a DSECT will be DS as the purpose is to express relationships but not to generate instructions or data.

Within a CSECT or DSECT, the programmer may wish to alter the assignment of locations. To do this he uses an ORG (origin) instruction. No name is allowed and the operand must be a relocatable expression or blank. The assembler will commence assembling instructions at the location specified. If no expression appears, it will continue assignment at the highest location in the current control section. The relocatable expression must refer to a previous location in the current control section. The effective address must not be less than the lowest address in the control section. However, it can be greater than the highest address.

Normally the assembler collects literals in a pool (deleting exact duplicates) at the end of the first control section. If the programmer wishes them elsewhere he can use a LTORG (literal origin) instruction. Upon encountering a LTORG instruction the assembler will place all the literals in the literal pool at the current location of the current control section.

The programmer may not specify a location in the operand field of LTORG. The assembler begins a new literal pool after processing each LTORG.

The END statement is used to end an assembly. The first executable instruction may appear in the operand field.

The EQU instruction is used to assign a value to the symbol which is in the name field. The operand field may be an absolute or relocatable expression. Here are three examples:

```
F       EQU   X'F'
ENTRY   EQU   *+6
LOOP    EQU   LOOP3-LOOP1+2
```

The most important restriction is that any symbol in the operand field must have been previously defined in the assembly.

One of the largest sources of errors in System/360 coding is incorrect alignment on byte boundaries. A typical error is assembling data on an incorrect boundary, as in a word constant assembled on a half-word or byte boundary. In order to minimize these errors, the assembler checks addresses and adjusts the location of data and instructions. All assembled addresses are checked to insure that they are on a legal boundary for the instruction in which they appear.

```
S     6,LOCX    LOCX must be a full-word address
AD    6,LOCX    LOCX must be a double-word address
MH    6,LOCX    LOCX must be a half-word address
STC   6,LOCX    LOCX may be any address
```

Of course, these instructions may be modified by indexing or by other means so the error indications given by the assembly are only warnings. They do not prevent loading and attempted execution. Conversely, an instruction that looks correct to the assembler may be incorrectly modified.

The assembly program will arbitrarily round up the assignment counter to the next half-word boundary rather than assemble an instruction on a half-word boundary. For example, suppose a branch and link to a subroutine is executed with a character constant as an argument.

```
BAL   10,SUBR
DC    C'A'
LM    3,6,BOTTOM
```

The LM instruction will be assembled 2 bytes after the BAL. After the character constant 'A' there will be an unused byte.

| BAL instr. | A | Unused | LM |
|---|---|---|---|

Constants are automatically assembled on their natural boundaries: D type on a double word; E, F, and A on a word; H on a half word; and all others on any boundary. The programmer can override this rounding up for constants by specifying a length modifier for constants. For example, an address constant that requires only 3 bytes can be expressed by

```
DC    AL3(POINT23)
```

When the length is explicitly stated no rounding takes place. This may be used to force the assembler to place a constant on an unnatural boundary. A call to a subroutine might be written

```
BAL   10,SUBR
DC    AL4(PARAM)
```

An A-type address constant has an implied length of four. The BAL may be assembled on a half-word boundary. If the L4 were not specified, 2 bytes would be skipped.

At times it is necessary to have data or instructions on a particular boundary. The assembly instruction CNOP (conditional no operation) may insert NOPR (BCR,0,0) to force the assembly to assign the next instruction on a specified boundary. The operand field of a CNOP has two subfields. The first indicates the particular byte within the field of the size specified in the second subfield. The following are legal forms of CNOP:

```
CNOP   0,4   beginning of a word
CNOP   2,4   middle of a word
CNOP   0,8   beginning of a double word
CNOP   2,8   second half of a double word
CNOP   4,8   middle (third half word) of a double
             word
CNOP   6,8   fourth half word of a double word
```

There are also assembly instructions to format the assembly listing: TITLE puts heading information on each page, EJECT causes a skip to the next page, SPACE puts spaces in the listing, and PRINT allows some control over the amount printed on the listing. There are other instructions but they are more specialized.

The instructions USING and DROP are peculiar to System/360 and will be fully discussed in Chapter 3. Their purpose is to inform the assembler what general registers have been loaded with base addresses. The operand field of a USING instruction has a memory location followed by one or more general-register numbers.

```
USING   LOCXYZ,6,8
```

This indicates that the address LOCXYZ is in general register 6 and LOCXYZ + 4096 is in general register 8.

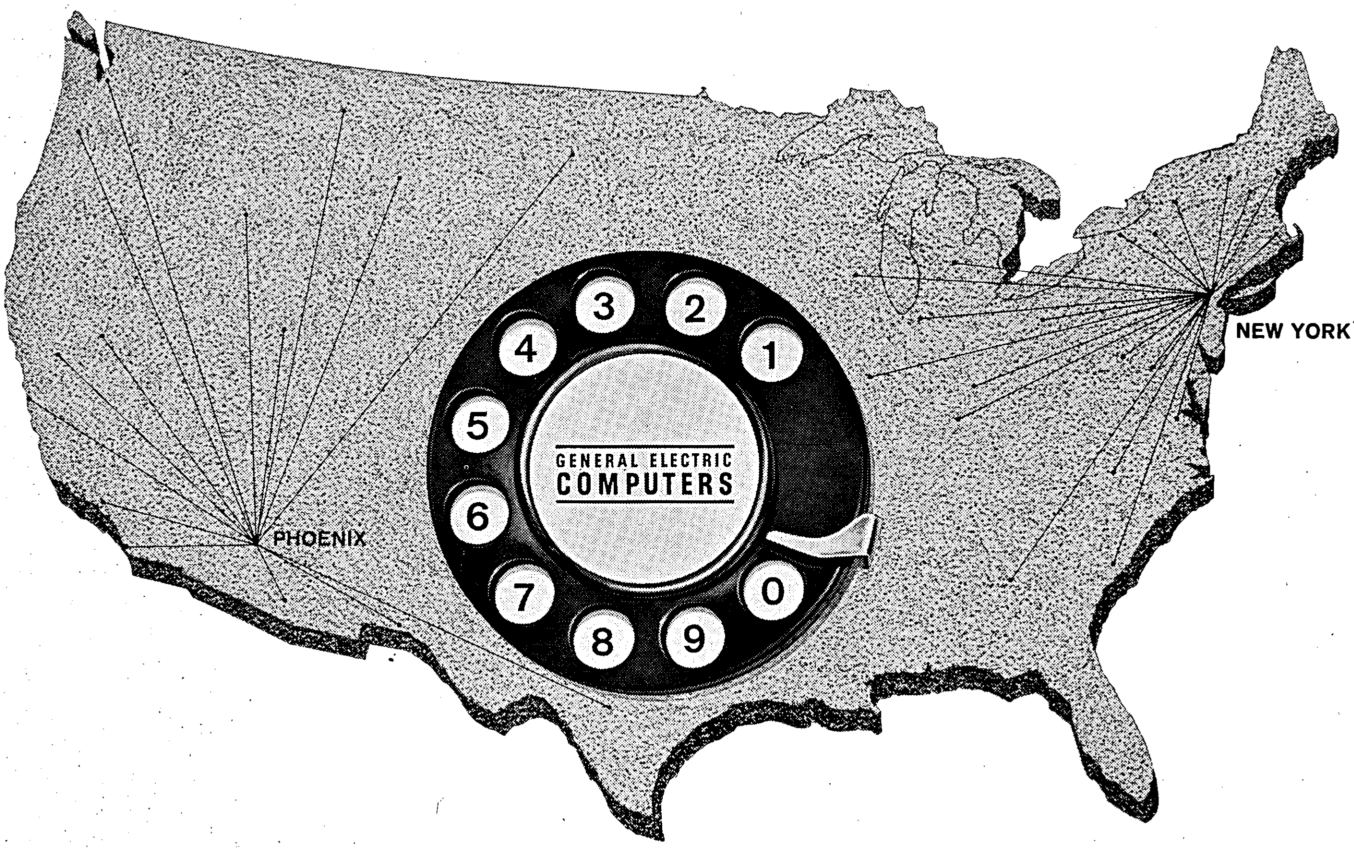
The programmer can override a USING by giving another USING for the same register. If the register is no longer available for use as a base register, a DROP for that register (or registers) is given. For example:

```
DROP   6,8
```

This indicates that registers 6 and 8 no longer contain LOCXYZ.

It must be noted that the USING instruction does not load the registers. It merely informs the assembler that they were loaded so that base-plus-displacement addresses can be created. ■

# Now dial G.E. for "instant computing"




## New service by General Electric's Information Processing Centers gives you direct access to a modern "time-sharing" computer system for as little as $350 per month

Wherever you're located, you can now have a direct line to a central computer system. All that's required is an inexpensive terminal device in your office or plant. Then you simply "talk" to the computer over an ordinary phone line. It's at your immediate command, whenever you need it.

**What is "time-sharing"?**

It's the next big step in electronic data processing—and General Electric is leading the way. Today's typical computer does its work one batch at a time. But G.E.'s new time-sharing systems are designed to utilize the total power of computers that perform thousands of additions or subtractions in a single second, so that they can be working on **many** jobs at the same time. As a result, each user receives such swift service he feels he's the **only** user—though a hundred or more other subscribers may also be using the computer.

**Who can benefit?**

Any business firm, scientific laboratory, engineering group, or school that occasionally needs the tremendous computing power of a system it could never afford to lease or own. Also: far-sighted companies that want to acquire practical experience before installing their own General Electric time-sharing systems.

**What does it cost?**

Only $350 per month, which entitles you to 25 hours of access to the computer (plus, of course, telephone toll charges and a modest installation and rental charge for the terminal device). Beyond that, you pay only for what you actually use, at a reduced rate.

**When will it be available?**

Right now from our New York and Phoenix Information Processing Centers. And we plan to make this new service available at other locations in the near future.

**Why don't you dial today for "instant computing"?**

Just phone your G-E Computer Representative for a hands-on demonstration of a General Electric time-sharing system. For complete details and a brochure explaining how easy it is, please write General Electric Computer Department, Section CPA-120-A, Phoenix, Ariz. 85023.

GENERAL ELECTRIC

CIRCLE 33 ON READER CARD

# NEWS BRIEFS

## WHAT WOULD HAPPEN IF THEY PULLED THE PLUG?

The night the lights went out over 80,000 square miles of the northeastern United States and parts of Canada, the worst did not happen. In New York, longest (up to 12 hours) and hardest hit, the crime rate was not much higher than usual, there were no mass auto or air crackups, and, according to computer manufacturers and users, not much damage was done to equipment or data.

The time of the blackout, around 5:30, was unfortunate for commuters but a lucky break for many computers, which were either being shut down for the night or lightly active because shifts were changing. Some programs had to be run again, but in only a few instances were files destroyed—two brokers reportedly had master tape files split.

The dollar loss will be measured primarily in loss of time. One service bureau operator noted that their loss of a day would be 5% of productivity for the month (a $200K/month bureau would lose say $10K—some of it recoverable by the great demand for computer time by users who had trouble getting their systems back up).

Many users didn't have insurance to cover losses. The common business interruption insurance only covers named perils, like fire or windstorm. What happens to rentals? IBM said a majority of its customers rent at 176 hours/month, so time lost could be made up. Univac said, "Our policy will be to consider the particular problem of each customer and work out an equitable agreement, treating each on a reasonable and business-like basis."

Computers came to the aid of stock brokers who were not getting ticker service the next day. Quotation systems of the New York and American Stock Exchanges and of commercial service firms came up on time, spouting information over the phone via voice-answer-back units and displays.

Computer back-up is no help without power, and many industries, like banks—which lost a full day in check-sort and clearance—are now considering buying auxiliary power units. Fortunately, Thursday was a holiday for NY banks and they spent it catching up.

Airline real-time systems had auxiliary back-up power. American Airlines' SABRE was down for almost three hours while engineers checked for damage, which was reported only in some circuit boards. Panamac of Pan-American was off for 30 minutes, also for a damage check. American noted that it takes a few minutes to go from standard to its diesel power, and at the time of the failure, the line was in the process of testing out battery power units which will in future effect a smooth transition from electrical to diesel power.

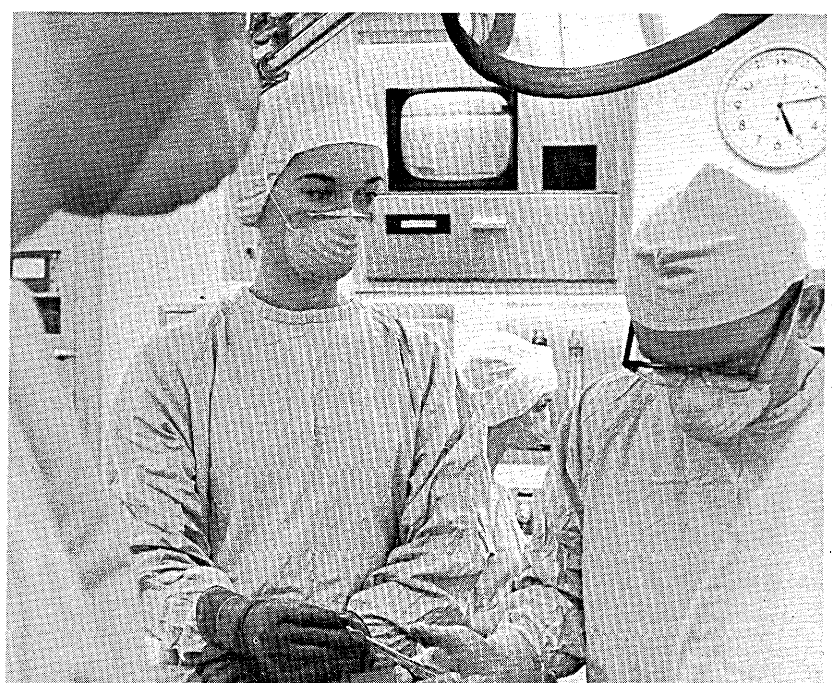
Automatic shut-off features on many systems, disc files with floating heads, and vacuum-controlled tape drives were among the factors which saved some installations from data loss. In other instances users reported that their customer engineers were on the

## MAYO CLINIC MONITOR WATCHES PATIENTS IN SURGERY

A surgical monitoring system displaying sudden physiological changes in a patient's condition has been developed jointly by the Mayo Clinic and IBM, with the first unit installed at St. Mary's Hospital in Rochester, Minn.

Key physiological changes, such as heart rate and respiration, are immediately sensed and displayed for the surgical team's information. The system also includes a means for automatic reading of electrocardiograms and electroencephalograms, with results displayed on a five-inch oscilloscope near the patient. A control unit in the operating room allows the anesthesiologist to select the combination of measurements of most interest at a given moment during the operation. For a permanent record, typewriter, magnetic tape, and paper tape output is provided.

A second operating room at St. Mary's will be hooked into the system at the end of the year and two others added later. Mayo physicians believe that the by-product library of medical data accumulated will be valuable for resident education.



spot to push the power-off button and pull back disc heads that could have crashed into the recording surfaces. Damage to some equipment was also prevented when the power fluctuations caused parity errors and a resultant machine hang-up. MIT said no damage was done at Project MAC and, besides, all their files were duplicated so any loss on discs would have been retrievable.

If anyone expected vacuum-tube computers to be the hardest hit, they were wrong, at least about heroic Whirlwind I at Wolf Research and Development in Massachusetts. The mammoth system felt the power failure before its operators did and automatically started to cycle down five minutes before everything went black. (To keep from running into some big vacuum tube, everyone went home).

The D-1000 at Honeywell EDP wasn't running; only three of the 20 computers at their various installations were. The worst that happened at Honeywell, we're told, was that 1000 fuses blew.

## ABA REPORTS PROGRESS IN BANKING AT BEMA SHOW

The automation committee of the American Bankers Association has been assigned a third major standardization program—the establishment of a universal customer identification system. This, said Dale Reistad at the BEMA annual convention in October, will be "our largest automation research program to date, and it will include a comprehensive study of the social security number and its applicability as a universal standard."

Reistad, director of automation of ABA, ticked off current major developments in computer use by the banking industry at BEMA's "look at the future" session. Along with customer identificationn and the MICR standards established in 1959, banks are also developing a "discrete identification number and description for securities" to be used by all organizations handling and processing securities. This project will be handled by the Procedures Committee on Uniform Security Identification.

Between 800 and 1,000 computers are installed in banks today, he said. Among new trends in edp are the use of central information files to develop a single record on each bank customer. The Bank of Delaware is conducting tests in this area, with an eye toward permitting customers to pay their bills by transmitting cash transfer data over a touch-tone phone.

The bank of tomorrow, he noted, is

here today, but not completely assembled in one bank. For example there is the automated customer service of Mellon National Bank in Pittsburgh and the Bank of America. Telecommunications for servicing remote locations are underway at United California Bank in L.A. and the First Bank Stock Corp. in Minneapolis. Bankers Trust Co. and Chase Manhattan in New York are active in operations research, and credit card plans for a "steady stream of consumer credit" are at the Bank of America, Valley National Bank, and First National City Bank.

### WESTERN UNION VS. BELL ON RECORD SERVICE RATES

Western Union contends that Bell competition in the communications record field is supported by monopoly operations in the voice field, and should not be if competition is to be maintained. With this stand, WU has notified the Federal Communications Commission that it intends to intervene in the FCC's investigation into the "lawfullness of the rate structures and rate levels of interstate services provided by the Bell System in the voice and record fields."

The FCC had said in ordering the investigation that "to the extent that these (record) services may be underpriced by the Bell System, this may have a competitive impact on other carriers." That Bell record services are subsidized, says WU, is borne out by a study made by AT&T at the FCC's request which shows that while toll telephone service was earning at a rate of 10% return after taxes, TWX showed 2.9%, Private Line Telegraph 1.4% and TELPAK 0.3%.

### BEMA MEMBERS GET SECOND INVITATION FROM GSA

GSA and the Department of Commerce have issued a joint letter to edp manufacturers and government computer users asking their opinion on the possible implementation of ASCII code as part of government purchase specifications starting in fiscal year 1967, Gordon Osborn of the Budget Bureau told the BEMA Data Processing Group at a general meeting during the association's annual conference.

The government only received four replies when it asked BEMA members to make suggestions on government selection and procurement procedures, Osborn regretfully noted to the handful in attendance. He reissued the invitation to comment on procedures, as well as ASCII, and admonished the manufacturers not to complain if they don't take the opportunity to speak up.

Reporting on government efforts to improve procurement and standards efforts, Osborn said GSA is collecting information on the performance of companies in meeting delivery dates, quality of equipment, etc., and will be sharing this information with all agencies. GSA has established procurement procedures with a special emphasis on software, and the Bureau of Standards is trying to develop criteria for measuring compiler performance in order to make objective tests. The government is extremely interested in working with industry to develop such standards, he said, and is especially pleased by the data elements and codes standardization effort of the BEMA group.

Osborn also noted that BuBud has joined with other agencies in research in such areas as the decision-making processes in agencies. For example, information handling in foreign affairs agencies involves 125 million pieces of paper a year, and better ways of handling them need to be figured out, he said.

### HONEYWELL JOINS IN WITH PRICE CHANGES

In the wake of IBM's price overhaul, based on the notion that computers are now immortal, Honeywell has announced changes in its rental and purchase policies for the 200 series.

Purpose of the changes is to make "longer-term rental and outright purchase" more attractive. Four types of purchase plans are offered, depending on the length of rental preceding the purchase. An example of the best deal—immediate purchase—is a saving of some $22,500 on an H-200 going for $300,000 before the change. Some other versions: if the machine has been leased for six months, the buyer gets a proportionate discount plus credit for 100% of rent paid; after 12 months, he would get the same discount plus 80% of rental fees paid: from one to two years, the buyer gets a 60% rental credit but no discount.

Honeywell has also changed lease rates to make four and five-year plans more inviting. For one-year agreements, the rate goes up but the user gets 200 hours instead of 176, resulting in lower hourly costs for most systems.

● The first IBM 360 system has been installed in Japan. A 65K-character Mod 40 has gone to the Tokai Bank of Nagoya for demand-deposit and general accounting. A Mod 30 will also be installed at the bank in Decem-


PhD-170

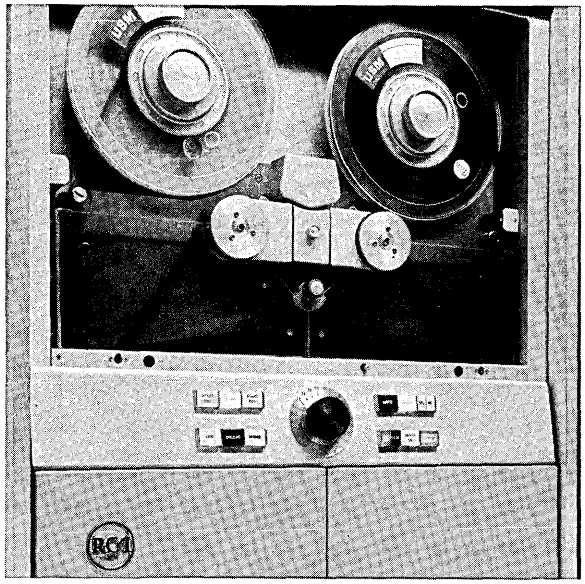
ber. Although the first systems for Japan are being manufactured in Poughkeepsie, N.Y., in mid-1966 IBM-Japan's plant in Tokyo will begin producing 360's for the Asia-Pacific market.

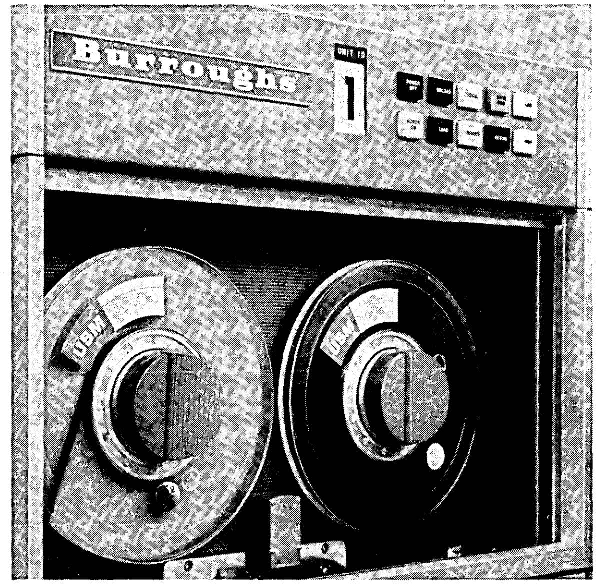
● Cornell University has established an intercollege department of computer science for the colleges of engineering and arts and sciences, chaired by Juris Hartmanis. The new department has a faculty of seven and is authorized to grant the MS and PhD degrees in computer science. The Alfred P. Sloan Foundation has awarded the university a grant of $1 million to help in founding the program.

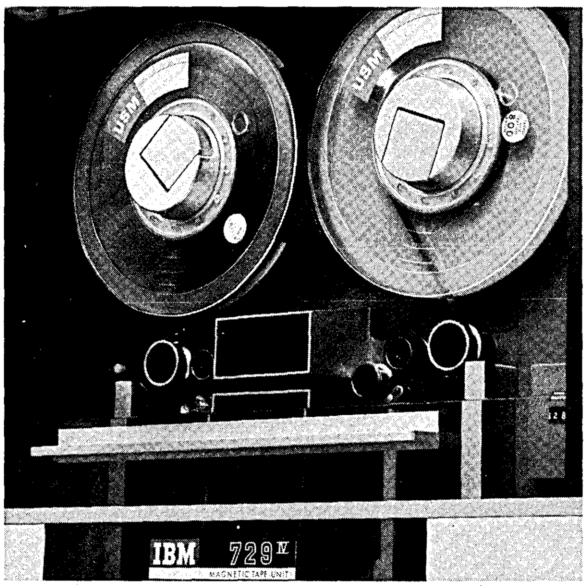
● The second of the strike-rattled New York City newspapers is going to a business computer—but only for general accounting. The New York Times will get an H-200 by mid-1966 for such functions as accounting on its vast advertising (67.7 million lines in 1964), payroll and records on more than 5,000 employees, and subscription fulfillment. The 200 will have a 24K-character cpu, four tape units, 950 lpm printer, card reader and punch and a console typewriter. Random access devices will be added later.

● To catch a thief, New York State Police will be using a Univac 418 switching system come March, 1966. One hundred forty-six state police, municipal, and sheriffs' stations will have Teletypes on-line to the 418. The primary function will be storage of registration numbers of stolen cars and license plates. Within 60 seconds, troopers will be able to call in numbers of suspicious cars and receive an answer. The configuration consists of a 16K-word memory, communications system, and 22 megacharacter Fastrand store.

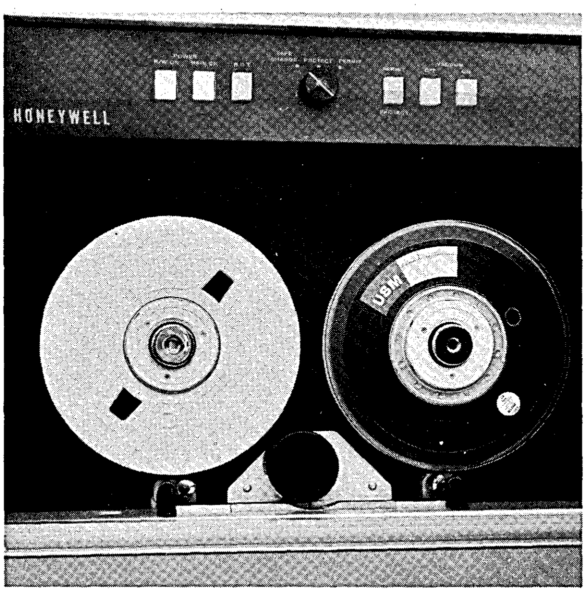
● An IBM Zone Order Processing System is making it possible for American Motors to ship out parts to any of its 3,000 dealers the same day the order is received. The heart of the system, a 1440, is located at the central parts plant in Milwaukee, Wisc. Every 15 minutes, the cpu queries the 24 zone locations for orders, which are transmitted via a 1050 terminal; it then prices the parts, sets up accounts receivable, stores invoicing information, and prints out the list at the appropriate shipping location. Previously, using mail and telephone, the order time was up to a week.

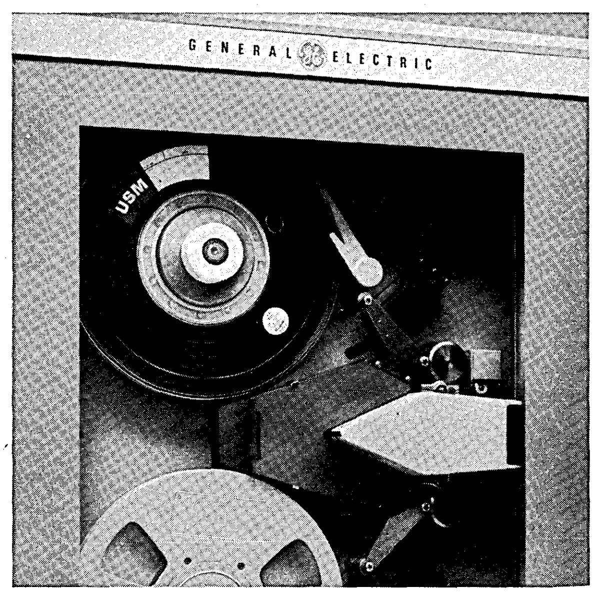


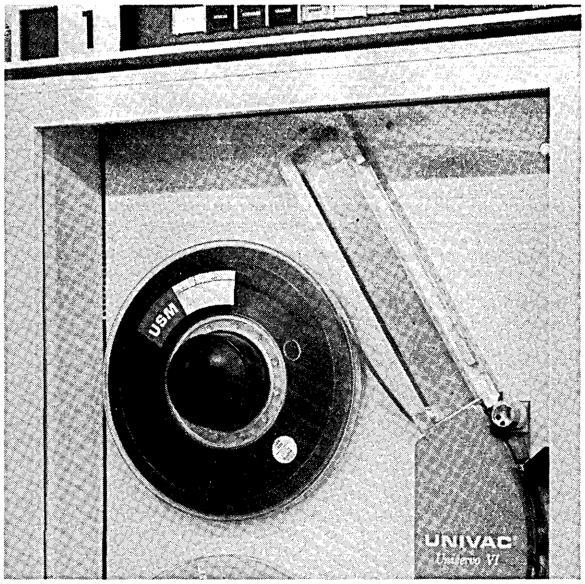




# Look familiar?







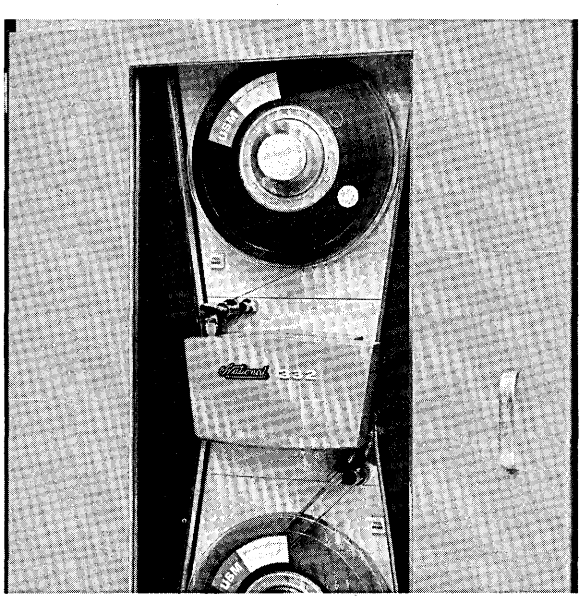
# It should.
# U.S. TAPE
# is a <u>natural</u> for compatible systems like these!

U. S. Tape performs superbly on **any** IBM compatible system. That's why it's the best digital tape you can buy for systems built by Burroughs, CDC, GE, Honeywell, IBM, NCR, RCA and Univac (solid state). U. S. Tape performance is supported by a 90-day life guarantee, a 200-pass guarantee and a 3-year warranty. See for yourself how this outstanding tape lasts longer, assures more profitable computer operation. Write for our test-it-yourself folder.

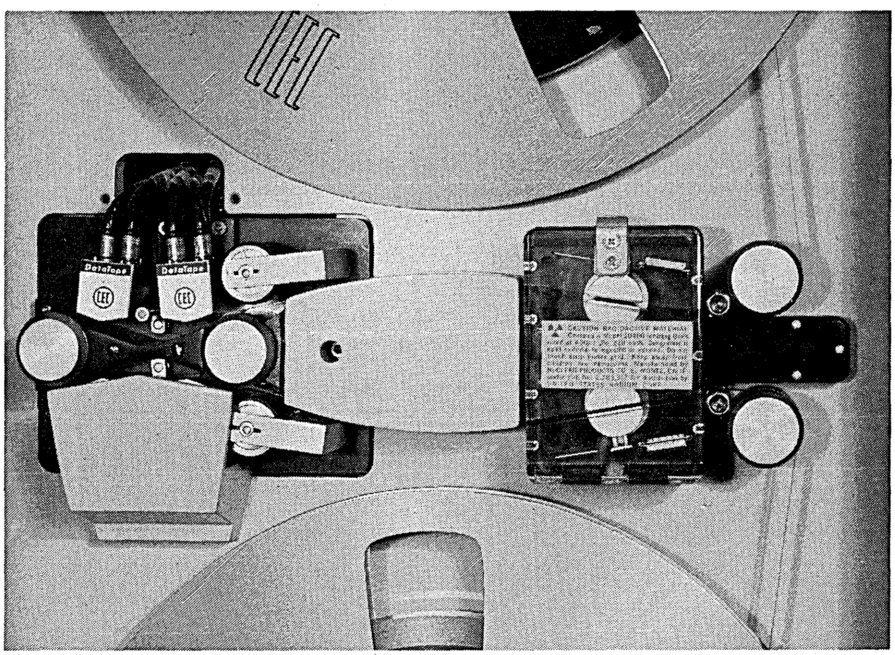
US TAPE

**U. S. MAGNETIC TAPE COMPANY**
*A Subsidiary of Wabash Magnetics, Inc.*
**HUNTLEY, ILLINOIS 60142**

CIRCLE 40 ON READER CARD



# CEC's VR-3600 establishes new record for head life



It is not news that the VR-3600 is the most advanced of all magnetic tape recorder/reproducers. This has been proved in countless telemetry and laboratory applications. But what *is* news, is the remarkable durability of the instrument's recording heads.

All reports have shown that CEC's head life guarantee of 1000 hours is not only realistic but very conservative, since in virtually every case the new recording heads have surpassed this figure with little sign of wear. Compare the 1000 hour achievement with the performance of the VR-3600's closest competitor, and the savings to the user become significant indeed.

Reason behind the performance: these CEC recording heads are of a unique material and solid metal pole-tip design which completely eliminates the weaknesses of conventional head lamination or other solid-tip designs.

Result: a head that both provides superior performance at frequencies to 1.5 mc and reduces head wear and cleaning to a minimum.

*Other advantages of the VR-3600 include...*

1 **Bandwidth switchability.** With a mere flick of a switch, the operator may instantly change from wideband to narrow band, and back again — thus *doubling* the unit's capability with *no change* of components required. (On special order.)

2 **Constant flux recording** for assured machine-to-machine compatibility at all frequencies and tape speeds (with IRIG standards).

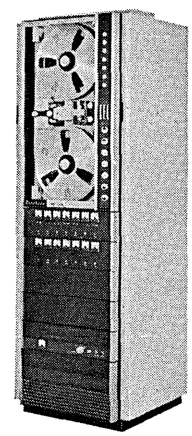
3 **Six speed switchable video FM** — d-c to 500 kc.

4 **Single source responsibility.** All components are designed and manufactured by CEC...including the video FM!

*Important features:*

- Pushbutton selection of *six* transport speeds along with associated electronics.
- Each of the VR-3600's 7 or 14 record/reproduce channels can be used for data storage in the 400 cps to 1.5 mc or d-c to 500 kc frequency range.
- Automatic end-of-reel sensing stops tape without leaders; transfer switch provides start command for nearby recorder and 30 second overlap of recorded data between machines — at no extra cost.
- IRIG or 18.24 kc AM servo system or time expansion/contraction servo system using common assemblies mean low cost for any version or combination of servo systems.
- Tape is constantly cleaned by optional vacuum/ionization; tension controlled, in all modes, by closed-loop servo control.
- Individual plug-in equalizers (6 per amplifier) meet all specifications simultaneously. Buy only those required, then set and forget.
- Record and reproduce amplifiers are solid state; the direct system fully amplitude- and phase-equalized.
- Tape transport skew is less than 0.5 μsec; complete cumulative flutter less than 0.30% p-p at 120 ips.
- The system may be supplied in single or dual rack configurations, with or without a dolly.

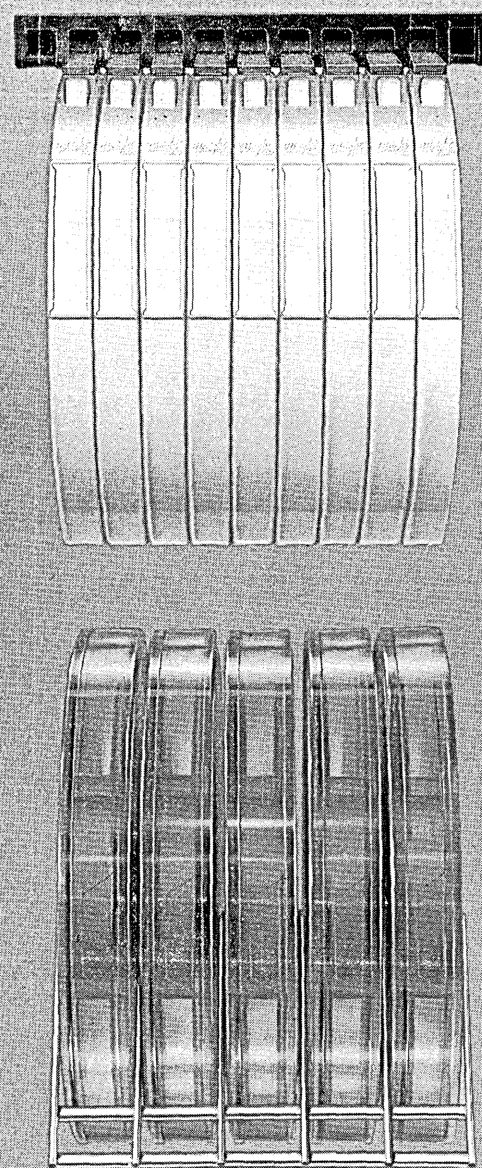
For *all* the facts about the VR-3600, call CEC or write for Bulletin 3600-X22.



CEC
Data Recorders Division
CONSOLIDATED ELECTRODYNAMICS
A SUBSIDIARY OF BELL & HOWELL/PASADENA, CALIF. 91109
INTERNATIONAL SUBSIDIARIES: WOKING, SURREY, ENGLAND AND FRIEDBERG (HESSEN), W. GERMANY

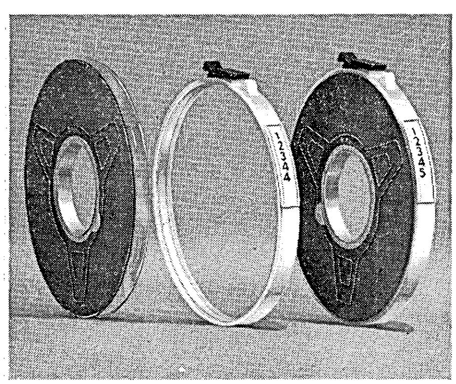
# You can store nine tapes in TAPE-SEAL™ Belts

# in the same space you now store five tapes in canisters.



## How's that for increased storage capacity?

With the Tape-Seal Computer Tape Storage System*, you use unique new polyethylene belts that hang in storage rather than sit between space-wasting wire supports. You store nine of them in the space five canisters fill. In Tape-Seal Cabinets, the ratio becomes 200 to 96, with no increase in floor space. And the tapes are better protected, easier to handle, and more conveniently labelled.



The Tape-Seal System is the only complete tape storage system available today. We'd like to tell you about it soon. Write now for a free demonstration in your office. We bet you nine to five you'll go for the Tape-Seal System — and start increasing storage capacity and saving space.
(When you order new tapes, insist that they be shipped without canisters. Buy Tape-Seal Belts and save.)

*Patents Pending

*Wright* LINE DATA PROCESSING ACCESSORIES

170 GOLD STAR BOULEVARD, WORCESTER, MASS. 01606

A division of Barry Wright Corporation BW

CIRCLE 35 ON READER CARD

# DPMA FALL CONFERENCE

"More memory, rather than dynamic relocation, is the way to time-share," according to Dr. Fred P. Brooks, architect of the 360's. And an attempt to prove this to skeptics will be made at the Univ. of North Carolina, said Brooks, who is now chairman of the Dept. of Information Science there.

Speaking at the fall conference of the Data Processing Management Assn. in Dallas, Brooks was one of four members of the Technology Panel with which the conference opened. Others were Drs. J. Presper Eckert of Univac, John Mauchly of Mauchly Associates, and John W. Weil of GE's Computer Dept.

The conference, which drew almost 800 registrants, was a credit to the association, to conference chairman Jack Taylor and his staff. Generally considered to be the organization's third fall conference, it was actually only the first that had the advantage of a full year's planning. "The program and papers are better than what we had in Philadelphia," a registrant commented, referring to DPMA's big annual meeting. "And that was good, too." The success of this conference virtually guarantees the continuation by DPMA of two annual meetings; next fall, it's in Los Angeles.

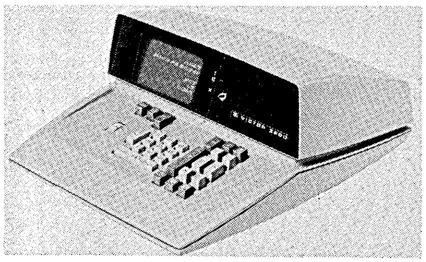
In contrast to the Joint Computer Conferences, the DPMA meetings are more specifically oriented to their audience — vertically by industry and horizontally by functions. In addition, general sessions covered Innovations in Input/Output, Computer Communications, and Graphic DP — topics that for a convention of this size drew surprising numbers.

The increasing sophistication of DPMA members in the latest technology was evident at the opening session. GE's John Weil, speaking on the Impact of Time-Sharing Systems, asked for a show of hands: "How many in the audience have a remote terminal or computer in their homes? Seven hands went up. Weil suggested that this question be asked each year to see how the number increases. Any guesses?

# NEW PRODUCTS

## electronic calculator

The 3900 has integrated circuits and a 4 x 2½-inch illuminated screen for the display of the contents of two storage registers holding running totals (or constants for repeated use) and three calculating registers. The



25-pound unit also features automatic truncation of answers and up to 15-place accuracy. Registers hold up to 20-digit numbers. VICTOR COMPTOMETER CORP., Chicago, Ill. For information:

CIRCLE 130 ON READER CARD

## communications recorder

The 1103 is an 1101 source document-to-mag tape recorder with circuitry adapted for remote tape-tape transmission. It uses standard modems, provides asynchronous operation at up to 1200 bps on standard commercial circuits, and uses half-inch tape NRZ recording. (See Apr. 1965, for 1101 description.) MOHAWK DATA SCIENCES, Herkimer, N.Y. For information:

CIRCLE 131 ON READER CARD

## core memory systems

The series of SEL core memory systems, which use silicon monolithic integrated circuits, have storage capacities of from 128-8129 words per unit and cycle times of 1.50 to 1.75 usec. Access time for read or read/restore is 600 nsec. Addressing methods available are random access, sequential, sequential/interlace and combinations of these. Options include special I/O voltage levels, split cycle capability, automatic worst-case pattern test, up-down address counting, bcd address, parity check and alarm, and interface logic for different data levels. SYSTEMS ENGINEERING LABORATORIES, INC., Ft. Lauderdale, Fla. For information:

CIRCLE 132 ON READER CARD

## line printers

Three additions for the 315 computer family have 132-position typeline and operate at up to 1,000 lpm. Models are buffered, unbuffered, and one that's buffered and wired for a six-tape lister attachment. The latter, when listing with a master and one slave tape, operates at up to 2,000 lpm numeric. NATIONAL CASH REGISTER CO., Dayton, Ohio. For information:

CIRCLE 133 ON READER CARD

## card punch

The Speedpunch 120 is a serial unit that punches pre-coded data from a processor or accepts data serially from a control unit, and punches column by column at 160 columns per second, or 100 cards/minute if all 80 columns are used. There's also a card eject feature. Capacity of the input and output hoppers is 1,000 cards. UPTIME CORP., Golden, Colo. For information:

CIRCLE 134 ON READER CARD

## display terminals

The 700 series consists of three CRT/keyboard units for basic information retrieval; I.R. with editing capabilities; and a model with vector capability and lightpen editing. The display and keyboard can be integrated or separate, with two keyboards serving one display. The latter duplicates a vertical 8½ x 11-inch printed page

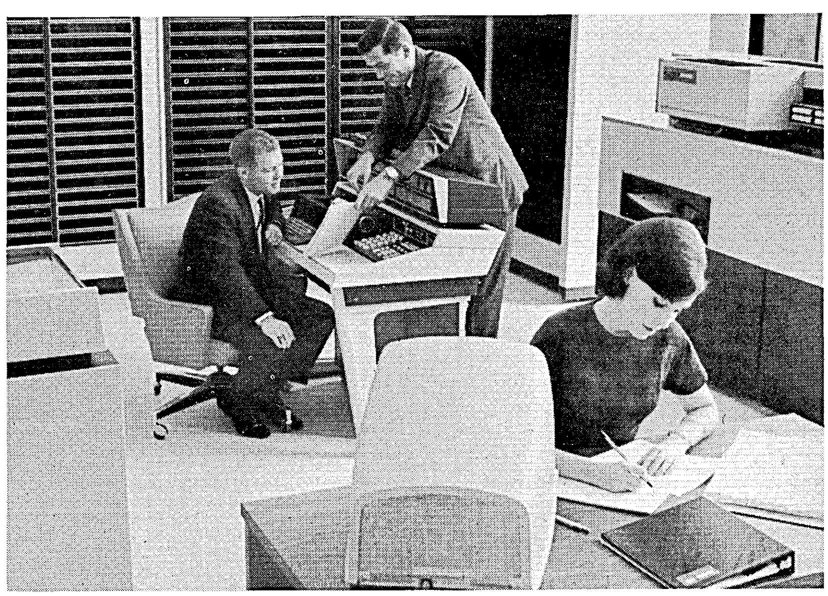
## PRODUCT OF THE MONTH

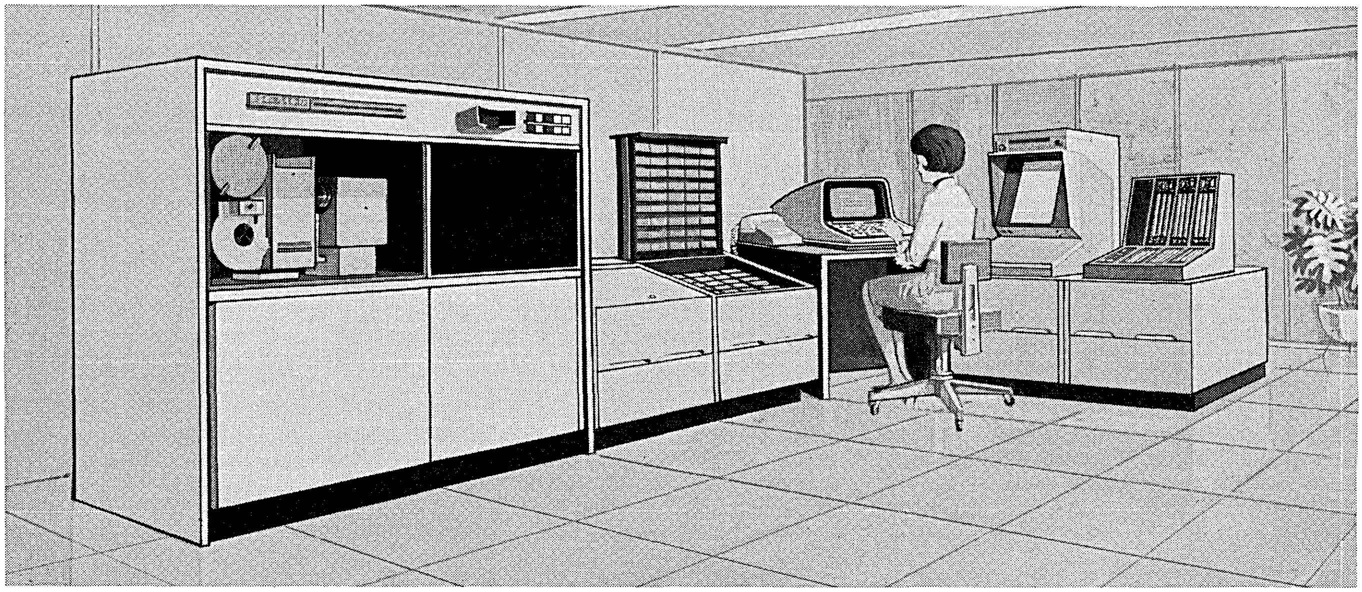
The 3300 and 3500 are time-sharing computers, the latest additions to the 3000 series. Core memory is expandable from 8K to 262K (24-bit) words, and cycle times are 1.25 and .80 usec, respectively. Respective access times are .75 and .40 usec. In addition to word and character-addressing capability, the memory is partitioned into 2K-word "pages;" each page, in turn, is divided into four sections.

Other features include dynamic relocation for multiprogramming, up to eight I/O channels, program protection, and interrupt for storage parity errors, illegal write interrupt to increase program protection, and an executive interrupt. Other capabilities are address modification, indirect addressing, and masked storage search.

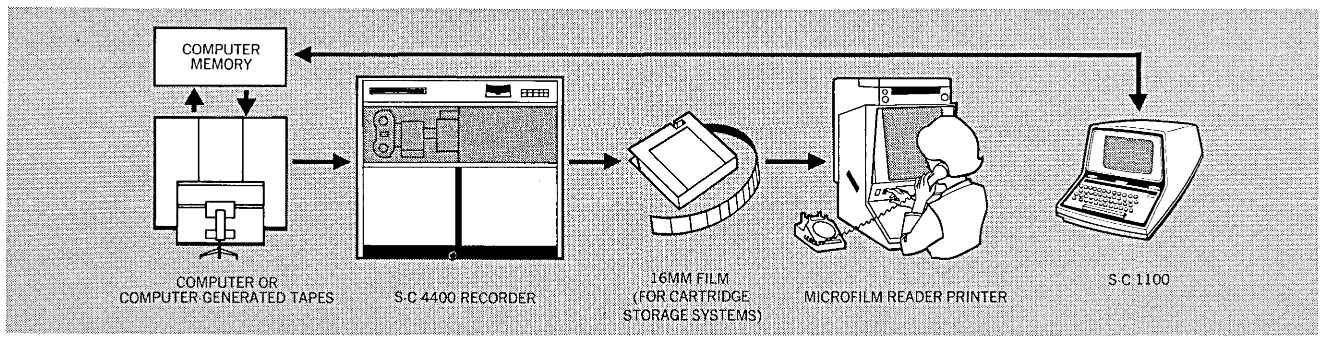
Software includes COBOL, a time-sharing executive, batch-processing operating system, and a mass storage controller. CONTROL DATA CORP., Minneapolis, Minn. For information:

CIRCLE 135 ON READER CARD





# Be the first to install the most practical high speed data storage and retrieval system!




Study the diagram above for a moment—the system it represents can save you thousands of dollars a month by eliminating costly steps in retrieving and adding to stored data.

The elements all exist today. Each piece of hardware has been *proven* in actual operation. Actually, this is a *triple data storage system.*

*PART I.* For storage of semi-permanent and permanent records, the S-C 4400 Document Recorder converts computer output into ordinary language and records it directly on 16mm or 35mm microfilm.

*PART II.* Modern microfilm storage and retrieval systems, such as Recordak's MIRACODE system, can retrieve one film record out of a million in 15 seconds and display it on a reader/printer.

*PART III.* New data entries which have not yet been recorded on microfilm can be stored in the computer memory. The S-C 1100 Inquiry Display System makes possible instantaneous retrieval and display of data from the computer memory. Operators can also *add* data to the stored record automatically, thus assuring up-to-the-minute accuracy of information. Over 400 of these desk-top units may be used to work with a centralized data system.

Stromberg-Carlson believes this *triple data storage system* is the fastest, most practical in the world for high-speed data handling.

Insurance companies, banks, utilities, airlines or other organizations which must store a large volume of computer-generated data (or add to it) can achieve multiple benefits from this system. These include: increase of computer efficiency, elimination of costly business forms inventory, paper copies, and magnetic tape (when S-C 4400 is operated on-line with the computer), better budget and inventory control, reduction in external and internal telephoning, manpower savings, greater personnel efficiency and better morale because of faster availability of stored information.

You can have these benefits by adding a triple data storage system to an existing EDP installation. When you install a third generation computer, the system will work equally well with your new equipment.

For details write: Stromberg-Carlson Corporation, Data Products Division, Dept. F-47, Post Office Box 2449, San Diego, California 92112.

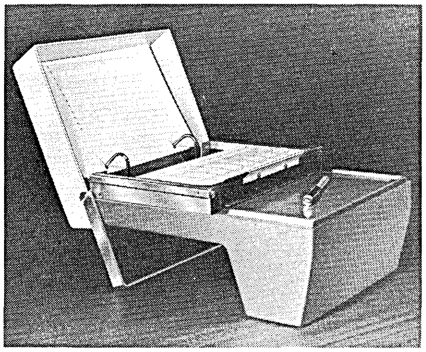
**STROMBERG-CARLSON**
CORPORATION
DATA PRODUCTS-SAN DIEGO

with a capacity of 1,000 characters. SANDERS ASSOCIATES INC., Nashua, New Hampshire. For information:

CIRCLE 136 ON READER CARD

### portable punch

The Record-A-Punch is a 30-ounce punch-card carrier equipped with a stylus for manual punching and an



overlay (for each application) which directs the user to the right position. Forty-column cards are used. MARKETSCOPE SYSTEMS DIVISION, New York, N.Y. For information:

CIRCLE 137 ON READER CARD

### elevated flooring

Improved design access system obviates use of supporting stringers. It features a solid core with integral side channels of steel; panels are of particle board core encased in steel. Pedestal head assembly is self-adjusting for desired height. Floor covering is optional. INFIN-AC DIV., D. B. FRAMPTON & CO., Columbus, Ohio. For information:

CIRCLE 138 ON READER CARD

### tape certifiers

Two off-line units are the 680 for 7- and 9-track and full-width testing of ½-inch tapes, and the 685 for 16-track, 1-inch tapes. In one pass, these devices detect dropout, noise, average amplitude, and dynamic skew errors. Channel location of flaws is indicated, and tape motion can be stopped on bad spots for microscope viewing and manual removal of non-permanent flaws. These units do not replace the 690, which is a 7-track, ½-inch model. CONTROL DATA CORP., Minneapolis, Minn. For information:

CIRCLE 139 ON READER CARD

### paper handler

The document processing system operates with a line printer to prepare reports without folds and perforated edges. It consists of a document converter that trims the paper and a feeder that supplies to the printer rolled (not folded) paper. Feed rate is 200 feet/minute. Controlled by program cards that are inserted into a slot, the document converter prepares documents in widths from 4¾ to 20 inches, up to 31 inches long. Deliveries begin first quarter of '66. IBM SUPPLIES DIV., Princeton, N.J. For information:

CIRCLE 140 ON READER CARD

### data collection

The 990 system consists of a central recording console, which punches time and data into tape, and pairs of transmitting stations. Applications are payroll processing and job costing. As many as 40 pairs of transmitters can operate with a console. Used is a notched key to represent an employee ID or job number; insertion of the key causes capture of that number, plus time-registry and other coded information. ADDO-X INC., New York, N.Y. For information:

CIRCLE 141 ON READER CARD

### serial printer

The 750 serial entry printer receives and prints alphanumeric data at up to 75 cps. The solid-state printer can be used on- or off-line with card, punched tape, and magnetic tape devices, and features interface flexibility, fully buffered input, and remote or local control. It accommodates roll paper up to 50 inches wide. THE BRISTOL COMPANY, Waterbury, Conn. For information:

CIRCLE 142 ON READER CARD

### paper tape reader

The Model 1402 reads serially-generated 5-level Teleprinter code from chad or chadless tape. There's a choice of two speeds in the range of 60 to 400 wpm, and dual readers arrange for automatic changeover at end of tape. The reader may operate free-running or stepped from external sources. FREDERICK ELECTRONICS CORP., Frederick, Md. For information:

CIRCLE 143 ON RDADER CARD

### document reader

The Series III reader is a multifont optical character reader that handles intermixed forms at 400 documents/minute. Among fonts read are the Farrington 12F and 7B, the ABA's font for OCR, and the IBM 1428. Featured is an infra-red technique which permits reading documents with overstamped or otherwise obscure printing. FARRINGTON MANUFACTURING CO., New York, N.Y. For information:

CIRCLE 144 ON READER CARD

# Walter Brunner on large-scale hybrid computation and the EAI® 8900

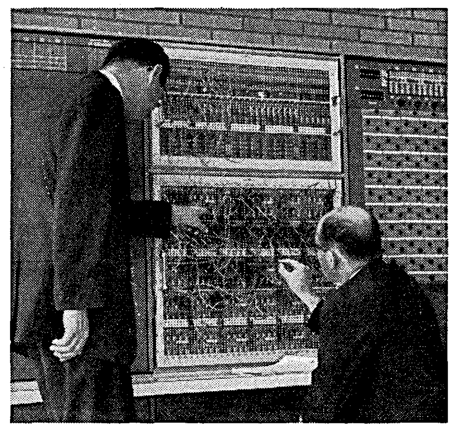
Walter Brunner has been with Electronic Associates' Princeton Computation Center for the past eleven years and has been director of the Center since 1961. During this period, he has helped solve hundreds of customer problems covering the complete spectrum of simulation applications. Walter was among the first laboratory managers responsible for tying an analog and digital computer together, as the Princeton Computation Center began operating its first hybrid computer in the fall of 1961. In the spring of 1964, the Center expanded its capability with the EAI HYDAC® 2400, the first integrated hybrid computer available. Since the initial hybrid installation, Walter and his staff have continually worked with hybrid problems from many areas of application. Throughout this period, he has made this experience available to the design team working on the newest EAI hybrid computer, the EAI 8900 Scientific Computing System. As a member of the 8900 Product Team, Walter's direct experience as manager of a large simulation laboratory has played an important part in the definition of this new system. A few of the more important criteria he recommended to the design team are presented on these pages—followed by the 8900 design features.

WALTER BRUNNER: *"At the Princeton Computation Center we must provide computational services that will attract and satisfy our customers in the same manner as other simulation laboratories. Although a large scale hybrid computer may be justified by one important program, every lab manager wants to obtain the most efficient utilization of his equipment possible. As the capital investment in a computing system grows, the economics of fast problem turnaround become increasingly important. In addition, equipment utilization is substantially improved by being able to use the digital computer portion of a large-scale hybrid system on background jobs whenever it is not processing data for hybrid problems."*

**EAI 8900 Hybrid Computing System:**
The EAI 8900 is a large-scale hybrid computer designed as a fully-integrated, standard system of hardware and software. It consists of an EAI 8800 Analog Computing System, an EAI 8400 Digital Computing System and an EAI Control and Data Interface System. This equipment and each of its major elements has been designed for efficient, practical, and productive hybrid computing.

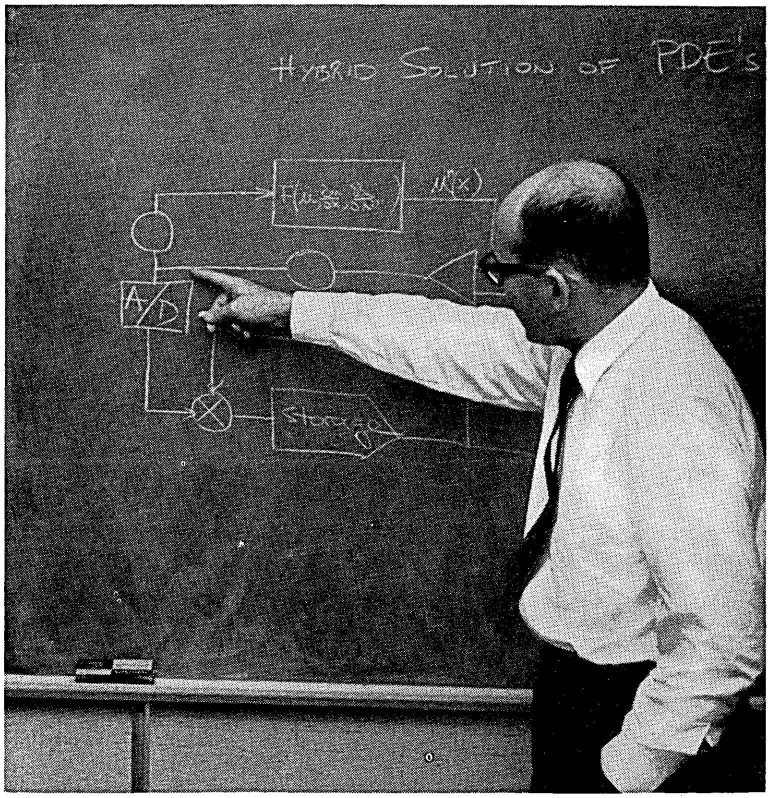
8900 DESIGN. The EAI 8900 Scientific Computing System was designed to permit rapid and efficient problem changeover. Also, the system's multi-programming capability enables operation of the digital processsor on hybrid or background programs at all times.

Rapid program changeover is accomplished by the fast problem set-up, check-out, and efficient operate time control made possible by the HYTRAN sm Operations Interpreter. Complete set-up instructions can be written in simple mnemonic language for off-line tape or card preparation. The HYTRAN program is then used to calculate a check solution which is used by the digital computer to run the static check, compare the analog outputs to the check solution, and diagnose any discrepancies for component or programmer error. Once the information is in the computer, the programmer

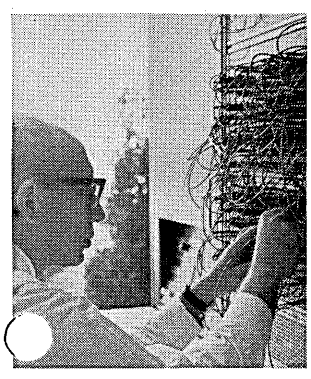


may make any desired modification to the analog program by simple typewriter entry. Further, a new static check solution incorporating these changes, can be obtained at any time. For operating control, the Operations Interpreter facilitates changing problem parameters by mnemonic addressing. A parameter that affects a number of pot settings may be varied by keyboard command which will result in the calculation and setting of all appropriate potentiometer coefficients.

The 8900 multi-programming capability allows the digital computer to work on background jobs when it is not computing as part of the hybrid program. Both hybrid and background programs reside in core memory, with background work being processed whenever the hybrid program routines are not in operation. To insure against interference from the background processing, the hybrid program storage is provided with memory protect. Priority interrupts permit immediate servicing of hybrid computing tasks in a preassigned order. As background programs are completed, readout and loading of new programs is done automatically under control of the resident monitor.




BRUNNER. *"Today's problems are increasingly complex, and the time available for their solution is decreasing. Computational speeds have to be fast enough so that design studies that used to be run in real-time because of accuracy requirements, can now be done at much higher speeds in repetitive operation. There is also a need to handle the high frequencies involved in shock situations, statistical studies and iterative boundary-value problems. Because of these requirements, the dynamic performance of hybrid systems becomes increasingly important."*



8900 DESIGN. The 8900 has excellent dynamic characteristics. The EAI 8800 Analog Computer has been designed with components directly behind the patch panel and maximum shielding to enable high accuracy 100-volt operation with component bandwidths of 125kc and higher. The 2mc parallel synchronous logic provides the extra time resolution which is essential with the higher frequency analog signals.

The EAI 8400 Digital Computer is equipped with extremely fast floating-point arithmetic and an extensive command repertoire ideally suited to efficient, high-speed FORTRAN execution. Data from conversion equipment can be processed directly by floating-point commands with no loss in speed since the conversion from fixed point to floating point format is accomplished by an EAI hardware design innovation.

The data conversion system with its 65kc analog-to-digital word rate is among the fastest available. Coupled with high-speed sample and hold amplifiers, double buffered digital-to-analog converters and the choice of random access, sequential or "burst" modes of operation, the conversion package meets the stringent system requirements for speed and synchronization. Conversion equipment is controlled from the digital computer, with timing provided optionally from the 2mc patchable logic.

*Mr. Brunner will review additional aspects of hybrid computation in a succeeding issue. A complete text of his remarks and the supporting dissertation on the EAI 8900 Scientific Computing System are available on request.*

## EAI 8900 Scientific Computing System Characteristics

**The EAI 8800 Analog Computer**
60-integrator capacity
125kc bandwidth
2mc synchronous logic

**The EAI 8900 Interface**
32x32 expandable to 128x128 conversion channel capacity
65kc analog-to-digital word rate
Single or double-buffered digital-to-analog channels
Sample and hold multiplexed analog-to-digital channels
Expandable interrupts, function lines, and status lines terminated on the logic patch panel

**The EAI 8400 Digital Computer**
32-bit word length plus 2 executive bits
5.5-7.0 $\mu$sec floating point multiply
64K memory capacity
7 hardware index registers

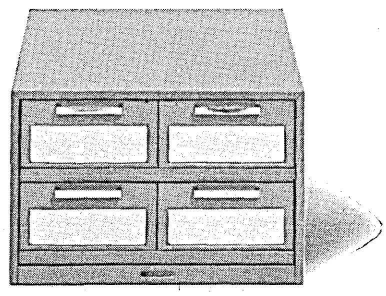
**The EAI 8900 Software**
FORTRAN IV
Macro Assembler
SPECTRE Debug System
Monitor and Real Time Scheduler
HYTRAN sm simulation Language
HYTRAN Operations Interpreter
Function Generation Programs
Numerical Integration Programs
Analog Control and Readout Programs

sm Service Mark of Electronic Associates, Inc.

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

CIRCLE 46 ON READER CARD

# A four-tray card file?



## So who needs it?

Not too many people. But we're the only manufacturer of data processing auxiliaries who seems to care about them. Most Datacase users get along just fine with our high-capacity 20- and 10-tray files for general use and with our two- and one-tray models for handy desk-top reference. But, there *are* those who require something in between and would be mighty put out if our four-tray file weren't available. Perhaps *you* don't need one but the fact that it's there is assurance that your requirements can be satisfied by the complete Datacase line—a line that is completely coordinated in style, color and function with the equally broad line of Steelcase fine office furniture. Your *local* Steelcase dealer will be happy to help with any of your office furniture or DP auxiliary storage needs—even a four-tray file. You'll find him listed in the Yellow Pages. Or write Dept. D, Steelcase Inc., Grand Rapids, Mich.; Los Angeles, Calif.; Canadian Steelcase Co., Ltd., Don Mills, Ont.

**DATACASE® / BY STEELCASE**

OFFICES AND SHOWROOMS: NEW YORK • CHICAGO • GRAND RAPIDS • ATLANTA • DALLAS • LOS ANGELES • PHILADELPHIA • PORTLAND, OREGON • TORONTO • MONTREAL

CIRCLE 47 ON READER CARD

# NEW LITERATURE

**COMPUTERS IN MEDICINE BIBLIOGRAPHY:** Based primarily on *Index Medicus* and *Biological Abstracts*, bibliography lists several hundred articles on computer applications in medicine written between 1959 and mid-1965. Copies are free while supply lasts. UNIV. OF MISSOURI, SCHOOL OF MEDICINE, Columbia, Mo. For copy:

CIRCLE 150 ON READER CARD

**SEND-RECEIVE PAGE PRINTERS:** Eight-page brochure covers details of Model 35 automatic send-receive set (ASR), send-receive page printer (KSR) and receive-only page printer (RO). Highlighted are technical specifications, operational features, components and optional features. TELETYPE CORP., Skokie, Ill. For copy:

CIRCLE 151 ON READER CARD

**BUSINESS PROGRAMMING:** 16-page brochure describes package that consists of MANAGE, a generalized file maintenance system, and a SORT/MERGE program geared for implementing corporate decision-making. Contents include description of these two systems and a glossary. SCIENTIFIC DATA SYSTEMS, Santa Monica, Calif. For copy:

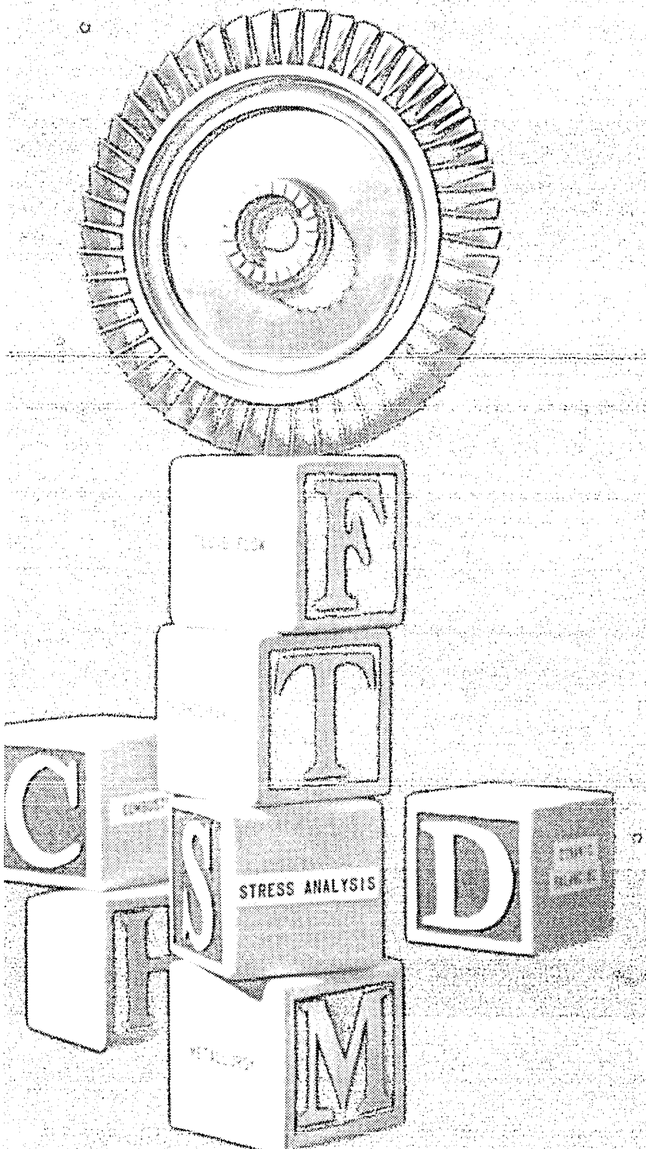
CIRCLE 152 ON READER CARD

**SCIENTIFIC COMPUTING SYSTEM:** 18-page brochure describes programming, performance, readout and display equipment of EAI 8800. Complete equipment summary on the analog and digital logic components is also provided. ELECTRONIC ASSOCIATES INC., West Long Branch, N.J. For copy:

CIRCLE 153 ON READER CARD

**COMPUTER STATUS QUO:** 40-page book gives historical account of the computer field since 1946 and breaks down developments into various periods. Authors feel that presently theoreticians in the field are concerned with scientific methods, social responsibility, certification, and formal establishment of a profession. Price: $2. AD 612 942N. CLEARINGHOUSE, U. S. DEPT. OF COMMERCE, Springfield, Va. 22151.

**COMPUTATIONAL LINGUISTICS BIBLIOGRAPHY:** References are cited from over 800 U.S. and foreign articles, reports and books. Also gives selective coverage in the fields of classification theory, computation and programming, computers and hardware, non-numerical applications of computers,




# Automotive Turbine Research —from the beginning

Thermodynamics. Fluid flow. Heat transfer. Metallurgy. Stress analysis. Dynamic balancing. Combustion.

A mechanical engineering syllabus? No. An outline of a gas turbine engine research program.

It started about 20 years ago when GM Research began studying all aspects of gas turbines and their operation. Turbines were successful in aircraft, but automotive vehicles presented an entirely new challenge. We had to go clear back to fundamentals.

Research on fluid flow characteristics led to new methods for designing compressors, turbines, and diffusers.

To learn more about combustion and to measure combustion efficiency, we had to sample and analyze elusive dynamic gases. A chromatographic gas analyzer was developed to do it.

There was no reliable way to measure temperatures of moving gases. We developed the techniques to do so. Further heat-transfer research produced a new parameter for describing conduction-convection processes.

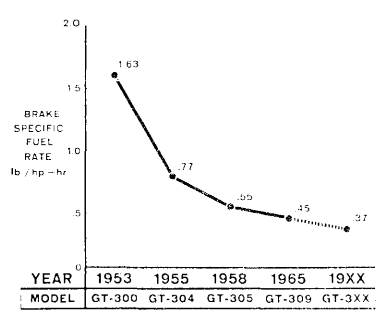
Materials research yielded the first castable nickel-aluminum-titanium turbine bucket material—forerunner of many of today's high temperature alloys.

Engines evolved too. In 1953, our GT-302 powered the XP-21 Firebird, the first gas-turbine automobile built in the United States. It provided baseline data for further research. Improvements in efficiency, performance, and engine braking followed. Latest experimental installations: GT-309's—in Chevrolet's Turbo-Titan III, a heavy-duty truck; and GMC's Turbo-Cruiser II, a transit bus.

Out of research . . . the scientific advances of today, the engineering for tomorrow.

## General Motors Research Laboratories

Warren, Michigan




Turbine Engine Progress—
from a recent paper.

and psycholinguistics, and includes pertinent papers from proceedings of conferences held by some professional societies in 1964. Price: $3. AD 613 311N. CLEARINGHOUSE, U.S. DEPT. OF COMMERCE, Springfield, Va. 22151.

**HIGH SPEED PRINTERS:** Booklet explains operation of MC 10-40 and MC 13-80 giving specifications, prices and optional accessory data. MONROE DATA/LOG DIV. LITTON INDUSTRIES, San Francisco, Calif. For copy:

CIRCLE 154 ON READER CARD

**DRUM SYSTEM:** 12-page booklet gives engineering specifications for the design of an economical bit serial mag drum system (700 KC-1.2 MC). Explained and illustrated are the elements that make up a basic drum system and the advantages of various options offered with system. Also, functional relationship of the elements making up the drum system and the relationship of the options with regard to the system are described. BRYANT COMPUTER PRODUCTS, DIV. OF EX-CELL-O CORP., Walled Lake, Mich. For copy:

CIRCLE 155 ON READER CARD

**DATA LOGGING SYSTEMS:** Eight-page brochure details capabilities and performance features and explains how data loggers can be used in process control. GENERAL ELECTRIC CO., PROCESS COMPUTER SECTION, Phoenix, Ariz. For copy:

CIRCLE 156 ON READER CARD

**TYPESETTING SYSTEM:** PDP-8, described in six-page brochure, accepts unjustified, unhyphenated perforated tape and produces a clean operating tape for use in automatic linecasting machines. Production rate is 12,000 lines/hour, keeping 12 linecasting machines busy. DIGITAL EQUIPMENT CORP., Maynard, Mass. For copy:

CIRCLE 157 ON READER CARD

**FORTRAN COMPILERS:** Software house discusses successful compiler implementation, technical features, company's background in software implementation, and technical summary. MESA SCIENTIFIC CORP., Santa Ana, Calif. For copy:

CIRCLE 158 ON READER CARD

**TRAFFIC CONTROLLER:** Four-page bulletin describes TACTIC control system which utilizes a continuous presence detection system, responds to demand and optimizes green time. Concept, operation, features, options and specifications are discussed. FISCHER & PORTER CO., Warminster, Pa. For copy:

CIRCLE 159 ON READER CARD

**MAG TAPE SYSTEMS:** Six-page bulletin details capabilities, describes equipment and lists optional features and accessories for Dartex-100 digital tape transport and 101 incremental recorder. DARTEX INC., Santa Ana, Calif. For copy:

CIRCLE 160 ON READER CARD

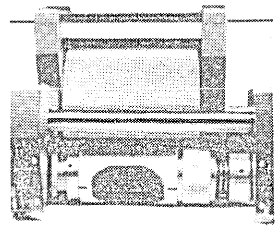
**OPTICAL SCANNING:** 16-page booklet explains in layman's language the basic concept of optical scanning, how the concept helps relieve automated business communications bottlenecks and covers printing, ink and type style. THE STANDARD REGISTER CO., Dayton, Ohio. For copy:

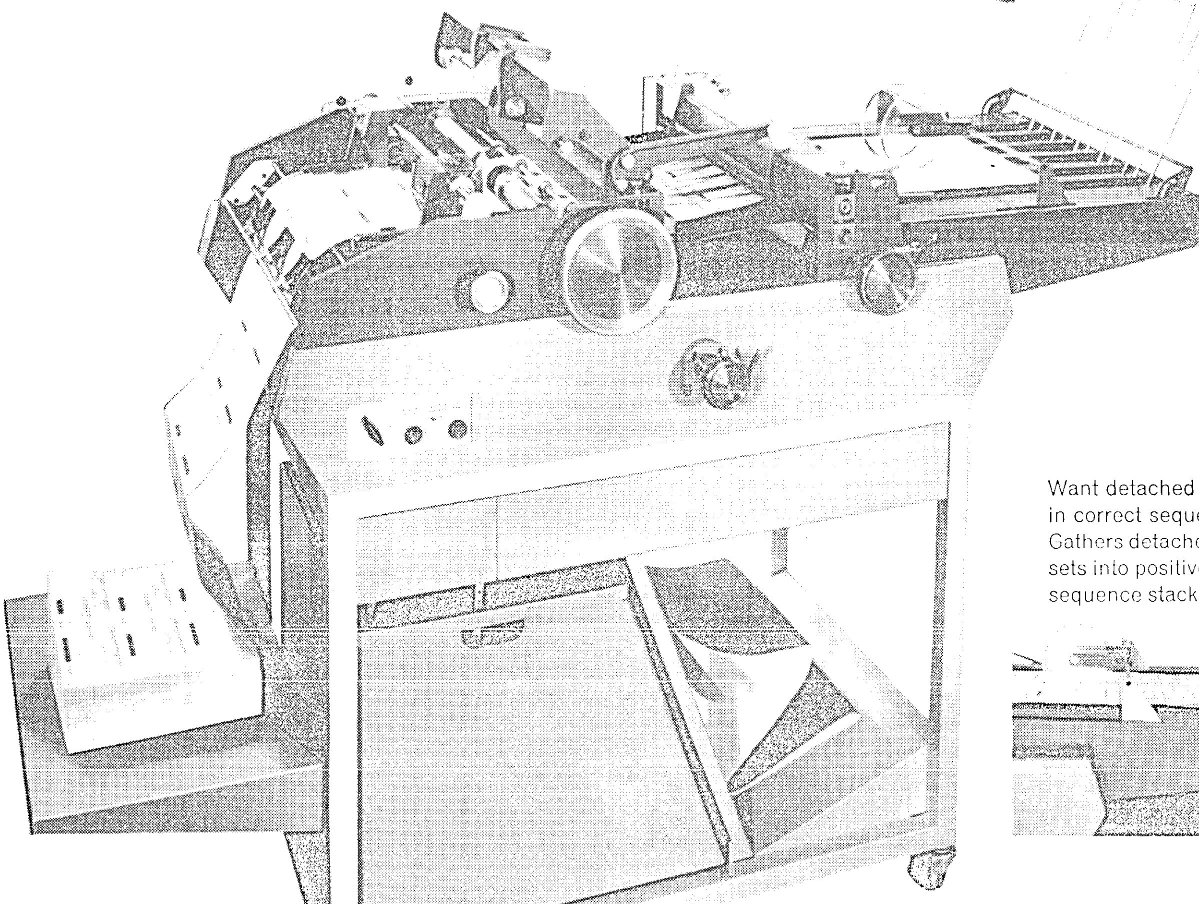
CIRCLE 161 ON READER CARD

**TAPE TRANSPORT:** Model SC-1060 is capable of bidirectional tape speeds of up to 120 ips and compatible with IBM phase modulation recording. Six-page brochure includes features, general description, equipment, accessories and specifications. POTTER INSTRUMENT CO. INC., Plainview, N.Y. For copy:

CIRCLE 162 ON READER CARD

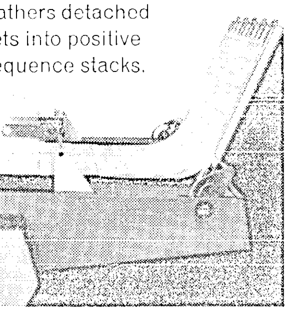
Easily handles output of one or more high-speed printers. Imprints signatures, dates, other fixed data.





Got 4 jobs to do? Moore Imprinter-Detacher does them all in one operation. Slits single- or multiple-part forms; imprints; detaches; stacks. A real timesaver!

Want detached forms in correct sequence? Gathers detached sets into positive sequence stacks.



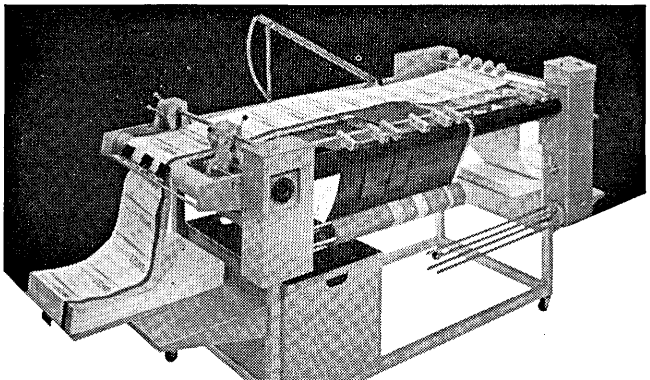
# Moore forms-handling equipment...

These timesavers from Moore! They lighten forms-handling loads; save expensive machine time; cut clerical operations.

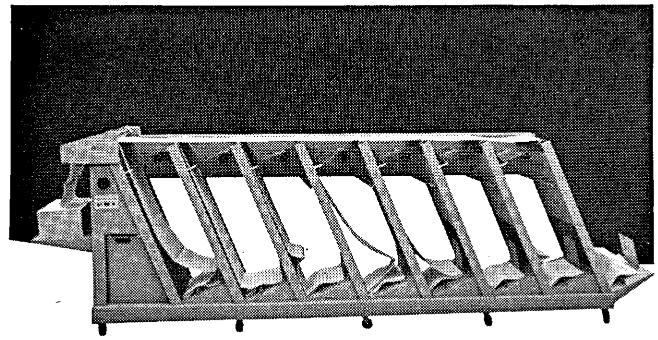
Whatever your problem—from margin-slitting, detaching, decollating, sorting, imprinting, stacking, to converting your typewriters into continuous typing production—Moore has just the right equipment to do the job faster, easier, more economically.

These dependable timesaving units are manufactured to precise specifications by the world's oldest and largest producer of business forms and forms-handling equipment.

With 80 years' experience behind it, Moore has the highly specialized research engineers and the technology to provide the finest line of efficient equipment for after-writing forms processing.

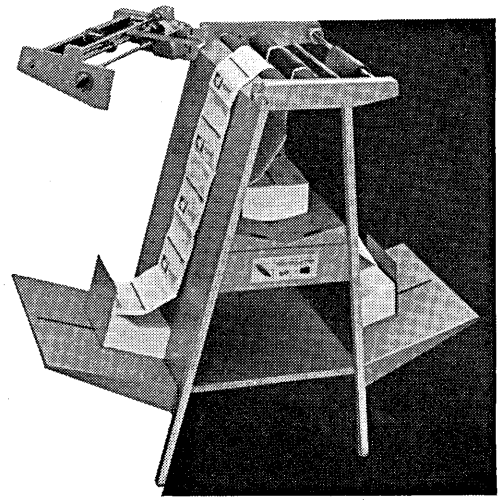


Slit margins, remove carbons, leave 2 or more parts held together for subsequent handling. Moore Power Deleaver removes carbons from continuous forms up to 8 parts.



For high-speed decollating, this Moore Multi-Web Decollator does the job. Slits margins; removes carbons; separates opaques; refolds. In 4-web, 6-web, 8-web units. A real timesaver!

Get continuous production from typewriters or bookkeeping machines. Moore Flexible Formaliner permits use of continuous forms in typing; Vertical Spacer skips forms past non-write areas.



Where forms are to be decollated, carbon neatly rolled for clean, easy disposal, this Moore Decollator does the fastest job. Slitter attachment available to remove one or both margins.

# for Total Value!

Attractive in appearance, Moore timesaving equipment lightens handling for forms-processing loads, makes the job easier.

In addition, Moore offers special equipment that can be designed and engineered to your specific forms-handling requirements.

These timesavers are also space-savers, taking minimum floor footage for each unit of effective modern design. Whatever your need, ask the Moore man for details. If you work with forms, we can show you how to make forms work for you.

**MOORE BUSINESS FORMS, INC.**

*'The right business form for every form of business.'* Niagara Falls, New York • Park Ridge, Illinois • Denton, Texas • Emeryville, Calif. • Over 500 offices and factories in North America.

**CIRCLE 50 ON READER CARD**

# COMPUTERS AND REDISTRICTING

Some said it represents a "giant step along the road to equal representation." Others feared it will mean invidious gerrymandering and political isolation for minority groups. Still others felt that it was of limited use and probably better left undone.

In each case "it" was the use of modern data processing techniques for reapportionment and redistricting. The source of these and other comments was a course on "Computers In Redistricting" sponsored by the American Law Institute and the American Bar Assn. in October.

More than 75 "students"—lawyers, computer experts, political scientists, mathematicians, ladies from the League of Women Voters, physicists, legislators and legislative representatives, and even a psychologist—attended this two-day course in Washington, D.C. The most interesting feature of the conference was the wide divergence of opinion on a topic which is less than two years old.

In January of 1964 the Supreme Court ruled that both houses of state legislatures must be filled by legislators elected from districts of substantially equal population. No state has been unaffected and 48 were hit with law suits demanding reapportionment. The search was on for a method of creating districts which was fast and inexpensive and most of all nonpartisan, or at least bipartisan.

In Connecticut, legislators were unable to adopt a redistricting plan satisfactory to both parties. The federal court then appointed Dr. Morris Davis, director of the Yale Computing Center, as a special master to produce some computer-generated districting plans. Faced with this prospect, the legislators compromised their differences and passed an acceptable bill. Dr. Davis added that the computer's plans were not much better than the one which came out of the smoke-filled room.

William Boyd of the National Municipal League explained that the average legislator is more interested in preserving his seat than in fair representation. For this reason many of them both fear and oppose computer redistricting which, no matter how fair and impartial, often redistricts Senators right out of their seats. On the other hand, more than a dozen legislatures had representatives at the course to learn how computer techniques can help them solve their reapportionment problems.

One speaker reported that at least one major party in California likes computers. It is now using them to redistrict the state in such a way that a maximum number of districts "safe" for that party are produced. He explained that his program could also be used to redistrict on the basis of race or religion if desired. This raised cries of "foul" and possible unconstitutionality from some members.

Several of the speakers indicated that computers were being overrated in this area. Some seemed to feel that the machines could never master the many political factors which go into districting. Others said that the problems were not difficult enough to require computer intervention.

A large portion of the conference was spent discussing several programs which have been developed to redistrict a state in accordance with the Supreme Court's "one man, one vote" mandate. Some programs were reportedly "nonpartisan" while others could accommodate several partisan political factors. Some were determinant while others produced results which depended either on hand-picked starting points or the particular orientation of the state.

There was general agreement that electoral districts should be as compact as possible but computer experts differed as to the best measure of compactness. Contiguity, another general requirement, also gave some trouble. Lawyers and computer men both were unsure whether a bridge over a river made a district "contiguous."

Programs were not the only redistricting problems. Part of the trouble was laid at the door of the Census Bureau, which provides the raw data. According to one Texas representative, their enumeration districts usually "extend from an unmarked drainage ditch to a nonexistent street."

The role of computers in this area is not confined to redistricting. Two speakers noted their use in analyzing such electoral plans as weighted voting and the use of multi-member districts. Another possible use is to simulate the effect of elections under proposed redistricting plans.

The best quote of the meeting was that of a rural state senator who remarked: "Hell, it's like being a manual laborer about to be put out of work by automation."

—John F. Banzhaf III

**NCR**

## TOTAL EDP SYSTEMS

Continued expansion of the EDP effort of the National Cash Register Company in the United States has created outstanding opportunities for individuals with professional experience in commercial EDP systems. Due to the nature of the EDP industry, there is a strong requirement for people with flexibility in their planning, but firmness in their objectives. Key positions for your consideration are listed below.

**PROGRAMMING RESEARCH** The desired background would be a college education plus two years or more of programming experience with magnetic tape and random-access systems. Challenging opportunities exist in new and diverse problem areas in commercial applications. Primary assignments would be in Dayton, Ohio; however, willingness to travel and relocate is necessary.

**SYSTEMS ANALYSIS CUSTOMER REPRESENTATIVE** General requirements are two years or more experience in programming with related systems analysis in commercial applications involving medium-to-large scale magnetic tape and random-access systems. Openings are in various parts of the United States. After an initial period of orientation, every attempt will be made to assign individuals to the general region of their preference.

This is the time to investigate these opportunities. Each reply will be promply acknowledged.

Please address inquiries to:

**Mr. Thomas F. Wade**
**Executive and Professional Placement**
**The National Cash Register Company**
**Main & K Streets**
**Dayton, Ohio 45409**

*An Equal Opportunity Employer*

CIRCLE 93 ON READER CARD

# PROCESS CONTROL BY COMPUTER

Aluminum Company of Canada, Limited has vacancies at Arvida Works for operations analysts to undertake studies and develop systems for on-line control of processes as well as other related technical systems projects. The openings provide challenge and opportunity for advancement in the rapidly expanding systems operations at various locations within our diverse operations.

Applicants should be graduates in Honours Mathematics, Physics or Engineering and have at least two years of experience with computer oriented systems. They should be in the 25 to 35 year age range and have a desire, ability and interest to accept the challenge of increased responsibility in the systems field.

Please apply in writing to:
Aluminum Company of Canada, Limited,
Staff Personnel Division,
P. O. Box 6090,
Montreal 3, Quebec.

ALCAN

## *WHAT IS YOUR TRUE WORTH?*

**FREE** **Data Processing Opportunities Bulletin**

Every month, in the privacy of your own home, you can evaluate the nation's finest openings in the data processing field. Cadillac, the nation's largest executive and professional placement service, represents the majority of the nation's top companies. Their best jobs at salaries from $6,000 to $75,000 appear in our monthly Data Processing Opportunities Bulletin.

Our placements show that the average data processing man is worth 10% to 20% more than his present income. The Bulletin helps you evaluate yourself in today's market. Both the Bulletin and our *confidential* placement service are free. Client companies pay all costs.

For your free Bulletin, without any obligation circle Subscriber Service Card No. 112. Please use *home address only.*

**LON D. BARTON,** *President*
**Cadillac Associates, Inc.***
29 E. Madison Bldg. Chicago, Ill. 60602
Financial 6-9400

* *"Where More Executives Find Their Positions Than Anywhere Else in the World."*

**In Los Angeles**—Lon Barton Associates, 3275 Wilshire Blvd.
**In San Francisco**—Lon Barton Associates, 120 Montgomery St.

CIRCLE 112 ON READER CARD

# people IN DATAMATION

■ Dr. George Marr has been named director, Systems Analysis Group, Research and Computation Division, Electronics Associates Inc., West Long Branch, N. J.

■ Fritz W. Wanzenberg has been named principal, management information systems, The Diebold Group Inc., New York City.

■ Robert M. March, senior systems analyst at Cyanamid's Plastics and Resins Div. has been promoted to manager, sales service and data processing, Building Products Div., Cambridge, Mass.

■ Edward Buurma has been chosen assistant to the president, Computer Usage Co., Inc., New York, N.Y.

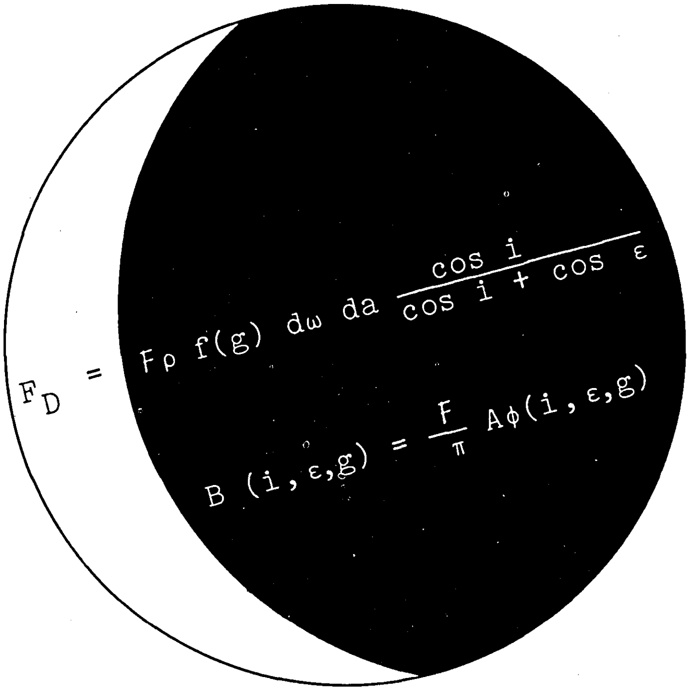
■ Jack E. Byk is now manager, data processing and systems, Institute for Scientific Information, Philadelphia, Pa.

■ Dr. Henri Semarne has been appointed senior consultant, computer systems of the California State Legislature.

■ Anthony C. Medin, former director, Metropolitan Data Center Project, has formed a new company, Anthony Medin and Associates, system design and consultants, Tulsa, Okla.

■ A. Marshall Cheney, former director and general manager of Honeywell's EDP Div., Frankfurt, Germany, has joined Planning Research Corp., Los Angeles, as senior associate, market research and development.

■ T. M. Butler, former head of the engineering group that developed the Sensimatic accounting machine, has been elected vp—engineering, Burroughs Corp., Detroit, Mich.




# There's a beautiful problem out tonight

You might like our way of looking at the moon.

It's a different way, because our assignment is to do systems engineering for the National Aeronautics and Space Administration's manned space flight effort.

Getting to the moon and back is a series of problems which not only have to be solved—first of all, they have to be identified, defined, understood.

Bellcomm has rewarding openings right now for advanced thinkers in such fields as physics, mathematics, engineering, chemistry, propulsion, flight mechanics, computing and programming, guidance and trajectory analysis.

If you are highly qualified and experienced, your résumé will be welcomed by Mr. N. W. Smusyn, Personnel Director, Bellcomm, Inc., Room 1312-E, 1100 17th St., N. W., Washington, D. C. 20036. We are an equal opportunity employer.

BELL SYSTEM

**Bellcomm, Inc.**
**A Bell System Company**

# LET A PROFESSIONAL HELP YOU MAKE YOUR PROFESSIONAL CAREER GO

•

•

•

# AND GROW!

And that's the reason top companies get top executives and EDP Specialists through Brentwood. Where professionals handle professionals. Where you'll talk to men who talk your language . . . men with degrees in engineering, physics, personnel practice. Men skilled in matching the right man and the right job . . . in the best interest of both! Let us help you put grow-power in your career! Start by sending us a resume . . .

## BRENTWOOD

**Where Professionals Place Professionals**

**COMPUTER CAREERS**

- ☐ Applied Systems
- ☐ Compilers
- ☐ Assemblers
- ☐ Automatic Languages
- ☐ Utility
- ☐ Commercial Programming
- ☐ Mathematics Scientific Computation & Analysis
  PhD in — Numerical & Mathematic Analysis
- ☐ Real Time — Operational
- ☐ Operations Research
- ☐ Systems Design
- ☐ Information Retrieval
- ☐ Diagnostics
- ☐ Digital and Logical Design

Fees are paid by the companies we serve.

Write in confidence, or call collect: Mr. F. X. Jones (201) MArket 2-0915

BRENTWOOD PERSONNEL ASSOCIATES
786 BROAD ST. NEWARK, N. J.

CIRCLE 102 ON READER CARD

***Library Planning for Automation*, edited by Allen Kent, Spartan, 1965.**

The development of national "information networks" appears to be inevitable as a means for solving the problems raised by the explosion of literature in science and technology. Over the years, proposals have proliferated, ranging from highly centralized structures patterned after Veniti (the approach of the USSR) to more or less decentralized ones.

Dr. Stafford L. Warren, Dean Emeritus of UCLA, in his capacity as Special Assistant to the President formulated an approach to this development which has probably had the most far-reaching effects. His proposal was first publicly disclosed at a conference held at the University of Pittsburgh in June, 1964. This book is the report of that conference in general; it therefore includes, in addition to the paper by Dr. Warren, two other papers (one on microphotography, given by Samuel B. Freedman, and one on the design of university libraries, given by Andrew D. Osborn), together with discussions and comments concerning some of the issues raised. However, without question the significant paper is that by Dr. Warren.

Dr. Warren's proposal for a "National Science Library System" calls for the establishment of a mechanized national network, with the great national libraries—Library of Congress, National Library of Medicine, National Agricultural Library, etc.—as primary resources and with regional centers as the points of service. The initial emphasis would be restricted to the published periodical literature, just as is the Medlars service of the National Library of Medicine. In fact, the fundamental premise of the proposal is that the kind of services provided by NLM are a model for a system with expanded scope. This already includes mechanization, and the proposal therefore would use the Medlars system at NLM as the focal point, expanding it and enlarging it as necessary to encompass the added scope of coverage.

The proposal involves technical considerations in the use of data processing technology, intellectual considerations in the handling of indexing and service, and political considerations in the establishment of a suitable mechanism to tie together the diversity of libraries and scientific groups.

The proposal does not attempt to resolve the many problems in the first set of considerations, although it strongly implies a decentralized operation, with the national center, in Washington, distributing magnetic tapes and microforms to the other six regional centers.

For the second set of considerations, the intellectual ones, the proposal suggests involving the professional societies and journals in development of standards for terminology, codes, formats, and processes, and in the execution of abstracting and indexing services.

The major emphasis of the proposal, however, lies in its approach to the political considerations. In fact, it includes a description of specific legislation for definition of an administrative structure as part of the Department of Health, Education, and Welfare. The organization calls for regional centers to carry the bulk of the operation, with the national center in Washington as a focal point. The operation would be guided, however, by an Advisory Committee on Operations consisting of 15 members drawn from the major federal libraries and agencies concerned and from the professional societies. The proposal estimates the costs for establishing this network at $122 million, over a period of three years. Subsequent operating expenses are estimated at about $60 million per year.

That this would be a controversial proposal was evident, and the discussion at the conference in response to it brought out most of the significant issues: the limitation to "published" literature, the use of Medlars as the technical basis, the philosophy of decentralized mechanization as such, the implication that the proposed system really could solve the problems in scientific literature service, the possible conflict between it and the potential automation in the Library of Congress, the inherent technical and intellectual difficulties, and the problems of copyright.

Still, recognizing all of the problems, one crucial point must be emphasized: The "Warren Proposal" is primarily concerned with organizational issues, not technical ones; its emphasis is rightly on the problems in creating a viable national information network from a diversity of interests. The choice between the Warren approach or some other is therefore not to be made on technical grounds, although they may be used to justify the choice.

—Robert M. Hayes

With Gemini/Apollo experience, you could go anywhere in the programming profession. Because there's no real-time programming or analysis experience anywhere else that can teach you what you'd acquire at NASA's Manned Spacecraft Center.

Here you'd have worked with the world's largest real-time system at one location . . . developed for a single massive problem. You would have helped to write the textbook on real-time operations. Your programming experience would be heavy in problem analysis—as much as 70% of it. And most of your skills would be transferable to other large-scale management and scientific systems.

The IBM programmers at NASA's Manned Spacecraft Center are invaluable—not only to IBM, but to the Gemini/Apollo program.

They've been trained to do every programming job there is to do. They write concise programs—fast. Sometimes they sit at the consoles in direct support of NASA Flight Controllers. They often work in real-time themselves, since their knowledge of programming detail may be called upon to support the system during its periods of critical operation.

We'd like to give you that experience. Teach you the real-time applications of the fundamentals you already know. Have you help us find the answers and write the programming textbook of the future. You'll be doing the most exciting work open to programmers today.

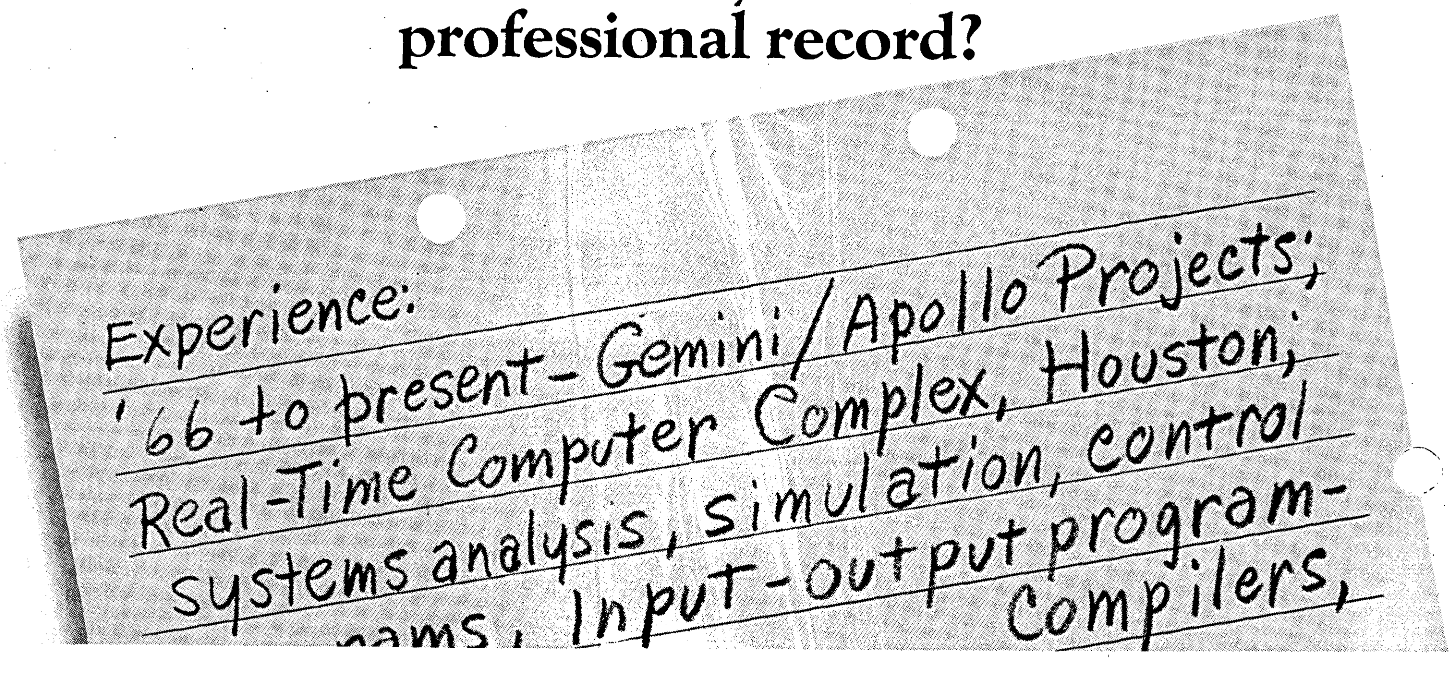
Right now you need at least one year's experience, preferably two or three, in programming large-scale computers. Experience in simulation, operations research, linear programming or systems analysis is also desirable. Relocation expenses and personal benefit programs are company-paid.

Write us a short letter, in longhand if you like. Tell us briefly about your education and experience. We'll get back to you fast—hopefully with an invitation to visit us in Houston.

Write to Mr. W. J. Baier, Dept. 690M, IBM Corporation, 16915 El Camino Real, Houston, Texas 77058. IBM is an Equal Opportunity Employer.

**IBM**

# Programmers: how'd you like to have this on your professional record?



*(Continued from page 19)*

## SPEAR INC.'S LAB LINC GROWS

Spear Inc., 12-man Massachusetts firm that put all its dough into building a commercial i.c. version of the MIT Linc biomedical computer, is now readying to make itself and the system bigger. SI's Micro-Linc II will have a faster cycle time (2 usec) and more memory (32K in 2K modules) than mod I (8 usec, 2K memory). The basic II, to be ready for delivery in March '66, will go for under $50K and include a passel of peripherals and software. A whole library of biomed programs are in public domain, as 12 units were built at MIT for giveaways to the field under NIH and NASA research grants.

Spear figures a 300-unit market for the laboratory system in fields like medicine, seismology, and oceanography, but the firm will also do research and provide processing services with it.

## PENN STATE GOES IBM; TEXAS ON THE FENCE

Latest university to go IBM is Penn State, which will get a 360/75 in April, paving the way for a plain old 67 late in '66. The system will include 512K-byte core, Datacell, four or five 2311's, tapes, transmission gear and probably bulk core, with terminals "later." The 67 was chosen over a GE 645; The 67M was shot down because of incompatibility with the standard 360 operating system to be used on the interim 75. Meanwhile, aided by a megabuck grant from NSF, Texas U. is trying to decide between 360/75 and a 6600.

## RUMORS AND RAW RANDOM DATA

The University of Illinois is slated for a 4.66-year contract from ARPA, through Rome Air Development Center, to study and design a parallel processing computer. An industrial firm will be picked later to help design and build the system. ... Two ex-CUC men, Marvin Kashan and Anthony Penta, are just starting a new software house in NYC, Computer Progress Inc.; merchandising will be a specialty. ... Another new programming/consulting house is Information Management, Inc. Heading the S. F. firm are Dan Haagens and John Gilbert, ex-CEIR men and independent consultants. Stan Naftaly is in charge of marketing. ... Col. Edward McCloy, head of the AF's EDP Equipment Office, retires for a job in industry Dec. 31, but there's no word yet on who fills his spot in the crack procurement group. ... California has just appointed Bob Smith, formerly of Motorola, as Chief, Systems Analysis for the Dept. of General Services. Smith heads a staff of 35 serving as edp and management consultants to state agencies, will have final approval of all state edp and communications contracts. The state now spends some $4-5 million on edp gear annually. ... CSC has won a contract to develop some large-scale 360 software. ... Dashew, which went into voluntary bankruptcy last August, may be making a comeback, with $250K in orders on the books, and another $500K almost locked up. Sam Greene is the new vp and general manager. ... Bud Feely, Martin Denver, has been elected president of the newly established GE 600 series user group.

# THE DATAMART

Address all replies to box number advertisements as follows:

Box.............
DATAMATION
F. D. Thompson Publications, Inc.
141 East 44th St.
New York, N. Y. 10017
Classified Advertising

## PROFESSIONAL SERVICES

ROBERT L. PATRICK
COMPUTER SPECIALIST

9935 DONNA 213-349-2225
NORTHRIDGE, CALIFORNIA

JUSTIN A. PERLMAN
PRESIDENT

THE LAMELLAR CORPORATION OF AMERICA

1011 SWARTHMORE AVENUE
PACIFIC PALISADES, CALIFORNIA 90272
TELEPHONE (213) 454-7244

## USED EQUIPMENT

HIGH PRICES PAID FOR USED I.B.M. DATA PROCESSING MACHINES: Sorters, verifiers, collators, computers, tape drives, key punches, reproducers, Interpreters, accounting machines. Advise exact model and serial numbers and we will quote prices by return mail. Phone: 212-ORegon 9-6535. L. A. PEARL CO., 801 SECOND AVENUE, NEW YORK, N.Y. 10017.

Please Contact Us Before Returning
LEASED KEY PUNCHES TO IBM CORP
This may mean $$$$ To You And Your Company
— ALSO —
Contact Us On Your Purchased Machines
I.O.A.
383 Lafayette St., New York City
Call collect (212) 673-9300

## USED EQUIPMENT

COMPUTER

BURROUGHS 220 COMPUTER SYSTEM. Good condition. Listing of components and other particulars available on request. Michigan Tech, Houghton, Michigan 49931. Phone: 906-482-1600 Ext. 221.

## PROFESSIONAL SERVICES

DIGITAL COMPUTER TECHNICIAN INSTRUCTORS: For the Computer Technology School established under the Federal Manpower Development and Training Act. Must have three years experience in Computer Maintenance or EAM experience to qualify. Equipment includes Burroughs B280, Control Data 160/160A Magnetic Tape Systems and full complement of IBM tab equipment. Salary commensurate with education and experience. Submit resume to: Mr. Bernard L. Terrill, Iowa Technical Education Center, Computer Maintenance Division, Municipal Airport, Ottumwa, Iowa 52501. Telephone: 515-682-8351

COMPUTER PROGRAMMERS, INC.
Is a company located in the midwest to serve the scientific and engineering needs of the midwest.
COMPUTER PROGRAMMERS, INC.
5455 University Chicago PLaza 2-6666

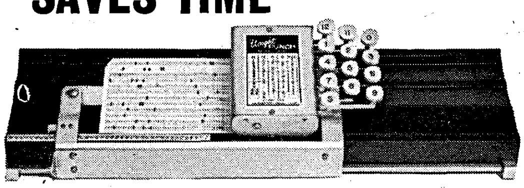
**DATAMATION**

Classified Advertising

The classified section is open for the following advertising categories: Used equipment; positions wanted; help wanted, educational institutions; maintenance services; professional cards; hobby products; business opportunities and educational courses. Rates are based on total number of insertions used within each contract year.

For further information please contact: DATAMATION Magazine, Classified Advertising Dept., 141 East 44th Street New York, N. Y. 10017—212-MU 7-5180.

# NEW PROGRAMMER CARD PUNCH SAVES TIME



**WRIGHT PUNCH MODEL 2600**

- Precision desk-top model simple to use.
- Lets you make computer corrections on the spot.
- Handles 80-column-and-shorter cards.
- Does not duplicate or print.
- Only $159 for accurate recording.

SEND NOW FOR COMPLETE DETAILS

*Wright LINE*
*DATA PROCESSING ACCESSORIES*
170 GOLD STAR BOULEVARD, WORCESTER, MASS. 01606
A division of Barry Wright Corporation

CIRCLE 52 ON READER CARD

# PROGRAMMERS . . . ANALYSTS . . . ENGINEERS . . .

*Our free booklet . . .*

**"COMPUTER OPPORTUNITY GUIDE"**

lists current positions open to professional computer personnel. All positions are given by geographic areas with complete salary ranges.

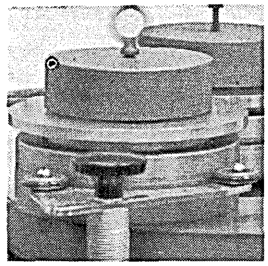
Client companies assume all expenses . . . hence the quick, personalized, completely confidential service of our experienced staff is available to you *at no cost*.

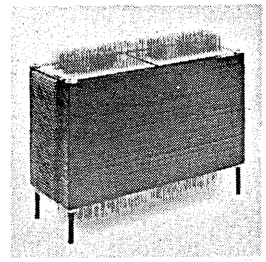
Our contacts are nationwide . . . our listings extensive. Send resume or circle number 92 on reader service card for your free copy. Please use home address.

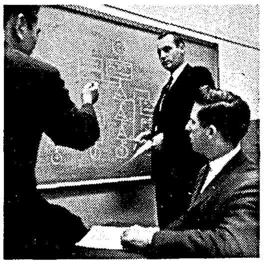
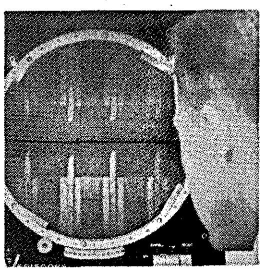
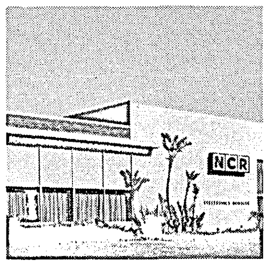
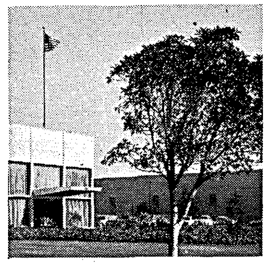
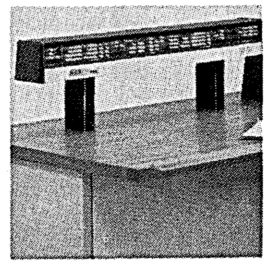
**ALPHA ASSOCIATES**
**PERSONNEL CONSULTANTS**
HOME OFFICE: 1 East Penn Sq.
Philadelphia 7, Penna.
BRANCH OFFICE: 25-27 Chestnut St.
Haddonfield, N. J.
Member: IEEE; Assoc. for Computer Machinery

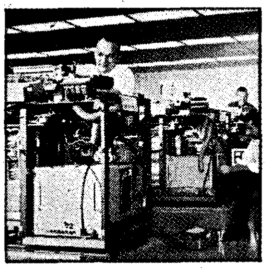
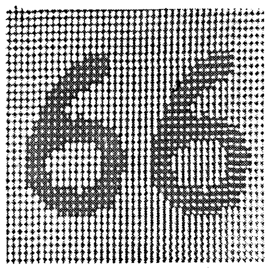
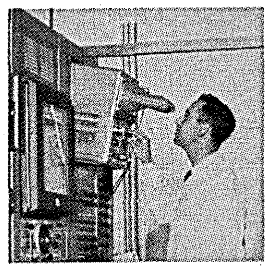
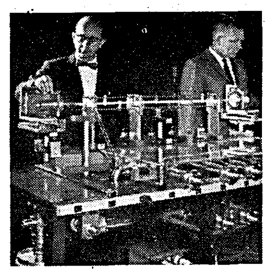
CIRCLE 92 ON READER CARD










NCR





66




EXIT

CIRCLE 106 ON READER CARD

CIRCLE 105 ON READER CARD

EVERETT KELLEY ASSOCIATES
CONSULTANTS TO THE COMPUTER INDUSTRY
CHAMBER OF COMMERCE BUILDING
121 SOUTH BROAD STREET
PHILADELPHIA, PENNA. 19107

SUITES 1300-1310

215-KI-6-5240

An Open Letter to
Programmers Analysts Engineers

It's time for review - and it's time for shaping your 1966 professional career plans - we'd like to talk with you about your future - our clients retain us to match important positions with qualified men at all levels - Junior, Senior and Management. If you have interest and experience in any of the following disciplines, let's discuss the fullest use of your professional potential.....

. Scientific Programming
. Digital or Logic Design
. Real Time Systems
. Circuit Design
. Software Development
. Commercial Programming
. Operations Research
. Mathematics
. Applied Systems
. Development Engineering
. Systems Design
. Communications

Starting salaries range to $25,000, according to your experience level; all fees and expenses are assumed by our client companies. Please forward your resume in strict confidence, including salary and geographic preference, directly to Mr. R. L. Keilholtz or Mr. Donald Wayne.

Everett Kelley
EVERETT KELLEY

P.S.
With Best Wishes For A
Happy Holiday Season

# ADVERTISERS' INDEX

# THE FORUM

## AUTOMATION, SOCIAL IMPLICATIONS AND OUR ECONOMIC SYSTEM

In discussing the social impact of computers and automation, people often ask, "How many are out of a job because of automation?" But the interplay between automation, technological change, cost and demand very crucially affects the answer to the question. There can be no controlled experiment in which all other factors are kept constant while automation is introduced. So, we don't really know, and can't know.

I submit that it is not necessary to have precise answers to such questions. I suggest that at this point, *what* is happening in detail is less important than *why* it is happening. I believe many people are looking for solutions in the wrong place—at least for long-term solutions. Their solutions are like giving aspirin for a persistent headache without attacking the underlying pathology that causes the headache. Examples of this aspirin are current cries for shorter work weeks, earlier retirement, etc. For, reducing overall production will result in a standard of living lower than we would otherwise have.

Many loud voices, in particular the Ad Hoc Committee on the Triple Revolution, are saying that we must immediately face up to paying men not to work—we must have a guaranteed annual income. It seems to me that an assumption implicit in the proposals is that men can now, or soon will be able to, produce more goods and services than society can consume. Why else do they want to reduce total production? One might want to do so as a temporary measure to relieve the present headache, but these solutions are advanced as permanent procedures rather than temporary symptom-relieving prescriptions.

There may be some limit to what society can consume but we are obviously a long, long way from saturation. I don't know what to do with Appalachian coal miners, but I think it's outrageous to propose that carpenters be paid not to produce when society as a whole needs more private housing, schools, hospitals, and other public buildings. If we look at the nation as a whole, I'm sure that the country could build up in a short time to consumption of 10 times what it is today. The problem *isn't* that we can't consume that much; the problem *is* that we won't be able to produce that much for a long time to come. And if we look at the world as a whole (and I'm certain that we must), then the factor is at least 100.

If solutions involving the reduction of total production by society are the wrong direction, what is a better one? Let me approach this by returning to my earlier suggestion of a shift in emphasis from "what" is happening to "why." I submit that the answer to "why" lies in the notion that there is something awry in the public sector of our society.

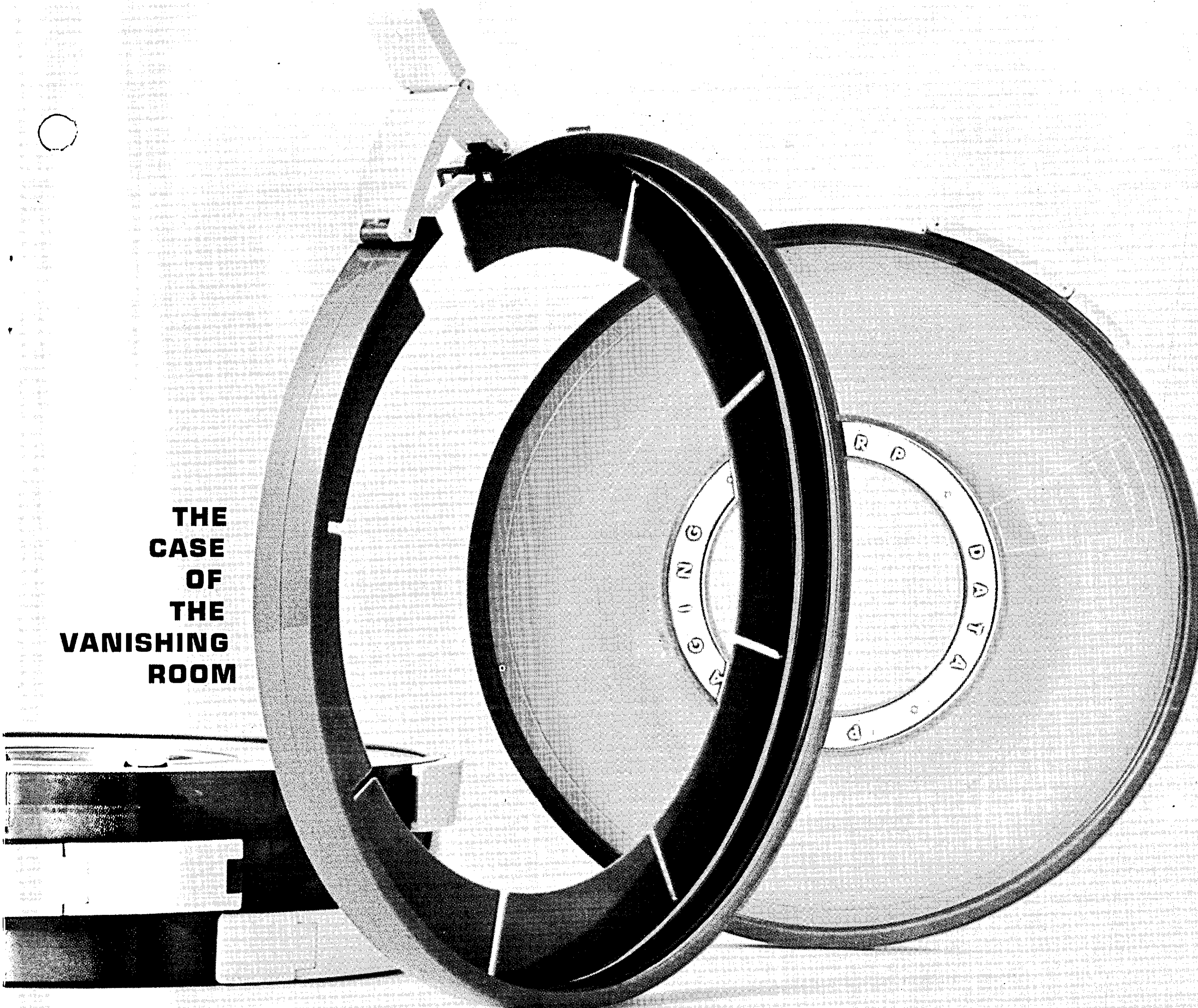
We face an ever-increasing pace of technological change in the private sector. One reason for this is that more and more of the brightest people in society spend their time figuring out how to change things. Nine out of 10 of all scientists are alive today. But where are the majority of these bright, innovative people? They are in the private sector! Very few are in the public sector inventing new ways for public accommodation to the fantastic rate of change going on in the private sector. Why?

Let me respond with a simple comparison between public and private sectors. Robert McNamara manages an organization about 10 times the size of General Motors. Yet his salary is much less than one-tenth that of the president of General Motors. Actually, despite this inequity, the nation does very well at attracting good men for jobs at Mr. McNamara's level, since a good deal of status and prestige is attached thereto. But no one accepts such positions as a career. If I remember correctly, prior to 1961 the average term in office, for the Secretary of Defense and the three service secretaries, was less than three years each. Most businesses would suffer considerably from that kind of continuous top-level turn-over. But what about the somewhat lower levels of management? How many General Motors executives earn more than $40,000 per year? Quite a few! None do in DOD, including Mr. McNamara. Where, in general, do you think you will find the better-qualified individuals? When I make this point, people often wail, "But we can't afford high salaries for public servants!" Who but the same "we" pays the salaries of General Motors executives?

The prime mover behind our economy is the profit motive, which is why the private sector works so well—it provides the necessary "feedback" (one of the OK words of this age of cybernetics). The feedback mechanism in the public sector is often non-existent. The problem is often that of what to use as a metric. For General Motors management, we look at the profit and loss statement. For DOD, we have but intuitive feelings as to performance. Need this always be the case? Possibly so—but how many of our experts on control systems and feedback are striving to innovate new systems in the public sector?

Another problem is that we lack knowledge of how our economy really works. Some economists attribute the present sustained period of prosperity to the tax cut. Others have different explanations—one of which is that the science of inventory control, as implemented on computers, has eliminated a major source of inherent instability in our economic system. With respect to the tax cut, some economists felt that the lower-income group should get most of the cut, others that it should be applied at the high-income level. Some economists feel that we could reduce unemployment to 2 or 3% today by raising the federal budget by 10% or by reducing income taxes by an additional 10%. Industry would then take over retraining and relocation—just as it did in World War II. Do we know that they are wrong? Or right? The problem of being unable to run a controlled experiment makes this all very difficult, but it seems to me that we could be devoting a lot more effort to trying to understand our economic system.

—PAUL ARMER



# THE CASE OF THE VANISHING ROOM

Here is a new tape storage case that saves important space, protects important data, and can be effectively used by real people working with real computers. Consider this:

You get 50% more storage because cases are thinner, it's even possible to use existing racks and cabinets. Case is always a circle, quick, easy to use. Place the reel against the shelf-back of the case, flip the lock. That's all. Reel is self registering to inner and outer rim. A stacking feature permits orderly storage on the desk, whether reel is in or out of case. Stacks on the arm, too, for quick computer changes. They're rugged. Cases are rigid, unbreakable when dropped, made of polycarbonate, hinged at lock with metal pins. Dual rubber seals mean best protection against tape contamination, better by far than any other space-saving case.

This new case is available from most every computer and tape manufacturer with their reels of tape. A ring of color around the hub of the reel identifies it as a quality reel with an aluminum winding surface from

**DATA PACKAGING CORPORATION**
205 Broadway, Cambridge, Massachusetts

Case patent number 3209904.

CIRCLE 2 ON READER CARD