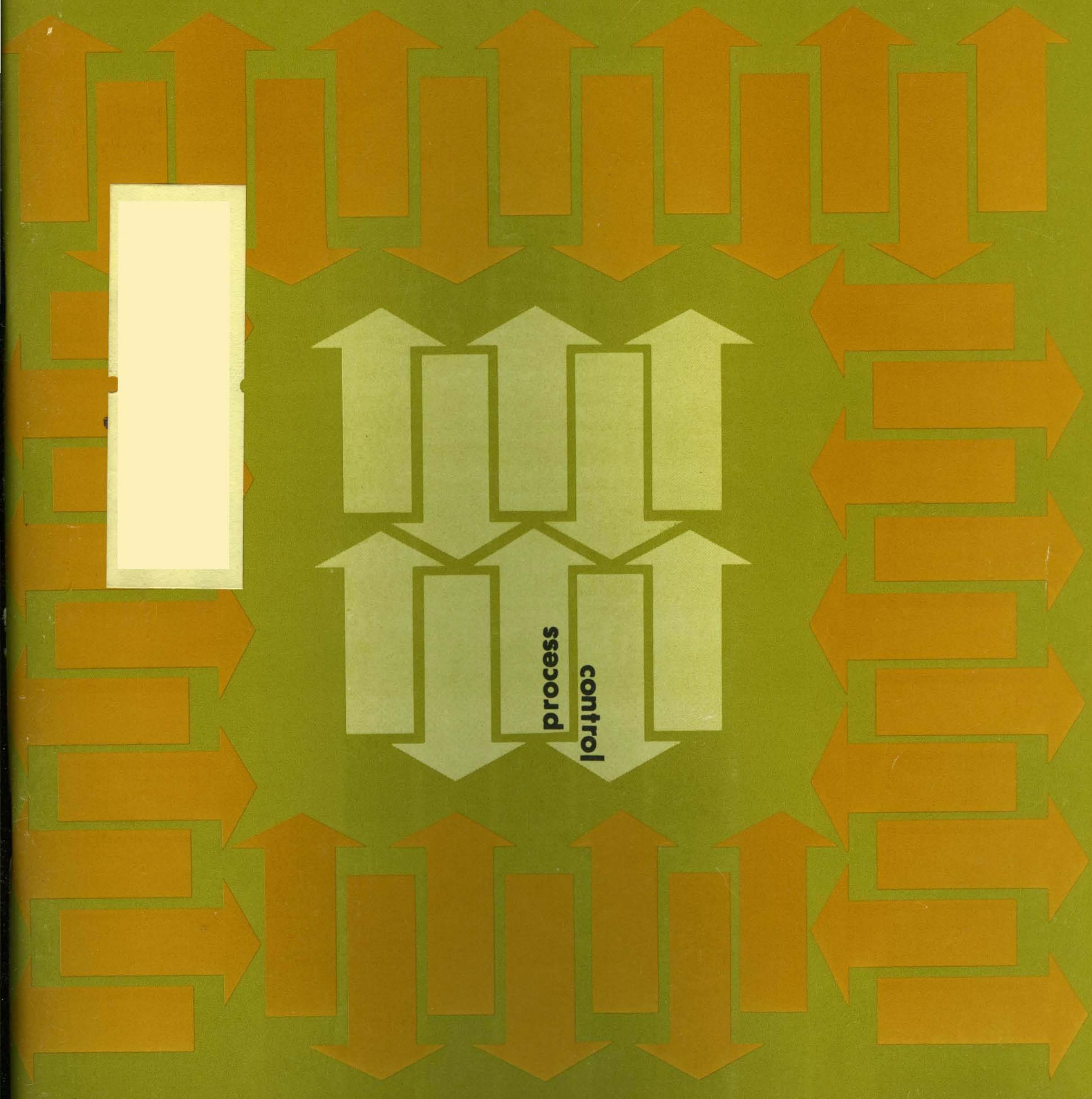
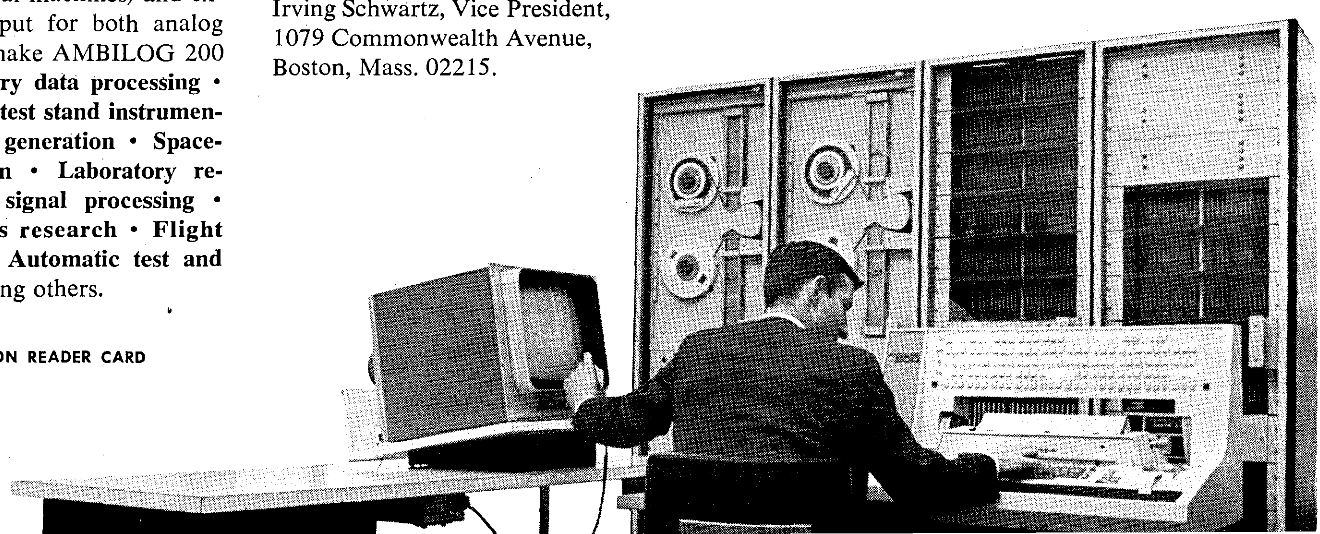
DATAMATION

66

February

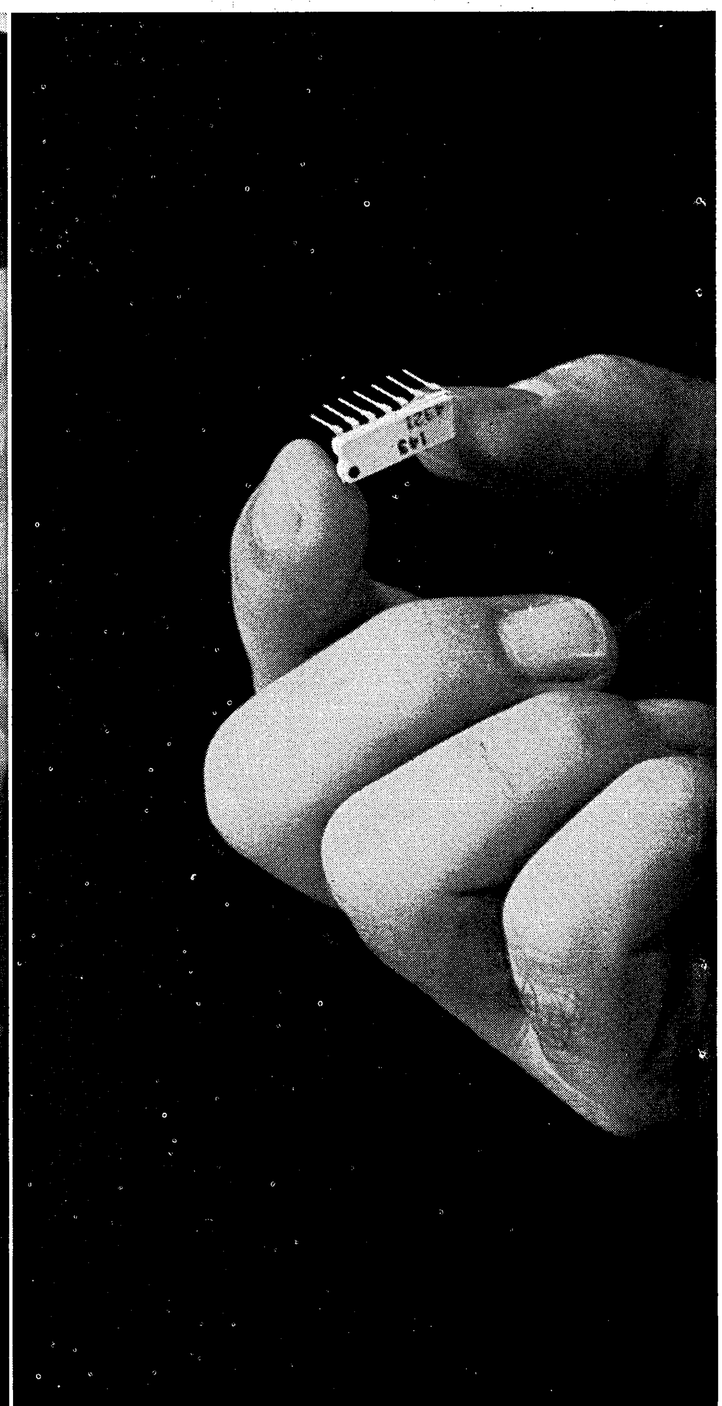




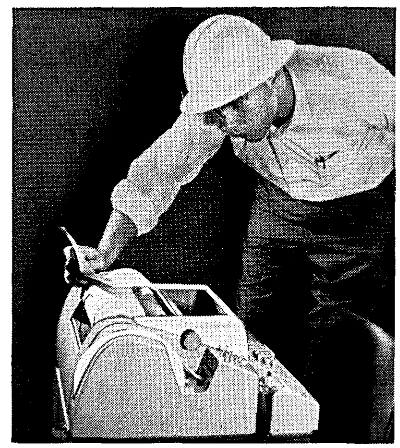
The new GE/PAC* 4020

process control computer gives you invested...in a compact and reliable

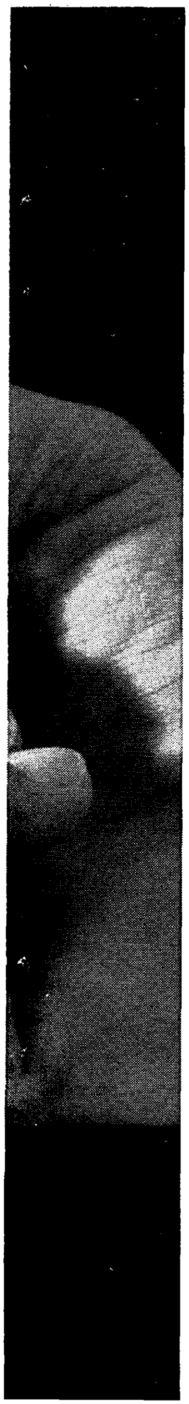
INSTANT SOFTWARE! 1.6 MICROSECOND SPEED! INTEGRATED CIRCUITS!



highest performance per dollar system!



GE/PAC 4020—newest member of the General Electric family of process control computers—combines high-speed, advanced design and low cost for both process control and scientific applications in the small computer field. Designed for either an upright cabinet or a desk, GE/PAC 4020 has a price tag below $50,000 including a basic input/output typewriter with integral paper tape equipment. The economy and flexibility of GE/PAC 4020 makes process automation a reality in broad new application areas in UTILITIES, CHEMICAL, PETROLEUM, STEEL, PAPER, CEMENT, TEXTILES, TRANSPORTATION, FOOD PROCESSING, RUBBER, DISCRETE PRODUCTS, MACHINE TOOLS, AND MUNICIPAL SERVICES.



Look at these advanced features!

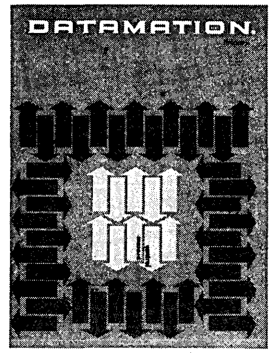
INTEGRATED CIRCUITS bring you highest performance, reliability and compactness. Vulnerability to connection failure is greatly reduced and a high degree of immunity to electrical noise is achieved. **1.6 MICROSECOND SPEED** gives you greater throughput per dollar invested. Process functions are performed faster, allowing time-sharing via I/O typewriters and other devices under control of the GE/PAC Free-time program. **OFF-THE-SHELF GE/PAC SOFTWARE,** compatible across the line, puts your process control computer on-line faster, with simplified programming utilizing GE/PAC's established 24-bit word length. The benefits—earlier return on your investment and lower programming costs. **DIRECT DIGITAL CONTROL CAPABILITY** is inherent through GE/PAC 4020's high-speed, reliability, and flexibility using standard input/output and man communication devices. **TOTAL INFORMATION SYSTEMS** with unit responsibility from General Electric are enhanced by the addition of GE/PAC 4020. Such systems can include other GE/PAC 4000 computers, Compatibles/400 and 600 business computers, Directo-Matic® II controls, GE/MAC instruments and GE/TAC telemetering and control.

Contact your nearest General Electric Apparatus Sales Office or the Process Computer Section, P. O. Box 2918, Phoenix, Arizona 85002.

GENERAL ELECTRIC

CIRCLE 5 ON READER CARD

*Trademark of General Electric Co.



february
1966

volume 12 number 2

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 WARREN A. TIBBETTS FELIX CHARNEY 141 E. 44th St., New York N.Y. 10017 [212] MUrray Hill 7-5180
New England District Manager & Vice President	WARREN A. TIBBETTS 112 West Haven Rd., Manchester, N.H., [603] NAtional 5-9498
Midwest District Manager	JOHN BRENNAN 205 West Wacker Drive, Chicago, Ill. 60606 [312] Financial 6-1026
Western District Manager & Vice President	HAMILTON S. STYRON 1830 W. Olympic Blvd., Los Angeles, Cal., 90006 [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. Reduced rate for qualified students. 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.
Printed by Beslow Associates, Inc.

This issue 59,395 copies

3M TASK FORCE Reports:

There's a group of systems development people at the 3M Company called the 3M Task Force. Their aim is to improve methods of storing and retrieving the mountains of information needed to keep our complex world going.

Now and then, the 3M Task Force will air a few of its activities and ideas in this publication . . . on the chance you might find a line of thought worth further probing.

Medium "reborn"

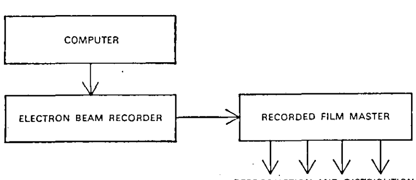
For the recording of total information, microfilm has no peer. Whether the information is of the quantitative type we process as data, or qualitative and textual, or purely graphic in nature, all types of information can be recorded on microfilm for storage and retrieval.

The growing attention to microfilm in basic information systems suggests that this medium, originally valued for purposes of security and dead storage, has been "reborn."

Computer graphics in parts catalog preparation and distribution

EDP systems generate a large quantity of printed output on bulky paper forms using relatively slow, mechanical printers.

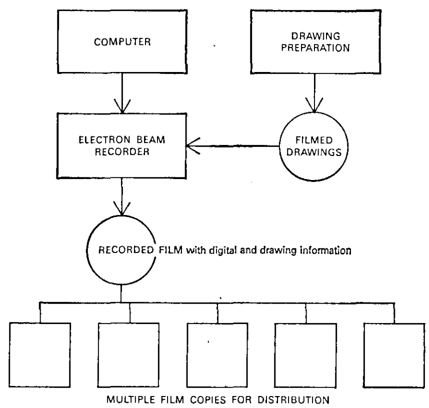
Developments in electron beam recording technology now make possible the direct microfilm printing of this information at electronic speeds with varied character font and format. This approach utilizes a unique electron beam recording film which is instantly processed for immediate use.



Computers are widely used for processing spare parts data in support of systems for equipment maintenance, inventory accounting or spare parts sales at retail outlets. These systems require frequent distribution of updated listings to many locations. An EBR system provides for the creation of a reproducible microfilm master at data rates compatible with internal memory operations.

The reproduction program uses duplicate film rather than the hard copy as the published medium. This means low cost duplication (1/10 cent per page), reduction in handling and distribution cost and easier retrieval.

Parts catalogs often contain line drawings and other graphics. Pictorial data can be input to the electron beam recorder from a digital source or from film for integration with the alpha-numerics on the output film. Graphics must be superimposed or interspersed for preparation of a catalog containing a combination of digital and analog data:



For more information about electron beams and computer graphics, get in touch with Rolf Westgard (612-733-4995) 3M Co., Building 209, Dept. FDJ-26, St. Paul, Minn. 55119.

Heartbeats on microfilm

The instrumentation and recording of biomedical data which is displayed on oscilloscopes or recorded graphically on paper can now be accomplished in yet another way. An example is this new method for the recording of electrocardiograms:

A unique computer program for the analysis of ECG's is being developed by M.D.'s at a well-known midwestern university. And a microfilm system is an important part of this program.

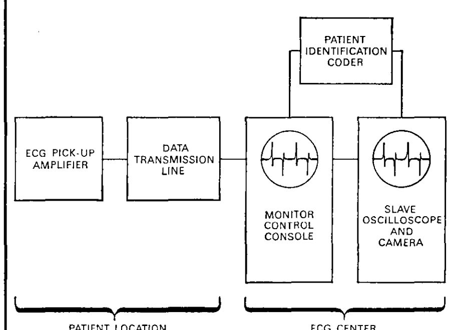
A proposed ECG Center will function as a central recording station for all electrocardiograms which are now recorded in two hospitals and the university's medical school.

Regardless of the patient's location, electrocardiograms will be transmitted via existing telephone circuits to the centralized recording station. With the new system, the technician will attach all leads to the patient at once, instead of one at a time as in the past. He will use any telephone to call the Electrocardiographic Center.

Once contact is established and verified, he will turn a switch and transmit up to six leads at one time, using the existing telephone or wired connections. In rapid sequence, all twelve standard orthagonal leads will be transmitted. Transmission of vector loops will also be accomplished in the future. All transmissions will be monitored at the monitor control console and recorded from the slave oscilloscope mounted beneath a special camera.

Here is where the microfilm aperture card system comes in. At the Center, the ECG data will be directly photographed from an oscilloscope screen by a microfilm processor-camera. In 45 seconds, the image is reduced to one frame of microfilm mounted on a data-processing card. After each ECG is recorded, a dry silver print is made for the cardiologist's interpretation. A microfilm viewer may also be used for interpretation.

Later, this information will be coded into the aperture card. The card is then filed and available for immediate recall. Whenever a cardiologist needs to look up an ECG, he simply puts the card in a Reader-Printer and the image appears on a large screen. He can get as many working-size copies as he needs by pressing a button. These copies can be sent back to the referring institution.



Immediate viewing of ECG's for consultation and training within each hospital in the complex will be possible by means of a closed-circuit TV hook-up. At the present time, it is possible to transmit a single channel ECG signal potential over any ordinary telephone circuit by means of a *telephone* link. ECG's from any out-patient or in-patient may be transmitted by a centralized ECG Center using this system.

A more efficient means of transmission will be the simultaneous transmission of 3 or 6 channels of data. Simultaneous recording on magnetic tape will facilitate the computer analysis of ECG's, which is the eventual aim of this project.

We are interested in talking with people about the areas of biomedical instrumentation recording. Write or call Walter F. Creigh (612-733-4884), 3M Co., Building 209, Dept. FDJ-26, St. Paul, Minn. 55119.

3M COMPANY

Mayday!

Ever have days when you get this sinking feeling? Tape problems — transport problems — dropout problems?

Next time maybe we can help. Before you go down for the third time, call your nearest Computron Regional Office and shout "Mayday". Your Computron customer engineer will be on his way in a trice. He is fully qualified in all phases of EDP. He is not a salesman. He knows tapes — he knows computers — and he has had a great deal of experience in getting them to talk to each other.

Of course, many people have solved their data recording problems simply by switching to Computape.

In any case, we are at your service. For advice, application assistance, problem solving, or just a reel of tape, call your nearest Computron office.

CIRCLE 8 ON READER CARD

A PRODUCT OF COMPUTRON, INC.
MEMBER OF THE BASF GROUP
122 CALVARY ST., WALTHAM, MASS. 02154

DATAMATION 66®

february

1966

volume 12 number 2

datamation departments

automatic information processing for business industry & science

Our brand-new time-sharing computer, already it speaks eight languages.

The SDS 940 is a low-cost, high-performance computer designed specifically for general-purpose time sharing.

The complete system is in operation now, and we'll make the first customer delivery in April.

If you'd like a demonstration, come to Santa Monica and converse with the system in any of its eight fully documented and debugged languages.

Or rent a Teletype and call up the system from where you are.

The 940 is very easy to talk to. No expert interpreters required.

It can handle an unlimited number of user stations. With more than 30 users talking at once, the 940 can respond in two to three seconds. With six simultaneous users the response time is less than one second.

The 940 does multi-programming, real-time processing and on-line remote data processing. Its hardware is designed to minimize programmed overhead and make the whole system available to the user.

Hardware features include monitor and user modes, dynamic program relocation, automatic memory fragmentation control, and system protection.

Users may be individuals, machines, or both at once, and they'll never get in each other's way. The Monitor program, and hardware protection, keep users from destroying or gaining unauthorized access to programs or data of other users.

The Executive program lets you call for the language that best suits your problem and your ability to operate the machine. Another program, HELP, tells you how to use the language.

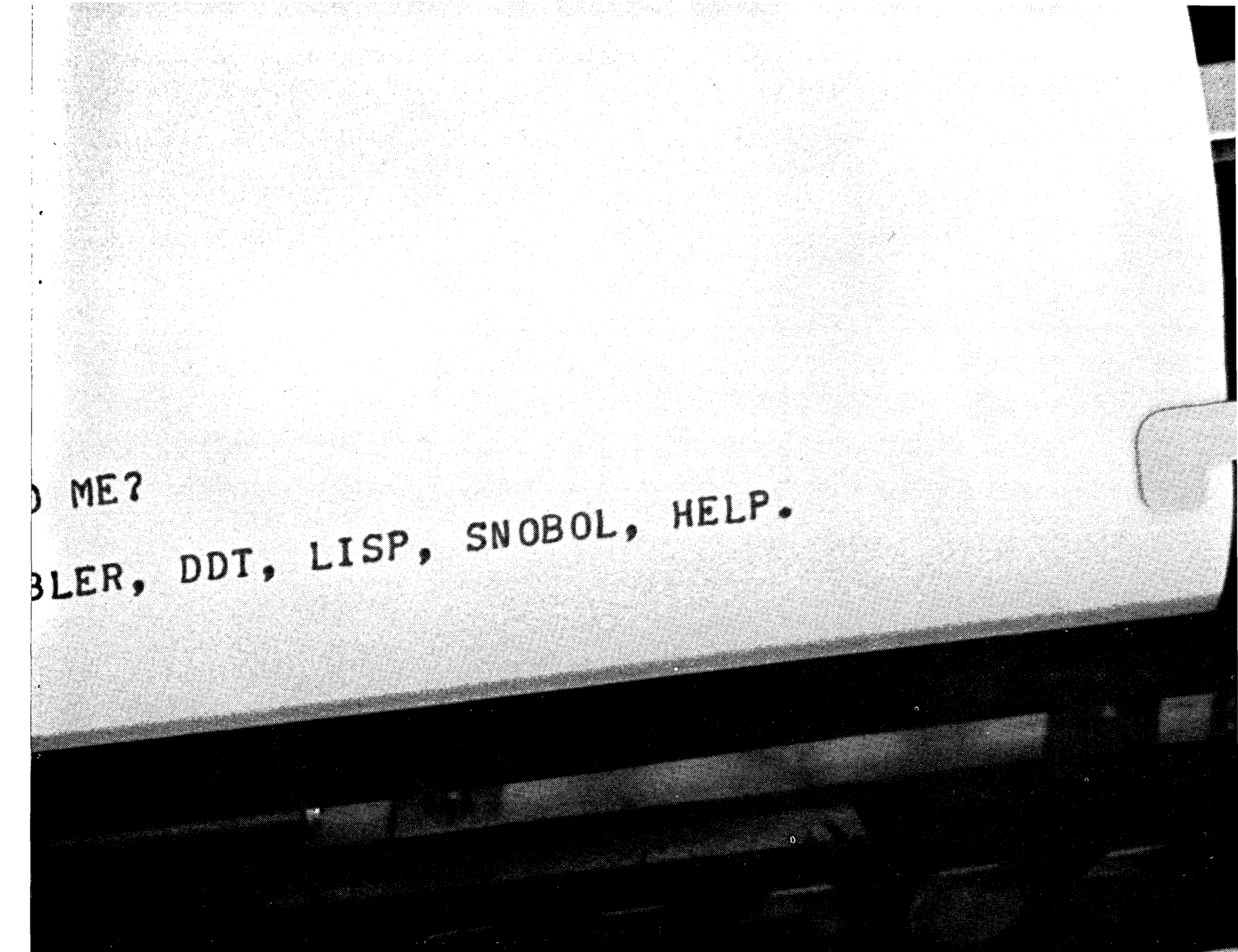
The following subsystems are operating now (with full documentation):

CAL (Conversational Algebraic Language). Resembles Joss. Is primarily aimed at small numerical problems in a highly interactive environment. It relieves the user of all burdens of storage allocation for both programs and data.

FORTRAN. Has all the features of the standard SDS 900 Series FORTRAN II. Can accept symbolic source-language input created on-line by QED, and thus an on-line compile-execute-edit-compile cycle is easily achieved in the system.

QED. A generalized text editor that allows the on-line user to create and modify symbolic text for any purpose. Includes inserting, deleting and changing lines of text; a line-edit feature; a powerful symbolic search feature; automatic tabs the user can set; and ten string buffers. The user can automatically save a set of editing commands for "canned" execution later (cliches).

SYMBOLIC MACRO-ASSEMBLER. A two-pass assem-



bler with subprogram, literal, and powerful macro facilities. It is similar to the standard SDS Meta-Symbol assembler. The output is accepted for use by the debugging program DDT, providing all the symbol tables for effective program checkout in terms of source languages.

DDT. A versatile, sophisticated on-line debugging package. Permits the user to examine, search, change, and insert break-point and step-trace instructions in his program at the symbolic level. Permits the use of literals in the same manner as the assembler. Can load both absolute and relocatable assembler-produced files. Its command language is geared to rapid interactive operation by the on-line user.

LISP. An extremely powerful symbol-manipulating language that uses recursive, list-processing techniques. Particularly valuable for nonnumeric applications and logical analysis. In its current application it is interpretive and has the added capability of employing M-expressions, which are closer to the user's problem language than the normal input form.

SNOBOL. A programming language that provides complete facilities for the manipulation of strings of characters. Is particularly applicable for programs associated with text editing, information retrieval, linguistics, compiling, and symbolic manipulation of algebraic expressions.

HELP. A valuable aid to the inexperienced. Provides on-line question-answering service for use by the time-sharing Executive and the above-described subsystems. HELP gives users convenient access to a direct self-teaching facility, which accepts questions on system or subsystem usage in natural language and answers in English.

Other subsystems are well along in development, including ALGOL.

When not required for time sharing, the 940 operates as an SDS 930 – a high-powered general-purpose and real-time computer.

An almost unlimited number of SDS peripheral devices may be used with the 940, including Random Access Disc (RAD) files, single-capstan magnetic tape unit, display scopes with character and vector generators, line printers, card readers and punches, paper tape equipment and digital plotters.

The SDS 940 is not an interim time-sharing system which will be obsolete in a couple of years when software for the "big" systems is delivered. You'll still be contentedly using your 940 system five years from now.

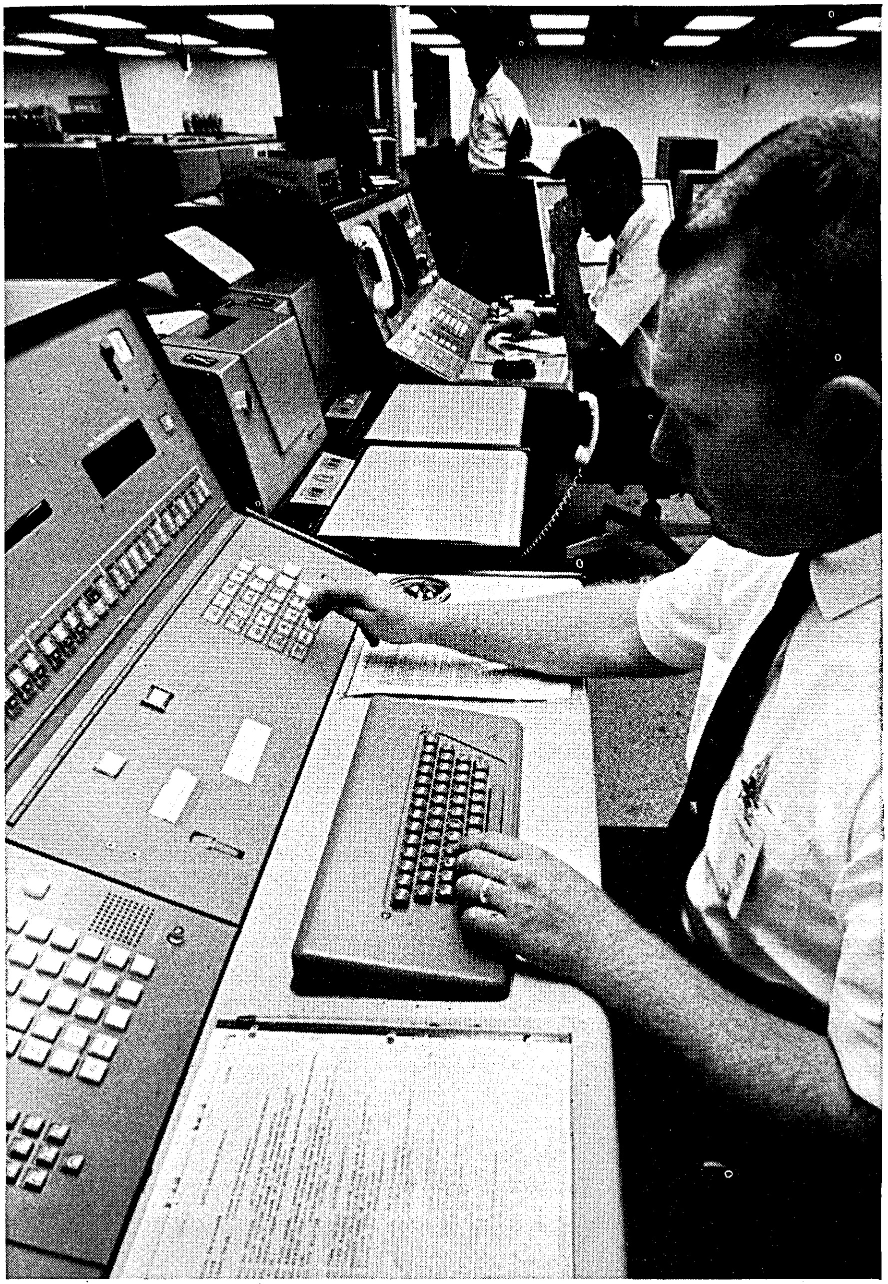
You can start using it in six months if you hurry.

Scientific Data Systems

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

SDS

CIRCLE 9 ON READER CARD



calendar

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

● American Management Assn. will sponsor a conference on dp, Feb. 28-March 2, Statler Hilton Hotel, New York City. Fee: $85, members, $100, non-members; and a briefing session, "Planning Direct Access Systems Using Remote Data Terminals," March 2-4, Hotel Roosevelt, New York City, Fee: $150, members, $175, non-members.

● Computer Usage Education Inc. is sponsoring four seminars: "IBM System/360 Software," March 1-3, International Hotel, Los Angeles; "Data Communication," March 8-10, Jack Tar Hotel, San Francisco; "Information Retrieval," March 14-16, and "Time-Sharing," March 22-24, Barbizon-Plaza, New York. Fee: $195.

● In-residence short courses on dp orientation for administrators and key personnel will meet on Calif. State Polytechnic College's Voorhis Campus Education Center, March 7-8 and 21-22.

● Course in edp audit and controls will be held March 7-11, Sheraton-Lincoln Hotel, Houston, Texas; April 25-29, City Squire Motor Inn, New York City; May 16-20, Jack Tar Hotel, San Francisco, Calif. Sponsor is Automation Training Center. Fee: $250.

● Canadian Operational Research Society's conference will be held March 12-13, McGill Univ., Montreal, Canada.

● Course in theory and techniques of linear programming will be given by Univ. of California Extension, March 15-25, San Francisco, Calif.

● Lomond Systems Inc. and Chevy Chase Travel, Inc., Bethesda, Md. will sponsor a group seminar tour of edp executives in eight European countries, March 21-April 7. Fee: $1455.

● The Div. of Continuing Education, Univ. of Texas Graduate School of Biomedical Sciences, is sponsoring a symposium "Biomathematics and Computers in Life Sciences," Mar. 24-26, Houston, Texas.

● Univ. of California Extension, Los Angeles, is offering two courses: "Use of Computers in Structural Engineering," Mar. 28-Apr. 8; "Hybrid Computation," April 25-May 6. Fees: $300.

● One-day technical symposium, sponsored by six southern California ACM chapters, will be held March 29, Disneyland Hotel, Anaheim, Calif.

● "The Challenge of Cybernetics to Education" will be presented by the American Univ., March 29-31, Twin Bridges Marriott Motor Hotel, Washington, D.C. Fee: $150.

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

● Symposium on process automation will be held April 18-20, Newporter Inn, Newport Beach, Calif. Sponsors are Beckman Instruments, Scientific Data Systems, Consolidated Electrodynamics Corp. and Control Data Corp.

● International conference on dp in hospitals will meet April 20-23, Hotel Marienlyst, Elsinore, Denmark.

● Meeting of the American Society of Mechanical Engineers on the theme "Computers and Instrumentation" will be April 25-27, Charleston, W.Va.

● Bionics symposium, sponsored by Air Force Systems Command's Aerospace Medical Div. and Research and Technology Div., will meet May 2-5, Sheraton Hilton Hotel, Dayton, Ohio.

● Telecommunications exposition to be held in conjunction with meeting of Industrial Communications Association will be May 2-5, Queen Elizabeth Hotel, Montreal, Canada.

● Data processing conference will meet May 3-5, Univ. of Alabama DP Center, Birmingham, Ala.

HOW TO MAKE PROCESSED DATA AVAILABLE

Few question the value of effective data processing for improving administration, production, and other business procedures. However, unless the processed data is available when and where it's needed—its effectiveness is lost. That's why data communications is so much a part of any system for collecting, processing, and distributing business information.

Speeds Information as Needed Teletype machines are the most widely used for transmitting data. They are the most efficient and least costly equipment to speed information from where it originates to where it must go to be most useful.

An added advantage—Teletype Models 33 and 35 page printers and automatic send-receive sets operate on the same permutation code as approved by the American Standards Association for information interchange. Therefore, they speak the same language as most computers and other business machines.

Provides Versatility as Needed Teletype equipment is being used in data processing systems as input/output devices for computers as well as for on-line communications. Messages and data can be punched on paper tape off-line for later transmission on-line at full capacity to distant points or directly to computers.

A new 4-row keyboard makes operation easy for any typist. There's no longer any need to "shift" between letters and numbers. And, Teletype machines can print on business forms providing multiple copies both locally and at remote stations. This speeds clerical procedures, as well as improves order processing, and production and inventory control.

Cuts Order Processing 75 Percent Getting information where it's needed as quickly as possible has helped a metal products manufacturer cut order processing time 75 percent. By using Teletype ASR (automatic send-receive) sets, minutes after an order comes in the data is sent to shipping and production departments—each one receiving the accurate information it needs. The results have been same-day shipment of in-stock items, orders scheduled into production 3 to 7 days faster, overtime reduced, errors nearly eliminated, and up-to-date sales reports and analyses provided to management.

Learn More About Moving Data These Teletype machines are made for the Bell System and others who require dependable and low cost communications. To learn more about how this equipment is used in other effective data communications systems, write for our "HERE'S HOW" brochure. Teletype Corporation, Dept. 81B, 5555 Touhy Avenue, Skokie, Illinois 60078.

machines that make data move

TELETYPE ®

letters

u.k. sunshine

Sir:

May I offer some sunny touches to your gloomy picture (Editor's Readout, Dec., p. 23) of computer education and the industry in the U.K.? The British Computer Society is growing fast, 30% in the last eight months, to over 5,000 . . . A BCS survey of U.K. computer education shows at least 350 courses available at various levels from universities down, excluding courses by manufacturers.

It is not universities but traditions that are likely to drown.

The BCS 5-day real-time symposium expected 600 participants; we got 2,500. I hope your readers will not write off the U.K.—history is very much against them.

J. G. Mackarness, Secretary
British Computer Society
London, England

computers & redistricting

Sir:

Some remarks are necessary on the article, "Computers and Redistricting," by John F. Banzhaf III (Dec., p. 103), where I am quoted as saying that the computer's plans for redistricting the state of Connecticut were not much better than the one that came out of the smoke-filled room.

In the first place, if we had presented the plan for redistricting the House of Representatives which the state legislature arrived at by its deliberations, it would very likely have been rejected by the federal district court because the population deviation would have been in excess of that permitted us in a computer solution. The reason for the rather large population deviation in the legislature's solution is the built-in error (reaching ±50% in some instances) inherent in the use of a rather large unit, namely the traditional township, in forming the legislative districts. Our solution would have used a smaller unit for constructing the House districts, thus reducing the population deviation to an error not in excess of ±10%.

Whenever the number of legislative districts to be constructed is not much smaller than the number of units upon which the districts are based—in mathematical terms, whenever the number of degrees of freedom is small—one is faced with an ill-conditioned problem and, as in the case of linear algebra, standard techniques of solution may not necessarily lead to the best solution. In the redistricting problem ill-conditioned problems have not, to my knowledge, been adequately studied but clearly will require investigation if the constraints of the problem *require* a small number of degrees of freedom. However, even with present techniques a solution by computer carries the merit of being non-partisan.

Morris S. Davis, Director
Computer Center
Yale University
New Haven, Connecticut

programming the 360

Sir:

Your December article, "System/360 Assembly Language" by Martin E. Hopkins, warns: "One of the largest sources of errors in 360 coding is incorrect alignment on byte boundaries." I submit that a greater source of errors is the hexadecimal to decimal conversion, or vice versa.

For example the middle of page 74 illustrates X'150' is equivalent to 320, and decimal 57943 is equivalent to X'E261'. However, this is not true, Hexadecimal or X'150' = 336 (or 320 = X'140'), and decimal 57943 = X'E 257' (or X'E261' = 57953).

Because of such recurring errors, which is quite common to 360 and Spectra 70 programming, the Spectra 70 Training Manual has a "Hexadecimal-Decimal Conversion Table" which is a great aid to the programmer.

Melvin Fishman
Systems Information
RCA-EDP
Camden, New Jersey

Author's reply: Thank you for correcting me and bringing the excellent RCA conversion chart to my attention. However, the value of this or any other hexadecimal conversion chart is, I believe, limited. Experienced programmers tend to operate within a number base. They think in hex . . . add and subtract in hex. The assembly language assists by allowing one to express oneself in hex, further reducing the need for conversion . . . For those cases in which one must work with data in decimal, dumps are available which give the desired format.

It is hard to pinpoint the cause of bugs, but a poll of 10 programmers in our shop, each having two years' coding and checkout experience on the 360, reveals that none can remember when they last manually converted a number; over half claim they never had to. All mentioned boundary alignment or its effect, a specification interrupt, as a frequent cause of error.

short-word computers

Sir:

Re: "Comparing the Compacts" by Edward O. Boutwell, Jr. (Dec., p. 61). In Fig. 3, p. 73, I believe the line sloping down to the right should be labeled "$/Performance," rather than "Performance/$."

JOHN C. TAYLOR

System Sciences Division
Control Data Corporation
Los Angeles, California

Unfortunately, the curve was labeled incorrectly; the horizontal line between the "1" and "performance/$" was left out. The parameter which is treated in the paper is "performance/$." The reciprocal of the parameter was plotted in order to better illustrate the combined effects of performance/$ improvements and increasing system complexity, and at the same time to conform to the general practice of labeling the ordinate axis "increasing" in the up direction.

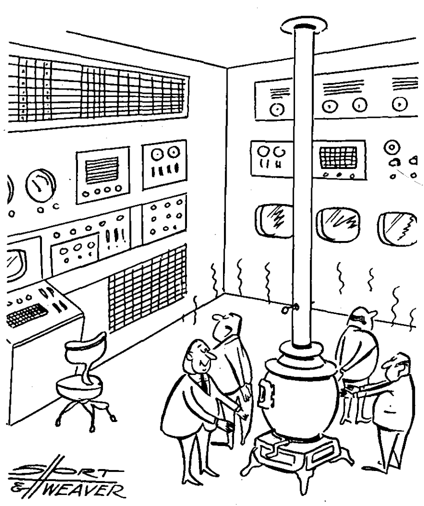
computer & the arts

Sir:

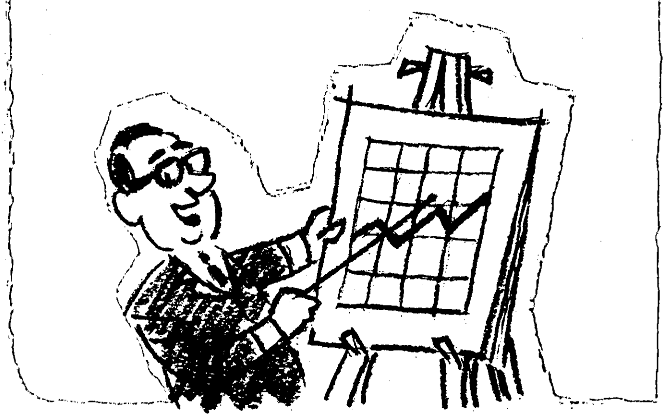
Much unpublished activity is going on in the application of computers to the arts. I would like to compile a list of research projects involving visual design, architectural design, music, ballet, poetry, drama, film and the like. Those working in this area are requested to send a brief description of the work.

I would also like to know how much interest there is in a conference on "The Computer and the Arts."

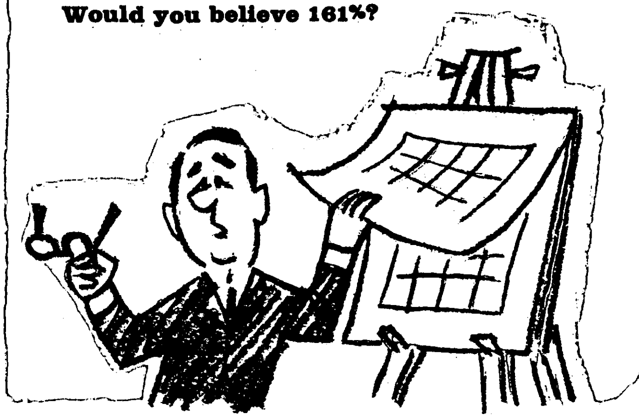
L. MEZEI
York University
2275 Bayview Avenue
Toronto 12, Ontario
Canada



Would you believe it, ASI increased its computer sales the past year by 186%?



Would you believe 161%?



THE FACTS ARE: Actual growth in 1965 was more than 300%. In three short years ASI has successfully developed, designed, manufactured, sold, and are servicing a line of computers in the scientific field starting with the 210 and the 2100. These were followed by the remarkable *ADVANCE* Series 6020, 6040, 6050, and 6070.

Our hardware, software, and peripheral equipment are second to none in our area; in addition, we provide the most eager assistance and support in the business.

ASI

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

look ahead

RETURN OF THE GIANTS

The Jan. 21 announcement of IBM's new "super" series, the 360/90, came as a surprise, since it hadn't been too long since IBM told some folks that it was getting out of the giant machine business (shades of Stretch). A sudden reversal was noted after IBM had withdrawn from competition at the Stanford Linear Accelerator Center in December, then came back in with a 360/91 bid three weeks later. It may be IBM's last shot at an AEC installation for awhile: it looks as if CDC might have the inside track at Argonne and at Los Alamos. Awaiting final AEC approval, Argonne will probably get a 3800 to supplement its 3600 until a 6800 arrives early in '68. Los Alamos looks as if it's ready to spend up to 7 megabucks on a 6800 which will be preceded by an interim 6600. The system will supplement three 7094's, a Stretch, and the home-made Maniac-II.

Meanwhile, Lawrence Radiation Labs at Livermore is on the prowl again for more hardware. (An old gag about Livermore: Don't worry if we can't fly to the moon; pile up all the computers there and climb up). This time, the rfp is for a parallel network computer, which really means several (10-100 maybe) small computers with restricted command repertoires which are hooked together. No such machine is now on the market, although Westinghouse has designed one. They, along with IBM and CDC, will probably bid. Another possible surprise entry: General Precision Librascope. The cost for the gear, expected to be better than anything now available: hopefully not more than $5 million.

...WHILE LITTLE ONES STAGGER FORWARD

Meanwhile, not all is quiet on the li'l machine, small company front. In Sunnyvale, Calif., Jim Chao's Information Technology, Inc. is shipping out its first 4900 computer, has orders for 12 more. The 4900 will go i.c.; memory cycle time has dropped from 6 usec to 1.75, and internal speeds hiked two to three times. The company has also installed some printer systems, some memory systems and multiplexers.

Decision Controls, in southern California, has delivered five of its Data Machines machines, has a backlog of 10, with maybe 60 cliff-hangers out on bid.

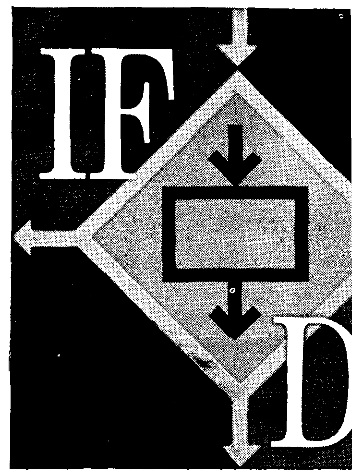
Texan outfit Scientific Control Systems says things are going great, but won't offer any supporting evidence, opining only that they have lots of money and that the Texas weather that day was terrible (does that mean it was raining pennies?).

One casualty amongst the little guys is GFI of Encino, California. (See Sept. '64, p. 17). The company sold its breadboard, then folded. Founder Marc Goldwater has turned to consulting; his partner, David Fuchs, is with IBM.

GOVERNMENT ROUNDS OUT ADP MANAGEMENT TEAM

The Bureau of the Budget has acquired a quarterback for its efforts to rationalize Government computer operations with the appointment of Joseph Cunningham to the newly created post of chief of the Bureau's ADP policy staff. Cunningham is a veteran computer hand who was associate director and ranking civilian in the AF's Data Automation Directorate. He'll be responsible for creating the broad policy guidelines

Scientific Pr



under which BOB, General Services Administration, and Bureau of Standards will try to help the biggest user of them all move toward hardware and software compatibility, equipment coordination and sharing, improved selection and procurement, better edp management in general.

Cunningham will also be involved in translating the dictates of the recently passed Brooks Bill -- including the revolving fund proviso -- into action. And his staff will work closely with those of GSA's Ed Dwyer and Norm Ream of the Bureau of Standards. Their general charter: make sure that the nation gets its money's worth out of what the President estimated last month as $2 billion/year in ADP expenditures.

AFIPS READIES INITIAL INDUSTRY REPORT

Concern over a lack of information and statistics about the edp industry (see this month's Readout) has led AFIPS to finance preparation of a literature search of certain aspects of the field. Under a $5K contract, CEIR has compiled a report which attempts to establish the number of machines, people employed in various types of jobs in the industry and their salaries, with projections for all three over the next several years. Now being scrutinized by AFIPS chieftains, the survey may be made available in condensed form at the next SJCC. Although limited, the survey will undoubtedly be welcomed by many as a step in the right direction. And its limitations might inspire more thorough, better financed research.

RUMORS AND RAW RANDOM DATA

Fabri-Tek has acquired Costello & Co., edp rep organization with offices in California, Arizona and Texas. Head man Joe Costello moves to Minneapolis as administrative vp, leaving Will Little as head man of the new subsidiary...Two OEM firms seek to broaden and diversify markets: Potter pushes a PS-6000 print station combining printer and tape unit; Data Products develops special upper/lower case printer/tape combo for printing of "personalized" form letters...It looks as if Univac has cornered the last big airline reservation order from Air France...Look for ASI to change its name soon in an attempt to make better use of its association with parent firm EMR, rich stepchild of financial goliath Schlumberger...Radiation, Inc. has won an $8-million contract from the Bureau of Naval Weapons to build one-way airborne data links for installation on jets, whose landing approach will be controlled by computer aboard the carrier...More dough for the U. of Utah, where ARPA plans to spend $500K over next two years for research in graphic I/O terminals and ancillary software, with emphasis on economics... Rumors are that the Reuben Donnelly airline reservation system may switch from ITT hardware to GE 600 series...We hear GE is delivering a GE 615 (stripped down 625?) to one customer. It may be the forerunner of an attempt to stretch the 600 line downward toward the 400 series. Also new from GE: Datanet 70...Nominees for new president of ACM: Harvard's Tony Oettinger, Bob Rector of Informatics ...Burroughs is trying to decide if its 2000 series, due out this spring, should be 360 compatible. Meanwhile, there's talk about the possibilities of upgrading the 5500...Stan Naftaly has been appointed chairman of an ACM committee to study the implications of the DPMA's certificate exam.

If you use a computer to draft your own paycheck,

PAID TO GEORGE SPELVIN 061-16-2265

STATEMENT OF EARNINGS AND PAYMENTS FOR EMPLOYEE'S RECORD — DETACH BEFORE CASHING CHECK

PERIOD ENDING	EXPLANATION OF YOUR EARNINGS				TOTAL EARNINGS	OUT OF YOUR TOTAL EARNINGS WE HAVE PAID FOR YOU					TOTAL PAID TO YOUR ACCOUNTS	BALANCE OF EARNINGS
	HOURS	RATE	AMOUNT EARNED AT REGULAR RATE	OVERTIME AND OTHER		FICA	SUI	WH	HOSP	MISC		
1-31-66	½MO	1100	550	00	550	23.10	6.05	61.40	16.00	00	103.39	446.61

PAY ROLL CHECK

you owe it to yourself to use the tape that never misses a bit

MEMOREX
PRECISION MAGNETIC TAPE

Everybody on the payroll stands to benefit if you use the computer tape least likely to develop errors caused by dropouts. Conventional tapes begin to shed dropout-causing oxide particles after only a few paydays. Memorex computer tape—using advanced coating formulations and processing methods to achieve a superior bond between the oxide particles—is essentially free from redeposition problems. Hence Memorex precision tapes are widely preferred for such important figures as your payroll records.

If you write Memorex Corporation at 210 Memorex Park, Santa Clara, California 95052, we will send you computer tape specification data and a complete bibliography of technical information available from the Memorex library of reprints.

Memorex Branch Offices in New York, Philadelphia, Washington, Atlanta, Orlando, Dayton, Chicago, Detroit, Dallas, Los Angeles, San Francisco; Offices and Affiliates in London, Cologne, and Paris

CIRCLE 17 ON READER CARD

editor's readout

THE MISSING DATA BASE

In Wolf Point, Montana, a bright high school senior wonders if perhaps information processing might offer him a career. He wants to know what positions he might begin to study for, which colleges offer the best programs. In California, the head of a university computer sciences department wonders how many people with what capabilities and backgrounds the industry will need 5, 10, 20 years from now.

The management of a Southern California defense-oriented electronics firm interested in diversifying wonders if there's a wider market for some of its consoles and display devices.

The marketing manager of a New England computer manufacturer wonders if there are special applications not now being served, or if there is some way to group or classify applications to point the way to a special system, a new software package or marketing approach. Across the country, the product planning manager of another computer maker wonders if indeed scientific computing and business data processing are becoming more similar. Will one programming language *really* do the job?

In Washington, D. C., a government employee charged with helping to channel research money wonders how to allocate it. What are the biggest bottlenecks in information processing? Who's tackling them now? What organizations and individuals are capable of taking on what kinds of work?

A New York investment counselor, manager of several large portfolios, wonders how to choose information processing firms in which to invest his clients' funds.

All of these fictional people have actual counterparts in real life. And they're asking these questions and other toughies with increasing frequency . . . and frustration. For there is no single source of information or statistics on which to base intelligent planning for education, research, product development, and investment in the information processing industry.

The information processing industry is, to put it mildly, information poor. How many computers of what classes are installed? What are they being used for? How much time is spent on sorting, on file maintenance, on compiling? What's the average life of a computer? How many hours a day are computers used? How much of that is productive? How much preventive maintenance is performed?

The answers — try to get them — to such questions would be extremely useful. They could mean better computers, more intelligently directed research, better planning by edp departments, wiser investment of capital . . . greater profits for manufacturers, users and investors.

The information on which answers to these and equally important questions could be based does exist. Some of it is made available in bits and drabs . . . sometimes clandestinely, sometimes as the result of privately supported research for a client here, a client there. But this is not the way a mature profession or industry goes about informing itself and its publics about its business. For an industry which so profoundly affects an amazingly wide spectrum of intellectual and economic activities, there is too much at stake for us to continue acting like a secret society or a high school sorority.

It's time that leaders of professional societies, manufacturers, user groups, in universities and government start thinking about what kinds of information and statistics are needed about our industry . . . and how we should go about collecting, synthesizing and making them available.

In a subsequent issue, we'll examine some of the possible sources and focal points for such an information gathering activity . . . and suggest some concrete courses of action.

PROCESS CONTROL

a tutorial

by THOMAS M. STOUT

Several years ago, according to reports, a vice president of a chemical company showed his wife around a computer-controlled plant. Passing through the control room, in the presence of five process operators, he thumped the computer and remarked to his wife, "Here's the machine that's going to put these men out of work."

Whatever the accuracy of this prediction for his plant, the gentleman in question probably deserves a low rating for diplomacy and, on an industry-wide basis, a fairly poor score for prophecy. A survey of companies using about one-fourth of the process control computers installed in the United States showed many instances of no reduction in operating manpower, an average of about one operating employee per computer, and frequent offsetting additions of technical and maintenance personnel.

If—contrary to popular understanding—manpower reductions are not a primary motivation, why are managements in the process industries installing control computers? What are the operating problems behind use of an on-line process control computer? What functions does it perform? What difficulties are encountered in system design and installation?

This article attempts to answer these questions in a general way. The following articles in this issue expand on these points with examples from specific industries.

process objectives

For purposes of this article, a process is an assembly of equipment performing physical and chemical transformations on raw materials to convert them into more useful or valuable products. Processes for making gasoline, chemicals, steel, paper, glass, synthetic rubber, and many other materials easily fit this definition. With only a slight stretch of the imagination, it can also be applied to generating electricity from coal, oil, gas or atomic fuels. It can even be stretched to include transport of gas or liquids by pipelines, where the material gains value by being moved close to the consumer.

As a further definition of the area of technology under discussion, the articles do not deal with plants and procedures for making consumer products such as automobiles and refrigerators. Nor do they consider on-line applications of control devices, computers, or digital equipment to such diverse jobs as machine tool control, engine testing, missile checkout, medical data collection, mail sorting, toll registration, television switching, or automatic warehousing, even though the same computers, techniques, and problems may be involved. Process control has enough unique aspects to warrant a discussion of its own.

Process owners and operators have a number of objectives. Since a process is generally run to return a profit to its owners, an operator's first objective may be to maximize earnings from equipment under his supervision. However, he must also consider a number of secondary, but nevertheless important, related objectives:

The author is now president of Profimatics, Inc., a Los Angeles firm offering consulting services on control technology for the process industries. He was formerly manager of Bunker-Ramo's Advanced Process Control Systems Dept., having joined Ramo-Wooldridge in 1956. He holds a BSEE from Iowa State College, and the MSE and PhD degrees from the University of Michigan.

1. Meet production schedules and have products ready for shipment at the desired times;
2. Keep product qualities within specifications;
3. Minimize waste of fuel, water, electricity, steam, catalysts, solvents, and so on;
4. Avoid conditions leading to equipment breakdowns, lost operating time, and unexpected or unnecessary maintenance costs;
5. Protect personnel from injury and equipment from destruction due to explosions or other catastrophes.

These objectives may be difficult to satisfy simultaneously. An operator may detect that one product quality is outside its specification and correct the situation, only to find that his correction has caused another product quality to become unacceptable; a number of corrections may be necessary to bring all of the product characteristics within the prescribed limits.

In some cases, these objectives may even be contradictory. Efforts to boost production rates, for example, may entail overloads of pumps and compressors (with increased maintenance costs), less efficient removal of impurities (with a degradation of product quality), or operations with more hazardous combinations of materials (with an increased risk of explosion). Improvements in quality may mean higher costs for removing contaminants or greater amounts of raw material. At very high production rates, yields may decline so much that excessive amounts of raw materials are required; operation at the high rates may then be uneconomic, even though necessary to meet a customer commitment.

By combining financial and technical considerations, process supervisors could determine a combination of process conditions providing the best compromise between the numerous objectives. The real need, unfortunately, is not a page describing a single set of process conditions but a whole book or library of books containing pages applicable to the many situations encountered in any process plant. This need arises from changes affecting the process:

1. Customers increase or decrease their orders, or ask for better or different products;
2. Prices for raw materials and products change from time to time;
3. Chemical and physical characteristics of raw materials vary;
4. The quantity of raw material available for processing increases or decreases;
5. Performance characteristics of process equipment change as catalysts lose their activity, heat exchanger surfaces become fouled, bearings wear, and so on;
6. New equipment is added to expand or improve the process;
7. Equipment breaks down unexpectedly and through no fault of the operators;
8. Weather conditions (such as air temperature, humidity, and wind velocity) vary continuously and may have significant effects on process performance.

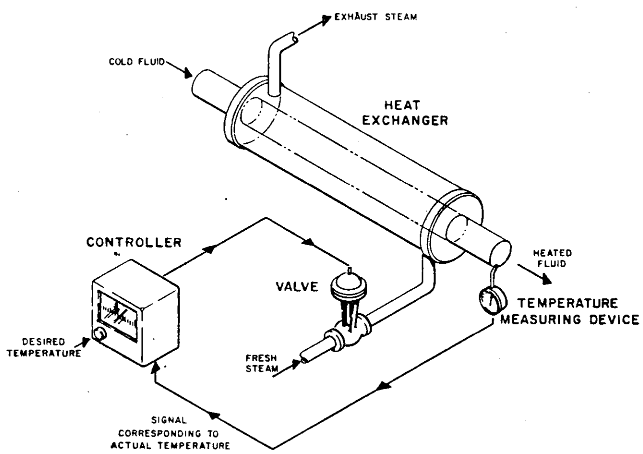
Without changes or disturbances of these kinds, no process control devices or procedures would be needed. In continuous processes, valves could be locked in place at positions leading to manufacture of the required products in the desired quantities. In batch processes, cam-actuated valves (which pay no attention to the progress of the operation) could be used to enforce pre-planned variations of process conditions. Because changes do occur, this approach is impractical.

The basic tool of industrial process control is the conventional *controller*. This device embodies means for measuring the condition to be controlled, comparing the measured value with a desired value, and automatically taking action to bring the two values into agreement. An early example was the steam engine governor. Controllers were soon used to regulate a wide variety of process conditions: flow, pressure, temperature, level, and speed, to name just a few.

A typical automatic control system is shown in Fig. 1. In this system, a process fluid is heated by passing through a pipe (or pipes) around which steam is made to flow. At the outlet of the heat exchanger, a measuring device senses the actual temperature of the process fluid. In the controller, a signal corresponding to the measured temperature is compared with a desired value which has been inserted by an operator. If the measured value is less than the desired value, a signal goes to the valve causing it to open wider, increasing the flow of steam to the heat exchanger and raising the temperature of the process fluid. If the measured temperature is greater than the desired value, the controller acts to close the valve, reducing the steam flow and lowering the temperature of the process fluid. The system shown in Fig. 1 performs the same function as a household thermostat.

By substituting different types of measuring devices, the technique illustrated in Fig. 1 can be used to regulate a

Fig. 1. Typical Automatic Control Loop



wide variety of process variables. In recent years, great effort has been exerted to develop *analysis instruments* which measure material qualities such as chemical composition, water or moisture content, thickness, hardness, opacity, color, viscosity, density, octane number, and so on. Instead of measuring the environment in which a product is made, these instruments sense characteristics of direct significance to the consumer. At the same time, they allow control to closer tolerances on these characteristics and thus production of higher-quality products.

As a supplement to conventional measuring and control devices, the automatic *data logger* was proposed about ten or fifteen years ago. Data loggers consisted of means for sequentially converting process variables to digital form and operating electric typewriters to produce a permanent record of process conditions. The equipment could perform some rudimentary calculations, such as multiplying incoming signals by a constant to give outputs in proper units, e.g., degrees Fahrenheit or gallons per minute. With the addition of an auxiliary memory, it could also provide daily totals for raw material consumption or production.

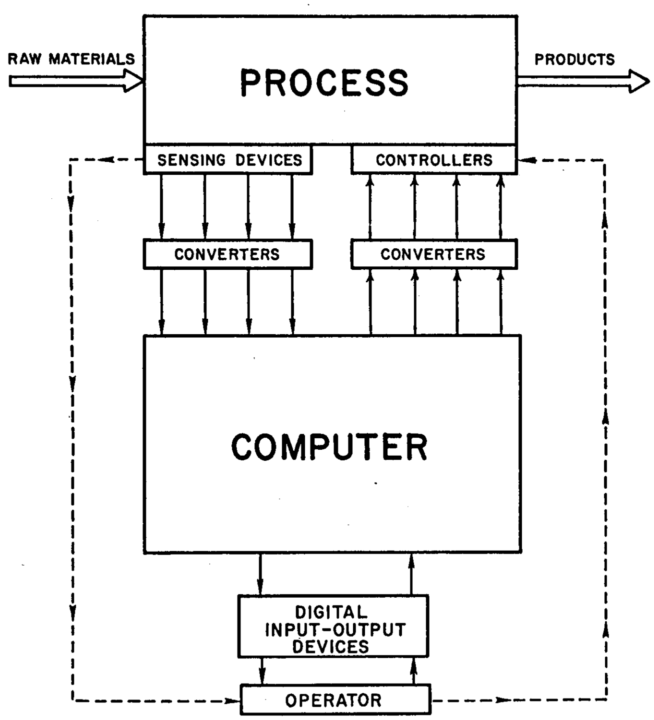
Data loggers cost perhaps $50,000 to $100,000 or more, depending on the number of variables involved. Justifications for such expenditures were supposed to be found in better data, for both accounting and engineering use; elimination of some standard recorders; and reduction in clerical labor needed to get routine accounting data from process records. In general, benefits proved less than adequate to justify the investments, and data loggers never became popular. Their functions are now performed in a growing number of plants by digital computers.

control techniques

The conventional, one-variable controller executes what is known as "feed-back control." That is, a direct measurement of a product quality or process condition is made and used to initiate control action at an earlier point in the process to correct any deviation of the measured variable from its desired value. Information flows generally in a direction opposite to material flow in the process. Very little knowledge of the process is required to implement this type of control, generally only a knowledge that an increase (or decrease) in a manipulated variable will eventually restore the measured variable to its desired value.

In computer control systems, on the other hand, control is exercised to a large extent in a "feed-forward" manner in which disturbances are sensed and corrective actions taken before the process has had a chance to be upset. These systems rely heavily on measurements of raw material characteristics and ambient conditions, rather than measurements of product characteristics as in "feed-back" systems. To exercise control in this manner, the computer must employ

Fig. 2. Schematic Diagram of Computer Control System



a set of process equations or a mathematical model to predict the effect of accidental or deliberate changes in process conditions.

In addition to continuous adjustment of process conditions, a control computer can also be programmed to carry out the complex sequence of operations needed to start up or shut down a large plant. The sequence used may be planned in advance or it may depend on measurements received from the process. Frequently, a control computer checks instrument readings for indications of trouble in the process by comparing the incoming signals against high and low limits.

The sort of process computer application just described is known as *supervisory control*; the computer assumes some of the supervisory functions of the operator. In case of a computer failure or other emergency, the operator can resume his original role.

With a sufficiently reliable digital computer, the controllers can be eliminated and the computer connected directly to the valves at the various locations in the process. As in other computer control systems, the computer receives measurements of process temperatures, flows, pressures, and other variables. Now, however, the computer checks each variable in turn, compares the present value with the desired value, and sends out signals to open or close the appropriate valve. This mode of control has been called *direct digital control (DDC)*, because a digital device is connected directly to the valves controlling process conditions. DDC is now receiving serious attention from both users and equipment manufacturers.

equipment configuration

A schematic diagram of a process control computer system is shown in Fig. 2. Process sensing devices are connected to the computer through converters which change the original signals into a form acceptable to the computer. Most process instruments provide continuous signals in the form of an electrical voltage or an air pressure which is proportional to the quantity, such as temperature or flow, which is being measured. These signals must first be changed to a common electrical form, using suitable amplifiers or pneumatic-to-electric converters. When computer outputs are used for control purposes, they must generally be converted from a digital form into a continuous electrical signal. Often. conversion of this type of signal into a corresponding air pressure is also required to operate pneumatic equipment.

A control computer communicates with process operators in two ways: to receive data, instructions, and programs for guiding its actions, and to send out information that may be useful to the operators. Three main methods are used for letting the operators communicate with a control computer:

1. Mechanical or optical devices for reading paper tape or cards (used to get the original program and later changes or corrections into the computer memory);
2. Push buttons and switches whose position can be detected by the computer (used to specify some special action by the computer);
3. Dials and keyboards for putting numerical data into the computer (used, for example, to insert results of laboratory tests which serve as a substitute for directly-connected instrument readings).

Many techniques are used to allow the computer to inform process operators of its actions and to record data for future use:

1. Automatic typewriters (used for special messages and also for routine summaries of process data, either periodically or on demand);
2. Lights, buzzers, bells and other on-off devices (used as alarm indicators to announce emergency conditions);
3. Arrays of indicators for display of decimal quantities and other symbols (used to show current values of a variable, or several in sequence, with appropriate identification);
4. Electrical meters which show, by the position of a pointer along a scale, the present value of a variable (used to give a continuous indication of the value);
5. Recorders, generally employing one or more pens writing on a strip or circular piece of paper (used to give a permanent and continuous record of process variables for visual inspection);
6. Devices to prepare punched cards, punched paper tape or magnetic tape (used to feed data into the same or another computer for later processing).

These devices may be located on or near a central operator's desk, or they may be placed throughout a plant at convenient places remote from the computer itself.

Digital computers for process control are general-purpose computers, capable of doing all the operations carried out by similar machines used for business or scientific data processing. In addition, they are provided with analog input-output systems and relatively sophisticated priority interrupt facilities. In contrast with the conventional controller, a digital computer used as a process controller is able to compare two numbers ("Is flow rate A greater than flow rate B?" or "Is Pump 5 loaded beyond its capacity?"); to make decisions ("Since the pump is overloaded, it is necessary to open Valve 107"); to take simultaneous control actions at many points in the process with due consideration of their effects on each other; and to produce detailed records of the incomnig data, results of intermediate calculations, and its control actions.

The full capabilities of a general-purpose digital computer are not necessary in all applications. For particular tasks, such as data logging or DDC, simpler special-purpose digital devices have been designed and offered for sale. In general, they have not enjoyed wide acceptance. To some extent, the expected equipment economies are offset by custom design charges, higher manufacturing costs, or both. Also, by comparison with the general-purpose computers, the special-purpose devices are not readily expanded to fit process growth, new instruments, or changing control concepts. For these reasons, greater emphasis has been placed on systems built around general-purpose computers.

control computer functions

Control calculations are the most publicized element of the process computer's program. In addition, however, a process computer has a number of other essential functions.

In preparation for calculations, incoming data are generally subjected to individual limit checks to detect instrument failures or out-of-normal process conditions, converted from their original form into meaningful engineering units, averaged or smoothed to minimize the effects of random variations, and perhaps tested for reasonableness by comparisons between variables. Where a given variable can be calculated in several ways from different sets of data, the results may be used to obtain more accurate data or to detect instrument failure.

Control calculations performed by a process computer often fit into one of three categories:

1. *Status* — Where is the process operating now? (This class of calculations is especially significant when values of certain variables, which can be computed but not measured directly, are necessary as a starting point for other control calculations).
2. *Optimization* — Where is the best operating point, that is, the best combination of flows, temperatures, pressures, levels, speeds, and other manipulated variables? Or, alternately, where is a better operating point? (If repeated enough times, a method for finding a better operating point will eventually find the best operating point; if done rapidly enough, such methods can be as effective as one which finds the best operating point in a single step).
3. *Regulation* — Given the results of the optimization calculations or merely an arbitrary but acceptable operating point, how should the computer maintain the desired process conditions? If the process is not at its desired operating point because of a disturbance which is not measured and does not appear in the process equations, how should the manipulated variables be changed to return the process to the desired operating point? (For a process with numerous objectives, time lags and interactions between the variables, the regulating function alone may constitute adequate justification for using a control computer).

Since the characteristics of any process change with time, control computers are usually programmed to keep the process equations up-to-date by periodically revising some of the numbers in the equations on the basis of data from the actual operation. For example, the yield for a chemical process may be expressed as

$$Y = k\, f_1\ (v_1)\ f_2\ (v_2)\ f_3\ (v_3)\ \ldots$$

where Y is the ratio of a product rate to a raw material rate; k is a catalyst activity; and the f's are functions expressing the effects of reaction time, temperature, pressure, composition, and so on. Taking the f's as known, the value of k is found by substituting measured values of Y and the v's into this equation. Over a short time interval, the equation may be used for control calculations with a fixed value of k. If the catalyst gradually declines in activity with time, as is often the case, new values of k must be determined at regular intervals. To a limited extent, these revisions are made automatically. More extensive modification of the process equations, based on data accumulated over a long period of operations, is usually left to an engineer.

Beyond its control calculations, the process computer can develop information for use by operators, technical personnel, or management. Examples are efficiencies, heat and material balances—quantities not directly measurable but easily computed from the available data. Other examples are production costs, average and total quantities of products and raw materials for the accounting department. Under some conditions, the process computer can perform other engineering or business calculations, using either parts of its control program or completely unrelated programs.

justification

To many users, a control computer is viewed as a means for putting management in real charge of the operating process. If a particular operating policy is desired, it can be built into the computer program and executed round-the-clock, even when the responsible supervisors are out of the plant. In the same fashion, research workers can insure that process conditions are held constant or are deliberately varied over a range of acceptable values to give them new data for testing theories or improving the mathematical model of the process. A computer control system represents an advance over previous techniques because it allows the continuous application of the most advanced knowledge of process behavior rather than the simplified procedures and control schemes that would otherwise have to be employed.

Investments in these advanced control systems are being justified by several kinds of benefits:

1. Increased production;
2. Improved control of product quality;
3. Better use of raw materials, catalysts, solvents, electricity, fuel, and so on;
4. Reduced maintenance;
5. Greater safety for personnel;
6. Reduced manpower;
7. Better technical and accounting data;
8. Increased process knowledge.

Although reduced labor costs are a potential source of benefits, manpower reductions have played a negligible part in justifying advanced control systems for plants which already use automatic control devices in great numbers; managements of process plants have not looked upon labor savings as the primary reason for installing a control computer.

Management in the process industries takes a hard look at expected costs and benefits before installing a computer control system. A desire to "keep up with the Joneses" plays an insignificant part in the decision. Despite a technical capacity to do all sorts of wonderful things, process computer users make strenuous efforts to select system functions offering a reasonable economic benefit in relationship to the costs involved.

Processes for which control computers are installed have had the following characteristics:

1. Value added in the process (the difference between product value and raw material cost) or the cost of operation is large;
2. Disturbances are frequent and have significant effects;
3. Best operating conditions are not obvious or are difficult to maintain, even for experienced operators;
4. Adequate instrumentation and process knowledge are available.

Suitable processes involve $3-30,000,000 per year in product value, sometimes more, a sufficient number of dollars that small improvements in performance will recover the cost of a computer control system in a short time.

The direct cost of a computer control system is composed of several elements:

1. Computer and associated peripheral devices (including logging and alarm typewriters, tape and/or card readers and punches, input selector, analog-to-digital converter, and so on);
2. New instruments and analyzers;
3. Transducers for connecting new and existing instruments and analyzers to the computer;
4. Equipment for connection of the computer to actuators (such as analog controller set points or valves);
5. Wiring, instrument air tubing, conduits, and so on;
6. Special consoles and devices for operator-computer communications;
7. Site preparations (such as space to house the new equipment and air conditioning);
8. Engineering effort and other labor directly associated with equipment planning, design, selection, testing, and installation;
9. Technical effort for developing process equations and control schemes;
10. Programming;
11. Project administration (for coordinating schedule, costs, and documentation);
12. Training;
13. Maintenance.

At the present time, the cost of a computer control system can be expected to fall between $200,000 and $400,000, possibly more for an unusually large system. The cost of the computer itself, item (1) above, is $50,000-$150,000; the remainder of the system cost arises from the other items in the list. In most cases, process management demands annual benefits equal to or greater than the system cost before approving its installation.

progress and problems

Approximately 20,000 digital computers are installed around the world for all applications, about 90 per cent of them in the United States. Of this total, only 2-3 per cent or 400-600 digital computers are installed or ordered for process control applications, again a substantial portion being in the United States. From the first pioneering installations by such organizations as Louisiana Power and Light, Texaco, Standard Oil, Monsanto, B. F. Goodrich, and Union Carbide starting in 1958-59, the use of process control computers has grown rapidly. More and more companies are taking their first steps in this field, and some of the pioneers now have six or more systems.

The path of progress has not always been smooth, however, and potholes still lie in the way of the uninitiated. Many of the systems now operating have required large expenditures of effort and money before reaching their present status. A few systems have been judged to be mistakes and removed. While a full explanation of the difficulties would require another article, some of the more significant problem areas can be summarized.

A major problem area has been *people:* the number and competence of people assigned to process computer projects, their motivation and continuity on the project, and the kind of support received from management. Successful projects have been characterized by adequate teams of engineers and programmers, anxious to do a good job and fully backed by their company.

Another source of trouble has been *poor project definition.* Projects have been started with only a vague idea of either project or system objectives; expected system performance has been inconsistent with the accuracy of process measurements; system goals (such as increased production) have not been defined broadly enough to cope with later market developments; and effort has not been concentrated in areas of greatest potential return. Some of these difficulties can be traced to viewing projects as research efforts, aimed at acquiring knowledge, rather than as programs for improving process performance. The most satisfying projects have focused on well-defined, attainable objectives with immediate significance to management.

Related problems, of a more technical nature, have resulted from *faulty system concepts.* These problems include belated recognition of the need for data editing; inadequate updating procedures; excessive use of manual inputs and poorly designed input panels; too much dependence on regression analysis to develop process models; and unwise division of computer and operator functions, such as asking the operators to take frequent and high-speed control actions while leaving infrequent tasks to the computer.

Equipment problems have taken many forms. Computers, input-output systems, and process instruments have been debugged in the field. Computer memory and speed have sometimes proved inadequate, causing useful functions to be discarded and forcing system designers to substitute ingenuity for more direct but cumbersome methods. Occasionally, where installations were attempted for new plants, ordinary process problems pushed the computer project into the background.

Several years ago, it was predicted that volume-production economies and general improvements in computing techniques would lead to reductions in computer equipment costs. To date, however, technical advances have resulted in the obsolescence of process control computers before very many copies of a given model were delivered. (More accurately, systems in operation continue to do the jobs for which they were designed, but users are attracted to new and more capable models for subsequent installations.) Thus a Volkswagen-like approach to hardware, emphasizing continual improvement of an acceptable piece of equipment, has not proved possible.

Furthermore, these technical advances have generally been exploited by offering far more capable computers at somewhat lower prices. Evidence to support this point can be found in comparison of current offerings with the early computers marketed for process control: arithmetic speeds are measured in micro- rather than milliseconds, core memories with disc or drum backup have replaced all-drum memories, interrupt facilities are much improved, and mainframe prices are one-third to one-half as great.* No

* The small heat load of today's solid-state computers has fostered the hope that they would operate without air conditioning in any sort of plant environment, but good reliabiilty still requires stable ambient conditions.

particular cost reduction trends have been observed in other equipment elements of a complete system. Thus, when the costs of the peripheral equipment necessary for process control are added to the basic computer prices, the cost ratio is less than two-to-one.

Manpower costs for developing and programming process equations and control schemes have been a major element in total system cost. Economies were expected here, too, as a result of experience gained in early installations. However, few truly duplicate processes have been found, and later systems have generally been designed for more complex processes, taking more engineering effort. Hence the anticipated savings have not materialized.

The programming area offers real opportunities for cost reductions. These savings could be realized in at least three different ways:

1. Wider markets so that development costs for general software could be spread over a larger number of computers;
2. Greater use of standard non-control programs;
3. More efficient techniques for writing special control programs.

General software does exist: computer vendors are expected to supply an extensive library of programs, including:

1. Assembler and compiler routines
2. Tape and card loading routines
3. Floating-point and double-precision arithmetic routines
4. Code conversion routines
   a. Decimal and binary-coded decimal to binary
   b. Binary to decimal and binary-coded decimal
5. Tape and card output routines
6. Subroutines for special functions
   a. Exponentials
   b. Logarithms
   c. Sine-cosine
   d. Square root
   e. Arc tangent
   and so on
7. Utility routines for program debugging
8. Special-purpose programs
   a. Matrix inversion
   b. Solution of simultaneous equations
   c. Linear programming
   d. Curve fitting and regression analysis
9. Diagnostic programs

Many computer vendors have also been supplying a variety of so-called non-control programs, such as:

1. Executive routine
2. Scan routines
3. Alarm routines
4. Logging routines
   a. Data editing and formating
   b. Periodic logs
   c. Trend logs
   d. Summary logs
5. Control output routines
6. Data entry routines
   a. Laboratory test data
   b. Time
7. Operator request routines
8. Display routines

These non-control routines are useable, in general, for any computer control system. Programmers continually face the choice of writing either widely applicable routines or efficient routines (in terms of running time or memory requirements). And they frequently reject available standard routines, writing new ones which better fit their particular application. The user plays a role, too, by asking for variations on the standard routines which cause his own or the vendor's programmers to expend additional time. Greater discipline on both sides, and possibly improved techniques for organizing and writing programs, might pay big dividends in this area.

Many potential process computer users see the use of compilers such as FORTRAN, already understood by process engineers, as a means for reducing the effort needed for programming of process equations and control schemes unique to a particular installation. Two difficulties are encountered in this approach: the need for additional memory to store the compiler itself (unless the computer is taken off its control functions to make memory available for temporary storage of the compiler), and the relative inefficiency of compiler-produced programs compared with programs written in either machine or symbolic language. Clearly, a trade-off between programming and equipment costs is involved here, but no careful comparisons have been reported; with the availability of relatively cheap bulk memory, the trend appears to be toward investing in equipment to save effort.

conclusion

As a technology, computer control of industrial processes is well established; announcements of new installations by user organizations, both veterans and newcomers to the field, testify to acceptance of the concept. Despite difficulties and frustrations, installed systems are now performing useful functions and earning dollars for their owners. Lessons learned in past projects, coupled with availability of cheaper and more capable equipment, open the way to new applications.

One concept receiving much attention these days is direct digital control. As mentioned earlier, DDC consists of using a single computer to exercise control in sequence over a large number of process conditions, replacing an equivalent number of conventional controllers. DDC performs no new functions but simplifies implementation of control techniques which are otherwise impractical. Not quite justified on a straight equipment cost basis, DDC is installed with hopes of better control and reduced maintenance costs, allowing some credit for data processing and logging that can be done at slight additional expense. It will undoubtedly find its greatest acceptance in new plants, where no existing equipment will have to be scrapped.

Multi-unit control, in which a single computer exercises control over several processes within a plant, is another concept now receiving consideration. Most of the presently installed systems control only a single unit, such as a rolling mill, a fluid catalytic cracking unit in a refinery, or a pulp digester in a paper mill. In the future, more attention will be given to computer applications for plant-wide control. These installations, employing several interconnected small computers or a single large computer, will concern themselves primarily with the relationships between units.

For the equipment vendors, the future will be a period for demonstrating that computer control is a business as well as a technology. In the last few years, many suppliers have been attracted to this field but few, if any, have found it profitable. Competitive pressures have pushed prices down, leaving no room for contingencies. At the same time, eager salesmen have made rash promises and inexperienced technical staffs have underestimated their work; both groups often and unwisely acquiesced to unreasonable customer requests. Frequent model changes and short product life have caused high development and debugging costs. As a result, many entrants in the field have backed out, leaving their customers with make-shift arrangements for maintenance and other support. For the sake of both vendors and users, one may hope for greater stability in the future. ■

CONTROL IN THE IRON AND STEEL INDUSTRY

problems and progress

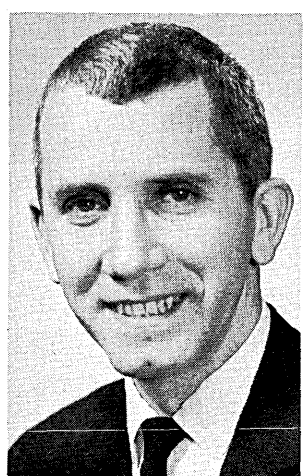
by THOMAS R. SCHUERGER and FRANK SLAMAR

Steelmaking, in principle, appears to involve only a relatively few, simple steps. The principal iron ores used in the United States consist of iron oxide mixed with varying percentages of useless earthly materials. To remove the oxygen and useless materials, the iron ore is mixed with coke and limestone and charged into a blast furnace. Hot air blown into the blast furnace burns the coke to generate heat. The hot carbon of the coke and the carbon-bearing gases generated by its burning combine with the oxygen of the iron oxide, leaving the iron in metallic form. The iron collects in a molten state in the hearth at the bottom of the blast furnace. The limestone combines with the useless part of the ore to form molten slag that floats on top of the pool of molten iron.

In the ironmaking process, the iron becomes saturated with some of the carbon from the coke. The product of the blast furnace, pig iron, may contain somewhat over 4% carbon. To make steel from pig iron, some of the carbon must be removed. (Most steels contain considerably less than 1% carbon). The unwanted carbon is removed during steelmaking, now principally accomplished in the open-hearth furnace and the basic oxygen steelmaking furnace. In basic oxygen steelmaking, oxygen is blown directly into the molten iron bath to burn out the excess carbon. The final product, steel, is poured into molds to form ingots, which are then formed into useful shapes by rolling or other forming processes.

A modern, integrated steel plant is made up of a group of massive, complex, interrelated, individual processes. The chemical, metallurgical, and thermal aspects of the steelmaking processes seem to be fairly obvious and simple. In practice, this is not quite so. Measurements are difficult to make and process theory is complex; consequently, precise knowledge of the state of the process is not always available. Much of the present-day process control actually consists of control of the processing machinery.

Raw materials, many times, are put through complex beneficiation or preparation processes before they are useful for iron or steelmaking. Many low-grade ores are now being mined which must be concentrated and then further prepared before they are available for blast-furnace burden. The preparation of coal as the metallurgical coke required for the blast furnace has, in present-day steelmaking, become a veritable chemical complex. Byproduct



Mr. Schuerger is section supervisor of Systems Engineering, Instrumentation and Control Div., U. S. Steel Applied Research Laboratory, Monroeville, Pa. Before joining the firm in '54, he was a consultant for the glass industry with Preston Labs, Butler, Pa. A senior member of the ISA and member of the ASME and Natl. Society of Professional Engineers, he holds a BS in physics from Case and MS in mechanical engineering from Univ. of Pittsburgh.

coal-chemical processes have led to large processing plants for anhydrous ammonia, phenols, and other chemicals.

The blast furnace itself is a large and expensive industrial complex. Modern furnaces are well over a hundred feet in height, and the regenerators, or stoves, used to heat the blast air are equally large. Three stoves are used for each blast furnace. Raw materials are charged into the top of the blast furnace in batches, and liquid iron is periodically discharged from the hearth. The reduction of iron ores inside the furnace takes place continuously, however, and it is a major task to start and stop the furnaces. Modern-day blast furnaces produce well over 2500 tons of iron a day.

Steelmaking, in the open-hearth or in the basic oxygen steelmaking furnace, is a batch process. These processes turn out hundreds of tons of steel per heat, or batch. In the open-hearth furnace, a heat of steel may be made in six to eight hours. In the basic oxygen steelmaking furnace, a heat of steel would be made in under one hour.

After steelmaking, the molten steel is poured into ingots, many tons in weight. These ingots are permitted to solidify; the mold is then removed and the ingot is placed in a soaking pit. The soaking pit brings the ingot to a uniform specified temperature in preparation for the rough-rolling or semifinishing operations.

blooms, billets & slabs

In the semifinishing operations an ingot is rolled into blooms (large, essentially square sections), or billets (small, essentially square sections), or slabs (flat sections). Each of these primary sections is intended for a special type of finishing operation. Blooms are sent to rail or structural mills for the rolling of steel rails and steel structural shapes. Billets are intended for bar, rod, wire, pipe, and tube mills. Slabs are sent to plate mills or hot-strip mills. Coils from hot-strip mills move to cold-reduction mills and then perhaps to tinplate mills.

All these rolled and finished products have both metallurgical and size specifications. During rolling operations, hot and cold working must be regulated to obtain desired metallurgical properties. The intermediate stages of annealing and tempering must also be regulated for metallurgical purposes. In addition, there are size specifications on both semifinished and finished products. Tolerances on the finished products in the finishing mills can be quite strict.

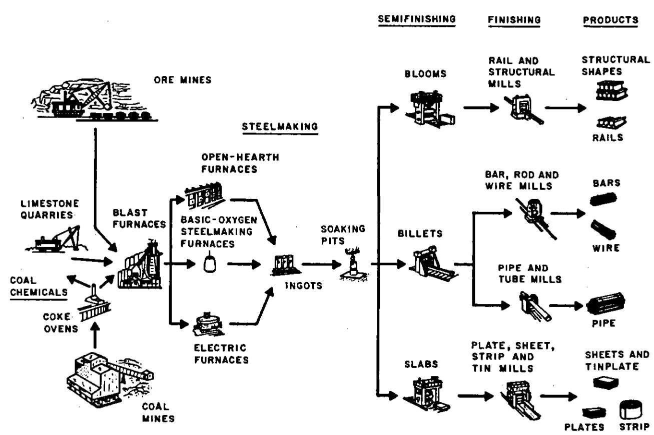
For example, commercial standards for steel sheet thickness permit a $\pm 10\%$ thickness variation. However, the steel industry strives to maintain an even closer tolerance of $\pm 5\%$. This tolerance amounts to ± 0.0005 inch for point-to-point control of rapidly-moving 0.010-inch thick strip.

Mr. Slamar is chief of the Instrumentation and Control Div., U.S. Steel Applied Research Laboratory. He was a control engineer with Westinghouse Electric, Buffalo, N.Y., before joining the firm in '55. Member of the IEEE and registered professional engineer in Pennsylvania, he has published many articles on process control in the steel industry. He holds a BS in EE from Newark College of Engineering and MS in EE from the Univ. of Pittsburgh.

During all these rolling operations massive problems in material handling are encountered. Tons of steel must be manipulated on roll tables, often at extremely high temperatures. On sheet and strip mills, operating often at several thousand feet per minute, precise control must be maintained over both temperatures and finished dimensions. It is apparent that the control required in the modern iron and steel industry is both broad and intense. All imaginable types of control problems are encountered at one phase or another of the operation. Chemical analysis must be known of raw materials, liquid iron and steel, and solid steel products. Temperatures of liquid and solid metals in various states must be measured. Dimensions of semifinished and finished products must be measured. Environments in the steel industry are harsh, and measurement and control equipment must be extremely durable if it is to function properly.

In the past, considerable progress has been made in the development of a wide variety of elementary control systems for such processing variables as temperature, position, and speed. However, the integrated control of these subsystems has been left primarily to the operator because to provide such control by means of equipment was extremely complicated. The required equipment must be capable of handling and manipulating the large amounts of data which are used in properly controlling the process under a wide range of operating conditions.

Fig. 1 The Principal Steps in Making Steel Products



With the advent of the modern industrial computer, equipment became available which made the extension of automatic process control feasible. Recognition of this is evidenced by the fact that many process-control computers have already been applied in the steel industry, and others are being planned. These applications include installations in sintering plants, blast furnaces, basic oxygen steelmaking plants, rolling mills, continuous annealing lines and electrolytic tinning lines.

move toward integrated control

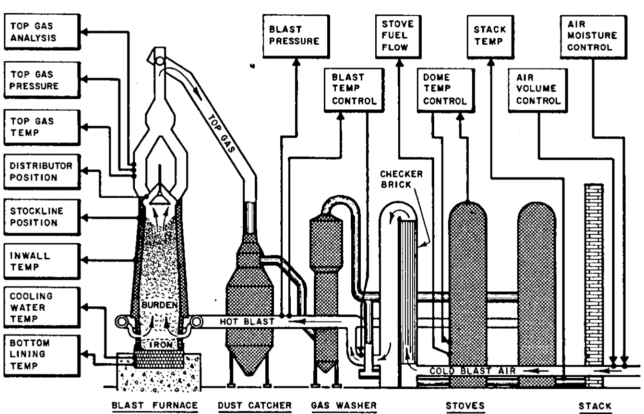
It is interesting to note that although this computer control equipment is generally equivalent in all cases, the use of the equipment ranges from data collection to highly sophisticated automatic control. Thus, it appears that the industry is presently in a transitional stage of process control in which the control equipment is changing in form, and objectives are leading to a greater extension in the integration of control systems.

An example of this transition can best be seen by looking at some of the facilities. First, consider the blast furnace. The blast furnace might be thought of as two separate component facilities—the regenerators, which preheat blast air, and the furnace, which reduces the ores to iron. Standard controllers of commercial manufacturers are used extensively to regulate the quantity and temperature of the blast air obtained from the regenerators. These regenerator controls are closed-loop feedback controls of the most simple functional types. The furnace itself, however, has essentially no feedback control. The operator calculates a burden, or charge, of raw materials. He has theoretical or empirical formulas available from which to make the calculations. Burden calculation might be thought of as a feed-forward type of control. There is feedback control through the operator by means of chemical analysis of samples of iron taken as the furnace is cast. In the ordinary sense, however, the operator uses the instrumentation on the blast furnace as a guide to the state of the furnace and then he manually controls the furnace operation. Extensive control rooms are found in most blast furnaces, but the majority of the instrumentation tells the operator the state of the various blast-furnace auxiliaries.

Recently, computers have been installed on blast furnaces for data logging and alarm monitoring. In a few cases, computers have been used to calculate the burden requirements for the operator, and in even fewer cases, to perform a limited amount of feedback control.

As in the blast-furnace process, the function of the basic oxygen steelmaking process is to produce a product of specified chemical composition. However, in addition to

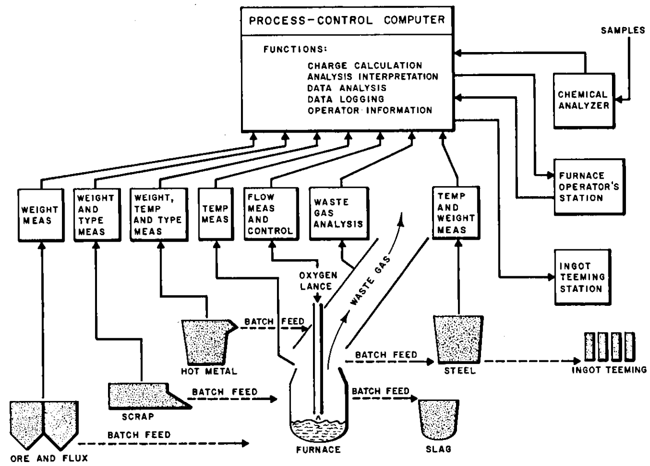
Fig. 2 Typical Blast Furnace Instrumentation



composition, the process must also produce steel at a specified temperature. Again, the operator has a great deal of difficulty determining the state of his process while steel is being produced. No method is presently available for continuously making temperature measurements in the furnace or, for that matter, determining the composition of the steel in the furnace. Both measurements must be made by stopping the furnace or at least stopping the blowing of oxygen into the furnace to take a single measurement sample. Again, knowledge of the process provides means for calculating the charge of liquid iron, flux materials, and oxygen required to produce the given temperature and composition. The charging, however, still lacks the desired precision largely because of inaccuracies in the measurement of the composition of input materials and sometimes in the quantities of materials charged. There are at present no generally used automatic feedback systems on the basic oxygen steelmaking process itself. There are, however, some experimental systems in operation. Even though there is room for improvement, the digital process computer has already made a significant contribution to process regulation.

For example, computer-control systems for basic oxygen steelmaking include the prediction of charge and blowing requirements for desired endpoint steel composition, the automatic interpretation of data from an off-line analyzer of steel samples, and the automatic handling of order information and information for various bookkeeping, metallurgical and data-logging functions. In these systems, order information (or the heat specifications), chemical analysis of iron from the off-line analyzer, and iron temperature are inputs to the computer which permit calculation of charge and blowing requirements. These requirements are automatically displayed on pulpit consoles for action by the

Fig. 3 Open-Loop Computer System for Oxygen-Steelmaking



operator. Interpretation of analyzer results is automatic in the computer through a direct-wire connection. Process information is handled automatically through wired inputs. Systems of this type constitute on-line, open-loop computer control.

feedback in the reversing mills

Perhaps a more dramatic example of changes occurring in control technology are those associated with the regulation of hot reversing mills. In this process, a hot ingot or slab is rolled back and forth in a single-stand mill to convert the original slab to a wider and much thinner shape or plate. As many as 25 passes, or reversals, might be required for this operation. In the early control forms, all control decisions and executions were performed by the operator. On each pass the operator would preset the roll gap to reduce the thickness of the steel shape. He had to do this in such a way that the plate being rolled would not become too cool but would end up at the proper final width and thickness. In addition, he controlled cooling sprays, the tables the plate moved on, manipulaters, side guards, and turnarounds.

Although the operations were manual, this was, in effect, a type of feedback system. The operator observed what was happening during rolling, and when the rolling was finished, measurements of width and thickness would be made and signalled back to the operator. If the plate was undersize it might have to be discarded. If it was oversize and still of suitable temperature, the operator could reduce it further. In this rolling operation, it is clear that the operator has two different functions which, of course, are closely coupled. One function is decision making: the operator must decide, on the basis of available information, just what must be done. The other function is the control execution, in which he performs various physical and mechanical operations to implement his decision making. The control step taken in the recent past was to split these two functions.

Controls, called card-program systems, were installed on reversing mills. Here the decisions were still made by the operator, but the execution was performed automatically in accordance with the decisions previously prepared and put on punched cards. These control functions, of course, were the manipulation of the mechanical aspects of the rolling operation: the movement of the plate on the roll tables, the movement of the rolls up and down, the speed of the rolls, and similar functions. This type of control—in which decisions are made by an operator and the execution is automatic—is adequate when variability due to the process is small and changes are at a relatively slow rate.

It was frequently difficult to realize the full advantages of the card-program type of system because many cards would be required to include all the various types and sizes of steel that were to be made on the plate mill. Consequently, a more advanced type of control system was proposed that includes not only all the sequencing, or logic, functions provided by the previous card-program mills but also the decision-making functions for determining the best rolling schedules consistent with existing workpiece conditions and mill capabilities. In this control system, the only information provided is that of general instructions and limitations for all rolling—that is, the dimensions of the slab, the grade of steel, and the desired dimensions of the finished piece.

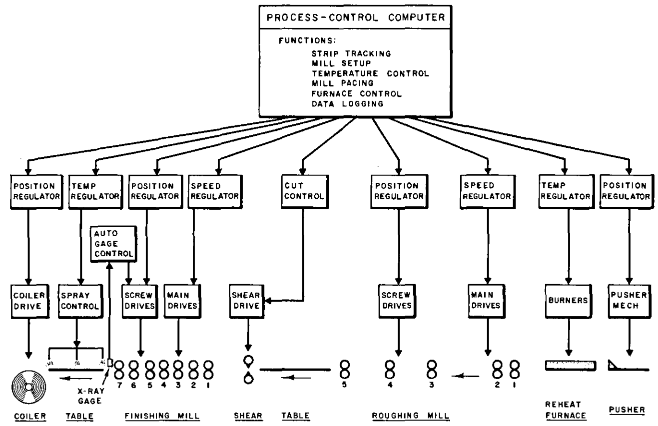
The feedback in this system does not include the operator. Instead, a new rolling schedule is calculated automatically for the remaining passes any time a discrepancy exists between measured performance and predicted performance in a particular pass. Computer systems of this type have been installed and are partially operable in the industry. Experimentation with them is still continuing.

highest degree of control

The hot-strip mill is, perhaps, one of the most highly controlled processes in the steel industry. First in a hot-strip mill are the reheat furnaces for heating slabs to a specified uniform temperature. These slabs are then delivered to a multistand roughing mill where preliminary reduction and width control is obtained. After the roughing stands, the steel is fed continuously to a multistand, continuous finishing mill. Here the steel is reduced to finished dimensions, cooled to a specified temperature on a runout table, and coiled. The finishing speed in these mills is several thousand feet per minute. During the processing, metallurgical requirements demand that temperatures be controlled, and product specifications require certain finished dimensions. These mills have elaborate electrical controls for driving and positioning the rolls. In addition, much equipment is employed in the form of gage-, force-, and temperature-measuring instrumentations. In the finishing stands, the steel strip is in all the stands at the same time so that reduction of strip thickness is accomplished not only through the position of the rolls in squeezing the steel but also through tension between the stands; therefore, roll position as well as interstand tensions must be carefully regulated. Present-day mills use fairly standard forms of continuous measuring equipment through feedback systems to regulate the thickness of the steel strip. The strip enters and moves through the mill at such a high rate of speed, however, that the mill stands must be properly set before the strip enters.

The requirements of a modern hot-strip mill are presently being integrated through computer systems. These requirements include strip tracking, roughing- and finishing-mill setup, temperature control, mill pacing, furnace assignment, and data logging. The computers do not usually function as closed-loop regulators, but they are used to calculate certain functions, send out references to the regulators previously mentioned, monitor individual operations, and coordinate the functions of various regulators. The high speed of the rolling operation and the precision required in the finished product make this an excellent application of computer systems.

Fig. 4 Computer Control for a Hot Strip Mill



The effective control of any process, whether manual or automatic, requires quantitative information on demand relative to the state of the process. Therefore, a prime requisite for control is instrumentation that will adequately translate selected process variables from their physical or chemical units to some usable form. These instruments can usually be considered in two parts: first, the conversion of a primary variable to an electrical signal, and second, the conversion of the electrical signal to a form that will provide a meaningful output. In many cases, these functions present no particular difficulties, but there are still some measurement needs that have not, as yet, been adequately covered in either or both of these respects.

measurement problems

Consider the continuous measurement of the temperature of molten metal in an open-hearth or basic oxygen steelmaking furnace. This would be a fairly straightforward measurement with the use of thermo-couples except that, to date, no suitable material is known that will withstand chemical attack under these operating conditions. No other approach is suggested at this time that might provide a continuous temperature measurement in this environment.

On the other hand, some quality measurements such as surface inspection of steel strip are difficult, not because of an inherent difficulty in obtaining a variety of electrical responses from the surface being inspected, but because the quantitative interpretation of these signals in terms of established standards would require extensive complex equipment that makes such instruments impractical and uneconomical.

One approach to these measurement problems is to use an indirect measure that utilizes existing types of practical instrumentation. In the indirect method, the variable to be measured is calculated in accordance with the functional relationship that exists between it and other measurable variables.

The indirect-measurement approach can be used most effectively when the digital control computer is available. For example it is impractical at present to measure the thickness of steel in excess of two inches with radiation-type measurement gages. However, the thickness can be measured during a rolling operation if the opening between the rolls and the amount the mill flexes during the rolling process are known. Since the mill is equipped with instrumentation to measure roll opening and rolling force, or mill loading, it is relatively simple, by means of Hook's law, to calculate the actual roll gap, which is the steel thickness.

In another example, it is necessary to know the average temperature of a steel piece being rolled because of the effect of this temperature on the resistance to rolling deformation, or reduction. Because surface temperatures are difficult to measure reliably under operating conditions and because average temperature in this case is more important than surface temperature, mathematical relationships are developed that relate the initial temperature of the piece, the time of furnace discharge, the changing geometric form of the piece, and the energy added during rolling. These calculated temperatures are then used as an indirect measurement for mill control. Although the use of computers may in some cases increase the demands on instrumentation, these are examples in which the computer can minimize or reduce the instrumentation requirements.

There is no doubt that the trend toward more and higher forms of automatic control is increasing in the iron and steel industry. The reasons for this trend are many. Process and product specifications are continually being tightened because of customer demands and the need for more economies in production. Along with these demands for tighter controls has come the search for new knowledge of the basic chemical and metallurgical aspects of the iron and steelmaking processes. These facts not only direct the industry toward more intensive control means; they, in themselves, make more control means possible. In addition, iron and steelmaking technology is tending toward a higher-speed, more closely coupled operation. Continuous casting is an example of a fairly new highspeed, close-coupled operation. Here, instead of making ingots of the steel from the steelmaking furnace, the steel is poured directly into an open-ended mold, and the slab itself is cast. The ingot, ingot stripping, and rough-rolling operations are eliminated. Needless to say, close regulation is required of this process to make it a feasible high-tonnage operation.

direct digital control

There presently appears to be a general trend toward the use of digital techniques in process control. The most common form of these trends is called direct digital control. Here general-purpose types of digital control computers are being used to replace individual analog controllers now in common use on process equipment. Considerable success has apparently been obtained in various industries with this approach. Success is judged on the basis of performance and overall economics. Although the iron and steel industry has had very little experience to date with direct digital control, we expect to see more efforts made. In the beginning, these efforts will be experimental to establish reliability factors, economics, and in some cases, quality of control.

Computers as control means, or as overall directing means, are being installed in very nearly all the finishing mills under construction in this country at the present time. Computers are becoming fairly common in the installation of new basic oxygen steelmaking processes. This does not necessarily mean that higher levels of control are being achieved, but it does point out the efforts being made to obtain them. Perhaps a stimulus is the decreasing cost of computer equipment. These present systems are mainly directed at actual process control: physical control over the particular product being formed or manufactured in the process.

As in other process industries, other aspects of control in the iron and steel industry being considered are only in the very formative stages. In Great Britain, an installation is presently under way in which not only the process is under the direction of computers, but several in-line processes are also tied together through what, at present, must be considered fairly loose control links. In this installation, control is extended to include process control and the regulation of information between processes, such as product specification and product and machinery requirements.

integrating dp & control

The use of computers in data processing, production planning, and decision making is quite common. The industry can look forward to the day when these functions will be combined with the process-control functions. Production planning, scheduling, customer orders, and production orders will all be coordinated to the actual process operator and process machinery. This coordination constitutes a form of multilevel control that will take into account the overall system economics in planning company-wide objectives, as well as the individual process requirements.

Extensive efforts are being made by the iron and steel industry through research, development, and application to continually improve its position. In the area of process control, or overall plant control, these efforts are demonstrated by the examples that have been given. However, much remains to be done. A great deal of effort is still required in the area of developing new means for process measurement. Process-control equipment is readily available, ranging from individual analog controllers through large-scale digital control computers. However, such equipment must be tested under actual operating conditions. One of tht most promising avenues though, for increasing the level of process control comes from the chemical, metallurgical, and process research presently under way. The development of more intensive knowlege of processing functions makes practical many computer-type predictive controls that seem, at present, to be most needed for the industry.

The very nature of control is perhaps what makes it one of the most difficult disciplines to implement in the field. Control requires the knowledge of many different disciplines. The control systems engineer, the process engineer, the electronics engineer, the mechanical engineer—all must work together to establish control technology, process technology, electronics, and electrical and mechanical equipment requirements. Only when all these functions are accomplished together in a practical sense can control systems be made workable and usable. ■

REFERENCES

1. "The Making, Shaping and Treating of Steel," United States Steel Corporation, Seventh Edition, April 1957.
2. Slamar, F., "Status Report on Computers in Steel Making," *Automation*, June 1963.
3. Schultz, R. G. and Smith, A. W., "Determination of a Mathematical Model for Rolling Mill Control," IEEE Conference Paper, No. CP 63-548.
4. Brower, A. S., "Controlling a Complete Hot Strip Mill," *Control Engineering*, October 1963.
5. Meyer, H., "Some Aspects of Automation in Rolling Mills," *The Brown Boveri Review*, November/December 1961.
6. Massey, R. G. and Hersom, S. E., "Three Interlinked Computers to Run New British Steel Works," *Control Engineering*, June 1962.

growing complications

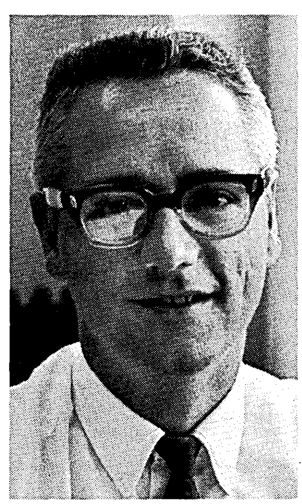
PROCESS CONTROL SOFTWARE

by JAMES D. SCHOEFFLER

The early expectation that process control computers would require little software support (because they would be programmed once and for all to do a specific job) was very quickly replaced by the realization that not only was all of the sophistication of conventional software required but, in addition, the real-time aspects of the process control application also had to be supported by software. This realization has led to a complete time-shared executive system with an extensive library of subroutines for communication between the computer and process. During process free-time, these executives permit use of the computer for off-line tasks under the control of a subroutine called the off-line monitor to distinguish it from the executive itself. The library of subroutines represents, in a sense, a language for process control, allowing programming of quite extensive real-time control systems. Process control software may best be understood by considering the control problem itself and the software and hardware needs it generates.

A description of typical processes and the problems encountered in controlling them are contained in Dr. Stout's article in this issue. Since the objective of such control systems is to successfully operate the process despite the presence of many disturbances, it is appropriate to partition the disturbances according to their relative frequency and consider the control of the system in the presence of each of these disturbances separately. The resulting control system, hierarchical in form, is shown in Fig. 1. (See p. 34)

The highest frequency disturbances which must be considered are physical upsets which cause process variables to deviate from their "reference" values. For example, flows, temperatures, pressures, and the like will not long stay constant without the continual intervention of a control of some kind. Such control is usually fast and, if accomplished by a digital computer, termed *direct digital control* (DDC), and is generally regulatory in nature. Often this first level of control is accomplished by analog controllers with the digital computer supplying only the higher levels of control (such a control system is termed a *supervisory control system*). This is especially true in existing plants which already have analog control and add the supervisory control in order to increase production, cut costs, etc. The operator communication task in Fig. 1 is concerned mainly with this first level of control. One of the most important tasks at this level is alarming in case any process variable exceeds prescribed safe limits. This involves informing the

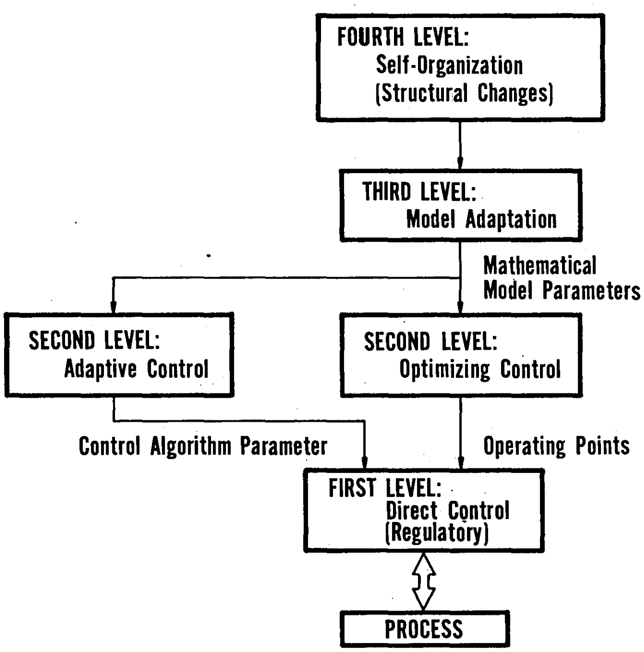


Mr. Schoeffler is associate professor of Engineering and a member of the Systems Research Center at Case Institute of Technology, Cleveland. He is engaged in teaching and research in the computer control of complex systems. Current research projects include real-time programming languages and automatic nonlinear model building for industrial process control applications. He received his ScD from MIT.

process operator and then either taking appropriate action or turning control over to the operator. The computer is especially efficient in alarming and displaying overloads and is a tremendous assist to the human operators.

The second set of disturbances of importance are less frequent in nature and are caused by the changing mode of operation of the process. For example, a power system has drastically different load requirements during day and night hours and the operation of the process differs considerably at high and low loads. The second level control system which compensates for these disturbances has two functions. First, as the disturbance changes, it may be desirable to change the operating points (reference values for process flows, pressures, etc.) in order to make the operation as economically attractive as possible. Such a control system supplies new reference points to the first

Fig. 1



level analog controllers or direct digital controllers and is termed an optimizing controller. Secondly, on the same level, the dynamics of the process itself may change as the operating conditions of the process change, requiring modification of the first level controllers if adequate dynamic performance is to be retained. Adaptive control is implemented on this level to update or adapt the parameters of the first level direct digital controllers. This is most easily done if the first level of control is DDC rather than analog control since the controller parameters are then merely numbers stored in machine memory.

The third class of disturbance is even slower in frequency and consists of changes in the parameters of the process itself. This may be due to seasonal changes, aging, corrosion, and many other factors.

If the optimizing control is to be effective, it must have an accurate mathematical model and consequently the objective of the third level controller is to make use of process data to update or adapt the parameters of the mathematical model of the process itself.

The highest level of control compensates for the lowest frequency disturbance of all, changing process structure (in contrast to changing process parameters). This fourth level of control is seldom automated but rather supplies appropriate information to management and operators of the process so that they can make the proper decision as to structural changes in the overall control system and process (Fig. 1). This level might include emergency restart of the process, emergency shut down, etc.

Observe that this breakdown of the problem results in a hierarchical control system in which each level of control effects directly the level of control directly below it and in turn is controlled by the level immediately above it. This structure is attractive not only from a conceptual viewpoint, but also because each level can be designed somewhat independently of each other level, thereby permitting the design of a complex control system by means of building blocks which are easily changed and improved upon as the appropiate technology becomes available.

From a software point of view, this division of a large task into many independent subtasks is very desirable, since the programming of each subtask may be done independently and is then easily documented and updated at later times. However, the various subtasks are not necessarily performed at the same rate or even in the same sequence. In fact, various tasks may be performed under emergency conditions or upon demand of management or the process operator. Consequently, the software must permit the programmer to efficiently control the sequencing of these tasks and to change the sequence easily when it is desired. Of particular interest is the observation that the computational load is approximately the same for each level of control. That is, going up in level decreases the frequency at which the computation must be performed, but the complexity of computation increases with the result that the load (product of computation time and frequency) remains about constant. In fact, it has been stated that such a division is desirable.[1]

real-time implications

Implementation of such a control system in real time requires certain hardware which significantly affects software requirements. Most important of these are the analog input and output hardware which requires relay and, possibly, solid state multiplexing devices together with a multilevel priority interrupt system. Since reliable operation of the control system is very important, it is necessary to make maximum use of the hardware to insure that the control system will seldom fail. For example, it is inexcusable to permit failure because of a card reader jamming or a relay multiplexor receiving an illegal address. Hardware interrupts and indicators are provided to check such contingencies and to obviate them. This of course complicates tremendously the software requirements since they generally must be written for the "worst case" situation. Moreover the slow operating speed of the analog multiplexor (50 to 100 points per second, for instance) and the need for data in real time necessitates careful consideration of the real-time control programming problem.

As control systems such as those described here were implemented, it became apparent that not only was the control system not to be programmed once and then run for many years but rather that it would probably be changing constantly throughout the life of the process and control systems. This is due in part to increasing knowledge of the process which permits better control systems to be designed for various levels, and also to the ever-changing characteristics of the process itself as it undergoes improvements, new instrumentation is added, and the like.

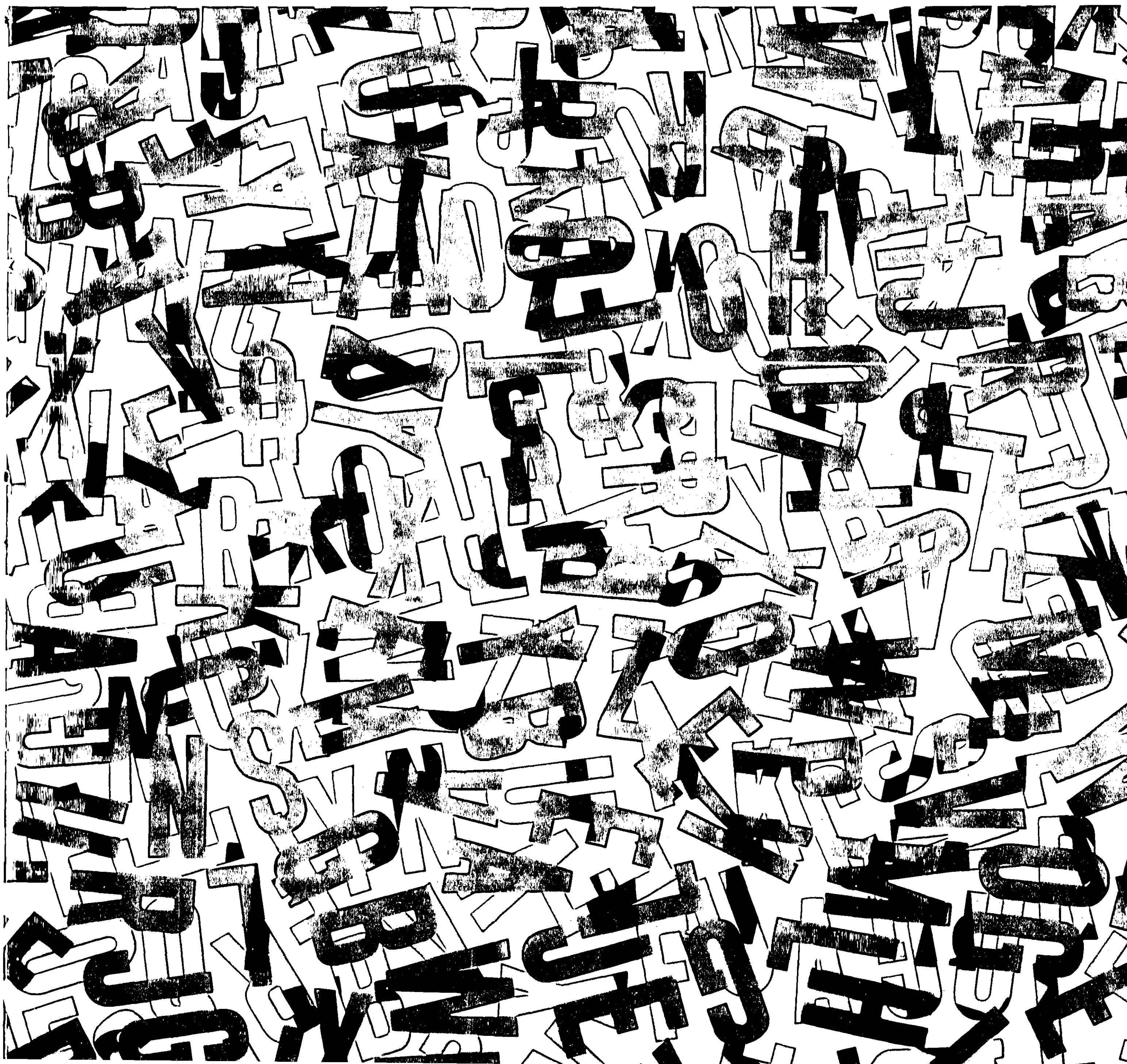
There is a significant difference in the programming requirements of the first and higher levels of control. The simple algorithms of first level control are applied to processes in which there are many variables, all of which are regulated in a similar fashion. Consequently the computa-
(Cont'd. on p. 39)

[1] I. Lefkowitz, Multilevel Approach Applied to Control System Design, *1965 JACC Proceedings*, pages 100-109.

One of a series on topics of importance to data processing management

Honeywell report on COBOL

COBOL, the collaborative effort by the computer user and manufacturer to develop a standard programming medium for business data processing, has come of age. It has evolved as a precise, well defined and fully mature data processing language. This report discusses the major factors behind the growing importance of COBOL, indicates the cost and performance areas management must take into account when evaluating COBOL, and



briefly describes Honeywell's efforts to provide the best possible COBOL systems for its users.

Composed essentially of familiar business terms, COBOL can be learned more easily by new programmers and help them become more productive sooner. As a standard language, it aids communication between projects and between programmers and management.

When properly implemented, COBOL simplifies the problem of exchanging programs among various makes of computers and eases the transition to newer, more powerful models.

COBOL as a system minimizes program checkout and debugging, provides disciplined documentation, and simplifies program maintenance.

COBOL — A TOOL FOR MANAGEMENT

Many of the nation's largest users have adopted COBOL as their standard programming language. More and more prospective users are making COBOL a pivotal issue in their computer selection process. As a result, COBOL has been, or is being, implemented for virtually every major computer model or family of models.

More than a common business-oriented language, COBOL is a powerful management tool that can provide definite and precise answers to problems in the six major decision areas shown below. In each of these areas, COBOL's contribution to effective computer utilization can be measured directly in terms of time and money saved.

DECISION AREA	HOW COBOL HELPS
1 **INTERSYSTEM COMPATIBILITY** . . . the effect of computer hardware differences on program and systems conversion requirements.	Machine independence of COBOL language offers a substantial reduction in programming costs.
2 **INTRAPROJECT COMMUNICATION** . . . the organization and cooperation of project personnel.	Provides a communication medium that offers a common base for data nomenclature, flow charting and programming conventions.
3 **STANDARDIZATION** . . . the universality of a precisely defined programming language.	Standards within the language lead to standards within the application area.
4 **PROGRAM TESTING** . . . the cost of nonproductive debugging time.	COBOL compilers always produce mechanically correct code. Clerical mistakes and logical errors are quickly pinpointed and eliminated, usually with only one recompilation.
5 **PROGRAMMER TRAINING . . .** the time it takes a programmer to become productive.	Programmers need be concerned with only a finite number of familiar terms, not the inner workings of the computer.
6 **PROGRAM DOCUMENTATION . . .** the basis for program maintenance and modification.	Close relationship between statement of problem and COBOL solution to problem. Compiler automatically provides comprehensive program documentation.

Consider the benefit of being able to move from one computer to another without a major reprogramming effort. As COBOL language is not dependent on the logic of any particular computer, any reprogramming effort is mainly a clerical one. Moreover, one of the design features of Honeywell's Series 200 COBOL compilers makes it possible for the compiler itself to perform much of this clerical function.

The following example, based on an actual benchmark situation, demonstrates how COBOL can minimize program conversion time. The program in the example was, by comparison to the average COBOL program, very large: 2,100 statements. It was originally written to be run on a computer with 192,000 characters of memory. The program was converted to run on a much smaller computer, a Honeywell Model 200 with 32,000 characters of memory. The following timetable gives a breakdown of the total conversion time to create an executable object program from the original source program:

1. Preprocessing of 2100-statement COBOL program (A special feature to assist the conversion process)	10 min.
2. Programmer time to make all manual changes indicated by preprocessing	60 min.
3. First compilation (produced object code greater than 32K char.)	6 min.
4. Programmer time to change program file blocking descriptions	10 min.
5. Second compilation (produced object program executable in available memory)	6 min.
Total conversion time to create executable object program	1 hr. 32 min.

It is estimated that had the program been written in the assembly language of the original computer, reprogramming time would have been measured not in hours, or even days, but months.

tional load is very repetitive in nature and efficient programming and core allocation are necessary. On the other hand, the higher levels of control are relatively complex and non-repetitive in nature and it is more advantageous here to use an algorithmic language in order to provide flexibility and good documentation.

The extensive input-output facilities of a process control computer may be needed by any one or all of the levels of control, since all make use of process data during their operation. Consequently, many decisions must be left to the programmer to make for each particular installation. For example, rate of scan of analog inputs, type of scan (sequential or random), changes in scan rate, strategy in case of input or output error detection, etc . . . all vary from application to application and in fact from one level of control to another within a given application. Thus any software system necessarily must permit the programmer to communicate easily with all of the hardware in the computer and cannot incorporate arbitrary decisions about these problems in a single executive.

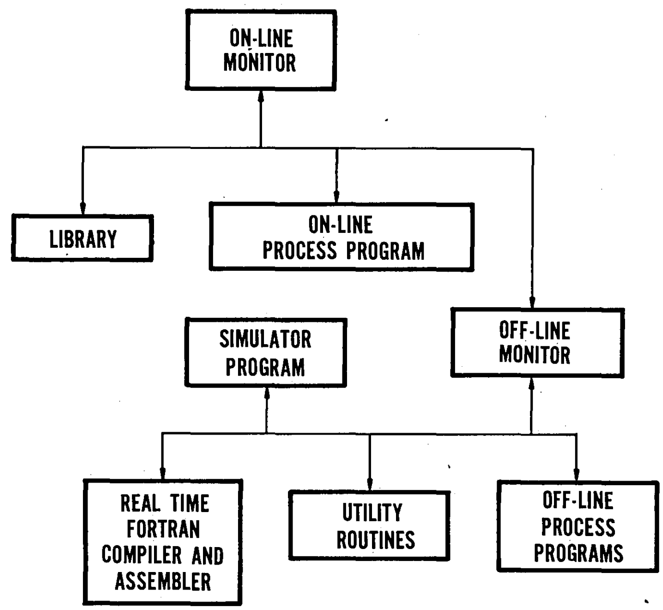
Most of the software systems currently available for process control are designed to support the higher levels of control (the so-called supervisory control levels) rather than the first level, and are in the form of an executive system with real-time Fortran as the basic language. Two factors permit such executives to be used with supervisory control systems.[2] First, the speed of machines has significantly increased so that Fortran-level programs can compete in terms of speed with machine-language programs in the earlier machines. Secondly, secondary storage has become readily available, permitting large executive systems and efficient storage and saving of programs outside of core. The problem of servicing the first level of control can be solved without sacrificing the executive if a two-computer system is used: one computer doing primarily first level control (DDC) and the second, under control of the executive system, performing supervisory tasks as well as backup of the DDC computer.

process control executives

The objective of an executive system is to relieve the programmer of the more burdensome tasks connected with real-time operation. It responds to interrupts, saves and restores partially executed programs, allocates primary and secondary storage, sequences programs, and responds to error conditions. In addition, if any time is left after the process control programs are executed, the executive often permits off-line use of the machine. That is, the executive permits the machine to be shared by the process and an off-line user. Thus non-process programs may be assembled, compiled, simulated, and debugged without interfering with the process. Such a use of the machine is usually called time-sharing by the computer manufacturers.

A diagram of a typical process control software structure is shown in Fig. 2. The key program is a monitor which responds to interrupts, determines the appropriate action to be taken with respect to servicing of an interrupt, sequences programs, and in general takes care of the bookkeeping and interprogram communication tasks in a real-time system. When free time is available, the monitor calls the off-line monitor, which is similar to any stack-job monitor system except that all calls to input-output devices are trapped and prevented unless there is no possibility of interference with the process. All assembling, compiling, and debugging is done under the control of the off-line monitor. A particularly interesting and useful routine is the simulator, which allows the testing of process programs without interference with the actual process. Input-output requests, interrupts, analog data, etc. are simulated, allowing efficient debugging of process control programs and interrupt routines while the computer is on-line. It is the rule rather than the exception that process control programs change often and it is very desirable to be able to do this at the installation without taking the computer off-line. The value of changes made at the installation far outweighs the slow running speed of such simulators. Within the off-line monitor are the usual utility routines which

Fig. 2



permit the control of programs stored in secondary memory and the changing of programs which are used for on and off-line process control.

The main task of the executive is the running of user-written process control programs which necessarily are greatly concerned with the many input-output devices. Although the executive cannot permit direct programming of input-output devices, it does permit their control through calls to a library of real-time subroutines. The combination of the Fortran language and these library routines results in something akin to a process control language which permits programming of any of the higher level control problems.

Elements of this "language" vary, of course, among different computers, but the basic functions are similar. The subroutines of the IBM Time Shared Executive are used here as illustrations.[3]

examples of the language

Commands may be divided into three categories. The first is Sequence Control, statements which permit the programmer to control the order in which tasks are performed, interrupts serviced, and off-line jobs permitted. Such control is important, since the various levels of control are necessarily carried out in sequence rather than in parallel and the order is critical. For example, a sequence of tasks might be to collect certain data, use a statistical identification routine to determine parameters of the process, and finally to use an adaptive routine to change the controller parameters. An optimizing routine too large for core can be executed in parts if the programmer has control over the sequence of programs. Commands which give him this

[2] K. Stapleford, PCP-88, *Foxboro publication.*

[3] IBM 1800 Time-Sharing Executive System Specification, *IBM* publication.

control include CHAIN (which specifies the next program to be executed), QUEUE and UNQUE (to enter or remove program in a waiting queue), VIAQUE (to call the highest priority program waiting in the queue to be executed next in sequence), and SHARE (to indicate free time is available in which non-process programs may be executed under the control of the *off-line* monitor). Such statements may be freely imbedded within process programs written in Fortran. Through use of these commands within programs, the programmer can control the frequency and order in which the various levels of control are performed. Even when various levels are not performed on a regular basis (for example, when a certain function is performed only upon operator demand), these commands permit control over the sequence. In response to an operator-initiated interrupt, the interrupt subroutine can decode the request and call for the appropriate program to be entered in the queue and then executed when it has the highest priority. Of equal importance is the ease by which sequence is changed as the process control problem changes with time.

A second division of the language is Interrupt Control, the control of the routines which service interrupts and the control of the interrupts themselves. For example, during certain routines it may be advantageous to delay the servicing of interrupts to minimize exchanges of programs (when it is known that a program is short and the interrupts can wait) or to prevent certain interrupts entirely (as when a routine cannot be used recursively and may be called from more than one level). Commands to permit this control include SPECL (to stop the program in progress, save it in secondary storage, and execute another program), BACK (to return to a program which was only partially executed), SERVE (to service interrupts which were not serviced at the time they occurred) and CLEAR (to ignore interrupts which occurred but were recorded rather than serviced immediately). These commands are most useful within interrupt subroutines which can determine the present status of the process (alarms, overloads, etc.) and decide what actions to take, including complete restart of the programs, aborting of certain actions, or even turning control over to the operator. Control over the interrupts themselves implies actual inhibiting or allowing of the interrupts to occur. This control is obtained through commands such as MASK, UNMASK, SAVEMASK, and RESTOREMASK, which inhibit or allow specified levels of interrupts and permit determination of the status of the interrupt levels (inhibited or not) at any time. Through selective use of masking, data channels can keep operating for the transmission of data in and out of core while process interrupts are inhibited until the short routine in progress is complete (assuming the hardware permits this). These masking control commands must be available to the programmer, for only he can decide in a given situation whether or not it is permissible to delay servicing of certain interrupts from the process. These commands give the programmer the opportunity of increased efficiency of execution of his program, but also place on him the burden of insuring that essential process functions not be prevented by indiscriminate masking of interrupts.

The third division of language statements, Input-Output Control, includes statements which permit communication between the process itself and the computer. At any level of control, data from the process may be necessary, requiring that any program be able to request analog or digital input data from specified locations in the process. Commands which permit this are various subroutine names which are programmed to convert one or more analog signals into digital form and store them in prescribed locations or to take prescribed variables, convert them to digital form and output them to the process. Such routines make use of the interrupt structure of the computer and data channels (if available) in order to perform such tasks asynchronously. These subroutines include various scanning options (sequentially, random, single variable) and alternatives in case of detection of errors. Because all of these subroutines make extensive use of data channels, device indicators, and interrupts, the form of the subroutines themselves is not under the control of the programmer. For example, a call for an analog input may find the multiplexor busy, in which case the subroutine may simply wait until it is free or return to the calling program . . . depending on the particular routine. Detection of an error in transfer of data may result in repeated attempts to read the data, the number of attempts being built into the subroutine. In some applications these subroutines might not be suitable because of the speed at which they run, the arbitrary way they respond to error conditions, etc.

It is, of course, possible to provide additional simple subroutines which test indicators for various error conditions and to call these before attempting to use a device. An extensive set of such routines is available in the General Electric GE/PAC executive system, including routines for saving machine indicators and registers.[4, 5] An important device is the interval timer, a counter which may be set up to cause a program interrupt at any desired time. This permits a watchdog type of operation for maximum reliability. For example, after performing some operation, an interrupt after a given length of time may be requested which will call out a program which determines if the operation actually was carried out.

The interval timer can be used to sequence certain operations by requesting an interrupt after a specified time interval followed by execution of the task. In the hierarchical control system, the higher the level, the less often the tasks are performed. Frequency of operation of the optimizing function, for example, may depend upon the detection of disturbances by a lower level and/or may be done at a fixed time interval through use of the interval timers.

another approach

One exception to the real-time Fortran approach to process control languages is the CONTRAN system being developed by Honeywell. This language is an outgrowth of the Consequent Procedure language developed by Fitzwater and Schweppe.[6, 7] Their language, called TASK 64, is a modification of ALGOL 60 to include task processing statements and consequent procedures (procedures which are initiated when certain prescribed conditions are fulfilled). Such a language operates within an executive system as does Fortran, but goes a step further than the subroutine library approach. Control of sequence of various portions of the control program is obtained by the specification of a set of Boolean variables or switches for each program so that the program will be executed when, and only if, these conditions are fulfilled. Thus these conditions, rather than the order of program statements or routines, determine the sequence of their operation. Con-

[4] GE/PAC 4000 Free-Time System User's Manual, GE publication.

[5] GE/PAC 4000 Monitor User's Manual, GE publication.

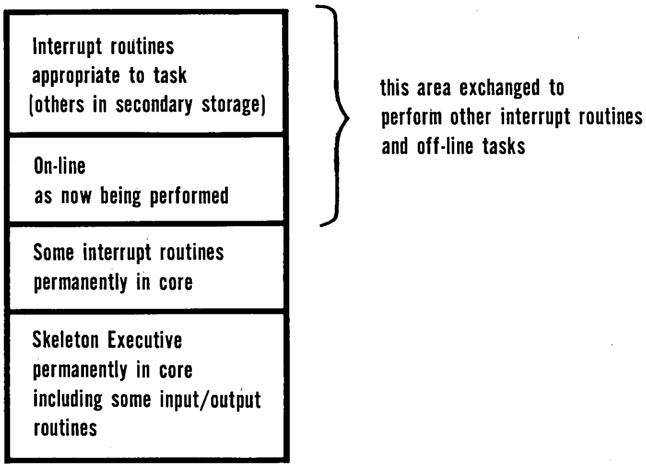
[6] D. R. Fitzwater, E. J. Schweppe, Consequent Procedures in Conventional Computers, FJCC, 1964.

[7] D. R. Fitzwater, D. E. McFarland, TASK 64-A Consequent Procedure Real Time Computer Language, *Iowa State University*, Ames, Iowa.

trol of interrupts and communication between the process and the computer through input-output devices are obtained through subroutine calls as in real-time Fortran.

With sufficiently large core storage (8K minimum) one of these executive systems can respond efficiently to process demands. A possible allocation of core is shown in Fig. 3. The skeleton executive program is permanently resident in core and includes all routines necessary for communica-

Fig. 3



tion, with secondary storage and the servicing of interrupts with very short response time requirements (mostly high speed data transfer devices). The non-permanent portion of core storage includes process programs and interrupt routines whose response time is slower than that of the permanent routines. Any interrupt which is not part of the skeleton executive system or loaded with the process program is serviced by exchanging the process program for a service routine in secondary memory followed by restoration of the interrupted program. To minimize secondary storage exchanges, such routines are usually not interruptible except by interrupts whose service routines are in the skeleton executive. Thus there are basically three response times for interrupts and the programmer may choose the combination which is best for a given application.

not for everyone

The supervisory executive described above is a very significant advance in process control software and should service the needs of a majority of control installations. What are the disadvantages of such executive systems which prevent their application at times? Three types of installations are not efficiently serviced by these executives.

The first are the very small systems which cannot justify the additional core storage and secondary storage necessary to use the executives. Many installations (at least in the past) started out small and, consequently, with special programming systems written especially for that job. Later they grew large enough to justify the use of an executive system. However, it is difficult to decide to scrap a great deal of working software in order to use an executive . . . even though in the long run it might be the best solution. Often a middle of the road solution which is not satisfactory to anyone is chosen.

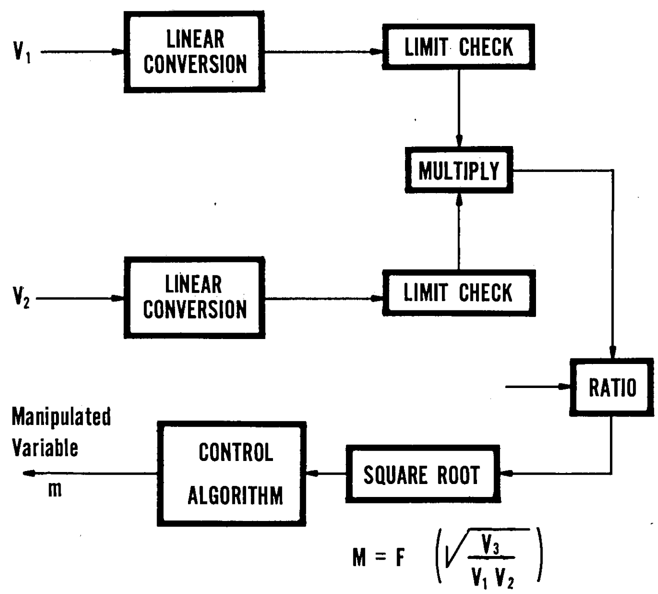
The second type of installation which cannot directly use the executive is a system which is primarily first-level (DDC). Efficiency, reliability, speed, and quick response time are the objectives here rather than simplified programming and convenience. As mentioned, when this function can be delegated to a separate computer with its own software the executive can still be used in the supervisors computer. This may be the solution in the long run as indicated by several installations in which this is now being applied.

The third exception application is a critical process where special programming requirements are necessary. For example, the nuclear reactor control system supplied by Control Data placed so great an emphasis on reliability that no executive now available could efficiently satisfy the requirements.[8] Of importance here is that such unique applications will occur more and more often as the volume of process control applications grows and some software support must become available.

software trends

Two solutions to the problems mentioned here are being considered. First, special software for DDC or first-level control is being considered. The importance of simple flexible software for DDC cannot be overemphasized, since it must be used by plant engineers, for example, in all process phases from startup through regular plant operation. A number of manufacturers are considering a DDC compiler system whose input language is a block diagram specification of the control algorithms to be implemented. The output of the compiler would then be a machine language program which could run by itself in a DDC computer. Such a block diagram language is similar to digital simulation languages such as Midas and Pactolus. A simple example of such a program is shown in Fig. 4. Changes in the first level of control would then merely

Fig. 4



require perhaps a recompilation of the block diagram statements. One advantage of this approach: this type of programming is familiar to plant engineers, since it is used in analog simulation. This approach is very attractive in that different sets of "blocks" could be supplied for different industries and applications, making it very easy for customers to make use of the computer. The problem is one of economics. Although the language may not differ much from one application to another, the implementation may be quite different because of different operating speeds required for scanning and output of data. Consequently, a different compiler might be required for different applications, making the approach uneconomical.

Within whatever DDC software is supplied, there may be included a routine which permits communication with

[8] J. E. Smith, Program Structure Considerations of Digital Control in a Nuclear Power Plant, *JACC Proceedings*, 1964.

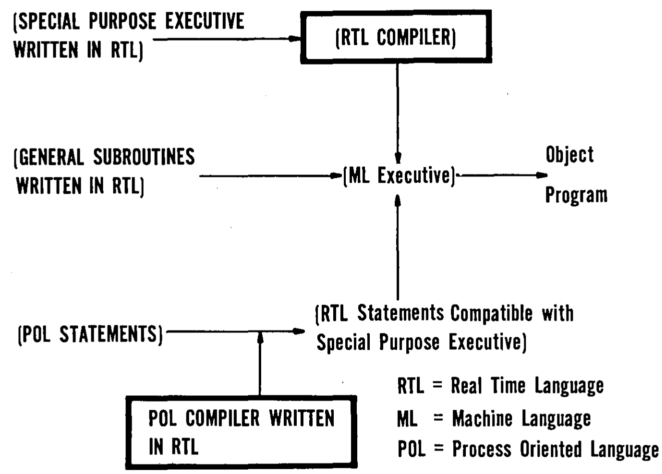
a supervisory computer operating under an executive system. Such systems are now available. For example, the PCP-88 system supplied by Foxboro is made up of two PDP-8 computers with Foxboro interfaces and a complete real-time Fortran executive system for the supervisory computer and DDC software for the first level computer.[9] Two big advantages of such an approach are the separation of the programming problem into two parts, with each serviced by the most convenient language . . . and the increased reliability of the system because of the duplication of central processors.

The second solution of problems of executive systems might be the development of a true process control language. The main difficulty with the Fortran library system of subroutines is that the programmer has no control over the inner workings of the executive system and the interrupt and error handling characteristics of the individual subroutines. It might be desirable to develop a real-time process control language which is algorithmic in nature and sufficiently powerful to produce the executive itself together with the subroutine library. Such a real-time language must permit control over the allocation and freeing of core and secondary storage, specification of interrupts and responses to interrupts and other functions which are normally reserved for the executive rather than being under the control of the programmer. If such a real-time language were available, the programming system shown in Fig. 5 could result.

[9] R. Rankin, A Summary Description of the Standard DDC Functions, Foxboro publication.

If the language were sufficiently powerful and efficient, the executive could be written in this language, thereby permitting easy changes for various applications which cannot use a standard executive. Special-purpose languages for DDC and other applications (process-oriented languages) could then be designed and compilers written to produce the real-time language as an intermediate rather

Fig. 5

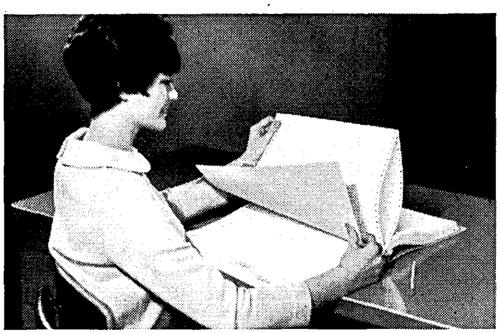


than machine language. This would decrease the cost of producing such special languages and decrease the problem of obsolescence because of hardware changes.

With the rapid increase in the number of computer control installations and the shortage of qualified systems engineers and programmers to install these systems, process control software will quickly develop in the direction of further simplification of the programming problem. ■

From the way they talk, you'd think Wilson Jones invented the Nylon Post Binder.

They did.



And they've been the leader ever since.

They developed and perfected the binder for marginal-punched unburst sheets—the remarkable time-saving, money-saving binding method that thousands of firms with high volume data processing departments are using today.

Sheets are bound exactly as they come from print-out—without stripping, punching and bursting—without any other extra steps. Wilson Jones developed binders for every conceivable data processing need. Binders for burst sheets...for stripped and unstripped sheets... for sheets of mixed sizes...loose-leaf forms...frequent or infrequent addition or removal of sheets...permanent binding...top and bottom loading. Binders in a wide range of colors for coding reports and records. And indexes to fit these binders, as shown in the photograph.

In fact, Wilson Jones makes a total of 314 different binders to house the 47 stock sizes of "tab" forms made today!

So, if you think you have an E.D.P. housing problem that can't be solved, you haven't checked the inventor of the nylon post binder recently! Just remember the name, "Wilson Jones", when you call your stationery or "tab" supply dealer. Or write directly to the inventors. Ask for Catalog GL 264-2.

WILSON JONES

209 South Jefferson Street Chicago 60606

RECORD KEEPING WJ ESSENTIALS

A DIVISION OF Swingline® INC.

CIRCLE 22 ON READER CARD

a growing choice

A SURVEY OF THE CHARACTER RECOGNITION FIELD

by LAWRENCE A. FEIDELMAN

In the early days of electronic data processing, when the amounts of information being handled in most computer applications were relatively small, the need to manually keypunch the information in a machine-readable code caused no particular concern. Today, when vastly more sophisticated machines are being used to store, retrieve, and process large amounts of information, this manual operation has come to be viewed as a fundamental weak point in computer-based information systems—too slow, expensive, and unreliable to be tolerated in applications involving large volumes of input information. The one solution to this problem is the automatic character reader—a device that has been developed to the point where it has replaced manual keypunching in selected application areas, although it still lacks the functional refinements to become standard across the full spectrum of computer input operations.

The character reader is a machine for directly converting alphanumeric characters or symbols into a machine-readable code. The output of the reader may be in the form of punched cards, punched paper tape, or magnetic tape . . . or the reader may be operated on-line (directly connected) to a computer.

Most current machines are rather severely limited in the type fonts they can read, and, in some cases, the size of the character set (alphanumeric vocabulary) they can handle, even in special type fonts. On the other hand, character readers are in effective and economically efficient use in several major industries. Banking is one, and probably is the largest application area for character readers. The credit-card industry, led by the oil companies, and utility bill processing are other major application areas. In addition, some retail merchandising firms have recently begun using character readers, and the United States Post Office has expressed interest in seeing a character reader developed to read hand-written addresses.

The character reader offers the advantage of being faster and more accurate than manual keypunching, since it permits printed data to be entered directly into the data-processing system without any additional human action. The present purchase price of commercial magnetic character readers averages around $80,000. The prices for optical character readers range from $75,000 upward, depending upon the speed and sophistication of the machine (rentals run between $3,000 and $15,000 per month).

character reader types and functions

There are two basic types of character readers: magnetic and optical. Magnetic character readers are used almost exclusively within the banking industry. They can handle only special type fonts printed in magnetic ink. The font most widely used in the United States and adopted as a standard by the American Bankers Association is E-13B (see Fig. 1), which can be used to represent only 10 numerics and four special symbols. Another font, which was developed by Compagnie des Machines Bull—General Electric, is capable of representing all

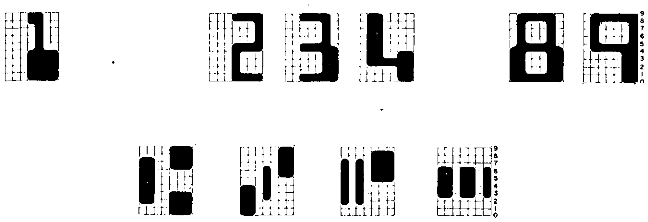
Mr. Feidelman, a member of the technical staff at the Auerbach Corporation, is a systems analyst and designer active in computer communications work. He has a BA in mathematics from NYU and an MS in engineering from the Moore School, Univ. of Pennsylvania, with research emphasis in pattern recognition and artificial intelligence.

This article is based on information from AUERBACH Standard EDP Reports.

the characters in the alphabet as well as all the numeric symbols. However, this font, which has been adopted as a standard by the European banking community, can presently be read only by the Bull CMC-7 and Olivetti 7750 magnetic character readers.

Since magnetic readers detect only magnetic marks, non-magnetic common dirt or other marks do not cause reading errors. However, considerable care must be taken with the quality of the printing on the documents. Ink densities and character image are both critical. Relatively high quality-control standards must be maintained in the printing process to prevent character deterioration and extraneous ink spots.

Fig. 1. Sample of E-13B Font Characters



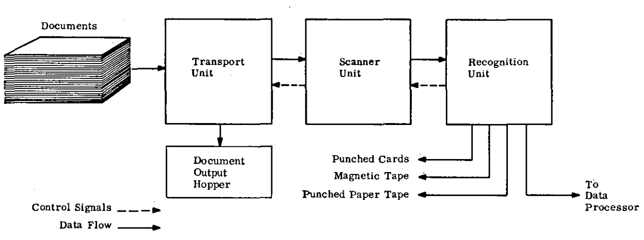
Optical character readers are used in nearly all the major application areas other than banking. They work on the principle of recognizing the difference in contrast between the characters and the background on which they are printed. Some do not require special fonts and are theoretically capable of reading most type fonts with suitable adjustment. So far, however, this theoretical capability is too expensive to realize for commercial use, although there are several optical character readers that can read more than one type font. The least expensive units are restricted to one font usually specially designed for low error rate and often restricted to numerics plus a few special symbols. Also, the optical reader tends to be somewhat less reliable than the magnetic reader because of its sensitivity to dirt, document creases, and poor paper quality. Despite these drawbacks, optical readers seem to offer the most promise for the future, and new techniques are being explored and developed to overcome the major functional problems.

All existing commercial character readers, whether magnetic or optical, consist of three basic functional units:

1. Document transport
2. Scanner
3. Recognition unit

A block diagram of a character reader is shown in Fig. 2.

Fig. 2. Character Reader Block Diagram



The function of a character reader's document transport is to move each document to the reading station, position it properly, and move it into an "out" hopper. Transport mechanisms can be divided into two basic types: one for handling individual documents (paper sheets or cards) and the other for handling continuous rolls (cash register or adding machine tapes).

The function of a character reader's scanner is to convert the alphanumeric characters and symbols on a document into some analog or digital representation that can be analyzed by the recognition unit. There are two basic methods for accomplishing this—magnetic and optical—and the method used is the basis of a character reader's designation as one type or the other.

The recognition unit is the heart of the character reader. This unit matches patterns from the scanner against the reference patterns stored in the machine and either identifies the patterns as specific characters or rejects them as being unidentifiable.

document transports

Document transports in character readers designed to handle adding machine or cash register tapes consist of a tape well, in which the paper roll is loaded; paper guides; and a paper drive control. Once the tape is manually threaded, the paper is automatically moved past the read head in a manner similar to the movement of a film reel in a movie projector. A vacuum system is frequently used to keep the paper flat. The maximum length of the paper roll that can be handled ranges from 100 feet for the National Cash Register Optical Journal Reader to any reasonable length for the Recognition Equipment Journal Tape Reader. The paper-roll mechanisms are usually designed so that the roll can be backed up any time rereading is required. A special feature of the feeder mechanism used in the Recognition Equipment Journal Tape Reader is an automatic tape advance, which speeds up tape movement when there are large spaces between print lines. In the other readers, tape speed is constant at all times.

In character readers designed to handle individual sheets or cards, the document-transport function is divided into two phases: (1) feeding the documents from the input hopper, and (2) transporting the documents past the reading station. A common device for document feeding is called a friction feeder. This consists of a belt wound around capstans and partially resting on the document stack. Constant pressure is exerted against the belt by the document stack. As the belt moves across the top of the stack, it pushes the top documents into a separator station, where a combination of rollers and another belt separates the top document from all documents below it. This technique is used in the IBM 1419 Magnetic Character Reader.

Vacuum or suction feeders are also used to lift documents off the input stack. One example of a vacuum feeder is used in the Philco General-Purpose Character Reader, which employs a pair of vacuum belts to lift the document from the stack and carry it forward to the transport unit.

Both the friction and vacuum devices, however, have problems in handling documents of thin paper and may occasionally feed more than one document at a time. A new type of feeder, which has been designed by Rabinow Electronics (subsidiary of Control Data Corporation), uses a set of cone-shaped rollers for feeding the documents. The rolling cones engage a corner of the top-most document and roll the corner away from the pile up into paper rollers, which carry the document to the transport unit. This unit is said to eliminate the possibility of feeding two sheets at a time.

A popular method for transporting the document to the reading station is a vacuum-drive conveyor belt. Some character readers, such as the IBM 1428 and the Rabinow RUR model, use the conveyor belt to place the document on a rotating drum, which moves the document past the read head. The paper is held to the drum by means of a vacuum.

One of the basic disadvantages of the above mechanical techniques is that they cannot move the document as fast as it can be read. One approach to this problem has been the use of a high-resolution CRT scanner, developed by Philco Corporation, which can scan the entire document without requiring any mechanical movement. Another method, used by UNIVAC Division of Sperry Rand Corporation, uses a vidicon scanner which takes a picture of the entire document at once. Both of these systems will be discussed later in this article.

scanner units — magnetic

Scanner units, as previously mentioned, are divided into two basic categories: magnetic and optical, designations that are used to characterize the readers themselves.

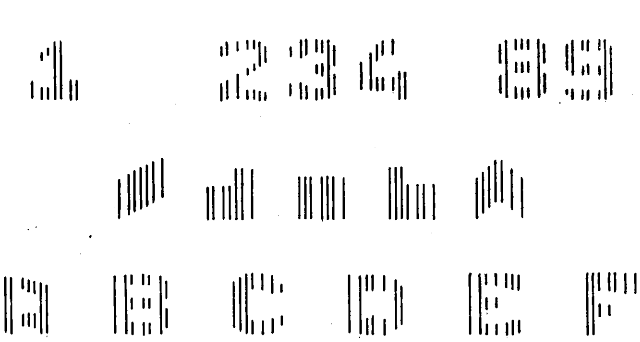
Since the banking field represents the major application area for magnetic character readers, all of the magnetic readers produced in the United States have scanning units designed to handle the E-13B font.

Most scanning units convert the magnetic characters into an analog voltage waveform for subsequent identification. The principle used is based on the electrical signal that is generated by moving a character past the read head. Each character generates a signal that has a unique waveform, which the recognition unit matches against reference waveforms. The companies presently using this technique are Burroughs, General Electric, and National Cash Register.

IBM uses a digital scanning technique, which is exemplified by the IBM 1419 Magnetic Character Reader. In this machine, the character is scanned by thirty magnetic heads stacked vertically and interconnected to give ten outputs. The outputs are transmitted to a 70-bit shift register in the recognition unit, where they are matched against stored reference patterns.

Another type of digital scanning technique is used in the Compagnie des Machines Bull—General Electric CMC-7 and Olivetti-General Electric 7750 magnetic readers, which are designed for the special BULL magnetic font shown in Fig. 3. This font, which has been adopted by the European banking community, can be used to represent

Fig. 3. Sample of BULL Magnetic Reader Type Font Characters



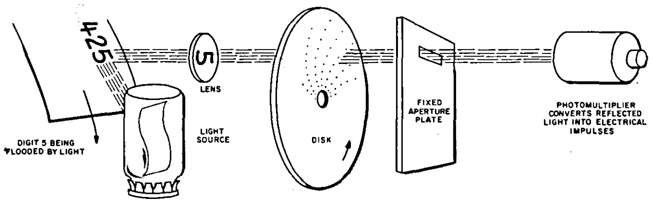
26 alphabetical characters, 10 numerals and 5 special symbols. Also, it is easy for human beings to read. Each character is composed of seven vertical strokes, which define six intervals of short and long duration (i.e., gap widths between strokes). The reader scans each character from left to right and records the variations in magnetic flux, which indicates the width of the gap between the strokes. Each character is then identified by the number and sequence of narrow and wide gap widths.

scanner units — optical

The optical-scanning methods are based on the difference in contrast between the characters and the background on which they appear. The function of the scanner is to sample either portions of a character or a complete character to determine the relationship between light and dark areas. The common scanners used are mechanical discs, flying spot scanners, parallel photocells and a vidicon scanner.

Mechanical-Disc Scanner. The mechanical-disc scanner consists of a lens system, a rotating disc, a fixed aperture plate and a photo-multiplier as shown in Fig. 4. The characters to be read are flooded with light, which is reflected from the surface of the document into a rotating

Fig. 4. Mechanical Disc Scanner



disc via the lens system. The disc has apertures extending from its center toward its periphery. As the disc rotates, the apertures pick up light samples. A fixed aperture plate regulates the amount of light and directs the light to a photo-multiplier. The photo-multiplier tube converts the eight samples into signal pulses. By varying the voltage threshold, the photocell outputs can be adjusted for different background colors.

The mechanical-disc scanner senses a character of data at a time. Movement between characters and lines is accomplished either by moving the document, as in the NCR Optical Journal Reader, or by respositioning the lens system, as in the IBM 1428 Alphameric Optical Reader. Consequently, this type of scanner is relatively slow, as compared with the other scanners mentioned.

Flying-Spot Scanner. The flying-spot scanner consists of a cathode ray tube, a projection lens, a phototube and a control unit. A beam of light is generated on the cathode ray tube and deflected across the CRT in a scan pattern. The lens system projects this scanning light spot onto the document, from which it is reflected into a phototube. The phototube generates a voltage signal whose level is proportional in each instant to the amount of reflected light, thus indicating light and dark areas. The resulting signals are then either fed directly to the recognition unit in analog form or first transformed into digital form.

The flying-spot scanner offers more flexibility than the mechanical disc, since its scanning pattern can be automatically adjusted by the control unit. This permits the
(Cont'd. p. 50)

CHARACTER READER COMPARISON CHART

The accompanying comparison chart summarizes the significant characteristics of representative optical and magnetic character readers in terms of the type of document feed and transport unit, document size, document speed (documents/minute) types of scanners and recognition units, type font, character set, and reading speed. It should be noted that the reading speed represents a potential speed. The actual speed is dependent on the size and number of documents being read. The notation N/O denotes that no information has been obtained on this characteristic for the specified device.

Name of Company	Equipment Model	Document Feed Type	Document Transport Type	Document Size (inches)	Documents per Minute	Scanner Type	Recognition Type	Type Font	Character Set	Reading Speed (Characters/Sec.)
Burroughs	Typed Page Reader	Vacuum	Drum	8½ x 11	N/O	Optical—Flying Spot Scanner	Matrix Matching	Upper Case Standard Elite Type	Alphanumerics, Punctuation Marks	75
	B102 & B103 Sorter-Reader	Friction	Conveyer Belt	Length: 5.94-9.06 Width: 2.69-4.06	1,000 to 1,565	Magnetic	Analog Waveform Matching	E-13B	Numerals, Four Special Characters	Max. 1,300
Farrington Electronics, Inc.	Selected Data Page Scanner	Vacuum	Drive Rollers	From: 4.5 x 5.5 To: 8.5 x 13.5	(1)	Optical—Mechanical Disc	Stroke Analysis	Selfchek 12F and/or Selfchek 12L	Alphanumerics, Punctuation Marks, Special Symbols	Max. 200
	1P Page Reader	Vacuum	Drive Rollers	From: 4.5 x 5.5 To: 8.5 x 13.5	(2)	Optical—Mechanical Disc	Stroke Analysis	Selfchek 12F and/or Selfchek 12H or 12L, A.S.A. Font, IBM 1428	Alphanumerics, Punctuation Marks, Special Symbols	Max. 280
	ID Document Reader	Vacuum	Drive Rollers	Card Stock: From: 2.2 x 2.75 To: 8.5 x 6.0 Documents: From: 2.625 x 2.75 To: 8.5 x 6.0	Max. 440	Optical—Mechanical Disc	Stroke Analysis	Selfchek 7B, 12F and/or Selfchek 12H IBM 403 IBM 1428	Alphanumerics, Punctuation Marks, Special Symbols	Max. 330
	9SP Model Series	Vacuum	Drive Rollers	Standard Tab. Cards: 80 column or 51 column	Max. 180	Optical—Mechanical Disc	Stroke Analysis	Selfchek 12F and/or 7B	Numerals	Max. 330
	2J3M Journal Tape Reader	Tape Spool	Vacuum Conveyer Belt	Length: to 350 ft. Width: 1 5/16 to 4½ inches	2,880 lines per minute maximum	Optical—Flying Spot Scanner	Stroke Analysis	Selfchek 9B or 12F IBM 1428, NCR Optical Font, A.S.A. Font	Alphanumerics, Special Symbols, Limited Punctuation	Max. 1,000
	2S3C Self-Punch	Vacuum	Drive Rollers	Standard Tab Cards; 51 or 80 column	Max. 550	Optical—Mechanical Disc	Stroke Analysis	Selfchek 7B, 7BR, 9B, 12F and 12L	Alphanumerics, Special Symbols, Punctuation	Max. 600
General Electric	MR-20 S-12D	Vacuum	Conveyer Belt	Length: 4.75 to 9.0 Width: 2.5 to 4.1	1,200	Magnetic	Analog Waveform Matching	E-13B	Numerals, Special Symbols	Max. 1,800
Compagnie des Machines BULL-General Electric	LD-1 (CMC-7 Reader)	Friction	Conveyer Belt	Length: 2.36-8.75 Width: 2.75-4.50	330-620	Magnetic	Frequency Analysis	Bull Font (CMC-7)	Alphanumerics	Max. 700
Olivetti-General Electric	7750	Friction	Conveyer Belt	Length: 5¾ to 8¾ Width: 2¾ to 4⅛	Max. 750	Magnetic	Frequency Analysis	Bull Font (CMC-7)	Alphanumerics	Max. 1,888
IBM	IBM 1428 I, II & III	Friction	Vacuum Drum and Conveyer Belt	From: 3½ x 2¼ To: 8.75 x 4¼	Max. 400	Optical—Mechanical Disc	Matrix Matching	IBM No. 1428	Alphanumerics, Symbols	Max. 480
	IBM 1412	Friction	Drum	Length: 6 to 8¾ Width: 2¾ to 3⅔	Max. 950	Magnetic	Matrix Matching	E-13B	Numerals, 4 special Symbols	Max. 1,600
	IBM 1282	Friction	Clutch	50-80 column cards	Max. 200	Optical	Matrix Matching	1428-Farrington Optical Code	Numerals, 3 Symbols	N/O
	IBM 1419 Model I	Friction	Conveyer Belt	Length: 6 to 8.75 Width: 2.75 to 3.67	Max. 1,600	Magnetic	Matrix Matching	E-13B	Numerals, 4 special Symbols	Max. 2,112
	IBM 1418 I and II	Friction	Vacuum Drum and Conveyer Belt	Length: 5.875 to 8.75 Width: 2.75 to 3.67	Max. 420	Optical—Mechanical Disc	Matrix Matching	IBM 407-1 Font or 407-E-1	Numerals, special Symbols	Max. 500

(1) Dependent upon number of lines and fields within lines to be read.
(2) Maximum processing speed is 5 lines per second; minimum 2.5 lines per second.

Name of Company	Equipment Model	Document Feed Type	Document Transport Type	Document Size (inches)	Documents per Minute	Scanner Type	Recognition Type	Type Font	Character Set	Reading Speed (Characters/Sec.)
	IBM 1285	Vacuum	Conveyer Belt	Journal Rolls Width: 1 5/16 to 3½ Length: 36 to 200′	Max. 2,190 CPM	Optical	Matrix Matching	1428-NCR Optical code	Numerals, 7 symbols	Max. 365
National Cash Register Co.	420-1	Automatic Cash Register Tape Spooling Device	Journal Tape Reader	From: 1.31 x 10.00 to 3.25 x 12.00	26 lines per second	Optical—Mechanical Disc	Matrix Matching	NCR Selfcheking	Numerals, special Symbols	Max. 832
	402-3 MICR Sorter Reader	Friction	Conveyer Belt	Length: 5.25 to 10 Width: 2.5 to 4.5	Max. 750	Magnetic	Analog Waveform Matching	E-13B	Numerals, 4 special Symbols	Max. 1,200
	407-1 MICR Sorter-Reader	Friction	Conveyer Belt	Length: 4 to 8.75 Width: 2.75 to 4.5	Max. 1,200	Magnetic	Analog Waveform Matching	E-13B	Numerals, 4 Special Symbols	Max. 3,200
Univac Division Sperry Rand Corp.	Readatron	Picker Belt	Card	Credit Card Size	Max. 200 credit cards	Optical—Vidicon Scanner	Matrix Matching	No. 281	Numerals	Max. 580
Philco Corp. (Div. of Ford Motor Company)	General Purpose Print Reader	Vacuum	Conveyer Belt	From 3 x 5 to 8½ x 11	180 for 8½ x 11 documents 360 for 3 x 5 cards	Optical—Flying Spot Scanner	Matrix Matching	Multiple Type Fonts	Alphanumerics, Punctuation, Special Symbols	Max. 2,000
Rabinow Electronics (Subsidiary of Control Data Corp.)	RUR 3200-1	Vacuum	Conveyer Belt	5.5 x 8.63	Max. 400	Optical—Parallel Photocells	Matrix Matching	Billing Open Type	Numerals	Max. 1,000
	RUR 4100-1	Tape Spooling Device	Continuous Tape	—	—	Optical—Parallel Photocells (Retina)	Matrix Matching	Cash Register Type	10 Digits and 14 Alpha Characters	Max. 110
	Control Data 915/Page Reader	Vacuum	Conveyer Belt	Length: 2½ to 14 Width: 4 to 12	Max. 180 for 8½ x 11½	Optical—Parallel Photocells.	Matrix Matching	Upper Case Type Fonts	Alphanumerics, Punctuation	Max. 370
Radio Corp. of America	5820	Vacuum	Conveyer Belt	Max. 4 x 8½ Min. 2½ x 2½	Max. 1500 Min. 750	Optical—Vidicon Scanner	Stroke Analysis	RCA N-2	10 Numerals, 5 Symbols	Max. 1,500
	70/251	Vacuum	Conveyer Belt and Drum	Max. 4 x 8½ Min. 2½ x 2½	Max. 1800	Optical—Vidicon Scanner	Stroke Analysis	RCA N-2	10 Numerals 5 Symbols	Max. 1,500
Recognition Equipment, Inc.	Electronic Retina Document Carrier	Vacuum	Conveyer Belt	From: 2.00 x 2.00 To: 5.00 x 8.75	1,200	Optical—Parallel Photocells (Retina)	Matrix Matching	Multiple type fonts	Alphanumerics, Punctuation marks, special symbols, mark sense	Max. 2,400
	Journal Tape Carriage Reader	Tape Roll	Journal	Width: 1 5/16 to 6	Max. 1,800 lines per minute	Optical—Parallel Photocells (Retina)	Matrix Matching	Multiple type fonts	Alphanumerics, Punctuation marks, special symbols, mark sense	Max. 2,400
	Electronic Retina Rapid Index Page Reader	N/O	Conveyer Belt and Drum	From: 3.25 x 4.88 To: 10.00 x 14.00	Max. 30	Optical—Parallel Photocells (Retina)	Matrix Matching	Multiple type fonts	Alphanumerics, Punctuation marks, special symbols, mark sense	Max. 2,400

(1) Dependent upon number of lines and fields within lines to be read.
(2) Maximum processing speed is 5 lines per second; minimum 2.5 lines per second.

use of different scanning modes (i.e., scanning certain character fields, scanning specified portions of document). Also, being completely electronic, it is faster than the mechanical disc and is generally classified as a medium-speed device.

The introduction of high-resolution cathode ray tubes (2000 optical lines) has made manufacturers look to the development of a reader in which a complete document can be scanned without any document motion, other than that required to position it under the read station. A scanner of this type is now being manufactured by Philco Corporation. Sylvania Corporation was also developing a similar device, which was expected to achieve very high reading speeds of up to 6000 characters per second, although it is not known if this work is being continued.

Parallel Photocells. The use of a vertical grouping of photocells speeds up scanning operations by simultaneously sampling a number of points, which combined, add up to a complete vertical slice of the character. The electrical signals generated by the photocells are then quantitized into either black, white, or grey levels. This data is fed into a shift register and stored until data on the entire character is accumulated. Due to the parallel sampling, this scanner can achieve higher speeds than the flying-spot scanner.

A variation of this method that eliminates the need for shift registers uses a full "retina" of photocells to sample an entire character rather than just one vertical slice. Besides eliminating the shift register, this method also increases reading speed to approximately 2400 characters per second. Presently, Rabinow Electronics (subsidiary of Control Data Corporation) and Recognition Equipment are two of the companies using a retina of photocells for sampling. This sampling technique has the present capability for achieving a higher speed than any of the previously mentioned techniques.

Vidicon Scanner. So far, we have discussed scanning methods that read characters by reflecting light from the document to one or more photocells. A totally different method being used is to project the characters onto a vidicon television camera tube and scan the active surface with an electron beam. The resulting video signals are quantitized to digitally indicate black or white.

This type of scanner is presently being used by UNIVAC Division of Sperry Rand Corporation. By storing a group of characters on the tube (the NDP vidicon scanner can store 45 characters), the need for document movement during the scanning operation is eliminated in cases where the document contains a small number of characters. The advent of high-resolution vidicon tubes could permit the character capacity to be increased to the point where document movement during scanning will be eliminated on most documents.

Another advantage of the vidicon scanner is speed. Since it takes only 30 milliseconds for the beam to scan the entire tube, a full grouping of stored characters can be read in that time. At present, due to the limited number of characters that can be stored on the tube, the scanner is only medium speed (i.e., 500 characters per second). However, once this limitation no longer exists, this type of scanner should be as fast as or faster than the flying-spot type.

recognition units

Recognition units probably represent the area of greatest technical development in the character reader field. Because of the rapidity of the progress being made, we will limit our discussion to the five most common types of recognition units now available commercially.

1. Optical matching
2. Analog waveform matching
3. Frequency analysis
4. Matrix matching
5. Stroke analysis

Optical Matching. Optical matching is one of the earliest recognition methods to be used. It is based on the use of two photographic masks for each character. One mask is a positive transparency of the character and the other is a negative transparency. The positive transparency shows all the significant areas that should be covered by the character, and the negative transparency shows those areas that should be left blank.

The negative and positive images of the unknown character are projected onto their opposite masks, i.e., the positive image onto the negative mask and the negative image onto the positive mask.

Phototubes behind each mask detect any light passing through. A character is identified by first measuring the total light passing through the reference masks and selecting the one that passes the smallest amount. Character identification or rejection is then made by comparing the amount of light passed through the selected mask against a threshold value. Ideally, no light should pass through the reference mask if it matches the character being identified. In practice, however, the match is seldom precise enough to completely blank out all light, which is the reason for the threshold value.

The RCA multi-font reading machine, which employs an optical-matching technique, can read up to 500 characters per second.

Although most readers using this technique do so in conjunction with a conventional scanning unit, a scanner is not required. For example, an optical character reader being designed by Rabinow Electronics uses a mirror beam splitter for projecting the character onto the optical masks. If developed, this should result in a significant increase in reading speed.

The advantages of the optical matching technique are its ability to identify a full alphanumeric character set and its relative simplicity, which makes it less expensive than some of the other techniques. Also, the masks can be manually changed to enable the reader to handle different character fonts. The major disadvantage is that errors are easily caused by characters that do not meet strict standards of shape and registration. Also, there may be problems in distinguishing between such similar letters as "Q" and "O" or between different punctuation marks.

Analog Waveform Matching. Analog waveform matching is another recognition method that has been in use for some time, particularly in the magnetic character readers used by the banking industry. It is based on the principle that each of certain characters passing under a read head will produce a unique voltage waveform as a function of time; that is, the waveform of each character will differ either in shape or length with respect to time. Characters are identified by matching their waveforms against reference waveforms.

Machines using this technique have reading speeds of approximately 500 characters per second. The principal disadvantage of this system is that only a limited number of characters have unique waveforms. Consequently, this technique is found in those systems dealing with a limited character set.

Frequency Analysis. Frequency analysis is a digital recognition method developed for fonts consisting of closely-spaced vertical lines. The outstanding example of this kind of font is the BULL magnetic-ink font shown in Fig. 3. Naturally, the BULL CMC-7 and Olivetti 7740 magnetic

character readers use this recognition technique.

The width of the gaps between the vertical lines of each character is measured by variations in magnetic flux. An unknown character is identified by comparing the sequence and number of its narrow and wide gaps with stored codes for each of the alphanumeric characters. An analog version of this technique is undergoing investigation at General Electric.

The advantage of the frequency-analysis technique is that it can accommodate a full character set. Speed is another advantage; the BULL CMC-7 magnetic reader, which uses this technique, has a maximum speed of 1300 characters per second.

Matrix Matching. This technique, one of the more widely used, stores the scanner signals in a digital register that is connected to a series of resistor matrices. Each matrix represents a single reference character. The other end of each matrix is connected to a second digital register, whose voltage outputs are representative of what should be obtained if the reference character were present. Recognition is based upon the resultant output voltage obtained from each matrix.

The advantage of the matrix-matching technique is that the resistor matrices can be modified easily, making it easy to change character fonts. In addition, a full alphanumeric character set can be read. The technique also has the advantage of being quite fast, since the matching is done by resistor matrices. Reading speeds of up to 2400 characters per second have been obtained. The technique is similar in theory to the optical-matching technique described earlier, but it can handle mis-registered characters much more effectively. The numerous machines using this technique are listed in the comparison chart.

Stroke Analysis. This technique, used by Farrington Electronics, is based on the stroke or line formation of each character. The characters are differentiated from each other by the number and position of vertical and horizontal strokes. The formation of the unknown character is matched by a special-purpose computer against a character truth table, which indicates the stroke formation for each reference character. At present, this technique is limited to identifying only a special character font called the Selfchek font, which emphasizes straight lines. Work is being done to apply the technique to any character font.

Stroke analysis has the advantage of being able to handle a full alphanumeric character set. However, the maximum speeds obtainable by the Farrington character readers are about 300 characters per second, which is low compared to the 2400 characters per second obtained by machines using the matrix-matching technique. Also, the stroke-analysis method does not have the font flexibility of the matrix-matching technique because of the need to rewire the wired recognition program in the special-purpose computer every time you want to change the character font.

does it pay?

The question of whether it pays to replace a manual keypunching operation with an automatic character reader cannot be answered in any general way. The answer depends upon the characteristics of the specific application, particularly the volume of input data that must be regularly handled, the accuracy requirements of the input operation, and the speed of the computer. A rule of thumb that can be helpful in reaching a preliminary decision on whether to seriously investigate the use of a character reader is that an installation preparing 10,000 input documents per day or requiring 8 to 12 keypunch operators might gain from using character-recognition equipment. As the daily input volume approaches 30,000 This is because human beings read letters within the context of the entire word and words within the context of the entire sentence. Consequently, the word "Ouic" in the phrase "Ouic and dirty" would easily be identified in context by a human reader as the word "Quick," even though the first letter of the word is an "O" and the last letter is missing.

The first thing needed to automate this process is a group of fundamental rules that will aid the machine in identifying the character on the basis of the context in which it is used. These context rules must be chosen to agree with the type of material being read. If a new application is desired, then new rules should be instituted. Changes of these rules can be accomplished by utilizing either hardware (i.e., plugboards) or programming techniques.

Although context recognition is not yet sophisticated enough to become the major part of a recognition scheme, it can be used as a backup method for recognizing illegible characters. The most obvious advantage is the ability to identify a complete word even if one or two characters present recognition difficulties. Context recognition will certainly involve an enormous increase in the storage capacity and logical capabilities of character readers, but this may be justified by the increase in efficiency that could be attained. However, the economics of context-recognition readers will remain highly speculative until considerably more development work has been undertaken.

Context recognition also promises to be useful in the problem of reading handwriting. It could be the basis of a technique for reading complete words rather than a character at a time. Again, it would radically increase the storage requirements and the cost for a reader, but the results might well be worth it; the economics will remain unclear, pending additional development work.

Another, but less critical, area of development emphasis in character-reader engineering is speed. The major limitation on reading speed is the amount of time it takes to mechanically move the document past the reading station. Work now under way indicates that this limitation will be removed by overlapping the two functions of transporting and scanning documents. This is already being done in the UNIVAC READATRON by using a vidicon scanner, which photographs an entire card-type document and performs the scanning function within the CRT tube. This allows a new document to be moved into place while the previous one is being read. Speed can be further increased by the use of control logic that permits selective scanning; i.e., scanning only necessary parts of the document.

summary

The character recognition field is still relatively new, with much work to be done on improving equipment performance and developing character readers at lower cost. Consequently, it is in an active state of developmental flux that can be expected to continue for several years. In the near future we can expect to see the multi-font capability in all standard character readers. Further away, possibly in five years, character readers able to read handwriting should be commercially available. By that time, we can expect to see the character reader replacing punch cards as the primary computer input medium. ■

CONTROLLING COMPUTER OPERATIONS

by R. S. HAAS

The lack of published articles on the operation of a computer center leads me to believe that operational personnel are busy in the machine room trying to keep the temperature down and the humidity up, trying to squeeze a trajectory run between PERT COST and PERT TIME, or negotiating with service personnel on whether they can have the machine between 5 and 6 a.m. or not at all, because of the excessive machine load.

However, they might just be hurrying to meet the schedules on stock inventory control and material status, two jobs delayed because lightning hit the high-tension lines and blew out the CPU's power supply. These are but a few of the normal and repetitive problems encountered by operations people. And this paper will attempt to fill a void by proposing solutions to some of these installation problems as well as to some of the more mundane problems of the operations area—with the hope that it will stimulate others to advance even better ones.

At the Martin-Denver computer facility, we have the following configurations: One IBM 7094 model II currently running about 425 meter hours a month, with power on 6½ days a week on a 3-shift basis. One IBM 7074 recording approximately 325 meter hours a month with power on 5 days a week, 3 shifts a day. One IBM 7044 averaging 200 meter hours a month with power on 2 shifts a day, 5 days a week. All this equipment is utilized as main computing equipment and is supported by peripheral equipment as follows: Two IBM 1401 systems, each with two slow-speed tapes since these systems are used only for input/output. One GE 415, which includes three printers, one card punch, and one card reader with total simultaneity. These are 1200-lpm printers, and all five units can be operational at the same time. One Stromberg-Carlson 4020 utilized in the production of microfilm and hardcopy to minimize volume output. Two Univac 1004 systems prepare data and provide edit checking for engineering personnel prior to input to the main equipment.

The 1401 systems have power on 3 shifts a day, six days a week, and are each averaging 400 hours of meter time a month. The GE 415 system also has power on 3 shifts, 6 days a week and is running 525 meter hours a month. The S-C 4020 and Univac 1004s are all running less than 200 hours a month on the meter and have power on for two shifts a day, 5 days a week. This equipment is supported by four administrative people (one manager and three section chiefs) and 148 people. The personnel are distributed in the following manner:

Keypunch	(2 shifts)	65 people
Machine Operators	(3 shifts)	41 people
Data Control	(3 shifts)	39 people
Quality Control	(3 shifts)	3 people

This will give you some perspective into the type of equipment at Martin-Denver and provide you with a base for comparison.

organization

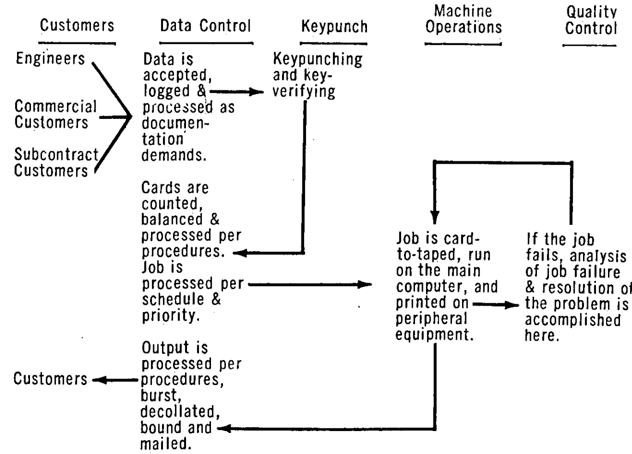
The organization of the computer operations area itself takes the form of three basic groups.

1. Data Control, sometimes called Input/Output Control, is the customer contact area; it accepts, checks, and edits input before moving it to Keypunch or the machine room.
2. Keypunch and verification punches and verifies cards from input transmittals.
3. Machine Operations. Here, the job is run on the computers as set up by Data Control. All control cards, tape assignments and detail input decks are assembled by Data Control. Operations personnel do not do any manipulating of the input; they run the job as set up by Data Control on whatever hardware is made available.
4. Quality Control. Whenever a job aborts on the computer, a trouble report is prepared by the operator indicating (to his best knowledge) the situation at abort time. This is given to the Quality Control personnel for immediate analysis and rescheduling. This effort is manned round the clock to find the source of the job problem and get it back on the machine in time to meet the schedule. These problems range from trivial procedure

Mr. Haas is section chief of Computer Control, in the Denver, Colo., division of the Martin Co. He has been in operations for the past four years, following three years in the area of data reduction programming associated with missile flight testing. Prior to that, he was a programmer in engineering and data reduction applications with the Douglas Long Beach division.

problems to the more complex hardware or software problems.

Following is the flow of work through, and the organizational structure of, the computer operations section.



Where does the operations organization stand in relation to the hardware justification and the systems programming organizations? The three should be under a common supervisor or should have a very good working relation with each other. Operations must run the hardware recommended by the hardware justification organization. If they do not report to a common supervisor, many problems will go unsolved. On accepting a new machine, failures can occur in the hardware, in the software, or on the part of the operator due to inexperience. In the checkout of new equipment, both in software and hardware, all problems encountered should be relayed to the hardware justification people; this information is important to them in their consideration for future vendors. Therefore, a good working relationship must exist among operations, systems programming, and the hardware development group to iron out new hardware problems.

scheduling

The distribution of workload in any shop determines the type of schedule that must be developed. By distribution of load is meant the mix of engineering vs. commercial applications. In my particular experience the work mix is about 50% engineering and 50% commercial. This mix leads to the type of schedule and amount of commercial work that can be scheduled on any one night. A detailed schedule of commercial applications must be established to show the flow of work through the shop and to fix group responsibility. Detailed schedules also define the responsibility of data processing to the customer and the customers responsibility to data processing.

The schedule should include schedule (amount) of input from the customer and maximum volumes of input he will provide at various times of the day or week. It should also include the time each group in the data processing area has to do its function, and the time it is to be run on the computer (daily, weekly, or monthly). These schedules are developed through negotiation with the customer, programmer, and systems people. Time to be returned to the customer must be the last entry. The schedule may represent a daily, weekly, monthly, quarterly, or semi-annual run. It can be based on the calendar month or the accounting month, and must be flexible enough to take into account priority runs on a crash basis.

Many business jobs may not be scheduled but may be on an "on request" basis. A schedule should still be created on the "on request" job to control the customer's input time and keypunch volume so as to avoid a last minute input problem.

With written schedules in hand and customer control on these schedules, it is then possible to do long-range scheduling studies to determine if schedules can or should be changed to improve the shop capacity and reaction time. The total shop load for any particular day might look something like this:

1. Scheduled Business (Schedule of each job)		8 hours
2. On Request Business (Schedule of each job)		3 hours
3. Engineering work		6 hours
4. Monitors (Monitoring non-scheduled runs)		1 hour
5. Checkout		5 hours
	TOTAL	23 hours

The monitor work represents time used by a programmer in the execution of his production program that has not formally been turned over to operations because his documentation of the program is not complete.

With setup time taking about 18% of the load (in this case 4.1 hours) and maintenance of the equipment taking one hour per day, 5.1 hours has already been consumed for this day. Therefore, with 19.9 hours available and 23 hours of work to do there would be a backlog of 3.1 hours in the morning. If this would be a consistent load, a subcontract might have to be let to assure that schedules could be met on a daily basis.

documentation

In order to efficiently process the data for any particular commercial application, procedures must be provided to the operations personnel showing "in detail" each step of the process. This is necessary because of the complexity of any particular job. An example of this would be a stock inventory control application. Depending on the definition of the system and the manner in which it was programmed, Data Control will receive the input in various forms: on input transmittals, cards punched in another area, marked-up cards previously punched and input for repunching, etc. Procedures must state what Data Control must do. Would they edit this data for validity? Count the data for balancing later? Retain the data for later use? Since there are multiple input forms, Keypunch must be provided with procedures for each type of input so as to create the data correctly. Machine operators must card-to-tape the data using the correct program and must run the job according to a prescribed tape setup as determined by Data Control through procedures provided. The reports must be printed on the correct preprinted paper, spaced properly, burst and decollated correctly, and sent to the correct customer.

This all requires detailed procedures, and is provided to operations by the programmer at the time the program is signed off as a production job and documentation is bought off by operations. It is important to have a sign-off process so that transfer of responsibility is set properly. Until the time of sign-off, the programmer is responsible for all reports and must "walk through" the job to assure job validity. After sign-off, operations takes over that responsibility.

Documentation of commercial jobs is imperative and must be controlled carefully. Some would question the need for this but consider 75 to 100 different commercial jobs, all on different schedules with different inputs and outputs, and all programmed by 25 or 50 different people with different ideas. The need for detailed documentation is evident. The documentation must include such things as:

1. A narrative procedure, a step-by-step process that provides Data Control and the machine operators with all the information they might need to make proper decisions during the execution of this job. Consider that this job is being run during the night and must be out correctly in the morning. Any problem must be resolved by the operations people at the time of execution and must be resolved correctly. Narrative procedures are designed to help operations make appropriate decisions.
2. A Keypunch procedure for every type of input transmittal.
3. Samples of input forms and output forms to show operations the type of input to expect and proper alignment of reports.
4. A program deck or program tape thoroughly checked out and ready for production.

priority system

In any active production shop a priority system is necessary to differentiate between the "hot," "very hot," and the "absolutely hot" jobs. The priority system utilized at Martin-Denver is as follows: Consider that there are two distinct classes of jobs, Engineering and Business. The schedule (as described previously for business jobs) determines what night of the month this job will run. The engineering work is accepted all day long and is run during the night, based on its priority. Checkout work is run during the day since the programming staff is available at that time. In determining what jobs run on what priorities, certain company goals must be established. The old argument of how much cost for how much computer capability raises its head each time there is insufficient computer time available to do all the work. The following goals have been set for computer turnaround time. Checkout will be turned around in two hours. Engineering work will be turned around overnight. Business jobs will meet their schedule, usually out by 8:00 in the morning. As long as there is adequate machine time available, all schedules and goals can be met and few problems are encountered.

A priority system is necessary to take care of the exceptions, and a priority system is mandatory when the shop load goes up and the shop goals are no longer met. At this time serious consideration must be given to subcontracting work or providing additional hardware during the peak load. An effective priority system similar to the one utilized at Martin-Denver is a two-digit numbering system utilized at Martin-Denver is a two-digit numbering system, with each group of 10 signifying the category involved and the nine digits within each group determining their order of importance. Since work is batched for the computer, batch number within priority number is an intermediate priority rating. As can be seen, the lower the priority number the more important the job.

0 - 10	Reserved for the "absolutely hot" jobs (directors' signatures required on jobs such as missile flights or major problems)
10 - 20	
20 - 30	(Managers' signature for very hot jobs—immediate access to the computer)
30 - 40	(Checkout—2-hour turnaround)
40 - 50	(Monitor priority—customer will stay into 2nd and 3rd shift for output)
50 - 60	(Scheduled and on-request business)
60 - 70	
70 - 80	(Section chief request for hot job)
80 - 90	
90 - 99	(Engineering work—first come, first served)

So a priority might look like this: 56 batch 4732. This would mean it is a scheduled business job and would be run after all checkout and after all monitor time, and in its order within the 50 - 60 priority category. The "signature" authority is a questionable method of priority in that when computer time is not available, many priority requests are received and soon the shop is saturated with priority work. However, I propose the question: "Show me a better way."

machine utilization accounting

To minimize the cost to your customers, it is essential to have a good automatic clocking system. Many installations still use a manual clock which allows no automatic clocking of jobs on and off the machine. With current computer costs as high as $10 per minute, and the time to manually clock a job on and off the machine, there may be several dollars' loss per job. To be fair to your customer, an automatic clock with an operational system that clocks him on and off the machine based on utilized time will minimize his computer costs.

In some installations the meters on the equipment will determine the vendor's billable time. However, in those installations without meters, the vendor will use the installation's recorded time. The more accurate accounting system you have, the fairer you are to yourself and to the vendor. It has been my experience that any automatic clocking will save your installation money and provide excellent records at auditing time.

From the time analysis work, a record of the job, customer's name, badge number, department, and elapsed time is created. This should be recorded on magnetic tape as a master file of information and a report generator program utilized to extract reports for customer interrogation of computer usage.

Lesson to be learned from our mistake: We once had a restricted-area buzzer wired into the same 110-volt outlet as the automatic clock. Each time the buzzer was sounded, the machine fell out of automatic and caused the job to blow. Not too frequent an occurrence, but it took some time to find. After using a different 110 plug for the automatic clock the problem was solved.

reporting of problems and reruns

To run a better data processing shop, the responsible individual must have information concerning problems in the shop so as to make corrections. The "trouble report" is used as the tool to provide this information. The position is taken that every job should be put on the machine and should run correctly at that time without restarts or reruns. If a restart or rerun is encountered, a trouble report is prepared by the operator and his best knowledge is recorded at the time of the problem as to the reason for the failure. These trouble reports go to a "Quality Control" man immediately for detailed analysis to determine what the real problem was—card-to-tape failure, input error, magnetic tape failure, etc.

From this analysis, a decision can be made concerning the problem. Perhaps a rerun is in order, or the programmer may have to be called to fix a program problem, or it may be input error requiring the customer's attention. It should be mentioned here that the day's schedule flags jobs as critical or non-critical, and this is the key for the night shift supervisor as to the requirement for that job. If the job is critical and operations has tried all corrections, the programmer will be called in for consultation and action immediately. Reports are then prepared by the Quality Control man, pinpointing the problem. This Quality Control man is a person who has experience with hardware, software, and operations procedures. It should also be emphasized to your people that the trouble report is a tool to improve procedures, programs, etc., and not a weapon with which to crucify each other. If this point is made, you will find trouble reports being submitted by the people who made an error and have corrected it themselves, but still writing the report to point out a system flaw which might be improved.

magnetic tapes

A competitive tape-testing process in the shop is invaluable. Our experience indicates that tapes purchased on a lowest-bid basis are troublesome; they develop bad spots (recoverable and unrecoverable) too soon, and cause unnecessary reruns. Therefore, after competitive tests, choose the vendor best suited for your installation and keep logs on the usage of your tapes. This will help determine their life span.

In my opinion, the magnetic tape storage is the weakest link in the computing loop. Dropouts, both permanent and non-permanent, can cause a complete rerun of the job or result in excessive machine cost in the attempts to clean the tape by using the programmed backspace-and-try-again techniques; after repeated failures a skip and blank must be done in order to continue. Consider the expense incurred if an extremely bad tape is present in your tape file. If it is extremely bad you could be utilizing only half of the tape and be spending more money in trying to write the tape than the tape itself is worth. The point is, know the condition of your magnetic tapes. If you don't, you could be wasting more money monthly than your entire file is worth. Once you know the condition of your file, intelligent action can be taken. Examples of action might be:

1. Clip your tapes periodically to ensure best reliability and least cost.
2. Make use of the commercial tape cleaning services available to determine what the condition of your file is or to increase the reliability of your file through periodic cleaning of tapes.
3. Physically destroy tapes after:
   a. They reach some minimum length which renders them useless for your needs.
   b. The tape cleaning service has proven that a section of your file is not cleanable due to excessive errors.
4. Totally recondition all or parts of your tape file when new equipment is justified and a higher bit rate or more channels on your existing tapes are to be used.

The relationship of the magnetic tapes to the tape drives used in any given installation is often a critical one. The argument will arise as to whether the problem is a drive or the tape itself. Shop standards should determine what is to be done at the time of the problem to isolate the trouble. When a tape-oriented problem arises:

1. Clean the tape drive head and retry. If the job works, write a trouble report based on a dirty unit.
2. If it fails again, mount the tape on another unit and retry. If it works, write a trouble report on the original unit and have the customer engineers inspect it.
3. If the job fails again, use a different tape on the same unit. If the job works, write a trouble report on the physical tape and have it reconditioned.
4. If, after all this, the job still fails and it is a critical job, recreate the tape being read by rerunning the previously scheduled cycle and then rerun this cycle.

In line with this, tape drives should be cleaned every eight hours. They are opened completely and cleaned thoroughly to eliminate contamination. (Cleanliness is important in the shop. The floor should be cleaned and waxed weekly and the subfloor vacuumed twice a year. Smoking should be prohibited, but in some cases this causes considerable lost time and must be a decision of the shop supervisor).

managing our own business

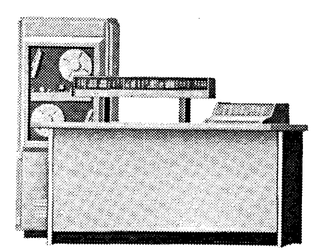
Machine Operations has many applications which lend themselves to mechanization. This requires programming time, checkout of the program, documentation of the application, and sign-off by operations prior to production status. In these cases we become our own customers.

One of the most obvious applications is that of the schedule. All job schedules can be punched on cards, retained as a master file on tape, and sorted by date, thus producing a daily, weekly, or yearly schedule if necessary. It is only the scheduled business jobs which lend themselves to this since checkout; on-request Business and Engineering work are walk-in applications. The mechanized schedule must therefore accept card input, which represent the walk-in activity as well as the master file information,

Some businesses are too small to use electronic data processing.

But not very many. Small businesses right down to little neighborhood grocery or hardware stores can now reap the fruits of electronic data processing. Because you don't have to buy, or even rent, your own computer system any more. You can use ours. By mail. Just send us the tape from your NCR cash register or adding machine equipped with "Optical Font" printing. (That's so our computer can read the printing as easily as you can.) NCR does the rest. Process your tapes at a nearby NCR Data Processing Center. Mail back reports on every phase of your business . . . accounts receivable, accounts payable, or whatever. At low cost. If you use a cash register, you're big enough for EDP.

NCR



THE NATIONAL CASH REGISTER COMPANY ® DAYTON, OHIO 45409

CIRCLE 25 ON READER CARD

to present a total daily picture. The report generator can be used to extract the yearly schedule of one job or to extract the daily schedule. This application can be run weekly on the computer to produce the daily schedules.

Record keeping for magnetic tape ownership and usage is another excellent programmed application. A master file of information can be established where each record represents a physical tape and all of the information concerning that tape. This would include:

1. Who owns that tape today and the title of the information on the tape.
2. How many times this tape has been used and how many recoverable and non-recoverable errors have occurred on that tape to date.
3. When was the tape placed in service in the file and what footage has been used on an average.

This application would have action against it daily since tapes would be canceled by some users and requested by others. Tapes must be inserted into, and purged from, the file. This record keeping is best done through a mechanized system. With tape files today in some installations pushing the 30,000 to 40,000 mark, the programming of this type of application is mandatory.

Stock inventory control is another function that can be placed on the computer. An installation using many different preprinted forms and multiple card stock, as well as much stock paper, has a stock control problem. A maximum, minimum, order-level, danger-level program can be developed with daily reports telling stock control personnel just when and how much to order. Cost data can be included in this system and the reports output can indicate cost and usage per day, providing the tool to minimize cost and optimize maximum quantities required. Do not overlook the advantages of mechanizing this application in any shop.

Many other applications arise, depending on the type of computer loads and organizations involved. We (Operations) run the computers and sometimes forget that applications in our own house can be just as important as our outside customers. One note of warning: don't become your own best customer. Overhead expenses should be controlled.

unscheduled occurrences

In this dynamic business, consider some of the less repetitive but frustrating experiences. There was the time too much static electricity was building up in the machine room; each time someone walked past the CPU a static spark would jump from the person to the CPU and cause the machine to halt, thus blowing the job on the machine. This caused immediate concern, and after using a different wax on the floor and increasing the humidity, the problem was solved.

Then there was the time the high-pressure water hydrant came close to bursting. If it had, it would have filled the computer-room subfloor with water. Fortunately, it was corrected without any major problem occurring, but it brings to light questions that operations people should be asking. Is there an automatic (or manual) power-off switch for the machine room? Is adequate fire protection and medical attention available in case of fire or electrical shock? Do people know what to do in case of an emergency? If these questions bother you, be sure you can answer them to your own and your company's satisfaction.

I have felt for some time the lack of written material on the computer operations area, and I believe the time has come for an increased exchange of information about operations problems and solutions. ■

How to spoon feed a high speed printer.
Simple. Feed it Machine Mated forms.
They're designed to operate flawlessly on your high speed printer. And we guarantee it. Here's how.
We work with the manufacturer who makes your printer. We find out what it can do. The range of forms. The sizes. The plies. The carbons. The fastenings.
Then we consider your needs. Draw up the specs to meet them. And follow them to the letter.
All of which means less printer downtime. More printer output. And a good reason for calling our local representative. Or for writing Standard Register, Dayton, Ohio 45401.
We'll show you why it pays to pamper your printer.
MACHINE MATED™ FORMS BY STANDARD REGISTER
CIRCLE 28 ON READER CARD

SIMULATED SHIPPING

to narrow the gap

by I. M. DATZ

The U. S. merchant marine is passing through some very critical days. We are pricing ourselves out of the world shipping market. Japanese and Russian commercial tonnage is growing at a phenomenal rate. Even the leading maritime powers, the United Kingdom and Norway, have expressed deep concern. Ship automation, considered essential to the reduction of our high operational costs, is being more quickly adopted by our foreign competitors than by us. The unfavorable cost gap is widening at a significant rate. Though this nation has been in the forefront in developing the basic technology and actual hardware of automation, institutional problems have restricted their application. Government subsidies, direct and indirect, have done little to remedy the crucial situation.

It has become apparent that we must examine the total transportation system if we are to have any chance of solving the highly complex problems characterizing the maritime industry. Too long have we concentrated on hacking out the less troublesome bits and pieces of the problem and attempting to solve these out of context. This approach has often led to not only fallacious conclusions but has placed those charged with the operating management of steamship companies in the unenviable position of having to solve important problems through actual sailing of ships. What is then required is a research technique equivalent to sailing ships.

an early analysis

In late 1958, the Matson Navigation Company of San Francisco, California, completed a feasibility study on the simulation of freighter fleet operations using high-speed digital computers and concluded it to be a practical objective. They then undertook to design a simulation generating detailed cost comparisons for the major commodity-ship-port-combinations of interest in Matson's freight operations. As conceived, it would enable management to derive tactical rules for selecting minimum cost modes of operation under any likely set of conditions involving cargo and ship availability. It also would provide a means of estimating probable changes in net freight revenue resulting from variations in such factors as total cargo mix, ship scheduling, fleet composition and labor practices. The model had to have the capability of handling a system at least as large as Matson's total West Coast-Hawaiian service simulating its stochastic variability in cargo offerings, stevedoring costs, duration of port stays, and interport steaming times. Further, it was necessary that it be able to treat operational, cost, and traffic data on up to 100 major commodity categories simultaneously and produce detailed balance sheets on the entire fleet over a reasonably long period of time for any mode of operation specified. This simulation has now been in regular use for over five years and has evolved into a highly useful planning tool. It is providing top management valuable insights into the activities studied from which profitable decisions are being derived.

In 1960, the Advisory Panel for Future Requirements for Ocean Transport of the National Academy of Sciences' Maritime Research Advisory Committee recommended that the Maritime Administration, Department of Commerce, develop and manipulate models for predicting requirements for commercial cargo movements, and for predicting the influence of technological advances on shipboard and longshore labor. As a result of these recommendations, the Maritime Administration solicited proposals to undertake a broad operations research investigation into these important aspects of the maritime industry. The Arthur D. Little/George G. Sharp bid was selected, and a contract awarded in January 1961.

The project consisted of three interrelated tasks. The first was a study of selected trade routes to define desirable operational features that might be incorporated into the design of improved ship systems servicing the specified areas. These generated inputs for the second, which dealt with the development of a mathematical simulation of merchant fleet operations. The third portion of this very extensive study was an analvsis of world-wide maritime and connecting inland transportation links. The following discussion is restricted to the second phase.

simulation objectives

This mathematical simulation of ship operations was developed as a joint effort between the Maritime Administration's staff and Arthur D. Little, Inc. It has been operational on the IBM 7090 for well over a year now. The model differs from Matson's in that it represents a far broader approach to the problem. It allows the user to consider trade conditions in any area of the world, while the Matson endeavors were directed, quite naturally, at answering questions relative to its operations in the West Coast-Hawaiian trade. There was no necessity to include the diversity of factors encountered in the world-wide maritime activities of the United States.

The objectives guiding the design and development of the Maritime Administration's simulation can be most effectively summarized in terms of the following areas of applicability:

a. **Evaluation of Construction Differential** Subsidy Applications: Simulation of proposed vessels and alternate designs in specified trades provides a check on their suitability from a commercial standpoint and compliance with the policies of the Subsidy Board.

b. **Vessel Replacement Programs:** Through use of the simulation, proposed ship characteristics and fleet replace-

Mr. Datz is head of the computer division, U. S. Navy Marine Engineering Laboratory, Annapolis, Md. He has a BS in mathematics from CCNY and has done graduate study at other colleges, including the Univ. of Bergen in Norway. Since 1955, he has been active in scientific computation for oceanography and aerospace.

ment schedules can be evaluated. It provides a means of investigating in detail the interaction between old and new vessels in a trade as affected by varying the rate of adding new ships and modifying itineraries and schedules. In line with these capabilities, the simulation is a useful tool in determining commercially feasible vessel speeds and the effect, if any, of higher speeds on the vessel replacement program, profits, and subsidy.

c. Trade Route Reviews: By simulating fleet operations in a trade, various route structures and levels of service can be investigated. The ramifications of dividing or combining portions of trade areas, realigning services and operating express and special services can be assessed.

d. Effects of Competitive Services: The input requirements allow the user to include competitive services characterized by their own operational rules. Cargo offerings can be made dependent on the behavior of the competition's ships.

e. Government Control of Cargo. The effect of varying degrees of government control of cargo offerings on fleet operations, profits, and subsidies can be investigated with the aid of the simulation.

f. Evaluation of Advanced Systems: The simulation provides a means for evaluating the effectiveness of proposed advanced ship systems, establishing their general characteristics, and justifying further studies.

g. The Effect of Seasonal Variations in Cargo Offerings on Choice of Vessel and Fleet Characteristics: Effects of seasonal cargo fluctuations can be evaluated. It should be emphasized that this ability of the simulation to handle variables in accordance with the uncertainties and fluctuations which actually face steamship companies provides a degree of realism which is a major advance over other techniques currently in use.

h. Mobilization Planning: Changes in operation to provide maximum service on a route when ships are withdrawn for military use can be developed using the simulation. Similarly, an increase in defense shipping requirements on a given trade route can be examined to determine the minimum additional ships required, and to integrate the existing ships with the added vessels as they can be made available.

tools and techniques

Let us consider what level of resolution would be most consistent with the objectives of the model. The designer must initially select a functionally homogeneous element that can portray an acceptable degree of realism when simulated in the computer.

To investigate the effects of placing ships of varying characteristics (e.g., speed, size, cargo handling capabilities, cargo space arrangements, etc.) on specified trade routes, the individual ships and ports would be designated as the dynamic and passive primary elements. It should be noted that the port is referred to as a passive primary element because, though it is a basic element in the simulation, the influence exerted is indirect. Essentially, the port's effects may be measured in terms of its modification on the ship's performance.

The continuum of possible ship activities is approximated by the following functionally and chronologically discrete events known as critical events:

a. At sea
b. Enter port
c. On berth
d. Leaving port
e. Laid up

The times at which these occur are termed critical event times. This type of simulation is known as a critical event model. Ships proceed from state to state in a discontinuous fashion without the gradual transitions which characterize the time-step mode of operation. Application of this approach has permitted us to introduce several markedly important simplifying assumptions relative to the mechanism of steaming ships from port to port, their port movements and cargo handling activities. These, in turn, have led to a significant decrease in the computer processing time.

The simulation consists of two major functional entities. These have been designated as roll call and schedule generator. Essentially, roll call controls the activities of the primary elements. Instead of tracing these in a continuous manner over time we have, as mentioned previously, defined five basic ship states, or critical events, where the time sequence is controlled by changes in ship status. The initial inputs provide each ship with an event time corresponding to the next critical event to be entered. From that point, the simulation will determine, on the basis of scheduling and cargo information, what and when changes in ship status are to occur.

The overall timing control rests with a device known as a game clock. This is nothing more than a counter which is incremented periodically by an amount provided at startup. Examination of critical event activity rates and achievable game time to real time ratios has indicated that a simulated four-hour interval would be consistent with the degree of detail modeled.

During a simulation time interval each of the internal ship status files is scanned in numerical order to compare the individual critical event times with the present contents of the game clock. At coincidence the pertinent ship's condition register is checked to determine which activity status is to be entered next. Program control is transferred to the appropriate routines which update the aforesaid files including the next event time. However, if the event time for a particular ship has not been reached, the computer proceeds onward to the next ship in sequence. Upon completion of a pass through the roster of ships, the game clock is advanced by an amount specified in the simulation time interval. The game clock will again be interrogated to determine whether a prespecified time has been reached, which would require preparation of tentative advanced itineraries, or if the roll call procedure should be reinitiated. Should the itinerary requirement be current, program control will be transferred to those routines known as the schedule generator.

Initiallv, a list of voyage requirements for the upcoming prespecified period is generated. A comparison is then made between this and the currently available active ships within the existent fleets. If there is a surplus of ships, those of the worst active class are put into layup while a deficit situation results in laying out an appropriate number of ships. Those due for layup are so designated at the conclusion of their current voyages. The assignment of actual itineraries to individual ships is initiated when these have somewhat less than a round voyage remaining within their itineraries or at that time when a ship in layup is ready for activation. During the course of stepping through an assigned itinerary a ship will be subject to several additional effects. Stochastic delays are introduced to represent the effects of weather and port overcrowding although individual queueing problems are not treated. Port entry and exit may also be delayed on the basis of the ship's draft requirements and the local tidal conditions. While "on berth," cargo is unloaded and new cargo for loading is generated taking into account the statistical characteristics of that which may become available. The ship's future schedule is scanned to see whether changes should be made—either eliminating a planned call for which inadequate cargo is aboard to justify the visit (relative to transshipping the cargo) or adding an unscheduled port where available cargo makes a visit economically desirable.

system limitations

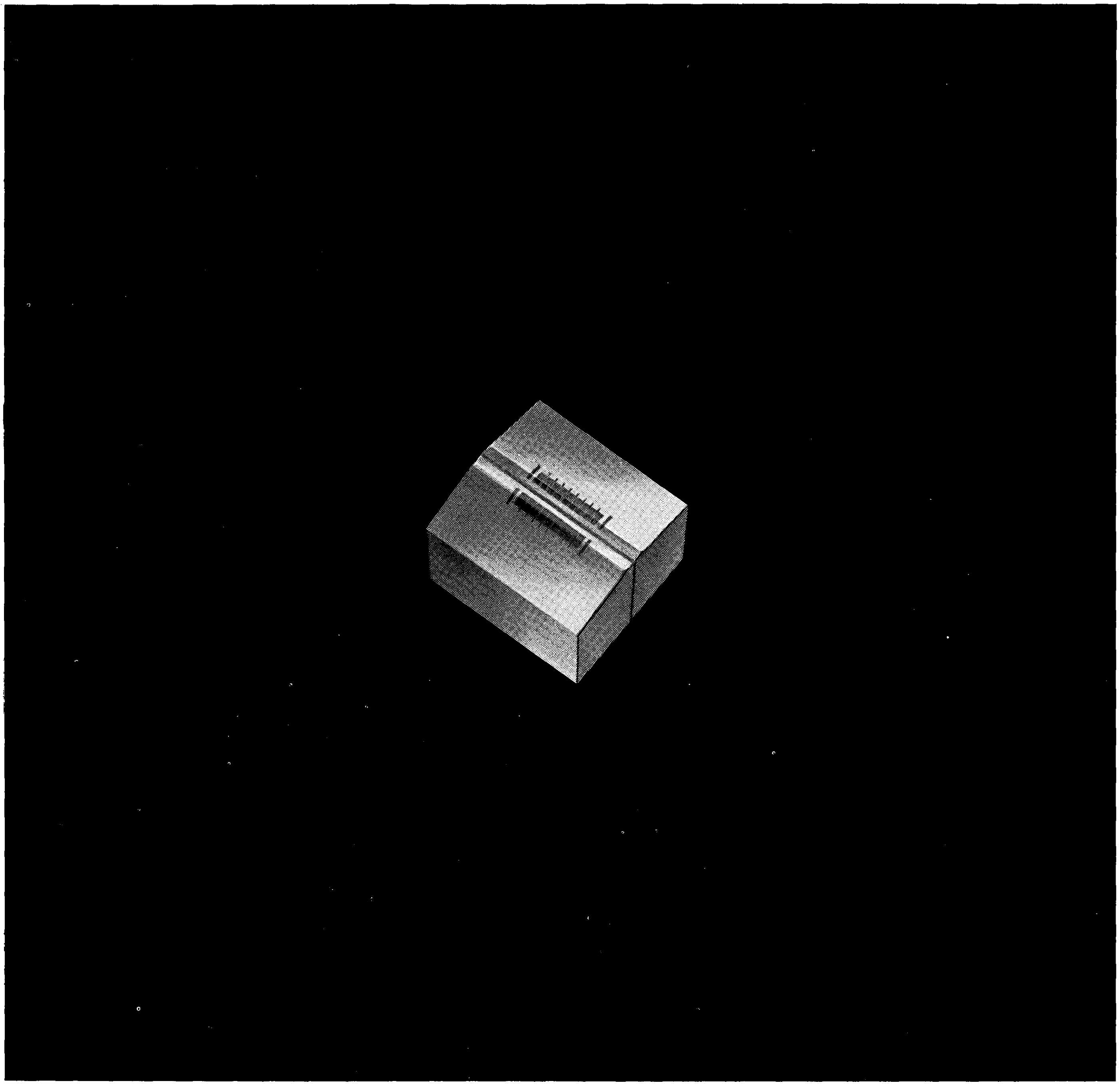
The single most dominant characteristic affecting the capacity of the simulation is the number of ports considered in a problem; this is due to the fact that a great deal of port-pair information (e. g., cargo flow in each direction between two ports, etc.) must be employed, so that the storage requirements increase roughly as the square of the number of ports considered. Other factors of importance include the number of ships, the number of ship space types (e. g., reefer, 'tween decks, lower holds, deep tanks, on deck, etc.), the number of cargo classes (e. g., reefer, vehicles, general, bulk, steel, etc.), shipping lines, and ship fleets in the study. It is believed that the capacity is adequate for most problems of practical importance. A typical case which would tax the simulation to its utmost might involve:

a. 30 ports, of which 20 are visited on most voyages.
b. 40 ships, divided among 4 ship types
c. 6 ship space types
d. 10 cargo classes
e. 2 lines, which between them operate 3 fleets of ships on 5 subservices, and
f. voyage lengths permitting an average of 10 voyages per year for each ship, with 20 port calls per average voyage.

Simulation processing speed is primarily dependent on the number of ship-port calls made during the period covered. For the extreme type of problem described above, machine requirements fall somewhere between 3½ to 5½ hours per year of simulated time. However, a simpler case involving 10 ports, 6 ships, and a total of 48 voyages per year would use 15 to 20 minutes of IBM 7090 running time per simulated year.

conclusion

At this point, let us consider what we can realistically expect of the simulation. First and foremost, the results can, in no way, be better than the inputs upon which they are based. A recognition of this limitation will permit the formulation of proper questions from which can be derived proper answers. Further, we have learned that the preparation of suitable inputs, even under the best of conditions, is not a routine task. It requires the highly subjective judgments of an experienced analyst. The program has a significant degree of flexibility which is dependent upon a judicious selection of input parameter values. Due to this aspect of design, experience has shown that it is essential to subject the simulation results to detailed analysis prior to release. Essentially, then, it will be this critique that provides the "answer" to the decision-maker's query. The term "answer" here should not be confused with mathematical results obtained, for example, from the solution of differential equations. Rather it refers to a comparative measure of the relationship between cause and effect. In other words, the decision-maker's query is translated into an investigation of the implications of several alternate solutions. The simulation provides us a vehicle through which both the immediate and long-range effects of any particular decision can be traced at high speed. Comparison of these computer generated efforts with those desired serve as a most useful feedback mechanism through which the analyst may iterate towards some acceptable solution. ■



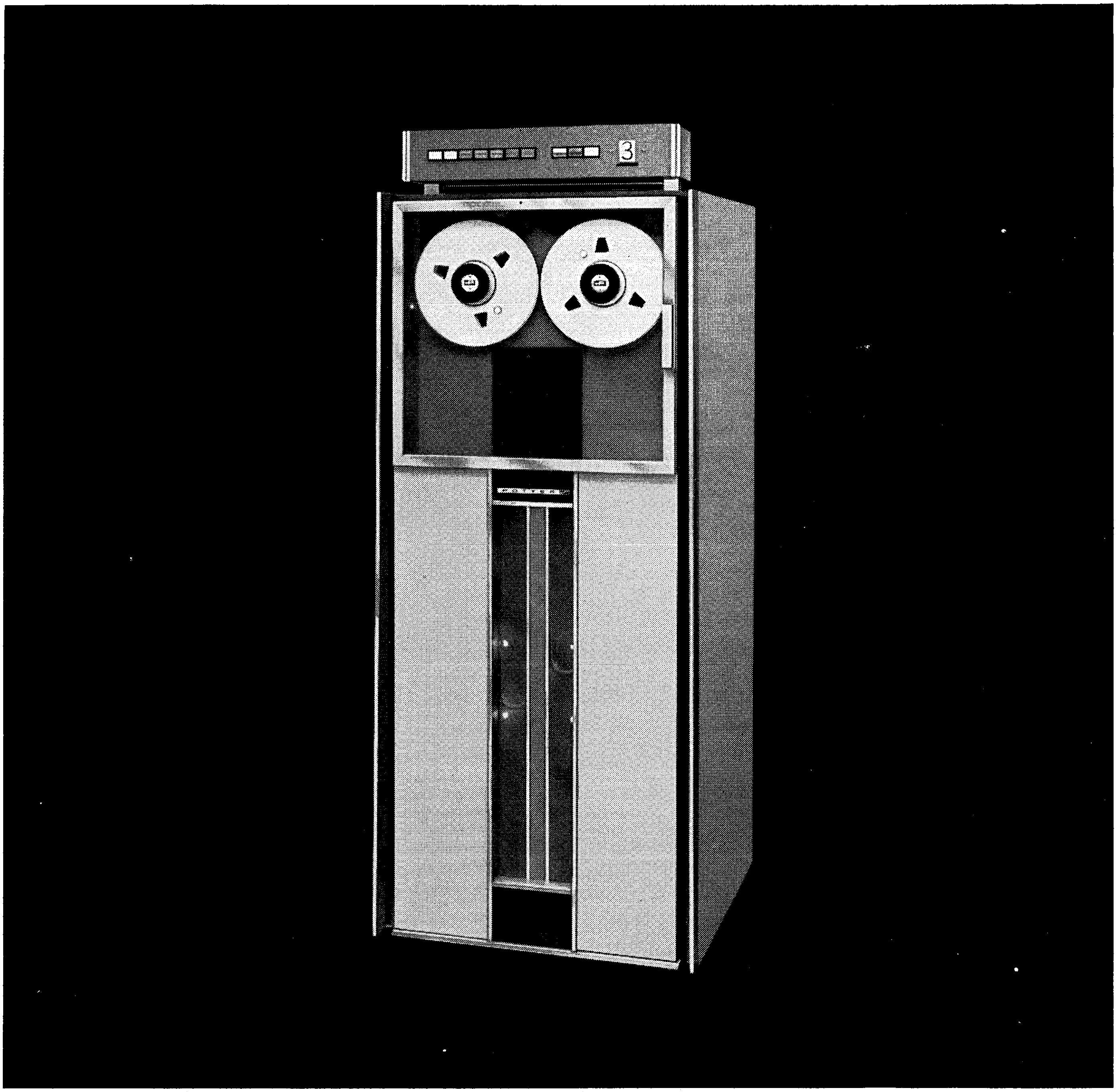
Here's all that touches the tape oxide surface

Potter Instrument Company's new single-capstan tape transports have a tape path in which tape oxide surfaces touch nothing but the read/write head . . . and touch not even that during high speed rewind.

Besides this, the new Potter transports have a guidance system precision matched to industry standards which guarantees 100% tape interchangeability with the most widely used transports now in operation. Here are some details:

Potter now has two all-new single capstan transports, the SC-1080 for speeds to 150 ips; and the SC-1060 for speeds to 120 ips. Both units have tape paths that eliminate the usual rollers, air bearings and other hardware that endanger data reliability and reduce tape life. On a model-by-model comparison with transports of other manufacture, Potter's have

POTTER
® INSTRUMENT COMPANY, INC.



in Potter's new single-capstan transports

the simplest tape path and consequently provide minimum tape wear. In the high-speed model, the head retracts except for actual read/write operation.

Because of design simplicity, the transports are the industry's lowest in cost while providing the highest performance. Their packing density is 800 bpi NRZ—1600 bpi in phase modulated recording. They rewind in less than 80 seconds for a full 2400 ft. reel. Both units feature solid state drive electronics and full test-points for easy maintenance.

For full details on the revolutionary design of these new units, and their fully compatible performance characteristics, write, phone, wire, or fill in the coupon.

PI-108

Send me full details on your single capstan transports

Name____________________

Company____________________

Address____________________

City__________ State__________

151 Sunnyside Blvd. • Plainview, N.Y. 11803 • (516) OV 1-3200 • TWX (510) 221-1852 • Cable-PICO

CIRCLE 31 ON READER CARD

TIME-SHARING: A STATUS REPORT

problems and prospects

by ART ROSENBERG

A seemingly magical term, "Time-Sharing," has become the subject of a great deal of popular interest and controversy. It has stimulated some members of the computing community to become prophets, others to become defensive. It has attracted the attention of the "outsiders"—the real-world users. Above all, it is providing another step forward in the practical use of those infernal machines called computers.

Although "time-sharing" is a popular term, it is one which sorely lacks definition. This lack of definition is one of the main causes of current confusion. Back in December, 1962, an elite group of computer specialists was asked to come up with a more suitable term. A hair-splitting debate produced no satisfactory replacement for good, old "time-sharing."

I have listed below those aspects of computer utilization which are popularly associated with time-sharing. Depending upon the application or goals of the particular users, emphasis upon one or more of these aspects will be predominant.

Multiprogramming—Several independent, but perhaps related, programs or routines concurrently residing and operating in an *interleaved* manner within a single computer system.

Multiprocessing—Several program processes executing simultaneously within a computer configuration consisting of two or more (hardware) processing elements.

Real-Time Processing—Program execution to satisfy a particular operational response time, which may range from microseconds to seconds or minutes.

Interactive or On-Line Processing—Human user or device serviced by a computer system through direct communication with an operating program. For human users, this includes "conversational" interaction.

Remote Processing—User input/output devices are connected by communication facilities to a remotely-located computer system.

Multiple-Access—A number of on-line communication channels provide concurrent access to a common computer system.

Confusion about time-sharing arises because of the interplay between goals of computer utilization and the techniques for achieving these goals. Time-sharing should really be called "resource-sharing," since not only time but storage and I/O facilities are also shared. The reason for sharing is primarily to fully utilize as much as possible of the available computing power in a given system configuration, while at the same time offering the user the kind of service he requires. Since a single user will not constantly employ all the facilities all the time, economics call for other jobs to take up the slack. The techniques for efficient sharing include those for multiprogramming and multiprocessing; multiple-access, remote communication facilities offer further conveniences to system-sharing users.

the spectrum of time-sharing

There is obviously not just one methodology or one goal involved with time-sharing, but rather a range of processing services that serve the varied needs of users. Within this spectrum, everyone is sure to find his place or places in computer life.

To facilitate classification of operational responsiveness required by users and their programs, three gross levels can be specified:

Production—Task inputs prespecified; no user interaction required during execution; turn-around time not normally critical, may be minutes, hours, days.

Interactive—On-line task; user inputs dynamically provided during run-time; response-time of approximately 2-5 seconds for conversation mode, can be longer for variable computing or retrieval tasks.

Critical Real-Time—On-line device serviced by task process; strict time-dependency with response requirements ranging from microseconds to minutes. High priority operation which may require special program privileges and resources.

Time-sharing is really effective allocation of computing resources, usually via a monitor program. If a program demands critical real-time responsiveness (milliseconds), direct coupling of the program to an interrupt source should be used. If the program is an interactive program for "conversational" use by human users, a satisfactory response cycle for simple dialogue should range from one to five seconds to keep people happy. Keeping users happy usually means giving them the impression that they have the entire machine to themselves. Production jobs do not usually have such critical time requirements; they should be processed as efficiently as the system can handle them, considering the more demanding competition.

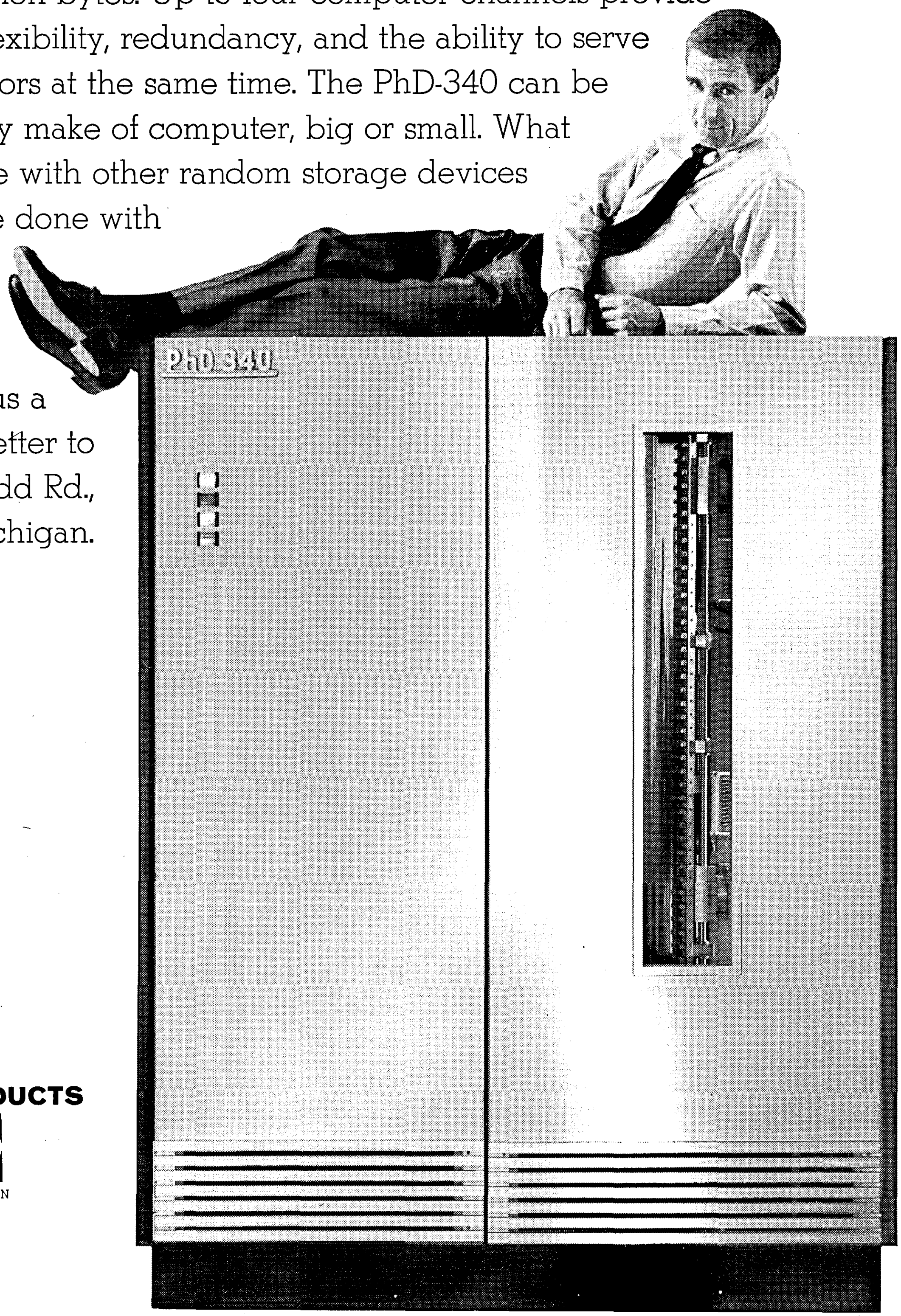
Within the bounds of system capacity, one or more of each of the three types can be operated on a time-shared basis. Production jobs could be operated two at a time by overlapping I/O with computation or by using two CPUs

(Cont'd. on p. 71)

Senior member of the technical staff, product planning, at Scientific Data Systems, Mr. Rosenberg formed the National Special Interest Committee and L. A. Special Interest Group on Time-Sharing for ACM. He has also been associated with System Development Corp., where he was involved in the design of one of the first general purpose time-sharing systems. He holds a BA in chemistry from NYU and has done graduate work at UCLA.

The creative systems designer and the Bryant PhD-340 were made for each other.

He finds himself with unlimited programming possibilities and a chance to plow new fields in advanced computer applications. The PhD-340 multiple channel drum has simultaneous random read-write access to 42 million bytes. Up to four computer channels provide programming flexibility, redundancy, and the ability to serve multiple processors at the same time. The PhD-340 can be plugged into any make of computer, big or small. What couldn't be done with other random storage devices can now be done with the PhD-340, inexpensively. Just imagine! Then send us a nice long letter to 850 Ladd Rd., Walled Lake, Michigan.



BRYANT COMPUTER PRODUCTS

XLO

EX-CELL-O CORPORATION

CIRCLE 32 ON READER CARD

Subject to the e

The speed, reliability, and cost-per-bit of an information storage system is largely subject to the individual memory element itself.

The ferrite core and the ferromagnetic film have consistently proven to be the most effective magnetic memory elements yet developed.

Cores provide high speed storage in large volume with moderate cost-per-bit. Films extend the speed capability of magnetic memories for very high speed data processing applications.

Briefly, without attempting complex cost and application comparisons, here are some of the basic differences.

Cores are manufactured as discrete elements and are individually wired into planes. Each core is essentially a closed-circuit magnet with its polarity controlled by fields produced by currents in wires strung through the center of the core. When a core switches polarity, a voltage is induced in a sense wire passed through the core. The bigger the core, the more output induced. Higher output has many advantages, but larger cores use up more power and, also, memory speed is reduced.

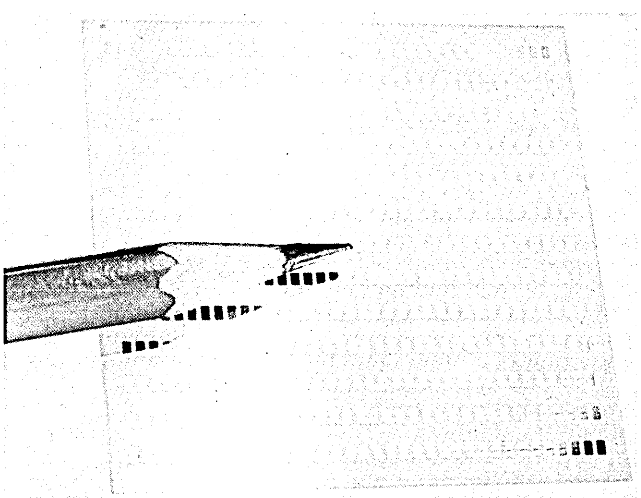
Film elements are batch-produced by vacuum deposition of a ferromagnetic material on substrates of glass or metal. To store data, fields in these elements are rotated by fields produced by current pulses in adjacent conductors. Elements are rectangles about .025″ x .050″ with a thickness of around 1000 angstroms ($\simeq 4X10^{-6}$ inches). Extreme thinness is necessary because film elements are essentially bar magnets with no continuous path for their remnant field. Too much mass in such elements allows magnetic pole concentrations to demagnetize the information storage field and the elements become useless for data storage. Therefore, the output of film elements is limited by a ratio between storage field and demagnetizing field.

Film memories use orthogonal arrays and are word organized. More complex electronic circuitry is required to achieve random access than is necessary with core memories. Film memories are more subject to noise problems and also more sensitive to extraneous fields and must be adequately shielded.

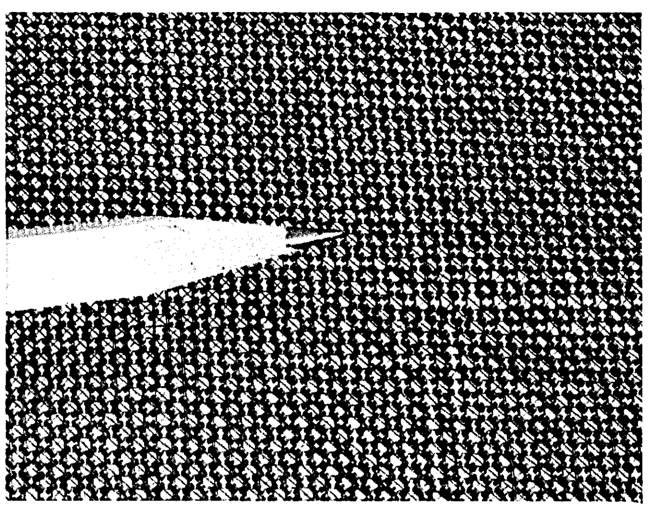
Individual cores can be replaced while bad film elements can't. Extra film "bits" can be built-in to the film memory plane to enable electronic "replacement" of bad bits by ignoring them in the circuit.

The magnetic properties of film elements allow much faster switching times than can be achieved with cores, thereby providing faster memory cycle speeds.

Still faster memories with larger capacities and lower cost-per-bit are the goals of the memory designer. Cores and films will go a long way yet to meet those goals before an entirely different storage element becomes essential.



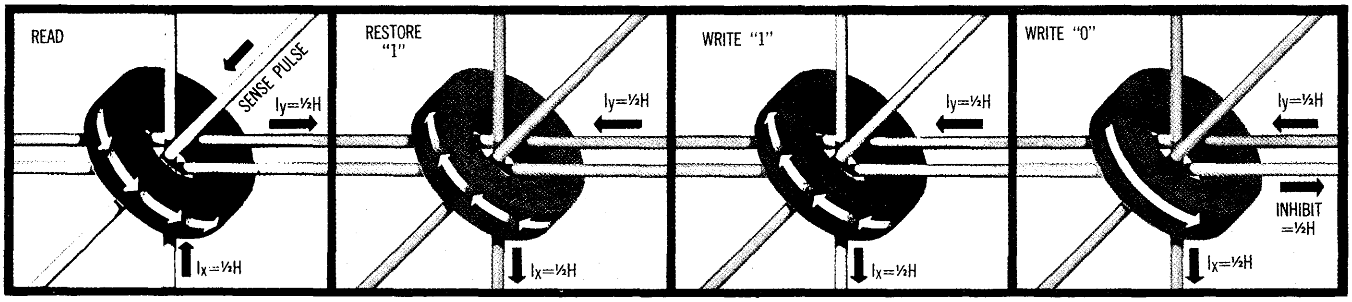
Deposited ferromagnetic film elements are batch fabricated. Elements are controlled by etched-circuit word and digit lines sandwiched with this glass substrate to make a complete memory plane. Typical plane has storage capacity of 128 words of 36 bits in about 80 square inches.



Discrete ferrite core elements can be packed about 250 per square inch. Individual cores can be replaced. Two to five wires are strung through each core to control the information storage functions. Practical memory speeds down to 500-billionths of a second can be achieved.

This is the fourth in a series of six brief discussions on the basic principles of memory systems. If you would like the complete series in booklet form, please circle 60 on reader card.

elements

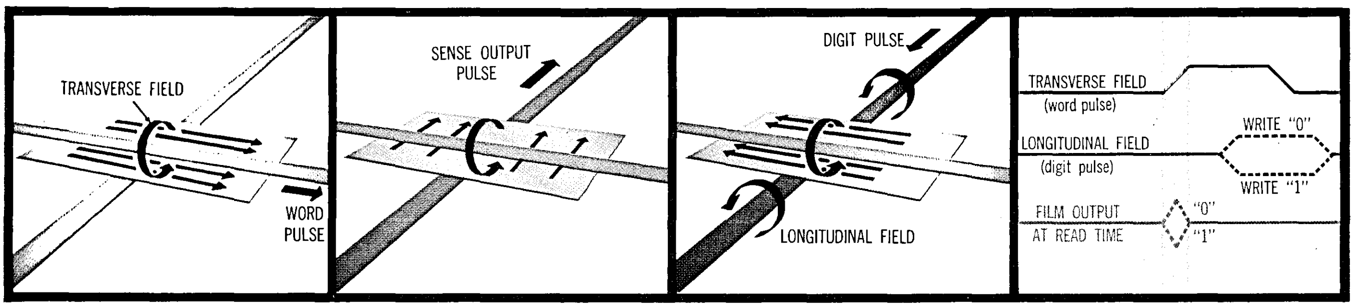


Core is "read" by coincidence of X & Y coordinate conductors, each producing ½ the necessary field to switch core's polarity. Sense conductor picks up a signal induced by this rapid polarity change. Sense signal polarity indicates a "1" or "0" was stored.

Core is restored to original "written" polarity by reversing X & Y coordinate currents immediately after read-out unless new information is to be stored. Entire "read/restore" cycle takes about 200-billionths of a second.

A digital "1" is "written" in a core by coincidence of X & Y coordinate conductors, each producing ½ the necessary field to overcome core's magnetic coercivity. The total switches core's polarity.

Inhibit conductor produces field opposing the Y conductor's field, thus preventing the core from switching polarity. This "writes" a zero data bit in that particular core.

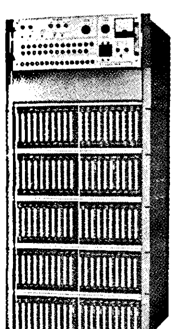


Film element is easy to magnetize in long dimension. Word line in that axis carries unidirectional current pulse producing approximately twice the transverse field necessary to overcome element's anisotropy (easy magnetization).

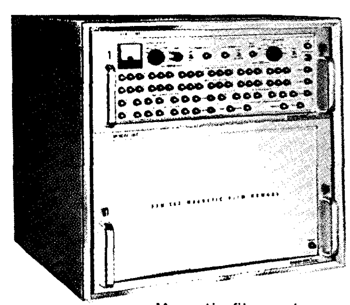
Film's magnetic polarity rotates nearly 90 degrees because of this transverse field. This rotation and accompanying flux change induces signal in sense-digit line. Polarity of signal indicates "1" or "0" was stored.

Bipolar pulse is impressed on sense-digit line to produce a field longitudinal to the element. This field "steers" the magnetic polarity to either "1" or "0" state when transverse field is removed.

Read/Write pulse sequence timing. This entire process, plus strobing of sense amplifiers and data register operation can be achieved at speeds in the neighborhood of 100-billionths of a second.



Coincident-current core systems — 1 usec to 10 usec.



Magnetic film systems — 300 nsec.

For either core or film element memories, Fabri-Tek has a system to match your requirements. Ask for complete information about Fabri-Tek memory systems! Write Fabri-Tek Incorporated, Amery, Wis.; or call 715-268-7155; or TWX 510-376-1710.

FABRI-TEK LEADS IN MEMORY TECHNOLOGY

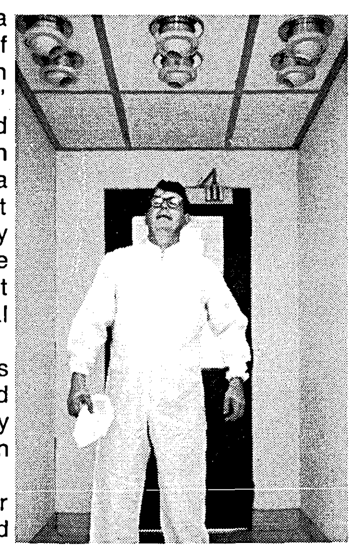
Check with Fabri-Tek for rewarding engineering opportunities!

How we turned Joe into a Mysophobic.

Precision tape manufacturers wanted a cleaner film. So, from the first roll of Celanar Polyester Film, our policy has been "It's got to be the *cleanest* in the industry." We go to extremes, like making Joe—and everyone else who enters our hospital-clean production area at Greer, S.C.—first take a shower. A high-velocity shower of air that whisks away dust and lint particles. Only then may they enter the "White Room" where air filtration systems effectively trap dirt specks as tiny as 0.3 microns—infinitesimal as the point of a needle.

This emphasis on cleanliness makes Celanar film a better base for computer and instrumentation tapes—a reason why Celanar gives higher production yields in film conversion.

Celanar film is stronger than the other polyester film—in both tensile break and



tensile yield strengths. Gauge uniformity from roll to roll is excellent. And Celanar film is exceptionally free of visual defects, such as cross-buckles or wrinkles. We also lean over backwards to supply it in the roll lengths, widths and gauges most convenient to manufacturers. We guard it during shipment with temperature recording flags, even impact recorders where necessary.

So, even if we did turn Joe into a mysophobic with an uncontrollable fear of dirt, we think you'll agree it was worth it.

Send for complete details about Celanar Polyester Film—and how we can help you make the best use of it. Celanese Plastics Company, Dept. 113-B, 744 Broad Street, Newark, N. J.

Celanese Plastics Company is a division of Celanese Corporation of America.
Celanese® Celanar®

CELANESE

CIRCLE 33 ON READER CARD

and data stores in a common re-entrant program process. On-line, interactive service can be provided to a host of remote users while production tasks are performed as a background job. A common occurrence is for a real-time control system that has spare capacity to perform some other background task.

types of time-sharing systems

Multiple-access, on-line, time-sharing systems can accommodate two general classes of on-line user programs:

Multi-user, common process—e.g., an inquiry system, reservation system, JOSS.

Multi-user, independent processes—e.g., MIT, SDC, Berkeley systems

The multi-user, common process affords distinct advantages in terms of storage requirements (re-entrant, non-replicated program) and swapping costs (normally data only). Systems may either be special-purpose for a given application or restricted to one or more specific languages. A system that permits multiple, independent program processes, particularly at the machine-language level, can be considered truly general-purpose. All types of efficient problem-oriented language systems can then be employed without hindering the development of new system software.

The spectrum of time-sharing encompasses simple sharing of a memory by two or more resident program processes; swapping of independent programs or data from high-speed mass storage; multi-user access to common processes; critical, high-priority real-time processes triggered by dedicated interrupt events; and batch-operation of production jobs. Depending upon the computer configuration employed and the user's needs, different slices of the time-sharing pie can be served.

the pay-offs in time-sharing

Time-sharing techniques can be used in any computer application where idle "time" (computer time) is available. In various process control systems, this spare time may exist automatically because the process is a periodic one and does not fully use up CPU time. On-line systems for humans (inquiry systems, generalized on-line systems) derive available time from the inherent slow response of human users. Input/output bound production jobs also offer spare CPU time that can be used profitably. There are obvious pay-offs in not letting excess computer time go to waste. This is, however, not the only point that is causing a big stir in the computer community.

If a highly efficient batch-processing system is developed, as has often been claimed, so that I/O time is overlapped completely and the CPU is computing at top speed, this would be considered commendable by users and certainly by computer shop management. At the other end of the spectrum, if a set of resident computer programs controlled a number of devices synchronously or asynchronously, it would cause a temporary ripple of interest. This type of real-time application will increase significantly, particularly because modern technology demands computer speeds for data acquisition, analysis, and control.

The main attraction, however, in the three-ring time-sharing circus is that of *interactive* (*on-line*), *personalized* computer usage. Why is it the source of so much curiosity, praise, prophecy, suspicion and reaction? The answer is fairly simple: on-line time-sharing involves people directly and personally. An on-line system is "alive and kicking," talking to the observer, which is more impressive than watching a computer console's lights and paper being spewed out voluminously from the printer. The use of time-sharing techniques in on-line operations relieves the user's conscience of the burden of guilt that he might feel because he is getting along so nicely with the costly computer at the expense of being its sole customer.

On-line operations imply personal interaction while production jobs are those with all inputs provided at load time. We would be short-sighted if we extrapolated today's production tasks into the future: many of them are not and should not be treated as purely production jobs.

General problem-solving tasks turn out to be highly suited to interactive computer service. The nature of problem solving involves much iterative manipulation of processes and/or data and the inspection of the results until a satisfactory product has been achieved. Effectively, the manipulation function is usually one of editing source language text or parameters, and on-line editing services have been demonstrated to be very efficient and powerful for the purpose. Thus, on-line problem solving can be accomplished more effectively and efficiently than using production techniques.

Another type of problem is the selective retrieval of information which cannot be specifically identified. What is desired is the ability to scan and search through data as rapidly as possible until the proper information is recognized. Interactive perusal of information files clearly provides a practical application for time-sharing techniques, particularly when utilizing display scope devices.

problems of time-sharing

The problem areas associated with time-sharing implementation can be placed in three categories:

1. Technical (hardware and software)
2. Sociological (organizational and administrative)
3. Economics

There is, of course, complete interplay between the three areas, since technical problems have an impact upon the economic and sociological problems and vice versa.

In general, time-sharing introduces greater demands for system reliability, both in hardware and software, more precision in performing present day functions such as file management and accounting, and more complex bookkeeping operations for controlling a number of users rather than one at a time. The techniques and facilities for accomplishing these are not that mysterious or unsolvable, but must be recognized and adopted. As Dr. Maurice Wilkes from England stated, "Just as management is being aided by computers, so must computer technology employ sound principles of management."

One might think that because of the label, *time* is a major source of concern for time-sharing. To a certain extent, it *is* significant; the appropriate allocation of process time to satisfy all user response-time needs is a fundamental function of scheduling logic. When one adds the complications of multilevel priority tasks, this can cause manipulation of scheduling algorithms in many ways. However, although the time scheduling function is a very sensitive mechanism in a time-system, it is a relatively small program component which lends itself easily to administrative experimentation and modification.

space-sharing

Tied in closely with time-scheduling is space allocation, since compute time can only be given to a user if his programs (or data) are in position for execution. Position means being in core memory. In the time-sharing environment users cannot count on having core memory continuously to themselves but will have to "space share." This is where time-sharing runs into the fundamental problem of dynamic space allocation. If one could have infinite core memory, the problem of word size and addressing appears immediately; "shifting gears" would be necessary to refer to upper levels of memory. Since we do not expect to have infinite core memory, we would be satisfied with large "virtual" memory consisting of *some amount* of main memory and large amounts of secondary storage.

The amount of core memory required should be enough to allow sufficient "user spaces" (programs and/or data) for processing one user *while* the previous and the next user are being swapped between core memory and secondary storage. If the system always has at least one such user ready for processing without waiting for completion of a swap, then swapping overhead has been "submerged."

This approach is what present time-sharing systems are attempting to do, using high-speed discs or drums. However, the cost of "swapping" or overlay becomes a significant ingredient in the overhead and efficiency rating of a time-sharing system. To reduce swapping overhead, dynamic space-sharing techniques are called upon to realize more "user spaces" in core memory. These include *dynamic relocatibility*, so that programs or data can be freely moved into core memory at any conveniently available location; *fragmentation* (paging), which enables programs or data to be broken apart into small chunks to take advantage of non-contiguous available core space; *list processing* techniques, for organizing non-contiguous program or data structures associatively in a dynamically changing environment. In all of these approaches two problems are attached: (1) getting programs and data into available space, when needed, (2) being able to reference dynamically changing address locations. The functions must be done efficiently to satisfy real-time (on-line) requirements.

Getting the space is an allocation function, which can be handled fairly easily if, indeed, space is available by shifting programs and data around. Problems appear when a complete program or data base cannot or should not (to maximize space-sharing) be sitting in core memory. One must then know how many and which elements (pages) are required for current execution. Otherwise, either excessive swaps (or overlays) will result in a slowdown of a program's operation, or, by playing it safe, efficiencies in space-sharing of core memory would be minimized by always bringing into main memory an entire program and/or data base.

It is obvious that a time-sharing monitor can know very little about a program's operating needs, unless programs and their data are better organized and such information communicated. Programs have functions (subroutines) which are in constant use, other functions which operate in a sequential manner, constant data, communication data, and a variable data base. To render efficient space-allocation and swapping service to a program, a time-sharing operating system should be able to recognize and bring in a minimal portion of a program (and its data) which can operate for a reasonable length of time, i.e., enough time to satisfy response requirements or enough time to submerge the swap time. Techniques such as tasking in PL/I and the "Fork" facility in the Berkeley time-sharing system allow functional partitioning of programs for efficient system operation.

With all this moving about, address referencing must now be dynamic unless the original core space allocation is retained with accompanying loss of flexibility of random, dynamic assignment. Dynamic relocation through software would pay too high a cost in overhead time, and thus hardware techniques are called for. The state-of-the-art has provided dynamic relocation and paging capabilities in many of the newer computers that satisfy an individual program's addressing requirements. However, addressing questions of page size, of independent program or data elements (segments), bookkeeping of page and segment activity are all being investigated now, and theories remain to be proven. Users of list processing languages, for example, anticipate serious problems with proposed paging techniques of the coming big time-sharing systems.

generalized software

Generalization imposes certain demands upon program design, particularly in a "live" system. For on-line time-sharing, these include the following characteristics: parameterization, "idiot-proofing," handling all applicable cases, indirect referencing of context data (for multi-user environment), separation of process from user context, and process re-entrancy (programs do not modify their code and can thus be interrupted to serve several jobs).

Some of these characteristics are valid for any type of generalization; parameterization and the handling of all cases, for example, are appropriate to production job processing. Indirect referencing, separation of process (instructions) from context (data), and process re-entrancy are multiprogramming and multiprocessing requirements to service several users at one time (concurrently). Finally, "idiot-proofing" is a necessity for the on-line human user; it requires not only error recovery, but also feedback and guidance to correct and avoid errors. This last item can cost a great deal in storage for text messages. Generalization is expensive to a single user, but in a time-shared environment these costs can be shared and thus supportable.

Through generalization, fundamental user problems can be both recognized and resolved more readily. For example, basic problems of data base maintenance, selective retrieval and report generation (formatting), are universal problems. They may appear to be different because of a user's environmental context, particularly if he applies a specific organization (packing) to his information structure in order to minimize time and space costs. Generated file maintenance and retrieval techniques employing descriptive dictionaries can satisfy most users' information needs. If data need reduction, special or general routines can be called upon to process raw information.

Generalization can take place most certainly at the subroutine level, as well as at the program level. In a time-sharing environment it becomes practical and desirable for user programs to capitalize on common functions by using the same subroutine. To conserve storage and swap time, such "public" subroutines should be pure procedure and not replicated in core or secondary storage; the data storage for these routines must reside in the user's context area, not in the routines themselves.

time-sharing for the systems programmer

Among on-line users of time-sharing systems will be programmers using various programming languages. System programmers are those who build the tools and services employed by other users and this class of user has special problems in the time-sharing environment. If the basic software mechanism (executive functions) must be modified or if a new such function is to be added to the system, can this effort be accomplished under the mantle of time-sharing or must such activity be confined to off-hours of the systems' operating schedule?

In one general-purpose time-sharing system, one of the executive service functions was being checked out as a normal object (user) program. However, it was noticed that the system would mysteriously fail several times a day. No clue was in evidence until, immediately after one such failure, the system programmer was noticed walking away from his terminal shaking his head disappointedly. When asked about his problem, he indicated that his program had just bombed out. How coincidental! Upon further questioning, it was learned that he had patched the operating system version to turn control over to the undebugged version. At that instant system reliability became vulnerable and the inevitable happened.

Debugging at the machine language level is possible through memory and operation protection features of the hardware. If the system function to be checked out requires access to privileged functions such as I/O, the problem arises of allowing "privileged" instructions to be executed without endangering normal time-shared operations. One would like to have a "junior executive" mode of operation whereby executive routines can be tested under controlled circumstances.

Questions have been raised concerning the debugging of a time-sharing system, where the dynamic environment is too elusive to reproduce. How do you re-enact the crime to catch the culprit? Thus far, patience and luck have been used. However, a systematic testing facility is called for, which can generate all the combinations and permutations and record the pertinent environmental behavior for analysis. It has been done before, way back in the early days of SAGE.

communications

There is no question that computers and communications go hand in hand. However, the subject of communications is currently a sore point with time-sharing enthusiasts. This is true, not necessarily because communications technology is inadequate to service remote on-line users, but because the mundane aspects of costs and communication service have not yet been mated to the lofty concepts of remote on-line time-sharing.

The problem breaks down into three main areas: terminal equipment, service, and transmission costs. Remote users want to have various kinds of terminal equipment (keyboards, display devices, etc.) suitable to their application needs appended to common carrier transmission facilities. They would like them to be portable as well. Such devices, for the most part, are still awkward or expensive (very often both) and cannot freely use public communications facilities. Service for talking to computers does not begin to approach that afforded people-to-people communications. Collect calls, "busy" signal for full system, "person-to-program" (if user wishes connection only to a particular service), forwarding service to another computer system, etc., could well be employed in a time-sharing utility environment. Finally, line charges (in particular, full-duplex transmission), must be reasonable enough so that they do not overshadow reduced computer usage cost. Line costs should be geared primarily towards actual line use and not only on elapsed time; the time-sharing philosophy should be applied to communications service as well as to computers.

sociological problems

No discussion of on-line time-sharing would be complete without touching upon one of the most important elements of such systems, namely, the human beings. Computers in the past have worked indirectly for people or directly for a small class of people (programmers, operators, etc.) Now that more direct computer contact will increase, new problems are arising in the computer's future, "people" problems; this calls for programs to be human engineered.

Education is vitally necessary to get the "user" message across, both to the programming community and the non-computer people. The programmers must recognize who will be on-line users; the non-computer people must be aware that computers will conveniently serve them and begin to concentrate upon their own application problems—not computer problems. Because innovation and fundamental environmental change are involved, the education task will necessarily not be an easy one.

Experience with on-line systems has shown that new users undergo a learning period with interactive program facilities. At the start of such a period they want complete, explicit guidance from the computer as to errors, input cues, information messages, etc. As time progresses, they become familiar with the program's communications and at some point begin to get impatient with long messages. They can often recognize the message by the first few characters or words. At this stage, the user has "learned" enough so that the on-line communications should be tailored to his new requirements. The concept of adapting a given program function to both new and experienced users has been referred to as the "terse" and "explanatory" modes of on-line program communication. By either explicit indication of user experience or need, or based on current operating difficulties, the program can provide shorter or longer messages and, if necessary, retrieval of documentation text for reference.

In the past, programming training was primarily aimed at teaching people how to code. Now the requirement will be to teach people how to use computer systems (and services). This training must be supported by the on-line systems themselves. A standard HELP function for all such systems has been often talked about and has already been implemented by Steve Carr in the Berkeley Time-Sharing System. In response to the HELP request (or obvious continuous errors by the user), the system offers reference information, instructions, and answers to specific user questions. Essentially this is on-line documentation and retrieval, but sensitive to the on-line users' needs (Fig. 1).

personal aspects of on-line operation

Much has been said about the advantages of being online; turn-around time is reduced, programs are directly controllable for dynamically changing user needs, etc. However, on-line users do have subtle reactions to the online environment. To some, there is a great satisfaction in the feeling of power, in that they can directly talk to the great electronic beast. Others enjoy on-line operations as a pastime and have a tendency to play. This tendency has been marked by a number of intriguing games which seem to be in vogue for demonstrations. For those users concentrating on serious work of a prolonged nature, on-line operations may be a source of tension. The computer can set a very fast pace for the user, always "waiting for input" before he is quite ready with his next thought. This might leave the user with a slight case of inferiority. It will probably be a good idea to have soothing services handy, such as Weizenbaum's Psychiatrist program, so that the on-line user can "unwind" after a prolonged session with the machine. Users must be discriminating in how and when they use on-line services. They should not feel forced into using an on-line computer service if it is inappropriate.

Fig. 1

```
*KILL. ?
*1,$KILL. ?
*HELP.

?HOW DO I CLEAR A BUFFER?

   DO YOU MEAN A STRING BUFFER OR THE MAIN TEXT BUFFER?

?MAIN TEXT BUFFER.

  TO DELETE ONE OR MANY LINES IN THE MAIN TEXT BUFFER,
USE THE "DELETE" COMMAND.  FOR EXAMPLE:

"1,$DELETE." CLEARS THE ENTIRE BUFFER WHILE
"3DELETE."  REMOVES LINE 3.

?
*1,$DELETE.
*
```

centralization and organization

Although time-sharing systems will enable private and independent use of a computer system, nevertheless they will also create a trend towards centralization. This will be particularly true in those cases where a common data base is used within an organizational structure.

The fact that a number of on-line users have direct access to a common data base suggests problems in coordination. For example, information might be retrieved before being properly updated or before the responsible organizational entity has had a chance to recognize and take appropriate action on a situation reflected in the information file. This type of problem was quite apparent in command and control systems, where there might be a tendency to avoid giving the computer certain information because the commander could see a problem before it could be remedied or before his subordinates could see it. From an organizational point of view, the filtering process in a line structure must be compatible with automation and not compromised by uncontrolled information flow. No one will trust a computer that is an irresponsible blabbermouth.

Centralization of computer facilities can cause repercussions in a line organization where several independent "shops" existed previously. Line managers or individuals may have to relinquish control over their little computer "empires" and become a mere subscriber to the large system. This fact may merely hurt the ego in some cases, but there may also be a serious feeling that somehow loss of absolute control of a machine will hinder research and experimentation. Certainly any user with his own machine will not be happy if all his programs have to be rewritten or certain special peripheral devices cannot be serviced by a centralized system.

security

In an informal time-sharing system where users do not deal with proprietary, sensitive, or classified data, security controls will not be a significant problem. However, under the concept of public, generalized systems, where users may not be friendly, related, or cleared, security is a major concern to potential users.

Checking user identification and data access levels must be additional bookkeeping performed by time-sharing monitors. Providing precautionary checks against illicit destinations would be necessary where programs can specify any of the available communication channels. The system must enable users to obtain permission for access to data or programs not belonging to them from the responsible "owners."

Security also means protection against any loss of data. No "accidents" should destroy information files left in trust with a time-sharing system's public storage, otherwise a private system would be called for. System back-up facilities are needed to maximize storage protection features.

When it comes to security measures for classified data, the rules of the military prevail and complete physical lockout of uncleared users would be required. In essence we would then have a private, restricted time-sharing system for such applications.

accounting

Computer usage accounting in the time-shared environment must be more precise than it has been in the past. Users must be charged for those resources and facilities of the system which they actually utilize on a time basis. These include: secondary storage, core memory, compute time, peripheral equipment (printer, magnetic tapes, etc.), and I/O channel usage.

Additional charges may be made for normal overhead costs (on an elapsed time basis) and, where appropriate, specialized services and priority treatment. Charge rates can be varied according to the level of service being provided, e.g., highly responsive, interactive service vs. background production processing.

Precise accounting will be necessary both in the practical commercialization of time-sharing service bureaus and for internal organizational auditing of departmental computer utilization. Proper user identification schemes must be used to avoid "time-stealing" from someone else's "account".

economics of on-line time-sharing

Almost without exception, the conservative, the suspicious, the curious, and the practical have sooner or later raised the question of economics. It is all well and good to have computer functions placed on-line, but at what additional cost? For a given cost, would several small machines have greater pay-off than a large time-shared machine? Would an efficient batch-processing system yield more useful throughput than an on-line system?

To properly evaluate on-line time-sharing, one must consider a number of factors which are significant to users and to management that pays the bills. These factors include: efficiency, effectiveness, elapsed time, convenience of use and accessibility. Other factors to be considered are initial investment, retraining cost, organizational compatibility, etc. However, let us assume that computers will be used for various applications but the mode of utilization is to be evaluated.

Efficiency vs Effectiveness. Many of the critics point at machine operating efficiency as a major issue. Their concern is with any excess overhead of an operating system which is not working directly for the user. This point is well taken, since time-sharing techniques are specifically aimed at minimizing idle machine time. In batch-processing systems, unless input/output time is overlapped with central processing unit time, there will often be idle compute time. To minimize this condition, batch monitors could buffer input/output on a fast drum or disc to approach a hardware configuration required by multi-user time-sharing. However, a computer kept busy at all times does not necessarily produce truly useful information.

Effectiveness is a more useful concept for evaluating a computer system. To be effective, the system must do *the* job—not *a* job—that is required, and it must do it when and in a manner appropriate to the task at hand. If a system is effective but possibly less efficient, it serves its main purpose. What is most desirable is that a system operate efficiently when appropriate, without railroading the user into just keeping the computer busy.

Elapsed Time. Another measure of computer effectiveness is the total elapsed time to solve a problem or retrieve desired data. To consider only batch-processing efficiency is to be "penny wise and pound foolish." However, we can "have our cake and eat it too." Time-sharing techniques are brought into play in order to minimize or eliminate all traces of idle time, but in on-line time sharing, the interactive user's time is considered first, not merely the elapsed time of the batch process. Time is not only money, but, in some cases, such as in command and control systems, elapsed time may be the difference between life and death.

Convenience and Accessibility. In evaluating the economics of a system, the factors of convenience and accessibility must not be discounted. Both are worth dollars! After all, we always pay more money for better service, and computers are there to provide service.

Small Machines vs. A Large Machine Configuration. Interactive operations can, of course, be accomplished on small machines. In fact, some people refer to on-line usage mainly in context with small machines and ask, why not buy a number of very small computers rather than a larger, time-shared system?

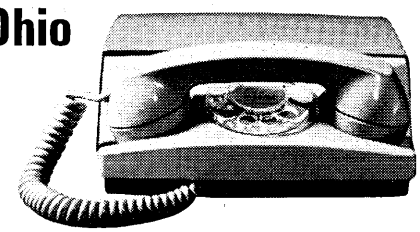
There are several advantages to using a larger computer configuration on a time-shared basis. There is greater capacity and flexibility available for private programs, whereas with the isolated small computer, what you have, you live with. The capacity of a large computer system offers the user more sophisticated services and bigger data bases, and the larger machine configuration will undoubtedly be more powerful in processing speed and input/output handling.

Small machines, however, still have their place in the time-sharing environment despite the claims for "monster" general-purpose machines. "Big" systems need not consist of monster machines but can be multiprocessor configurations or networks of medium and small machines, some doing specialized tasks. Brute force computing problems, however, will still require the larger computers.

The very small computer itself can be a useful time-sharing terminal processor for a user, or a number of users, connected into a large time-sharing network. Message switching, display generation, driving special devices, high-speed data transmission, private storage, formatting, preprocessing, etc., are all functions which complement large control computers. From the reliability standpoint, if a large time-shared system "dies," everyone dies with it. A multiprocessing configuration, consisting of several central processing units, input/output processors, and memories, offer backup capability when one of the system elements is disabled, as well as additional processing power and flexibility.

Time-Sharing Complexity and Costs. The spectre of hardware and software complexity to implement on-line time-sharing seems to haunt many computer people. Require-

Bell System Data-Phone service clears blizzards of bits for Standard Oil of Ohio



Bell System Dataspeed* data communications service at SOHIO'S Cleveland headquarters use regular telephone lines to transmit some 14,000 heating oil orders a day to 16 truck terminals in Ohio.

During the peak cold weather season, nearly one billion bits of data a month are interchanged between Cleveland and the terminals.

At the terminals, teletypewriter machines print out delivery tickets from the tape. The tickets give the drivers complete information, even telling them how to locate fill pipes.

After delivery, the exact amount of oil received by the customer is stamped on the tickets. A punched tape of the day's deliveries is made and this tape is fed into the terminal's Dataspeed unit. The data is automatically sent back to Cleveland, where computers process the information for billing and inventory control.

SOHIO installed its data system primarily to improve profit margins on heating oil sales. The system achieved this goal as it centralized operations, reduced paperwork, speeded cash flow and improved customer service.

Consider the advantages of Bell System Data-Phone* service for your data system. One of our Communications Consultants will be happy to go over them with you in detail. Just call your Bell Telephone Business Office and ask for his services.

*Service mark of the Bell System

Bell System

American Telephone & Telegraph and Associated Companies

CIRCLE 37 ON READER CARD

ments for memory and operation protection, dynamic relocatability, fast random access secondary storage, communications equipment, complex scheduling logic, space allocation and control, etc., seem terribly involved. Design costs, hardware costs, overhead costs, all appear to be an excessive burden to system planners, constraining the implementation of on-line time-sharing. On the other hand, powerful batch-processing systems are just as complex, but less convenient to use. Modern computers now offer as standard features the hardware functions required by time-sharing. With the primary exception of remote communication facilities, batch-processing systems will differ little from time-sharing systems except in scheduling concept. The batch system does not involve humans (except the operator) and is efficient by means of selective scheduling and computing overlapped with input/output. The on-line time-sharing system involves human participation and the resultant idle time for multiple service.

Time-sharing overhead stems from two major functions: management of system operation; swapping programs between core memory and secondary storage. System management functions include scheduling, servicing interrupts, bookkeeping, request processing, etc. This activity may cost roughly 5 to 10% of the total operating time, based on current experience with time-sharing systems. This in itself is not very expensive. The second cost factor, swapping, can be much higher, depending upon the hardware and swapping logic. Because swapping costs can vary greatly, they have been separated from the basic management overhead.

Remembering that time costs may be traded off against storage costs, it is possible to submerge swapping time overhead completely. Care must be taken to insure that the minimal operating time required by the executing program (i.e., conversational processing) will normally equal or exceed the total swap time. Swapping costs can be reduced to zero (provided enough core space is available for submerging the swap) or at least cut in half if a re-entrant process must be moved out. Access and transfer times for secondary memory swaps should therefore align themselves with conversational process time; this may range from 30 to 200 milliseconds, depending upon the process application. If swapping cannot be submerged because space-sharing of core is not possible, then the overhead will rest completely upon the speed of the swapping mechanism. This can cost as much as 25% and more of the total operating time.

system capacity and number of users

To determine how many users can be serviced by a given computer configuration, it is necessary to know the user's application and what processing is to be done. Space requirements, the size of a user's program and/or data, must be known. Time allocation is also a significant factor, since on-line response-time cycles must be divided among users and, in multiprocessor configurations, among central processing units.

The timing ingredients for determining how much can be accommodated on a time-shared basis are: critical real-time process duty cycle or process time (if any); on-line response-time cycle, 1-5 seconds; system management overhead, 5-10%; swap time, 0-?; communications processing of user, 5%; and terminals (low speed).

The critical real-time process operates on a priority basis, and its time needs are subtracted from the on-line user response cycle of approximately two seconds. System management overhead is then deducted. The remaining time in the response cycle is thus available for distribution among all users, including those with batch-process jobs. For each user or job, swap time must be subtracted if it cannot be submerged.

The division of the available time remaining into "quanta," or time slices for each user, is now a function of the user's application needs and scheduling logic. The minimum quantum size should enable basic, responsive service processing. If this factor for the application in question is known, division of the available time is straightforward. Otherwise, some empirical experimentation will be required.

It is obvious that the number of users who can be serviced concurrently will depend upon the basic unit time of the service. If this process time for a service requires only a few milliseconds of simple computing, e.g., "conversational" text scanning, storage, and response, many users could be accommodated within a 2-3 second response cycle. If, on the other hand, a user input triggers a large computation or a prolonged memory data search, the process is no longer conversational, and the number of users who can be handled concurrently will diminish.

when to time-share, when to go on-line?

Time-sharing techniques should be employed whenever there exists spare computer capacity (time and storage) and the cost of adding system management (executive functions) is not excessive. Interactive applications generate a justifiable requirement for time-sharing.

The question of when to go on-line remains. Short or one-shot tasks should be accessible on-line, even though the output function of such tasks may be treated as production work. A retrieval request may be entered on-line, while the output report could be returned (e.g., in an hour). Problems which cannot be fully defined, that is, the inputs cannot be perfectly specified, require interactive processing in order to realize the desired output. If elapsed time is a consideration, on-line interaction will provide the required feedback immediately. Any form of group operation between individuals and a common process and/or data base lends itself to on-line time-sharing.

In cases where correct program inputs can be completely provided for a sustantial or routine processing task (no interaction required), where turn-around time is not significant, or where the user is not present, production procedures should be used. That is, jobs should be processed from a stack. However, machine access may be profitably placed on-line (remote) for production processing. If a computer is serving a critical real-time task that absorbs most of the available central processing unit time, time-sharing is neither feasible nor desirable.

It is important to remember that every individual, organization, and installation will usually have a variety of tasks which can be performed by a computer. Some of these tasks are suitable for on-line use, others for batch processing. A properly integrated time-sharing system should give the users the choice that is most suitable for the problem at hand and the time constraints involved. Overall cost factors, not just computer costs, must be considered in the light of appropriate approaches to the users' problem needs.

summary

Time-sharing represents a number of techniques which afford maximum utilization of computer capacity. These techniques are proving particularly valuable for real-time processes of all kinds. The popularity of the time-sharing concept stems largely from the application of on-line, personalized computing on a multi-user basis. The economics of interactive computer usage have thus been improved by several orders of magnitude. With advances in computer technology and applications, on-line utilization will become cheaper and easier both for individual and group users.■

news briefs

YOUNG FIRM, OLD CODE GIVE LAW RESEARCH A BOOST

With the aid of the central citation system in U.S. law (a standardization effort begun by the Romans), Law Research Service, Inc., is rapidly developing a computer file of state and federal cases and statutes.

In March, the New York firm will be offering nationally on-line access to three million case references stored in a Univac 418 system. It is expected that within six months, the file will cover all rulings in the federal courts and in 15 states. Western Union, partner to the firm, owns and will operate the equipment. The venture marks the first of the data bank operations with which WU has indicated it will become involved.

Subscribers will query the system via Telex, indicating the question with a 10-digit number taken from a coded directory, Computer Thesaurus. Cost will be $10 to $15 per inquiry (including communications lines), plus Telex equipment rental.

Since 1963, LRS has been using a Univac III to store one million references covering all New York State rulings. Presently, the firm, headed by lawyer Ellias Hoppenfeld, has more than 6500 subscribers (off-line) in the New York area. A complete data file increases the potential market to the 300,000 lawyers in the U.S.

NEW COMPUTER PROGRAMS FOR MERCHANDISE MANAGEMENT

The interrelated needs for merchandise classification, sales analysis, and inventory control in retail stores were repeatedly emphasized at the recent convention of the National Retail Merchants Assn. in New York. And NCR, IBM, and May Co. of Southern California were there with announcements of programs guaranteed to solve the difficulties of merchandise management.

The three programs, NCR's REACT, May's CLASS (both written for the NCR 315 computer), and IBM's IMPACT (for the 360 systems), are conceptually similar. They center on the information taken from cash register tapes, which will contain classification, department, and price numbers on each item sold. The computer will analyse this against such stored data as inventory, orders, financial facts (markup, discounts, etc.), and seasonal trends, and produce sales and inventory reports. When an item has reached a certain stock level, a vendor order will also be printed out.

REACT is said to represent a $2 million, 60 man-year programming and testing effort. IMPACT consists of 40 programs, which have been tested on 1400 series computers in five department stores during the last four years. Both involve staples and fashions.

May Co. will be putting CLASS into operation in its Southern Calif. outlets over the next three years, using a 315 and 315 RMC and 1000 NCR Class 53 registers. It will be applied to 300,000 staple items.

CIVIL SERVICE SETS UP EDP MANAGEMENT COURSES

The U.S. Civil Service Commission has announced plans to establish a training center for managers of federal activities.

Sponsored by the Office of Career Development, the center will be headed by Joseph W. Lowell, Jr. Initially it will offer 30 different training programs covering areas described by the center as ADP for Management, ADP-Related Management Sciences, and ADP Career Skills. The first group includes courses on "management applications and implications" of computers and the second on computer-related disciplines, such as operations research. The third group is aimed at those presently working directly with computers, offering them training in systems analysis and management.

ENGINEERS DIAL COMPUTER TO GET APOLLO/SATURN CHANGES

North American Aviation's Space and Information Systems Division has installed an audio response information system to give engineers current re-

TWA CHOOSES BURROUGHS FOR $25 MILLION SYSTEM

Burroughs Corp. will supply the equipment for TWA's new passenger reservation and management information system, to be based in Rockleigh, N. J.

The airline will get a twin-processor D830—a later version of the D825 used in air defense command/control applications—plus 40 disc files and some 2000 specially designed terminals for reservations agents. The $25 million price tag is exclusive of communications and facility costs.

Installation schedule calls for a first stage in the spring of 1967, with agent sets going on line to the computer center. The second phase, full transfer of present operations to the Burroughs equipment, is to take place in mid-1968. According to a TWA spokesman, the set-up "will provide capacity far into the supersonic age."

ports on Saturn and Apollo design status.

Developed by the division jointly with IBM and General Telephone, the system allows any of the company's 42,000 telephones to tie in to an IBM 1460 with a 7770 audio response unit. Details of some 75,000 drawings for the two big space projects are in disc storage, while a drum stores the response elements that make up the answers to inquiries. Eight calls can be handled simultaneously while new input is being processed.

The system replaces a manual card file that required either a visit or a phone call to a clerk to look for the right card. New engineering groups both at headquarters and remote facilities can dial a code number, followed by the drawing number, and a pleasant female voice lists the latest changes.

APPLIED LOGIC CORPORATION OPENS TIME-SHARED CENTER

New Jersey's first time-shared computer center has been opened in Princeton by Applied Logic Corp.

Using a 32K PDP-6 backed by a 1.2 megaword drum, the center is going after both scientific and business customers. Five terminals are now on line, with 25 more scheduled this spring. Peripherals include DEC incremental CRT display with character generator and light pen, CalComp plotter, printer, paper tape and card units. FORTRAN II and IV are offered, as well as the Macro-6 assembly language. Subscriber fees are $360/hour for main-frame time plus communications costs.

FIRST UNIVAC 1108'S GO TO LOCKHEED, FRANCE, AIRLINES

Installations of Univac's new 1108 have begun, almost simultaneously with announcement of the big machine.

Lockheed Missiles and Space Co. at Sunnyvale, California gets the first one, complete with a 64K core, eight drums, and a tape 1004. They will keep the 1107 as well, delivered less than a year ago.

Other announced 1108 orders include a two-processor system for the French National Railways, one each for United Airlines and Boeing.

• A comprehensive census of science-information activities is being conducted by the Columbus Laboratories of Battelle Memorial Institute for the National Science Foundation. The ob-

Available now 122 FORTRAN subroutines for SYSTEM/360.

The new IBM Scientific Subroutine Package, SSP/360, is ready.

It contains 122 subroutines to speed the solution of equations, the manipulation of matrices, the evaluation of functions and the handling of other operations often used in FORTRAN programs.

These programs are wholly independent of all input/output device configurations. This means they will work with any SYSTEM/360 FORTRAN compiler. Data formats are up to you.

SSP/360 is really part programming system and part application program.

It can help you to simplify and speed solutions to current and planned applications. At the same time, it opens the door to new applications of greater scope. In any case, SSP/360 will get you on the air sooner.

With SSP/360, you have an entire mathematical and statistical subroutine library that you may add to or modify as your computing needs change.

Many Statistical Techniques

SSP/360 gives the FORTRAN programmer some of the more basic techniques of statistics.

For example: In factor analysis, where the correlations within a set of variables must be analyzed, just five SSP/360 subroutines are needed to find a solution.

In multiple linear regression—a technique for analyzing the relationship between a dependent variable and a set of independent variables—you need only four SSP/360 subroutines. You can use this technique in applications like these:

CHEMICALS—optical density vs. concentration . . . ECONOMETRICS—probability of mortgage debt vs. marital status, age, education and other factors . . . MEDICAL—heart disease, vs. height, weight, family history, blood data and up to nine additional factors . . . BEHAVIORAL SCIENCES—class rank of graduating seniors vs. six mental-ability tests . . . AGRICULTURE—milk production vs. hay consumption, inbreeding, weight, age and other factors.

Matrix and Mathematical Subroutines

SSP/360 brings you a host of matrix subroutines and mathematical subroutines that provide a tremendous boost to FORTRAN programmers in virtually all areas of industry.

SSP/360 has already been tested and proved, both in IBM and customer installations.

For further information, call your local IBM representative.

IBM®

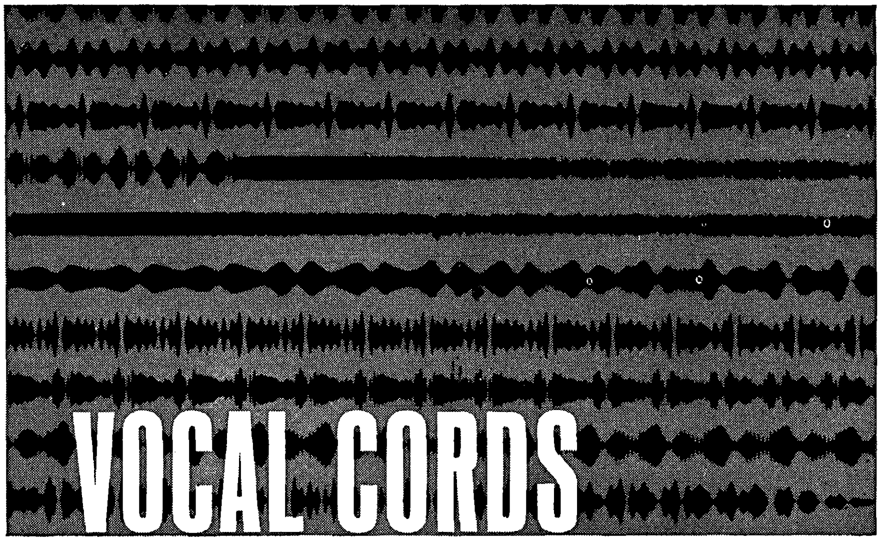
CIRCLE 42 ON READER CARD

jective is to supply the NSF with information needed in making decisions on training and education requirements in the field. Questionnaires are being sent to those "scientists, engineers, or information specialists engaged in research, design, operation, or management of science-information systems that are part of the process of transferring, storing, retrieving, analyzing, disseminating, and summarizing scientific or technical information, or otherwise contributing to communication among scientists and practitioners of engineering and the natural sciences." Those who think this definition includes their activities but who haven't received a questionnaire are asked to write for one, addressing Robert S. Kohn, Information Systems Engineering Division, Columbus Laboratories, Battelle Memorial Institute, 505 King Ave., Columbus, Ohio, 43201.

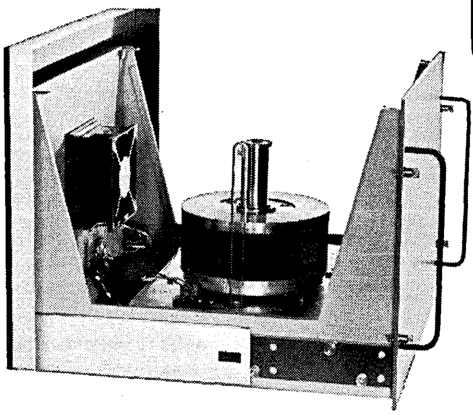
● Latest application of computers to education is an experimental program to help high school seniors select the college best suited to their interests and qualifications. The trial run is being conducted jointly by Pittsfield High School and Computer College Selection Service, Inc., both of Pittsfield, Mass. Students fill out questionnaires and the answers are matched against 18 characteristics for each accredited four-year college in the U. S. Typical characteristics are cost, subject majors, location, admission requirements, and size of community. Some 230,000 entries, covering nearly 1200 schools, are available to the program. One goal of the experiment is to find out how many colleges not previously considered by the seniors turn out to be logical choices.

● The systems engineering department at the University of Arizona in Tucson, is now offering a Ph.D. program in systems engineering. The department, headed by A. Wayne Wymore, will accept students with an MS who pass a qualifying examination covering probability and statistics, engineering mathematics, numerical analysis and computers, optimization and operations research, human factors, and system theory. Students with bachelor's degrees may take an MS program that includes these subjects.

● The fourth annual conference of the Computer Personnel Research Group will be held at UCLA June 27-28. Papers are requested in four general areas: identification of poten-



VOCAL CORDS for your COMPUTER



the new COGNITRONICS SPEECHMAKER®

Provides Direct Audio Response to Digital Interrogation

- Vocabulary to 63 Words (to 189 for special applications)
- Standard Binary Input
- 200 cps to 8 kc Frequency Response
- 1.6 Second Word or Phrase Length
- Long Life — No Contact Heads

For the first time, a complete audio response system with a vocabulary of up to 63 words or phrases from standard digital input. The Speechmaker provides a complete add-on system for direct computer-to-man communications and is designed for compatibility with most standard telephone and audio equipment.

Messages up to 1.6 seconds long are pre-recorded on a unique photographic film memory drum and selected at random by a decoding matrix. Modulated light sensing techniques eliminate signal deterioration associated with magnetic recording techniques. Mechanical components, including precision pre-loaded ball bearings, are designed to give years of service with minimum maintenance requirements.

If your data processing requirements include an automatic audio response to digital interrogation—contact us, we have just what you're looking for!

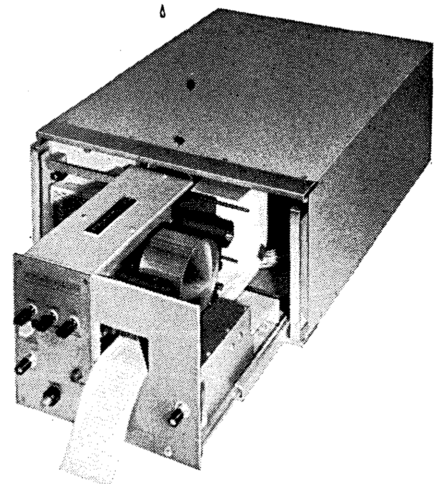
Additional Speechmaker models are available for switch, relay or other signal selection.

Cognitronics Corporation

549 PLEASANTVILLE ROAD ■ BRIARCLIFF MANOR, N. Y. ■ 914-769-7900

CIRCLE 44 ON READER CARD

maintenance tools for the



World's Fastest, Low-Cost Digital Printer

Apply several drops of oil to the drive-motor shaft-ends each year (or every fifty-million lines). Brush out any accumulated dust or lint. Clean the air filter periodically.

That's the extent of maintenance for a Franklin Model 1000 . . . the only digital printer that offers a printing rate of 40 lines per second (or less) at low, low, OEM prices.

REQUEST BULLETIN 2301

FRANKLIN electronics, inc.

East Fourth St. • Bridgeport, Pa. 19405
A Division of the Anelex Corporation

CIRCLE 45 ON READER CARD

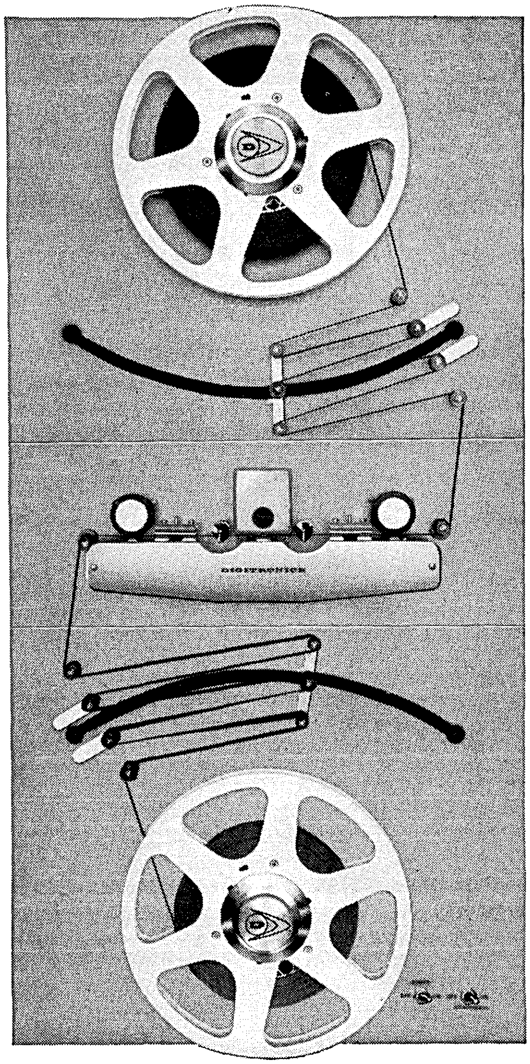
tial skills and selection of computer personnel; training and performance appraisal; identification of new skill requirements; and problems in computer personnel administration. Three copies of a 500-word summary should reach Professor A. W. Stalnaker, Program Chairman, School of Industrial Management, Georgia Institute of Technology, Atlanta, Ga. by March 15.

● Planning Research Corporation has been retained by the city of Washington, D.C., to undertake a study of traffic flow there and recommend the most feasible method of control. Initial findings are that computer-controlled signals could improve efficiency by 10 to 25% over the present system of fixed-time signals that are adjusted to fit traffic patterns at different times during the day but do not respond to actual, fast-changing conditions.

● The annual Florida State University Computing Conference will be held in Tallahassee March 12-19. Theme this year is The Impact of the Computer Upon Society. Different segments of society will be considered, including education, business, industry, law, accounting, and publishing.

● The American Institute of Aeronautics and Astronautics has established a technical subcommittee on computers, with Dr. Barry Boehm of the RAND Corp. as the first chairman. Activities will include compiling of a catalog of aerospace computer programs, sponsoring technical sessions, and disseminating information on the problems and progress of computer sciences to aerospace professionals.

● A new international organization, the Association for the Advancement of Medical Instrumentation, has been set up to help the transition from the "little black bag to the little black box." Leadership will include both doctors and representatives from electronics organizations. The AAMI will be concerned with equipment used in research, diagnosis, treatment, and administration. One of the organization's first projects is sponsorship of an international symposium on medical instrumentation for discussion, exhibition, and demonstration of new instruments and techniques. First meeting will be held in Boston during July this year. The new organization's mailing address is P.O. Box 314, Harvard Square, Cambridge, Mass. 02138.



Digitronics Model 6090 Tape Handler equipped with 10½" NAB reel operates at 1000 cps.

What's your handle?

Digitronics new tape handlers are designed to operate with 10½" NAB reels. Hardly any of that size around. They have twice the capacity of an 8" reel. Surprisingly, we've priced them to compare favorably with what you'd expect to pay for 8" reel equipment.

What else?

They go fast. Model 6090, with 10½" reels, whirs at a smart 1000 cps. And it is compatible with our high-speed reader, Model B3000.

Or they go slow. Model 6071, with 10½" reels, purrs at 300 cps. It is compatible with our low-speed readers, Models 2500 and B2500.

Some operate at in-between speeds. Model 6070, with 10½" reels, glides along at a brisk 500 cps. It is compatible with all of our high-speed readers.

Our 10½" reels spool up to 1300 feet of 5 to 8 level paper, paper mylar laminated and mylar tape, interchangeably.

We also have several 8" reel tape handlers. And, if you have a king-size volume of punched paper tape, say 3000 feet, we'll deliver a tape handler with a 16" NAB reel. It will go as fast as the punch that feeds it, or up to 300 cps with a reader.

No matter what your handle is, we have a quality tape handler (and tape reader) to fit your requirements. For complete information, contact your local Digitronics representative. Or, if you prefer, write direct to Digitronics Corporation, Albertson, New York or call Area Code 516, HT 4-1000.

DIGITRONICS

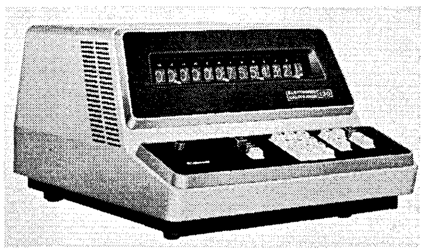
when every bit counts

CIRCLE 47 ON READER CARD

new products

solid-state calculator

The 130 is a desk-top unit with automatic decimal point-off and answers in numerals ⅝-inch tall. Speeds of add/subtract, multiply and divide are 0.01, 0.25, and 0.5 second, respectively. In addition to 10 numeral keys,



there are a decimal-point key, backspace, clear, recall and accumulate keys, and arithmetic function keys. ELECTRONIC CALCULATOR DIV. CANON CAMERA CO. INC., New York, N.Y. For information:

CIRCLE 130 ON READER CARD

retail media conversion

For off-line conversion of punched tags to mag tape, KROME consists of an incremental tape drive linked to a Kimball KRC tag reader. Converting at the rate of 200 tags/minute (200 bpi), input speed would be 18,000 tags/minute. Density of 556 bpi is also available. Mag tape reel has a capacity for 120,000 punch-marked tags. KIMBALL SYSTEMS DIV., LITTON INDUSTRIES, Belleville, N.J. For information:

CIRCLE 131 ON READER CARD

gp computer

The 650-2 has 4-32K (12-bit) words of core with a cycle time of 2 usec. There are 2-64 priority interrupt channels, an index register, and built-in multiply divide. Add time is 4 usec, multiply time is 16 usec. Software includes an 8K FORTRAN II and assembler. A 4K system with console I/O costs $14.8K. SCIENTIFIC CONTROL SYSTEMS INC., Dallas, Texas. For information:

CIRCLE 132 ON READER CARD

digital readout

Using ultra-miniature, high-intensity incandescent lamps and "light pipe" segments to the viewing surface, this line of readouts features characters with a minimum brilliance rating of 500 foot-lamberts. The standard character is composed of seven segmented bars, producing the 10 numerals plus 10 characters. TUNG-SOL ELECTRIC INC., Newark, N.J. For information:

CIRCLE 133 ON READER CARD

data loggers

The 1500, 1510, and 1520 have applications in medical, process analysis, and quality control. They scan and log data at up to 120 cps on 8-level paper tape or 20 lines/second on hard copy. The 1500 has a digital voltmeter, serializer, and tape punch. The 1510 adds a 10-channel, 3-wire reed relay scanner, expandable to 100 channels. The 1520 has a printer in place of the serializer and punch. The units operate in several modes, and the punch systems can provide digital code translation. ELECTRONIC ASSOCIATES INC., West Long Branch, N.J. For information:

CIRCLE 134 ON READER CARD

disc storage

The Series 7300 consists of 1-4 discs, each with 128 tracks. Maximum capacity is 10.24 million bits with an average access time of 8.5 msec. Each disc surface has 64 floating read-write heads. The self-contained package,

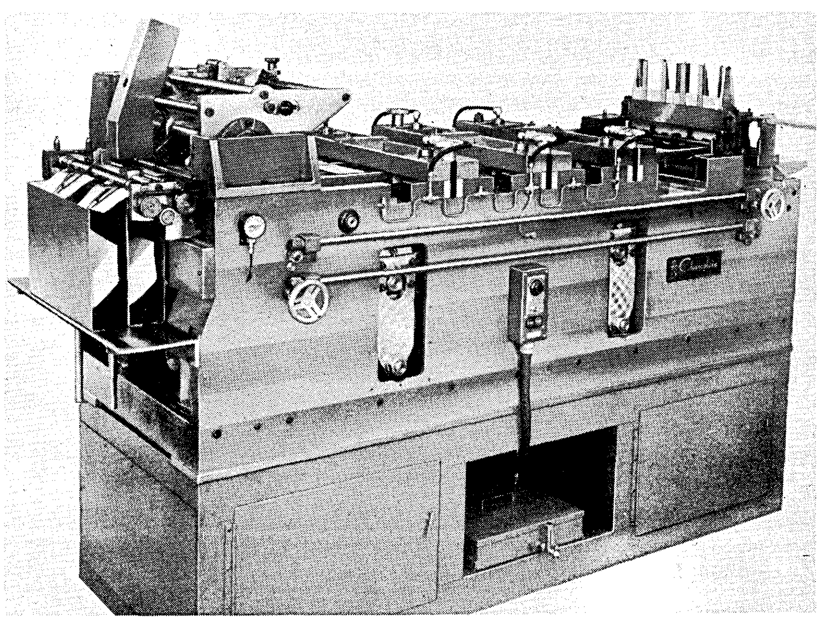
PRODUCT OF THE MONTH

In the manufacture of tabulating cards and card sets, with or without stubs, the CNP-66 performs the basic operations of counting, numbering, and punching in a single pass. It can produce card packs that accompany shipment of products, consisting of cards for warranty, shipping, model identification, trouble-shooting, etc.; multipurpose manifold card sets; IBM and Royal McBee key sort (E13-B characters) cards; MICR-encoded check books; time-payment and coupon books, and continuous-form cards.

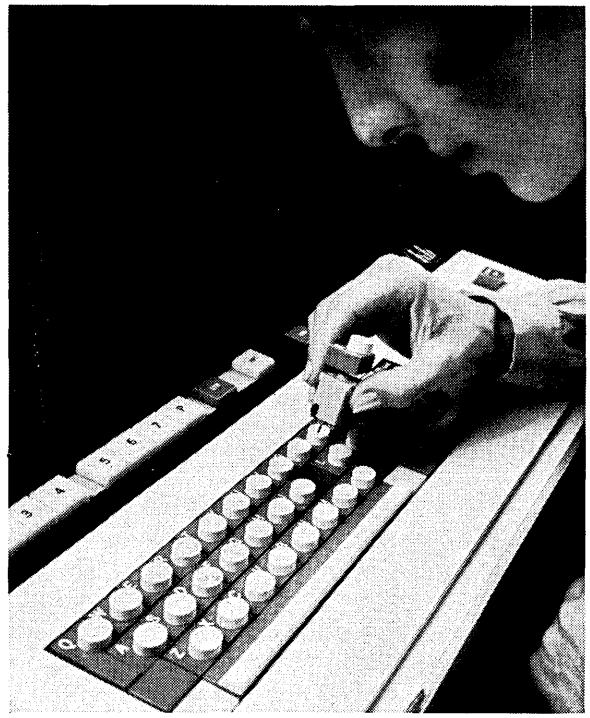
Measuring 7½ x 3½ x 5-feet high, maximum production is 350 cpm, or 700 cpm with optional accessories. The unit can prepunch and number cards repetitively or consecutively up to nine digits, cut diagonal and round corners, cross-perforate, cut- and die-score, imprint and MICR-encode, fold crease, and deliver cards or card sets in stacks of predetermined quantities.

Completely automatic, the machine requires an operator to load the input hopper, remove and inspect finished cards, and make periodic operational adjustments. Modified version permits fabrication and fan folding of short-grain continuous forms from web material. BOBST CHAMPLAIN INC., Roseland, N.J. For information:

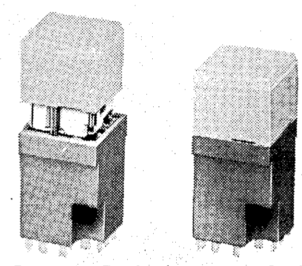
CIRCLE 135 ON READER CARD



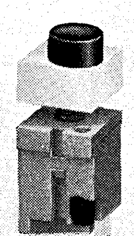
NEW MICRO SWITCH KB makes it practical for you to customize any keyboard or panel



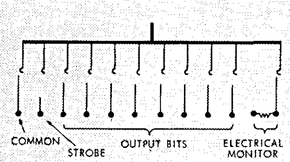
KB gives you a complete new set of modular switch/display keyboard components—makes it practical for you to design and assemble a custom man/machine interface for each individual keyboard. KB is a totally new concept in panel design with *modular* components like these:



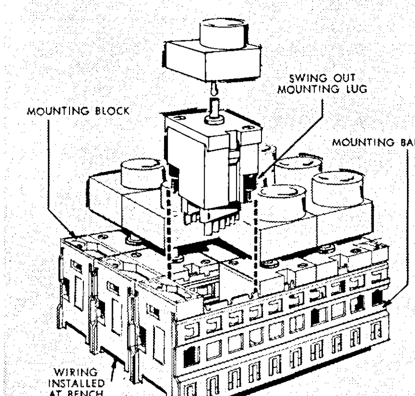
Plug-in Power Switches and Indicators with lighted display, wide variety of button color combinations. Two- or four-pole, momentary or alternate action switches.



Plug-in Encoding Switches with up to eight output bits in each. Up to 256 possible code combinations may be set up within the switch using simple encoding strips. Electrical monitor and delayed strobe. Wide variety of button color combinations.



Contact Arrangement. The common and electrical monitor circuits are made first, followed by the output bits, and the strobe circuit which tells other equipment, "All circuits made and ready." ("Repeat" function optional.)



Unique Mounting Matrix Modules allow you to bench-assemble a complete keyboard matrix without special tools. Assembly, encoding and wiring may be done at the bench before the keyboard is installed.

For the first time, KB allows you to arrange all switches and indicators in only *one* panel cutout. You can now do all your encoding at the switches. Plug-in or lift-out switches without disturbing adjacent units. Use *modular* interlock components for bailing or lockout systems.

KB now makes it practical for you to customize every keyboard or control panel. KB saves on engineering time, tooling costs, assembly costs, panel space and weight.

Call a MICRO SWITCH Branch Office for a demonstration. Or, write for literature.

MICRO SWITCH
FREEPORT, ILLINOIS 61033
A DIVISION OF HONEYWELL
IN CANADA: HONEYWELL CONTROLS LIMITED, TORONTO 17, ONTARIO

HONEYWELL IS WORLDWIDE • Sales and service offices in all principal cities of the world. Manufacturing in Brazil, Canada, France, Germany, Japan, Mexico, Netherlands, United Kingdom, United States

CIRCLE 48 ON READER CARD

new products

consisting of electronics for reading, writing, track selection, and generation of timing signals, can be mounted in a 19-inch rack. The units are hermetically sealed, and feature optional provisions for multiple bank storage with simultaneous multiple-channel access, simultaneous read-write, write "lock out" switches, serial registers, and protection circuitry. DIGITAL DEVELOPMENT CORP., San Diego, Calif. For information:

CIRCLE 136 ON READER CARD

decimal plugboard

The Six-Pak is a 60-position plugboard with 16 decimal digits in each square inch of panel face. Each module, the equivalent of 10 full decimal switches, measures ¼ x 2¾-inch. Applications include decimal memory, decimal-oriented program control, temperature limits, voltage limits, and time-code generation. VERSELECTOR CO., Burbank, Calif. For information:

CIRCLE 137 ON READER CARD

desk-top calculator

A solid-state unit, the model 300 is about the size of a telephone. Answers are displayed on the console in ⅝-inch-high characters. Two independent but interconnected add/subtract sections can serve as storage registers for sums and products; a third section handles multiplication and division. By one keystroke, entry and recall from any register is effected. Up to four consoles can operate with one electronics package. WANG LABORATORIES INC., Tewksbury, Mass. For information:

CIRCLE 138 ON READER CARD

solid-state tape drive

The TU55, for use with Dectapes on the PDP-7 and 8 computers, does away with the relay control components and with one of the two transports. And the price is lower. Features include tape tension controlled electromagnetically, dual direct-drive hubs, and front panel switches. DIGITAL EQUIPMENT CORP., Maynard, Mass. For information:

CIRCLE 139 ON READER CARD

paper tape readers

The 5100 series consists of photoelectric and mechanical tape readers with operating speeds of up to 150 cps asynchronously, and 500 cps synchronously. Features include electronic lamp-output servo to eliminate amplifier adjustments, and self-adjusting electromagnetic brakes. Panel height is 3½ inches. CHALCO ENGINEERING CORP., Gardena, Calif. For information:

CIRCLE 140 ON READER CARD

reader-spooler

The RR-702 paper tape reader has companion spooler, comes in uni- and bidirectional models operating at speeds to 700 cps. The spooler has bidirectional rewind from push button or remote control at 200 ips. RHEEM ELECTRONICS, Hawthorne, Calif. For information:

CIRCLE 141 ON READER CARD

job timer

The Monitron system, for measuring computer processing time used by a job, consists of a Monicorder card input station and central control unit. Standard keypunch machine provides card output. Before a run, job identification card is put into the system, which will then measure time used (to hundredths of an hour) and output it, along with job data, on a new card. Two jobs may be handled simultaneously by one unit, and two input units may be hooked into a computer. The control unit will handle up to

new products

25 Monicorders. Monitron will also automatically punch cards for all idle computer time. COMMUNITRON INC., New York, N.Y. For information:

CIRCLE 142 ON READER CARD

scientific software

Developed for the 360, the Scientific Subroutine Package consists of 122 problem-solving segments, including matrix inversion, multiple linear regression, time series analysis, canonical correlation, simultaneous linear algebraic equations, finding real and complex roots of real polynomial equations, and like that. IBM DP DIV., White Plains, N.Y. For information:

CIRCLE 143 ON READER CARD

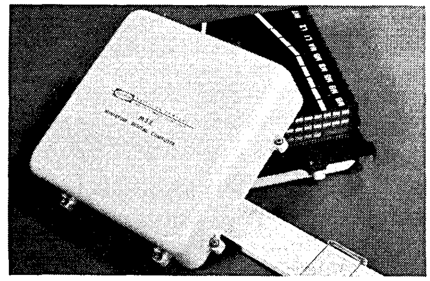
tape reader-punch

The DE-60-RP is for use with the DE-60 computer. It operates in either mode at 50 cps, and has coding matrices that enable it to function with 5, 6, 7, and 8-level code. It can also read in one code and punch in another, and do so independently of the DE-60. CLARY CORP., San Gabriel, Calif. For information:

CIRCLE 144 ON READER CARD

miniature dda

The M3X is a digital differential analyzer occupying less than 0.1 cubic foot in volume. It has a 12-word (17-bit) memory, and dissipates 5 watts of power. Microelectronic modules are a sandwich configuration of matrices formed from solid nickel tape-



machine-punched automatically from type-written paper tape. No interior matrix connections are required. Applications include missile guidance and fast-access control systems. SPACE & INFORMATION SYSTEMS DIV., RAYTHEON CO., Sudbury, Mass. For information:

CIRCLE 145 ON READER CARD

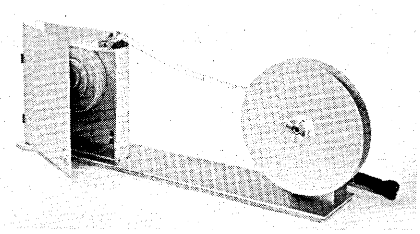
military computer

The L-304 weights 34 pounds with power supply, and occupies 0.3 cubic foot. It has 4-32K (32-bit) words, further expandable to 128K, and cycle time of 1.6 usec. In a multiprocessor configuration, each computer can communicate with up to 16 8K memory modules, and each module can communicate with up to four computers. With automatic priority control, multiprogramming is also said to be possible. DATA SYSTEMS DIV., LITTON INDUSTRIES, Canoga Park Calif. For information:

CIRCLE 146 ON READER CARD

paper tape rewinder

The model 6501 features a 9 x 9½-inch unwind can with full-roll capacity and a 225-feet/minute winding



speed. Tape tension control pins maintain firmness of the paper roll being wound. DRESSER PRODUCTS INC., Providence, R.I. For information:

CIRCLE 147 ON READER CARD

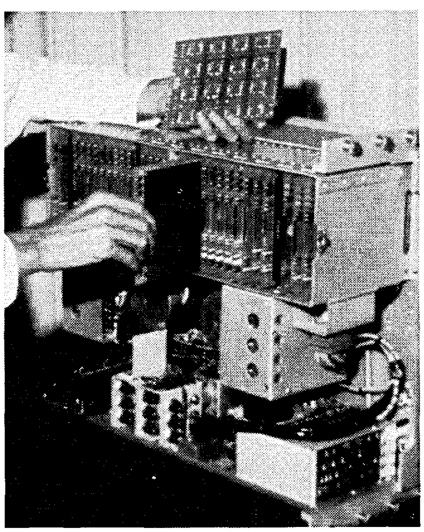
t-s computer

The 645 is the time-sharing version of the 635, accommodating up to

Why invent a rack-sized mil-spec incremental tape system?

Cubic has one!

Need one for your own program? A compact, rugged incremental/continuous magnetic tape system that performs the same functions as a medium-scale computer's tape stand and synchronizer? If you need one that's compacted to fit in a 10″ space within an ordinary rack, then save the lead-time and trouble needed to develop it. Call on Cubic.



Rear view of Cubic's tape system. Note use of integrated circuits for high density and low power drain.

Cubic's militarized tape system contains integral and replaceable control and buffer logic—all in a 105-pound unit measuring only 23″ x 10″ x 17″. It is designed to read and write computer compatible tapes in a relatively program-free manner.

It provides 23 separate and distinct I/O commands—can stack many of them to be performed in sequence. The system writes binary tapes incrementally at a speed in excess of 300 steps per second—can be converted to handle BCD tapes by moving 3 plug-in wires. Continuous forward and reverse speed is 30 IPS.

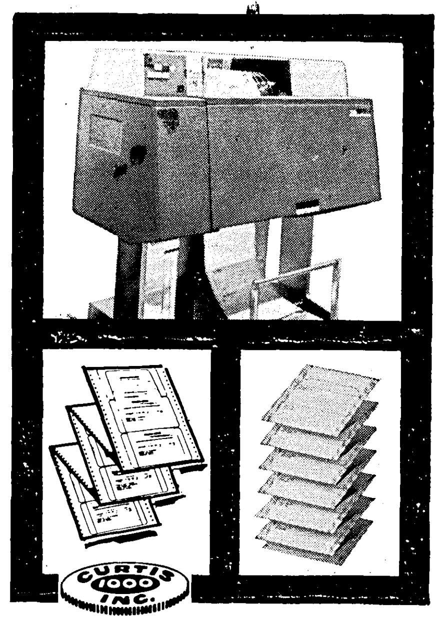
Further, the system offers read-after-write performance, generates parity, sends a "complete" signal to the computer as operations are performed.

You get all this and more—in a system that is already on the line and at work in a military application. It provides another example of the inventive work now being done at Cubic Data Systems Division. Cubic is also producing special purpose buffers, and computer peripheral equipment.

If your needs go beyond the standard, get in touch with Cubic. Write Cubic Corporation, Data Systems Div., Dept. E-131, San Diego, Cal. 92123.

CUBIC CORPORATION
SAN DIEGO, CALIFORNIA 92123
DATA SYSTEMS DIV.

CIRCLE 51 ON READER CARD



electronic addressing or tabulating directly on envelopes . . .

CHAIN-O-MATIC CONTINUOUS ENVELOPES

Chain-O-Matic Continuous Envelopes speed operations with automatic addressing or tabulating directly on envelopes from punched cards or tape.

Selection of desired information is computer fast — no slow downs for running and rerunning stencil trays. The attractive personalized appearance of addressed Chain-O-Matic Envelopes creates good impressions wherever they go.

And now computer print-out directly on a growing assortment of ready-to-mail Chain-O-Matic Systems envelopes reduces handling and supply costs for many uses, including billings, past due, insurance premium and interest earned notices.

CURTIS 1000 INC.
P.O. Box 28154, Atlanta, Georgia 30328

Mail coupon for samples and descriptive brochure of Chain-O-Matic Continuous Envelopes.

Your Name

Your Company

Your Position

Company Address

2DM66

CIRCLE 52 ON READER CARD

new products

1,000 terminals of which 300 can be operating at once. Arithmetic speeds are essentially the same, but methods of addressing program storage are changed. The core is divided into pages and symbolically addressed, enabling program segmentation and storage in non-adjacent sections. There's also a new I/O controller, plus a drum memory with a capacity of 4-million words and a transfer rate of 500,000 words/second. This is the system ordered by Project MAC, Bell Labs, and Ohio State Univ. GENERAL ELECTRIC COMPUTER DEPT., Phoenix, Ariz. For information:

CIRCLE 148 ON READER CARD

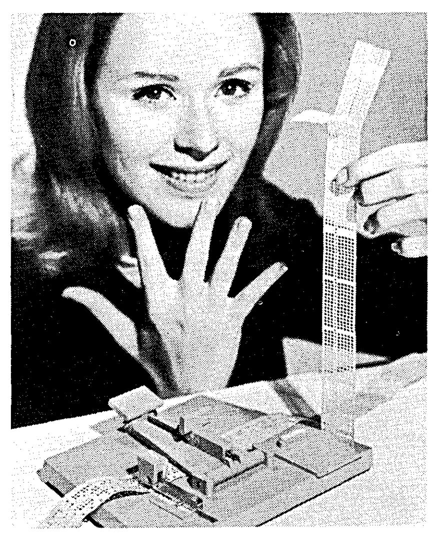
mass storage

Through a doubling of recording density, the old RACE unit for storing information on magnetic cards has been upgraded to the Spectra 70/568-11. Each unit stores 560-million (8-bit) bytes with an average access time of less than 0.4 seconds. Hook up eight such devices to a controller and there are 4.5 billion bytes on-line to a Spectra computer. RCA EDP, Cherry Hill, N.J. For information.

CIRCLE 149 ON READER CARD

paper tape patch

A self-adhering strip for splicing 7- and 8-channel punched tape is 1-inch wide and full of holes. Peeling off the backing strip, the user can form tape loops or splice torn tapes. The 1-foot-long strip includes one blank code level in four individual positions, and



two to five blank code levels in different positions. The blank code level, or levels, can be placed over improper codes, or spliced into position and the desired codes punched. DATA-LINK CORP., Los Altos, Calif. For information:

CIRCLE 165 ON READER CARD

Announcing a new companion to the Dura® Mach 10®...

DURA® EDIT CONTROL

New way to automatically retype material like this:

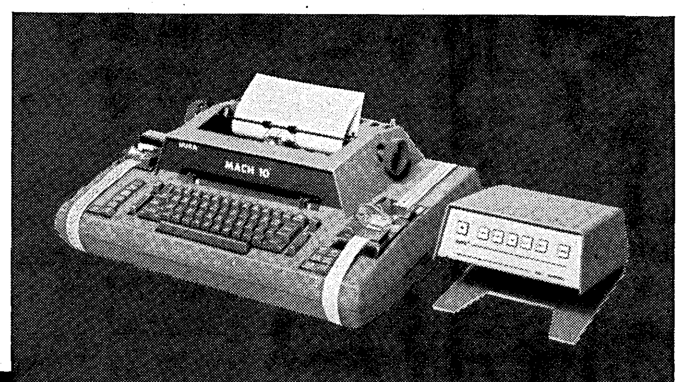
WORKS
The new Dura Edit Control ~~goes~~
AND CHANGE
with the Dura MACH 10 to update bus-
SIMPLY
iness information ~~easily~~ and inexpen-
WITH SIX-POSITION ELECTRONIC CONTROL, CAN STOP
sively. The Edit Control ~~stops~~ the
typewriter automatically after a
, SENTENCE
character, word, line or paragraph
PERMITS
has been read, and ~~allows~~ the operator
to make any corrections necessary.
Original data is retyped automatically,
CORRECTIONS *MANUALLY* *DURA EDIT CONTROL*
only ~~changes~~ are typed. The new ~~feature~~
, TOO
automatically changes right-hand margins.
¶

To look like this:

The new Dura Edit Control works with the Dura MACH 10 to update and change business information simply and inexpensively. The Edit Control with six-position electronic control, can stop the typewriter automatically after a character, word, line, sentence or paragraph has been read, and permits the operator to make any corrections necessary. Original data is retyped automatically, only corrections are typed manually.

The new Dura Edit Control automatically changes right-hand margins, too.

The Dura MACH 10 with new Dura Edit Control—faster, low cost way to edit and retype legal documents, catalog and engineering specifications, personalized letters, manuscripts, plus endless others. For details, see your local Dura representative. Or write: Dura Business Machines, Dept. D 22-26, 32200 Stephenson Highway, Madison Heights, Michigan 48071.



DURA BUSINESS MACHINES
Division of DC* *dura corporation*
*Trademark Dura Corporation

CIRCLE 53 ON READER CARD

What does it cost to get useable real-time computing power?

H21 Central Processor with 8K core memory, integral tape reader and punch, and I/O typewriter.

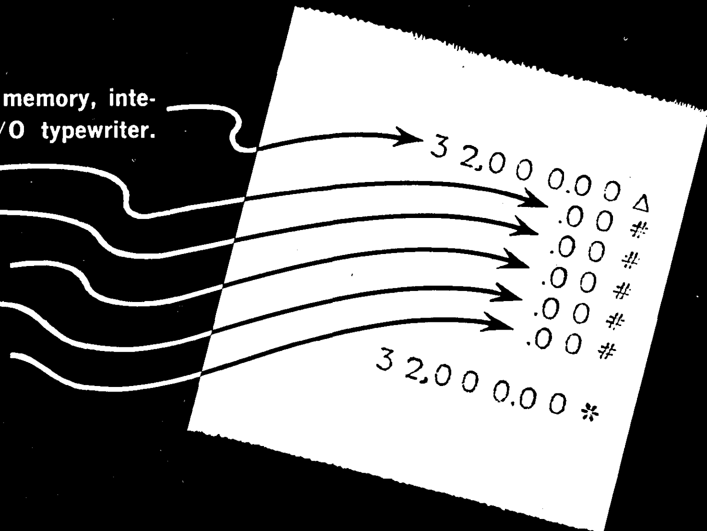
Hardware multiply (standard)

Parity checking (standard)

Hardware Memory Guard (standard)

Hardware Indexing (standard)

Hardware Program Flags (standard)



compare these features at this price with any other "real-time" computer.

We all know you can get a "minimum configuration computer" at a bargain price. But consider the features you need for practical real-time computation. With the bargain priced computers, they're "optional at extra cost." They're standard with the Honeywell 21.

Other H21 features include:

- 20-bit word length including parity and memory guard bits
- Direct addressability of up to 8K core with single word instructions. Eliminates inefficient paging and double-word addressing
- Core memory locations are individually guarded
- Software includes real-time FORTRAN IV, executive control system, and mathematical and control program libraries

H20 systems offer additional real-time power through multi-level priority interrupt and parallel input-output channels plus a variety of on-line, real-time peripheral equipment, including A/D and D/A conversion subsystems.

There's a lot more we can tell you. For a starter, write or call A. L. Rogers, Honeywell, Philadelphia Division, Fort Washington, Pa. 19034. Phone: 215-643-1300.

HONEYWELL IS WORLDWIDE. Sales and service offices in all principal cities of the world. Manufacturing in Brazil, Canada, France, Germany, Japan, Mexico, Netherlands, United Kingdom, United States.

Honeywell

CIRCLE 54 ON READER CARD

new literature

WIDTH GAUGE SYSTEM: Four-page booklet describes digital non-contact system for measurement of hot or cold strip material during processing. System uses two sequentially synchronized optical systems and can scan across the mill table with accuracy up to 1/16″ on strips up to 80″ wide. Diagrams explain system and typical performance, and optional equipment are listed. GULTON INDUSTRIES INC., Metuchen, N.J. For copy:

CIRCLE 150 ON READER CARD

COMPUTER DIRECTORY: Available from the International Computation Centre is a three-volume directory of computer installations at private research organization, universities and service centers in 39 countries. Supplementary sheets are published four times a year and entries are revised annually. It's available for $18. ICC PUBLICATIONS SECTION, Box 10053, Rome, E.U.R., Italy.

DATA DISPLAY: Data sheet and brochure illustrate method of projecting data on illuminated screen. Up to four colors can be shown simultaneously, using only one projector. Scribed traces go on 20 surfaces that mount on one annular disc. KOLLSMAN INSTRUMENTS CORP., Syosset, N.Y. For copy:

CIRCLE 151 ON READER CARD

DATA ACQUISITION: Data sheet gives description and specifications for model 8001, features high common mode rejection on all measurement models, low thermal offset, and capability for remotely programming all scanner functions. DANA LABORATORIES, INC., Irvine, Calif. For copy:

CIRCLE 152 ON READER CARD

DISPLAY SYSTEMS: Four-page booklet gives specifications and application information on four cathode ray tube displays. Incremental display combines line-generating capability with subroutining capability; programmed buffered satellite terminal. Precision and oscilloscope displays are also described. DIGITAL EQUIPMENT CORP., Maynard, Mass. For copy:

CIRCLE 153 ON READER CARD

PROCESSING SYSTEM: Leaflet describes 4020 system that combines accounting machine with solid state programmable computing unit, and is able to perform instructions for data handling or arithmetic operations ranging from single discrete commands to preprogrammed subroutines of 96 program levels. DPA INC., Dallas, Texas. For copy:

CIRCLE 154 ON READER CARD

DISC FILES: Six-page booklet describes model 2, series 4000 disc file, which is equipped with self-contained environmental controls to maintain disc file modules at fixed operating temperature. Diagrams illustrate drum mode capacities and total access time. Physical specifications and characteristics are outlined. BRYANT COMPUTER PRODUCTS, Walled Lake, Mich. For copy:

CIRCLE 155 ON READER CARD

PROGRAMMING SERVICES: 16-page pamphlet presents services available in CPM systems design, business and scientific applications, program conversions and real-time. UNITED COMPUTING CORP., Redondo Beach, Calif. For copy:

CIRCLE 156 ON READER CARD

PROCESSING SYSTEM: Book discusses method of recording textual data by identification of content rather than typographic form, allowing primary record to be processed into variety of secondary products. Order PB-168 256, Clearinghouse, U. S. DEPT OF COMMERCE, Springfield, Va. 22125. Cost: $4.00

GP COMPUTER: 16-page booklet describes medium-scale machine designed for scientific computation and real-time systems integration, features

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

How we compressed a year into two minutes

In the creative synthesis of ideas, an end product frequently becomes the point of departure for a fruitful new train of thought. Such was the case when one of our research chemists set out to unriddle the mechanisms of corrosion on chromium plated trim . . . and wound up with a new accelerated corrosion test 1000 times faster than CASS, a widely used standard we helped develop years ago.

Actually, CASS (copper modified acetic acid salt spray) provided just the tool we needed to demonstrate that corrosion on nickel-chromium plating is a cathodically limited electrochemical process. A paper describing this work won the American Electroplaters' Society's award for ". . . the best contribution to the knowledge and art of chromium plating during the year 1961-1962."*

Then a new thought: Could the reaction be accelerated by somehow overcoming the cathodic limitation? As it turned out, we got around the limitation completely by devising a test that required only the anodic reaction at the specimen surface. The resulting electrolytic corrosion test gives nickel-chromium plating the equivalent of a year's service exposure in just *two minutes*.

Such tests have led to major improvements in the service life of automotive trim . . . another example of the way research in depth leads to a better way.

*R. L. Saur, "Toward Protective-Decorative Chromium Plating," *Plating*, Vol. 48 (Dec. 1961) 1310-1319.

General Motors Research Laboratories
Warren, Michigan 48090

CIRCLE 56 ON READER CARD

new literature

cycle time of 1.75 usec, core memory expandable from 4K to over 32K addressable words, and any number of I/O channels with rates as high as 572K words/second. SCIENTIFIC DATA SYSTEMS, Santa Monica, Calif. For copy:

CIRCLE 157 ON READER CARD

PRINT STATION: Brochure describes on- and off-line equipment capable of printing 1250 lpm and up to 160 columns. Model 2500 connects directly to 1400's or 7000's and can be used with Anelex 2100 mag tape unit in off-line applications. Series 3500 can be used with IBM System 360 and for off-line use with seven or nine channel tapes. ANELEX CORP., Boston, Mass. For copy:

CIRCLE 158 ON READER CARD

CIRCUIT DESIGN: Brochure informs engineer-designers on requirements, preparation of artwork, location and alignments of holes, physical characteristics, conductors, solderability, plated conductors, and printed circuit board markings. LOCKHEED ELECTRONICS, Los Angeles, Calif. For copy:

CIRCLE 159 ON READER CARD

PROGRAMMING BY QUESTIONNAIRE: 48-page book discusses technique which reduces cost and time required to produce programs. The user is given a set of possible options expressed in English and by choosing from these options, he specifies all the information necessary to construct the desired program. Advantages of this method are the use of English, not requiring knowledge of a programming language, creation of programs that are efficient in use of computer time and memory space, and provisions for a large range of options. Cost: $2. AD 613 976N. CLEARINGHOUSE, U.S. DEPT. OF COMMERCE, Springfield, Va. 22151.

DESK-TOP CALCULATOR: EPIC 2000 is designed for business use. Printing calculator has simple keyboard, routines can be keyed in; multiplies at 3/10 sec., divides ¼ sec., and adds and subtracts 4/1000th sec. MONROE INTERNATIONAL, INC., Orange, N.J. For copy:

CIRCLE 160 ON READER CARD

GP COMPUTER: Brochure describes PDS 1020, designed for solving problems in mechanical, electrical, civil, chemical, petroleum, mining, aerospace, metallurgical, geological, marine and safety engineering. Listed are 10 cost-cutting advantages and descriptions of Versi-touch keyboard, tape punch and reader, and printer which prints out answers in the same language and units the engineer starts with. PACIFIC DATA SYSTEMS INC., Santa Ana, Calif. For copy:

CIRCLE 161 ON READER CARD

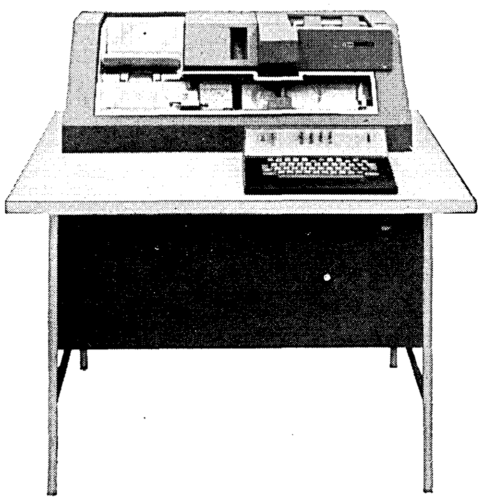
MAG TAPES: Tapes for IBM and IBM-compatible computer systems are described and performance specifications are detailed in eight-page brochure. AMPEX CORP., Redwood City, Calif. For copy:

CIRCLE 162 ON READER CARD

TAPE TRANSPORT ACCURACY MEASUREMENT: Four-page brochure details seven-pound test instrument that gives reading of tape skew, dynamic and static. Included in the specifications are controls, inputs and outputs. DARTEX INC., Santa Ana, Calif. For copy:

CIRCLE 163 ON READER CARD

Put the new IBM #29 Key Punch in its place!



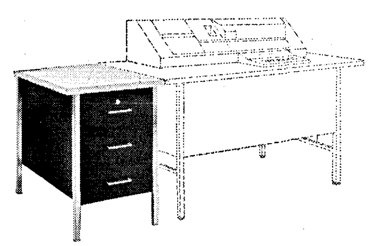
In our new 7229 Key Punch Console!

When you do, your key punch operators will smile, too! Instead of just a key punch, each will have a comfortable, efficient, attractive work station with a large top surface of non-glare plastic laminate . . . three box drawers that can be partitioned to accommodate cards and drums (or a box drawer and file drawer with full progressive suspension) . . . full-depth reference shelf . . . sound deadened pedestal to reduce noise . . . non-skid leg glides that hold her console steady and in place. And, the ''computer'' styling of the Datacase console gives your machine department a coordinated look. You can select consoles in a wide choice of Steelcase's long-wearing acrylic finishes, including four IBM-matched colors. Only Steelcase makes this new console—only your Steelcase dealer has it. He provides *local* delivery, installation and service on all Datacase DP auxiliaries. Check with him soon—he's listed in the Yellow Pages. Or write Department D for more information. Steelcase Inc., Grand Rapids, Michigan; Los Angeles, California; Canadian Steelcase Co., Ltd., Ontario.

These key punch consoles and desks also are included in the extensive Datacase line

7200 Key Punch Desk
for use with any IBM Key Punch and Verifier

7205 Key Punch Console
for use with IBM #24 Key Punch and #56 Verifier



7225 Key Punch Desk
for use with #29 Key Punch and #59 Verifier

DATACASE® / BY STEELCASE

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

CIRCLE 58 ON READER CARD

COBOL EFFICIENCY IS A FUNCTION OF MANUFACTURER KNOW-HOW

A major feature of COBOL is that it shifts much of the responsibility for the production of a program from the user's programming staff to the computer manufacturer's COBOL programming staff. In effect, the experience and capabilities of the manufacturer's staff are placed at the disposal of the user via the COBOL compiler. The quality of the translation from source COBOL statements to machine codes depends very heavily on the quality of the manufacturer's implementation of COBOL.

HONEYWELL'S COBOL CREDENTIALS

Honeywell's record of achievement in the implementation of COBOL indicates the extensive background necessary to create a high-performance product.

For example:

Honeywell has been an active member of the CODASYL committee since the committee's inception.

Honeywell COBOL has been acclaimed as offering the fastest compilation speeds at the lowest costs.

Honeywell produced one of the first operational Syntax-directed COBOL compilers.

Honeywell COBOL offers the most comprehensive set of implementations of DOD COBOL language elements.

Honeywell Series 200 COBOL D offers the greatest number of DOD COBOL language elements in a compiler requiring only 16,000 characters of memory.

Honeywell Series 200 COBOL B offers a compact compiler capable of operating in as few as 8,000 characters of memory, yet using a fully compatible language subset.

And Honeywell is continually reinvesting its COBOL experience in the design of new compilers as well as in the upgrading of existing Honeywell COBOL systems.

COBOL IS MORE THAN A LANGUAGE AND A COMPILER

Many computer users tend to associate the term COBOL with just two elements — a manufacturer's selection of COBOL language elements and the compiler provided for translating a COBOL program into its machine-language equivalent. Actually these two elements are only a small part of what might be called a total COBOL system. The major portion of the total COBOL system cannot be appreciated by evaluating just the language and the compiler. In effect, the language and compiler can be all but useless if an extensive array of features is not provided to assist in the production, maintenance and usage of COBOL programs. Conversely the value of the total system can be diminished by a limited language or poorly designed compiler.

Granted that the compiler is a key element in the overall system, a logical question would be, "What makes a good compiler?" or "Are there differences in compilers?"

The answer comes from evaluating how well the compiler stacks up in the following areas:

1. Language Implemented — This includes not only the number of language elements but the overall power or richness of the language. Does it include time-saving coding tools, such as the copy verb or automatic segmentation of the object program?
2. Compile Time — An important consideration, since compilation is a parasitic operation using valuable machine time for nonproduction work. A compiler must offer optimum balance between a high compilation rate and efficient object code. A high-speed compiler makes it economically feasible to operate completely in source language for even the most trivial changes in the program. No machine-language patches are required.
3. Object Code Efficiency — How does the code produced by the compiler compare with the code produced by the computer's assembly system?
4. Reliability — How reliable is the compiler? Does it work when you want it to? Does the compiler introduce undetected errors into the object code?

The summary table on the last page shows the capabilities of the Honeywell Series 200 COBOL D compiler in these important areas.

Now take a look beyond the compiler, at the total COBOL system. The depth of coverage in this area is a measure of the manufacturer's commitment to COBOL. This is where the impact of COBOL really lies. This is where the manufacturer provides the tools for the preparation, maintenance and execution of COBOL programs.

More specifically, the following is a list of system features that are all-important in the efficient application of COBOL, yet have had all too little recognition in its overall evaluation.

Program Preparation

- Source-language file maintenance
- Library copy facilities
- Batch compilation
- Load-and-go facility
- Fast diagnostic scan
- Composite program listing with imbedded diagnostics
- Monitor control
- Environmental adaptability

Program Execution and Maintenance

- Object program file maintenance
- Job-oriented testing
- Monitor control
- Debugging facilities
- Object-time file relocation
- Dynamic control of I/O channels

In short, any attempt to evaluate COBOL on the basis of compiler speed and language implementation alone is like judging a cake solely by its frosting.

HONEYWELL SERIES 200 COBOL

Honeywell in implementing COBOL for Series 200 has taken a modular approach consistent with its operating system design concept. Series 200 COBOL consists of five levels, each identified by its minimum memory requirements. The five levels are: 8,000, 16,000, 32,000, 65,000, and 131,000 characters of memory, *including operating system memory requirements.*

Each level affords a rich and powerful implementation of the COBOL language and a fast and efficient compiler. Moreover, all levels incorporate the program preparation, execution and maintenance capabilities that distinguish a total system from just a compiler.

Make Your Own Comparison

The following table lists the characteristics of Honeywell Series 200 COBOL D (16K level). You can compare the superior capabilities of Honeywell COBOL D with those of any competitive system of similar design level simply by filling in the blank column in the table.

CHECK LIST OF COBOL SYSTEM FEATURES

	Honeywell COBOL D	Other
Core Memory Required	16K	______
Memory Required for Compiler	14K	______
Operating System Overhead	2K	______
Language Elements	270	______
Minimum Peripheral Configuration	4 tapes	______
	card reader	______
	card punch	______
	printer	______
Compile Time for Typical COBOL Programs:		
500 statements	1.7 min.	______
1000 statements	2.9 min.	______
Compilation Cost Per 100 Statements	19 cents	______
Object Code Efficiency	85-90%	______
System Features:		
Stacked-job Operation?	Yes	______
Composite Program Listing?	Yes	______
Fast Diagnostic Scan?	Yes	______
Library Copy Facilities?	Yes	______
Job-Oriented Testing?	Yes	______
Operating System Controlled?	Yes	______
Environmental Adaptability?	Yes	______
Load-and-go?	Yes	______
Extensive Debugging Facilities?	Yes	______

WRITE FOR MORE ON HONEYWELL COBOL

For in-depth coverage of the points discussed in this report, send for the Honeywell publication entitled "COBOL Orientation for Management." This booklet includes a description of all levels of Honeywell Series 200 COBOL.

Honeywell

ELECTRONIC DATA PROCESSING

B C D E F G

TO: Honeywell EDP
60 Walnut Street
Wellesley Hills, Mass. 02181
Attention: Information Services

Please send me your publication entitled "COBOL Orientation for Management."

Name____________________

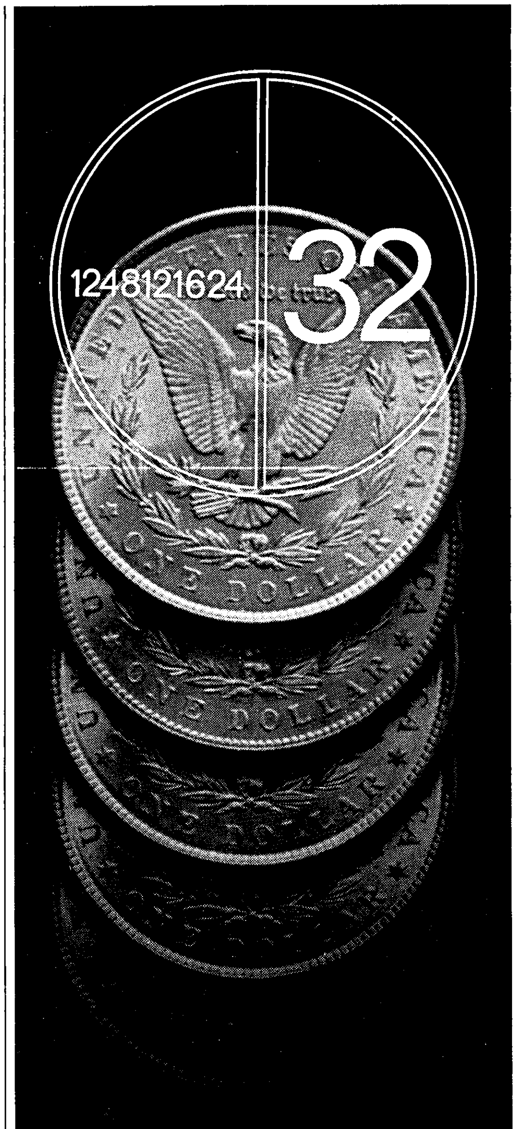
Title____________________

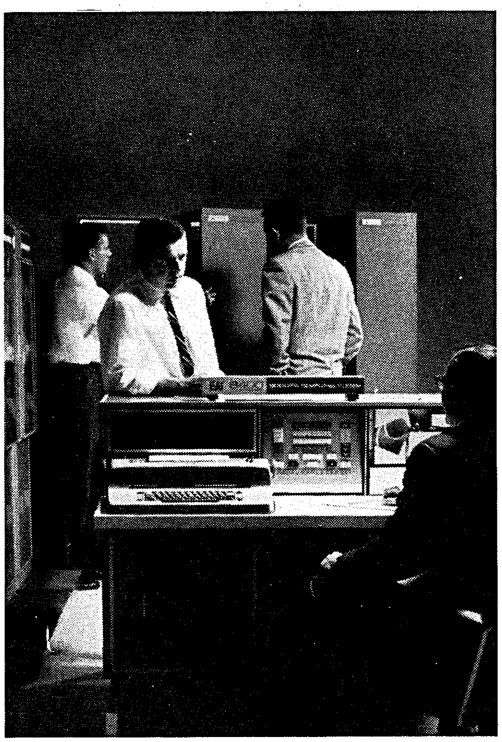
Company____________________

Address____________________

City__________ State__________ Zip Code________

An extra 8 bits adds a lot to a Digital Computer





When choosing between the EAI 8400 32-bit-word-length-computer and a 24-bit machine, consider the value of its 8 premium bits. They make a powerful difference. In the data format those 8 extra bits effectively double working core storage by providing enough precision in one memory location to store a full floating-point-word or two fixed-point-words.

In the instruction format, one extra bit in the address field doubles the amount of directly addressable core storage to provide up to 64K for the really big problem. The 7 remaining extra bits provide control over 7 index registers, immediate addressing, indirect addressing, integer arithmetic, byte manipulation and many other powerful command directives and modifiers.

EAI's 15 years of leadership in the field of simulation convince us that space and industrial simulation laboratories need this large scale power to solve today's increasingly complex problems. Even if you're not in the field of simulation this extra capability could be what you are missing. Write for more details about this new digital computer, the EAI 8400 Scientific Computing System.

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

CIRCLE 59 ON READER CARD

IBM'S CONSENT DECREE AND TIME-SHARING

The IBM consent decree of 1956, engineered by the Justice Dept. to preserve competition in the computer industry, passed its 10th anniversary on January 25 amid growing indications that it is getting the technological creaks. Time-sharing, not even in the vocabulary a decade ago, is fast becoming a commercial reality, and government anti-trust lawyers admit to watching closely IBM's Quiktran and any similar projects to see whether they violate decree provisos against No. 1 participating directly in the service bureau business. One argument says IBM's offering of time-shared computer services constitutes "the preparation with tabulating and/or EDP machines of accounting, statistical and mathematical information and reports on a fee basis," and hence violates the decree. The opposite view holds that a time-sharing service is merely an extension of standard machine leasing arrangements with a long distance twist, and is OK as long as there's no intermediate, manual handling of client data. Says one Justice Dept. lawyer: "I'd hate to go to court and argue the case either way." Nothing formal is likely to happen until and if time-sharing becomes much bigger commercially than it is now.

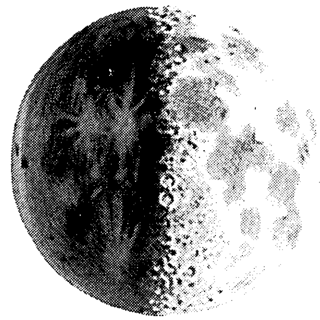
While its main provisions remain in force, the decree's 10th birthday also saw the shedding of several restrictions placed on IBM back in the dim, dark days of computing. No longer does Papa Poughkeepsie bear the "burden of proof" in any legal tiffs with the Justice Dept. over whether it is willing to sell, as well as lease, equipment, and no longer is it barred from entering into long-term, non-cancellable leasing agreements for dp equipment.

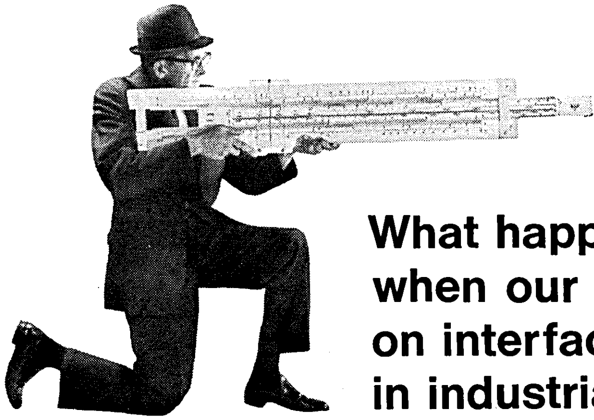
VOILA! COBOL 65

The long-heralded Cobol 65, making its debut not uncharacteristically in 1966, arrives on the scene just as the American Standards Assn. is getting serious about creating Cobol standards acceptable to all users and manufacturers -- a Solomonic task if ever there was one. The new Cobol, with its segmentation and immediate access storage features, is expected to lend weight to the arguments of big users, especially the Air Force, who want to see tough ASA specs enacted. One possible solution being contemplated by ASA: a hierarchy of standards -- full, intermediate, minimal, etc. -- from which each manufacturer could choose the most congenial, according to taste and interest. How this approach would go over with Codasyl is another matter. Anyway, copies of Cobol 65 are available from the Gov't Printing Office at $1.75. Ask for catalog number D-1.31,965.

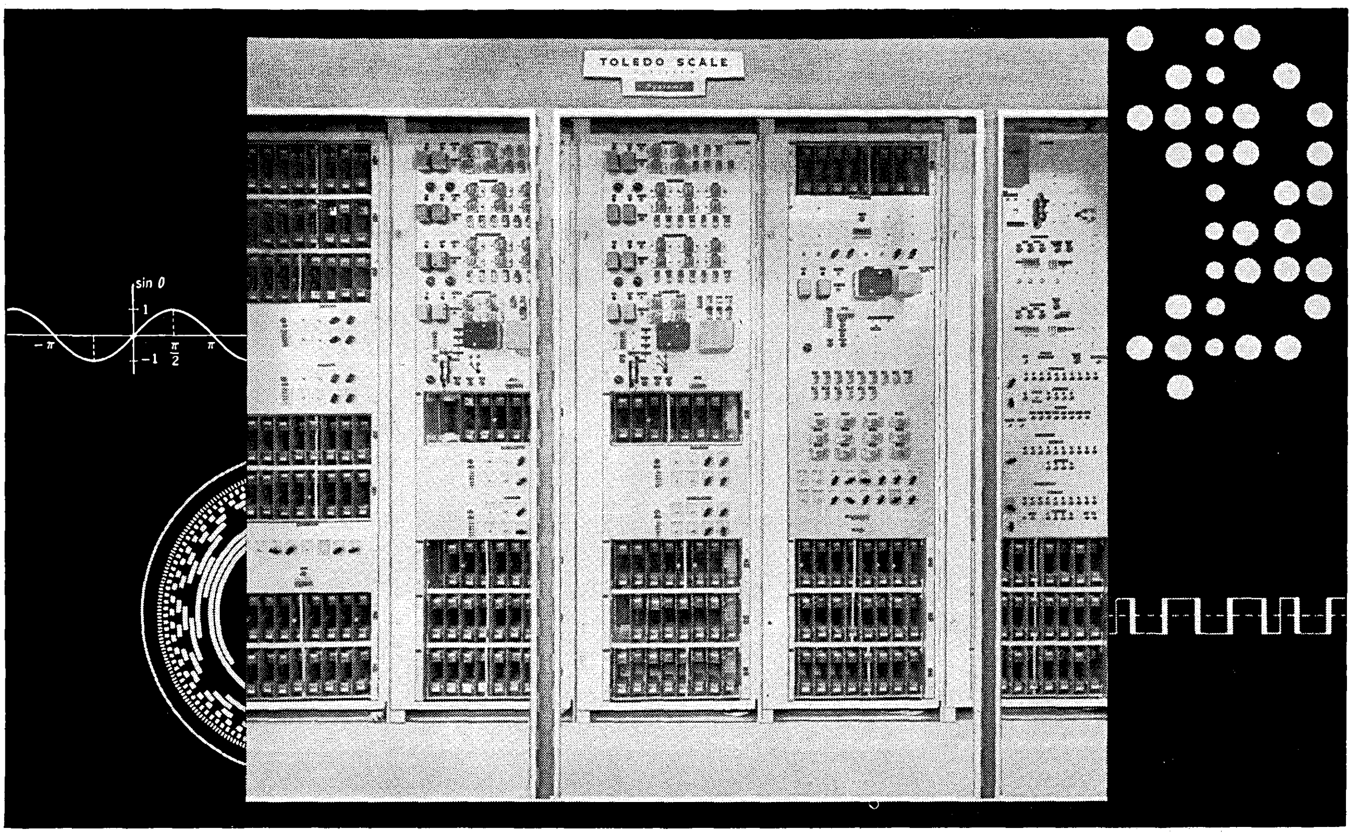
WASHINGTON'S ANSWER TO 360 SLIPPAGE

Reports of 360 hardware-software delivery woes accumulate. One Navy user is socking IBM $100 a day for each of five new systems rendered hors de combat for lack of promised but not yet delivered software. This means possible damages ranging up to $90,000. Three of the Atomic Energy Commission's GOCO's reportedly are also assessing liquidated damages for "defective" software. On the hardware front, Control Data has a 3100 going to Operations Research Inc., in place of an originally ordered 360 configuration.





What happens when our engineers zero in on interface problems in industrial data processing?



They solve them.

Just ask Republic Steel, Armour, Ford Motor, Tennessee Eastman, Thiokol Chemical, etc.

You'll learn that our engineers are wizards at making the incompatible . . . compatible.

Many industrial data processing systems must be designed with hardware that is basically incompatible. Data transmitters and receivers don't always communicate in the same language.

So interface sub-systems are needed to translate data into forms usable by all machines . . . computers, peripheral equipment, processing equipment.

Our engineers are in the unique position of having solved the interface problems for leading companies in widely different industries. They have pioneered interface techniques that can help you realize the optimum in data processing and industrial process control.

So ask them to zero in on your interface problems. You'll like the way they get on target—fast!

Who knows what our ingenious systems engineers will come up with next? One thing is certain, though. You should talk to them if you have a problem in measurement, material handling, control or data processing.

TOLEDO SCALE ® SYSTEMS DIVISION

TOLEDO SCALE, TOLEDO, OHIO 43612

CIRCLE 62 ON READER CARD

world report

ANGLO-FRENCH GIANT PROSPECTS SHRINK

Signs are that the projected Anglo-French large-scale computer scheme is wallowing in deep water. A January meeting between Britain's Minister of Technology, Frank Cousins, and French Minister for Scientific Affairs, M. Peyrefitte, was expected to end in joint government approval for the project. Although neither party was prepared to state an after-meeting policy, indications are that the idea has been scrubbed after almost six months of wishful thinking. Main reasons for the sudden attack of cold feet: escalating development costs compared with first estimates, doubts about the size of the market for a machine 10 times bigger than CDC's 6800, and a growing conviction that at least two U.S. firms are in a position to beat the Anglo-French project to the draw.

GOV'T SPENDING BOOSTS U.K. OUTLOOK

Despite this disappointment, Britain's computer industry is in buoyant mood. Government plans to spend $85 million on universities and research councils, and to build a National Computer Centre, reported here in January, are now rapidly taking shape. Fifteen universities will share the bulk of the money in getting new facilities, with most orders being placed by spring. Local manufacturers are expecting to get two-thirds of the business. A further $750,000 will be spent equipping the National Centre in Manchester. A firm policy now emerging for this group is to establish better cooperation between the academic and the commercial and industrial computing communities. Emphasis is to be on establishing software standards and influencing training and education.

On top of this activity, the government has legislated for new investment incentives that apply to a wide section of business. In the form of a 20% cash grant for modernisation schemes, this compares with an existing tax allowance applied to capital plant expenditure. Major advantage is that the grant is paid within six months of the claim being made as against an 18-month to two-year wait before old allowances paid off. Resulting trend should be toward more outright purchase, with particular benefits for ICT (desperately short of cash) and leasing companies (who are eligible for the grant on leasing contracts).

CZECHS LOOK AROUND, PLAN AHEAD

It is time that Czechoslovakia re-examined its position in respect to computers and dp, according to an editorial in the economic weekly Hospodarske Noviney. This is based on a survey indicating that by 1970 the country would need 300 computer systems and 560 card installations. At present, Czech industry is unlikely to be able to meet more than a small percentage of the demand. It is suggested that a joint development program with the Soviets, East Germany and Poland may solve the problem. The object would be to work on a third-generation

(Continued on page 107)

More to it than meets the eye because it meets all your requirements!

The Sanders 720 COMMUNICATOR was designed by our engineers with primary emphasis on the users' needs. That's why the 720 COMMUNICATOR offers, at low cost, more standard working features than any comparable equipment.

Format, for example . . . with Sanders unique page concept, 30% more usable information is presented on the screen. You can position 1000 different characters anywhere on the exclusive 2000 space screen. When you call out reports, records or any data at all, you read the information just like typewritten copy on a page.

Versatility, for another . . . the 720 provides, as standard, full editing capabilities. You can add, delete, correct information anywhere on the screen — insert new letters, words, even sentences in the middle of a line or paragraph. The data already on the screen simply moves over making room for additions or closing the gap caused by deletions. There is no special training or programming required.

Superior techniques in microcircuitry make the Sanders 720 COMMUNICATOR Information Display a compact video/keyboard system that fits perfectly on a desk, table or counter-top. Clear, bright, solid letters, numerals and symbols, properly spaced, make every message easy to read under any lighting conditions.

The Sanders 720 COMMUNICATOR works directly with all modern high speed computers. You can install it in your present system or plan it into a future set-up and never worry about obsolescence.

There's more to it than meets the eye. For detailed information on Sanders 720 COMMUNICATOR and discussion of your requirements, call or write Sanders Associates, Inc., Commercial Display Marketing, Nashua, New Hampshire 03060, Area Code 603 883-3321, Extension 1545.

Sanders Associates, Inc. *

CREATING NEW DIRECTIONS IN ELECTRONICS

*T. M., Sanders Associates, Inc.

CIRCLE 66 ON READER CARD

(Continued from page 105)

machine range over a two-year period and plug existing gaps with imports from the West. The present situation is said to be fraugth with obsolescence. 31 small and medium size machines of 12 different makes are now in use. Apart from Minsk and Ural computers from the USSR and a Polish Odra, they are mainly Western machines from such firms as Elliott, Zuse, Librascope and Univac.

MIS A HIT IN JAPAN

35% of Japanese firms using computers for five or more years now apply them to management information systems and decision-making. This is the gist of a study made by the Electronic Computer Development Assn. of Japan. 45% of companies acquiring machines are reported to be using them to carry out re-alignment of their work force. Of the 1,840 installations made up to March '65, 10% ran into labour-management disputes, although only 5% are reported to have dismissed employees.

GE BUSY IN BRITAIN

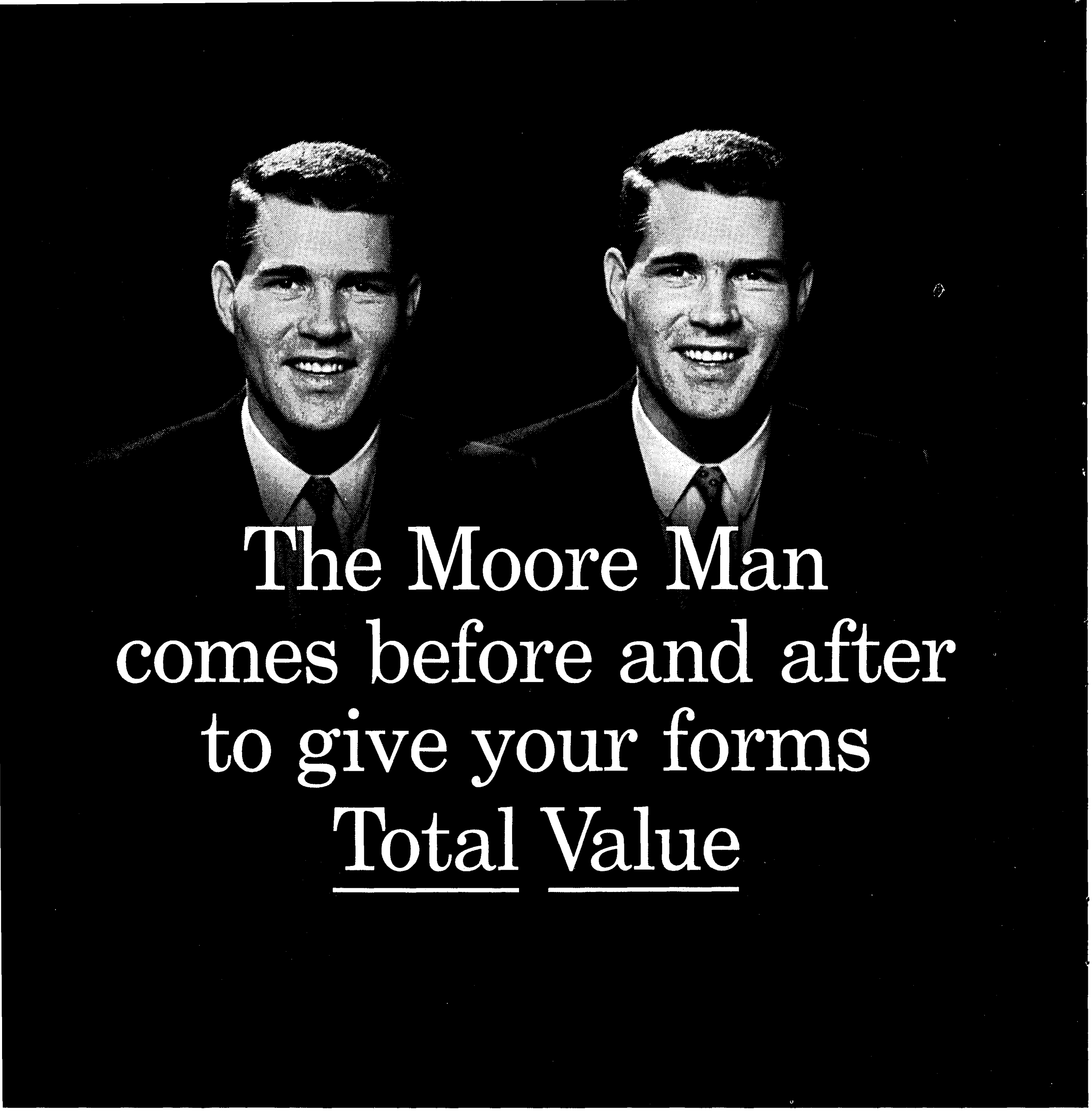
Strong rumors in circulation predict further moves by GE to capture a large share of Europe's blossoming big-machine and real-time market. Suggestions that a deal is likely with Associated Electrical Industries Ltd. in the U.K. for the manufacture of 600 systems were not confirmed, although reports of talks between the companies were not denied. Such a move is expected to follow a reorganization of GE's activity in Britain where it sells through De la Rue Bull Machines. De la Rue, a large investment group and printer of banknotes, is expected to yield a large part of its stake in the De la Rue Bull marketing operation in favor of GE.

AFTER THE FALL...

GE is joined by other companies determined to grab possible business following IBM's big slip in hardware and software. Almost every European country reports great confusion and different stories on the effect of the giant's blunder. Main interest, however, centers on the big systems and almost every manufacturer has made tentative lists of the hard bargaining customers likely to go out to re-tender. On the other hand, battle lines are forming across Europe for a Cobol vs. PL/1 struggle. Already large users in the plastics, chemical and petro-chemical field have shown an inclination to back PL/1, while most local machine makers are taking the opposite side.

BITS & PIECES

Redifon-Astrodata Ltd., a British company in which Astrodata Inc. holds a minority share, has in three months moved into a new factory, started first customer deliveries, and picked up a near $1 million in business. Customers include the Royal Aircraft Establishment, Farnborough, for two Ci 5000 hybrids valued at $420,000; the Univ. of North Wales, and a continental research agency, also with hybrids. Europe is expected to yield $15 million this year on analogs and hybrids in a largely re-equipment market ...Digital Equipment has made an arrangement with Lancashire Dynamo, a subsidiary of the Metal Industries Group, for the latter to use PDP's in industrial control hook-ups. Lancashire is also producing special-purpose stored-program processors for tasks such as store-keeping in factories... At the British Computer Society's real-time conference in London last month, Professor Stanley Gill of Imperial College suggested that it seemed reasonable for a transatlantic link to be established ultimately between a European and U.S. computer grid.



Before and after a sale, we mean.

Service in forms is important. We at Moore know this and render continuous before-and-after service to assure you of optimum results.

This might be in designing, or helping to design, a form you need. Our experienced men know forms and systems, and machines, and are a real help in seeing that you get the form that's right for your system needs.

It might be in their up-to-the-minute knowledge about new forms and machines in this fast-changing field. Or details about a form that is solving a problem you may have, which are available in our Forms Library Service.

Above all, Moore Men are problem-solvers. There are 2000 of these men across the continent, near you for service when you need it—before the sale and after. And they are backed by specialists in new methods, in research, in expert system applications.

Use our representative, and our facilities, to get Total Value in your forms. If you work with forms, we can show you how to make forms work for you.

CIRCLE 65 ON READER CARD

MOORE

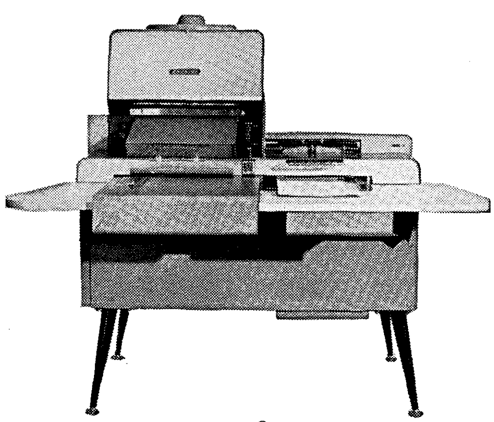
MOORE BUSINESS FORMS INC

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

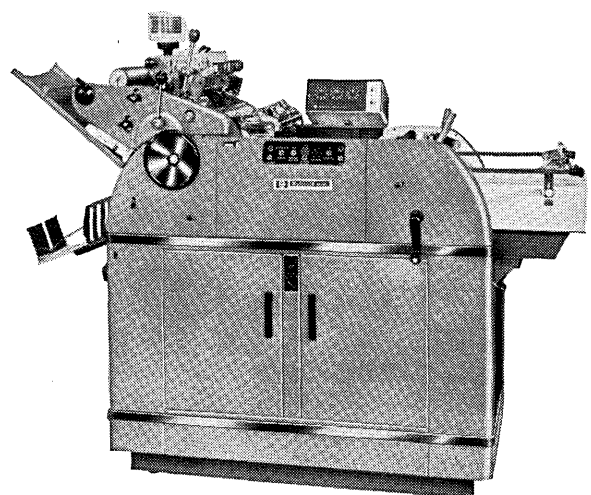
Now just a copy-pickin' minute!

Tired of being bombarded with copying talk? Fancy claims? Cost figures that vary all over the lot? "Performance" talk that sounds good but never quite lives up to promises? Then look to Addressograph Multigraph for the right copy duplicating system.

Remember AM



Bruning® 2000



Multilith® 2550

Quality—Our Multilith Offset 2550, teamed with our Bruning 2000 copier, gives you sharp, clear "original" copies every time.

Speed—You won't have to wait an hour to get 2400 copies. Multilith 2550 duplicates at 9000 copies per hour. Reproduces halftones and color faithfully.

Versatility—You can duplicate copies on a wide assortment of sizes and paper stock. No special paper required. And, if you like, copies can be sorted automatically, ready for immediate distribution.

Save money, too—You know the *exact* cost of duplicating copies with Multigraph® equipment. The more you make the *lower* the cost. You can even duplicate on *both* sides of the paper, if desired. Ideal for *all* kinds of business documents.

So, talk to your Multigraph man today. He's in the Yellow Pages. Or write Addressograph Multigraph Corporation, 1200 Babbitt Road, Cleveland, Ohio 44117.

Multigraph
DIVISION OF
ADDRESSOGRAPH MULTIGRAPH CORPORATION

CIRCLE 67 ON READER CARD

T.M.

CPC SPECIALIZES IN EXECUTIVE RECRUITMENT

DATA PROCESSING | **OPERATIONS RESEARCH**

- *MANAGERS*
- *CONSULTANTS*
- *SYSTEM ANALYSTS*
- *PROGRAMMERS*
- *OPERATIONS RESEARCH ANALYSTS*
- *APPLIED MATHEMATICIANS*

COMPUTER PERSONNEL CONSULTANTS, INC.

**236-0900 (312) Suite 1460 135 S. La Salle St.
Chicago, Ill. 60603**

CIRCLE 112 ON READER CARD

MANAGER SCIENTIFIC DATA PROCESSING

Challenging assignment at the National Reactor Testing Station near Idaho Falls, Idaho, for a man with 5 to 10 years of experience in managing a scientific computing installation. This position entails supervision of a well established group of analysts and programmers who handle computer applications in the areas of reactor analysis, reduction of experimental data from reactor tests, statistical analysis, nuclear safety tests, and a variety of commercial data processing problems. presently installed equipment includes an 7040/1401 system, with a CDC-3100 on order. The computing load is 80% scientific, 20% commercial.

Candidates should have a PhD degree or equivalent outstanding experience. Salary commensurate with qualifications.

Contact

PHILLIPS PETROLEUM COMPANY

Atomic Energy Division
P. O. Box 2067-KT
Idaho Falls, Idaho

An equal opportunity employer. *U. S. citizenship required.*

CIRCLE 115 ON READER CARD

SUPERVISOR

COMPUTER PROGRAMMING

Dynamic Stratos Division of Fairchild Hiller, a national leader in environmental control, life support and space power systems now has an immediate permanent opening for a qualified computer programming supervisor. The position requires familiarity with IBM 1620 and 7094 equipment and knowledge of FORTRAN. Applicants should have a degree in mathematics (advanced degree preferred) with heavy engineering background and previous exposure to programs in thermodynamics. Some supervisory experience is required, plus the ability to respond swiftly to diverse program responsibilities.

Stratos offers an attractive starting salary, liberal fringe benefits and excellent opportunity for advancement. Location, at Stratos' modern facility on Long Island, is just on hour's drive from New York City.

Please send your resume and salary requirements to: Mr. M. E. Jenkins, Stratos Division, Fairchild Hiller, Orinoco Drive, Bay Shore, Long Island, N. Y. Refer to position #5223.

FAIRCHILD HILLER
STRATOS DIVISION

An Equal opportunity employer M/F

CIRCLE 113 ON READER CARD

COMMERCIAL SYSTEMS PERSONNEL

Expanding corporate operations have created unique opportunities for Systems Personnel with varied degrees of accomplishment. Several job types are presently open: *Senior Systems Analyst, Manager of Information Systems, Research Analyst* and *Programmers.*

Candidates should have major project experience in the installation of forward-looking EDP applications. Areas of application will include the following:

1. **Distribution and Merchandising Control.**
2. **Production Control and Scheduling.**
3. **Personnel and Payroll.**
4. **Accounting and Responsibility Reporting.**

Spring "66" will mark the Fourth Generation of DP Systems at Stop & Shop (3 IBM Systems/360). Responsibilities include the servicing of retail food and mercantile (Bradlees) outlets with a sales volume approaching $500 million.

Complete Fringe Benefit Program available with attractive starting salaries. Interested applicants should submit resume in strict confidence, giving salary requirements, to Mr. Joseph Riemer, Director of Information Systems:

STOP & SHOP, INC.

397 "D" Street
South Boston, Massachusetts

"AN EQUAL OPPORTUNITY EMPLOYER"

CIRCLE 116 ON READER CARD

THERE ARE FEW times in any career when an opportunity for substantial advancement presents itself —a so-called "ground floor" opportunity. NOW comes one such occasion for those growth-minded Systems Analysts and Programmers who would share the challenge and profit which accrues to a dynamic and successful young company.

COMPUTING TECHNOLOGY INCORPORATED has a limited number of positions available for professionals with experience in Compilers, Assemblers, Operating Systems, Real-Time Systems, Management Systems, Military Systems, and Scientific Programming and Mathematical Analysis.

If your experience encompasses any of these areas, and such an opportunity appeals to you, considered attention will be given your resume, sent to

S. R. Button

COMPUTING TECHNOLOGY INCORPORATED

P.O. Box 803 Tuxedo, N. Y.

an equal opportunity employer

CIRCLE 94 ON READER CARD

FREE! CAREER OPPORTUNITIES BULLETIN

A complete and comprehensive listing of outstanding positions at salaries from $6,000 to $30,000 with National Companies for:

ENGINEERS / DATA PROCESSING

Our professional staff combines Customized Service with technical know how to insure for you maximum career development in the following areas:

- LOGIC DESIGN
- CIRCUIT DESIGN
- SYSTEMS DESIGN
- SYSTEMS ENGINEERS
- OPERATIONS RESEARCH
- PROGRAMMING
- PROCESS CONTROL
- APPLICATIONS PROGRAMMERS
- SYSTEMS PROGRAMMERS
- INFORMATION RETRIEVAL
- MATH ANALYSIS
- MANUFACTURING

No charge to you for our custom service. Employers pay our fee. Expedite your development by sending resume in confidence with present salary & geographic preference to:

La Salle Associates

Professional Search Dept.

2136 Locust Street, Philadelphia, Pa. 19103

For your free bulletin without any obligation, circle subscriber service card. Please use home address only.

CIRCLE 95 ON READER CARD

INSTITUTE OF TECHNOLOGY

MASSACHUSETTS

PROGRAMMERS

The M I T Computation Center is preparing for a major expansion of its computing facilities and services and offers exceptional opportunities for qualified systems programmers.

Services include a comprehensive remote-access time sharing system and a multi-language batch processing system. The present 7094 is to be replaced by the S/360 which will increase the capacity and diversity of the time sharing service.

M I T offers a liberal benefit program, including educational opportunities at the Institute and competitive salaries. Interested programmers with a degree and more than one year's experience are invited to submit resumes, including salary information to:

Mr. L. V. Sullivan

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

77 Massachusetts Ave.
Building E 19-285

UN 4-6900, Ext. 4275
Cambridge, Massachusetts

An Equal Opportunity Employer

COMPUTATION CENTER

CIRCLE 93 ON READER CARD

Simulator-Computer Engineer or Mathematician

The Navy's Mine Defense Laboratory at Panama City, Florida, performs RDT&E in mine defense, acoustic and torpedo countermeasures, inshore warfare, swimmer/diver operations, and related fields of underseas technology.

We will offer a starting salary of $12,510 with increases to $16,425 to a simulator-computer engineer or mathematician in the field of simulation including analog and digital computer. Duties consist of technical administration of contract for development of the simulator which determines optimum acoustic and torpedo countermeasures characteristic and measures effectiveness of doctrines, devices and techniques. Also responsible for programming computer problems and supervising installation and evaluation of the simulator. Opportunity exists for heading simulator complex when it becomes operational.

Send resume or SF-57 to E. T. Castleberry, Sr., Civilian Personnel Office, U. S. Navy Mine Defense Laboratory, Panama City, Florida, 32402. (These positions enjoy all the benefits of career Civil Service, and applicants will be considered on an equal opportunity basis.)

CIRCLE 97 ON READER CARD

SYSTEMAT

1107 Spring Street
Silver Spring, Maryland
20910
301-587-3650

Room 2-F
24 Crescent Street
Waltham, Massachusetts
02154
617-891-5200

BOSTON LOCATIONS

We have recently opened an office to serve EDP applicants and employers in the Boston area. We plan to offer the same type of personal service we furnish in the Washington, D.C. area.

Positions are available in both locations for the following personnel.

Scientific Programmers
Systems Programmers
Systems Analysts
Computer Salesmen
Business Programmers

$7,000 - $20,000

All fees, interviewing and relocation expenses are paid by the employer. There is no cost to you — no contract to sign.

If you are interested in either Washington, D.C. or Boston, send a resume to the nearest office, or check the reader service card.

CIRCLE 99 ON READER CARD

FREE

. . . a comprehensive digest of scientific and engineering DATA PROCESSING opportunities for our client organizations from coast to coast. Salaries range from $8,000 to $25,000 commensurate with ability and experience. These opportunities include such areas as:

Basic Research	**Diagnostic Programming**
Command and Control	**Scientific Programming**
Communications	**Statistical Analysis**
Operations Research	**Simulation**
Logic Design	**Information Storage and Retrieval**
Circuit Design	**Mathematical Analysis**
Software Development	**Engineering Computer Field**

As specialists in the scientific and engineering computer field, EDP is able to provide the widest possible selection of career positions. Each allows the individual to make significant contributions that will challenge his best efforts, in a scientific atmosphere, at a salary in keeping with his technical competence.

For immediate consideration, write in confidence outlining your experience, education, career objectives, and compensation requirements to:

David N. Grimes
edp personnel, inc.
"exclusively data processing"
100 S. Wacker Drive Suite 212
Chicago, Ill. 60606 Ph. (312) 782-0857

CLIENT COMPANIES ASSUME OUR CHARGES

CIRCLE 96 ON READER CARD

UNIVERSITY COMPUTING CENTER

ASSISTANT MANAGERS

At State University of New York at Buffalo (1) to supervise systems programming staff and (2) to supervise applications programming staff and graduate assistants. Scientific computing background desirable. Salary negotiable depending upon experience.

Contact Dr. A. Ralston, Computing Center,
State University of New York at Buffalo,
Buffalo, New York 14214; 716-831-4015

CIRCLE 98 ON READER CARD

books

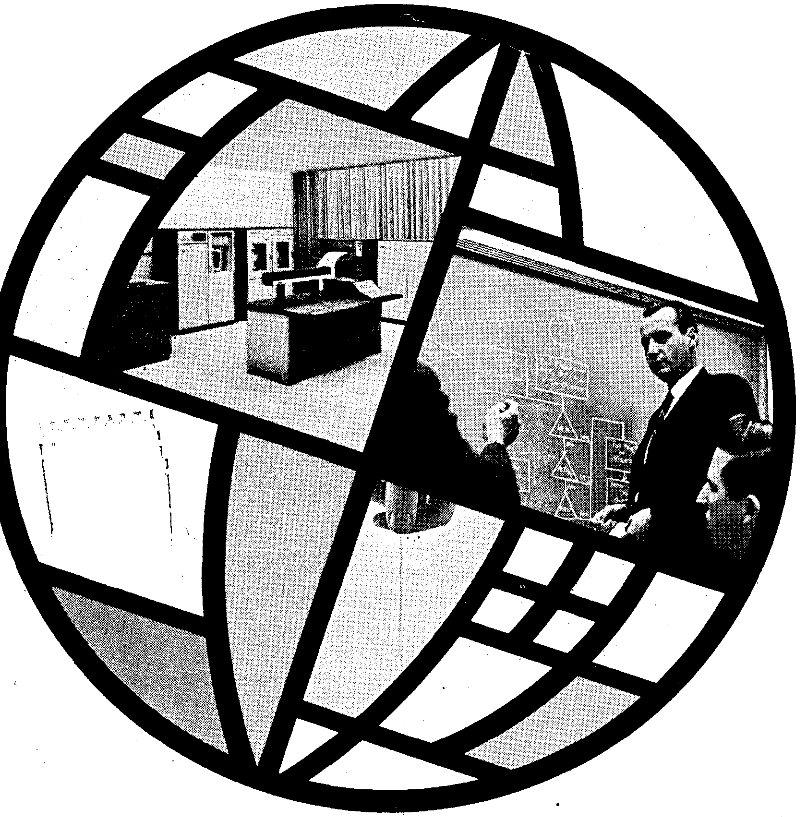
***Automatic and Remote Control: Proceedings of the Second Congress of the International Federation of Automatic Control, Basle, Switzerland, 1963*, edited by Victor Broida, D. H. Barlow, and Otto Schafer. Volume I (Applications and Components), 749 pages, $60; Volume II (Theory); 695 pages, $65 (purchased as a set, $115); available from Butterworth, Inc., 7235 Wisconsin Avenue, 14, Washington, D. C.**

These two volumes contain the papers presented at the Second IFAC Congress held at Basle from August 27 to September 4, 1963. Approximately 1500 specialists from 32 different countries attended to hear and discuss 160 papers. This Congress was the second of the triennial IFAC meetings, beginning with the 1960 Congress in Moscow and continuing with the Third Congress to be held in London June 20-25, 1966.

Papers presented at the Congress are grouped in three fields: Theory, Application, and Components. The 84 papers on theory fill one volume of the *Proceedings*; 55 papers on applications and 21 papers on components occupy the other. Except for nine papers in French, all of the papers in the two volumes are in English. In addition, a summary is given in English, French, and German for each paper.

Some items are common to both volumes. The table of contents of the entire *Proceedings,* in English, French, and German, is presented in each volume, as is a list of authors' names and addresses. (A regrettable omission is an index to permit finding a paper knowing only the author's name.) Also repeated are introductory and welcoming addresses by the past and present presidents of IFAC, and an address by I. L. Auerbach, president of IFIP, who describes information processing, its relation to automatic control, and the history and interests of IFIP.

The volume on theory is divided into six sections identified as Non-Linear Systems Theory (15); Discrete Systems (16); Optimal Systems (18); Theory of Self-Adjusting Systems (18); Techniques for System Stability Assessment (6); and System Dynamics and Other Problems (11). The number of papers in each section is given in parentheses. As expected, the subject matter of many papers crosses



At the NCR Electronics Division, you build your career on hardware—not hope. Advanced developments like CRAM and the NCR 315 RMC Rod Memory Computer—the first commerically available computer with an all-thin-film main memory—are a marketplace reality. (And bear in mind that the NCR marketplace consists of more than 120 countries!) If you want to combine career stability with go-ahead, on-line opportunity...if you want to earn a good living while enjoying the good Southern California life... look into the opportunities listed here.

BUILD YOUR IN WORLD-WIDE BUSINESS AUTOMATION AT NCR, LOS ANGELES

MAGNETIC RECORDING

Senior and intermediate positions for men with experience in advanced magnetic recording techniques. Knowledge of media, circuitry and magnetic head design necessary. Requires BS in engineering or physics.

MEMORY DESIGN

Positions are available to perform memory design. Requires a BS in EE and previous experience with high speed applications of magnetic cores or thin films to memories. Must also be familiar with computer systems logic and hardware.

PACKAGING

GROUP LEADER

To provide technical and administrative direction for electronic packaging of digital computers, including processors, memories, and peripherals. Requires a minimum of 6 years' experience in electronic packaging and some previous supervisory experience. Must be knowledgeable of heat transfer and advanced manufacturing techniques. BS in engineering required.

ADVANCED LEVEL

To perform advanced packaging of computer systems, including processors, memories and peripherals. Requires BS in engineering and thorough knowledge of packaging concepts as related to digital computers.

INTERMEDIATE LEVEL

These positions entail layout and design of packaging for computer systems. Applicants must have previous experience with electronic computers or electromechanical devices. Background in miniaturization utilizing thin films and integrated circuits is desirable but not required. BS in engineering desirable.

LOGIC DESIGN

For design of advanced integrated circuit computers. Requires BSEE and 2 to 5 years' experience in logic design; experience on processor and float-point design desirable.

QUALITY ENGINEERS

Assignments will entail mechanical and electrical analyses with responsibilities for project testing and inspection specifications, including processes for automatic wirewrapping, cabling and electrical and mechanical assemblies. Requires BSEE or BSME and 3 years' related experience.

PROGRAMMERS

SOFTWARE

Positions entail development of software for various computer input/output routines, operation systems and monitors. Applicants must have previous programming experience with machine language on a large file computer.

DESIGN AUTOMATION

Positions require 2 years' previous experience in programming. Good understanding of engineering and hardware problems desirable, BS degree in math, engineering or related field required.

DIAGNOSTIC

Position entails the writing of diagnostic programs for checkout, acceptance test and field maintenance of EDP systems. Requires previous programming experience; college degree desirable.

ADVANCED MECHANISMS SPECIALIST

For analysis and design of complex computer mechanisms. Must have knowledge of applied mechanics and high-level mathematical ability. PhD required.

PROJECT ENGINEERING

COMPUTING SYSTEMS

Assignment will entail technical and administrative leadership of engineers involved in advanced digital computer system and logic design. Requires BSEE and 5 years' experience in logic design of digital computers. Must have system design capability and knowledge of peripheral equipment operation and interfacing. Previous team leader experience desirable.

books

division boundaries, so numbers alone are not a complete indication of the coverage in a particular subject.

In addition to the technical papers and the discussions provoked, the theory volume also contains five "survey papers" on basic fields of automatic control and the recent progress in these fields. Subjects covered in the survey papers are statistical methods, synthesis of optimal regulators, adaptive control, learning systems, and process dynamics. These survey papers, each with a generous bibliography, provide the reader with concise descriptions of the current state of the various fields and serve to place the more specialized technical papers presented at the Congress in perspective relative to the broad subject of automatic control.

Included in the theory volume are some purely mathematical developments, some interesting work on "inverse" problems, and a description of the development of a new theory ("Dual Control Theory Problems") for which the author admits, in part of the discussion, "There are as yet no practical applications . . . for the creation of real controllers." There are three papers on learning systems, which lead to self-adjusting systems, a subject also well-covered at the Congress and highlighted by G. Pask's excellent survey paper on the subject which contains a list of 124 references.

Of probably more direct interest to aerospace, rather than industrial, control engineers is the somewhat disproportionate number of papers concerned with development of design procedures for time- and energy-optimal systems. These papers do, however, provide a good background for two papers of contemporary interest on trajectory deviations and orbital transfer and rendezvous problems.

Thinking of the oft-discussed and much-lamented "gap" between theory and practice in control engineering, it is interesting to note the clean division of these topics in the two volumes. From the material presented, a gap can certainly be detected. It is also apparent, however, that the gap is not due to the theoreticians' lack of practical knowledge and experience or to the practicing engineers' difficulty in following the theory as it develops. The gap is largely due to the lack of adequate computational equipment and methods. A. A. Feldbaum states that ". . . the most important problem is the development of approximate solution methods . . ." A. M. Letov, in his survey paper, expresses this problem as a need for consideration of the "problem of compromise" between the results obtained by rigorous mathematical development and the resulting complexity (and cost) of the controller. Following a paper on the subject, V. W. Eveleigh in his discussion provides a survey of current computational methods and repeats the requirement for a theory of error for these approximation techniques. Helping to bridge the gap are papers describing approximating techniques, iterative numerical procedures, and quantization errors.

Always important in control systems, the assessment of stability is the subject of six papers. Since methods for linear systems are almost completely developed and the only method available for non-linear systems is Liapunov's second method, the emphasis in stability assessment is placed on the method of Liapunov and the construction of Liapunov functions.

In summary, one can find in the volume on theory many papers on a variety of topics, covering continuous and discrete systems, linear and non-linear systems, deterministic and stochastic systems, and papers on system design, synthesis, and analysis. As mentioned previously, this variety is given cohesion by the excellent group of survey papers which help the reader to connect the various subjects together and therefore make the entire volume interesting even to those concerned primarily with a particular subject.

The second volume contains the papers presented in the fields of applications and components: 55 technical papers and four survey papers on applications, and 21 technical papers and two survey papers on components. As in the theory volume, the survey papers are presented by persons very well qualified for the task and are a very valuable addition to the *Proceedings*.

The 55 papers on applications are divided into seven sections: the Electrical Utility Field (11); Steel Industry (8); Chemical and Oil Industries (12); Automation in Industrial Processes (9); Combined Man-Machine Systems (5); Application Techniques (3); and Automatic Control of Aerospace Systems (7). The survey papers cover electrical utility systems, metal rolling and processing, the steel industry, and the chemical and petroleum industries.

The electrical utility field appears to lead in the application of automatic control theory in industry, and it is apparent from the papers that in the electrical utility industry more freedom exists for the interchange of information regarding the techniques developed. There are several interesting papers, probably the most noteworthy being that of Kirchmayer and Ringlee, who compared variational methods and dynamic programming for optimal control of hydro-power systems.

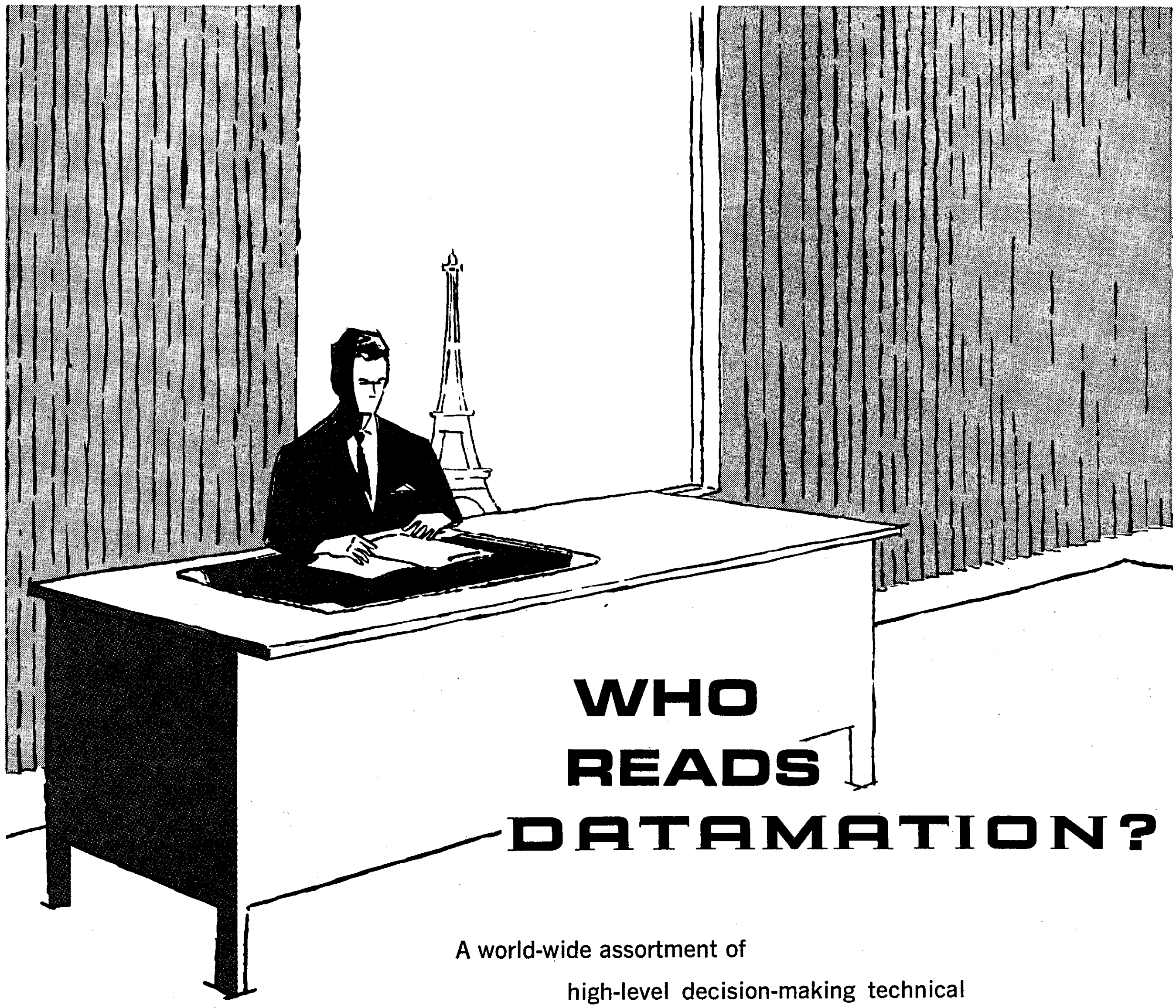
In the section on the steel industry, a variety of subjects is discussed: sintering, open-hearth scheduling, forging, blooming mills, hot strip mills, and annealing. In the section on the chemical and oil industries, papers cover studies of the dynamic characteristics of distillation columns, catalytic cracker power-recovery systems, heat exchange and mixing, and plate-column rectification. Other papers cover automatic control of polyethylene production, the controllability of a flare-gas recovery system, an automatic system for the emptying of petroleum products from tankers, and several other more general topics.

A variety of subjects appears under the heading "Automation in Industrial Processes," including one on cement applications, one on dither-adaptive systems, four on steam-system control, and two concerned with automotive industry applications. The applications section is then completed with the five papers on man-machine systems, three on application techniques, and seven on aerospace applications.

The components section is highlighted by an excellent survey paper prepared by J. L. Shearer and 16 co-authors. Topics covered in the survey are electromechanical components, magnetic amplifiers, semi-conductor and solid-state components, wide-band transformers, semi-conductor and metal strain gauges, gyroscopic instruments, electrohydraulic servo-valves, position servomechanisms, pneumatic components and systems, and pure-fluid systems. In addition to this comprehensive survey, the section includes 21 papers distributed as follows: mechanical, hydraulic and pneumatic devices (4); electromechanical devices (4); electronic components (3); digital devices (3); process instrumentation (3); and reliability (4). There is something for everyone in this section.

Individuals thinking about purchasing the *Proceedings* may be staggered by the price. However, on a per-page (8 cents), per-paper (75 cents) or per-year (under $40) basis, the price seems much more reasonable; moreover, buying the volumes costs much less than attending the Congress. In any case, these volumes deserve to be made available to and should be read by every engineer and mathematician practicing in the field of automatic control.

—V. A. Kaiser, T. M. Stout



CIRCLE 106 ON READER CARD

people

■ Dr. Louis T. Rader is director of GE's new Information Systems Div., Charlottesville, Va. Division general managers are: Jerome T. Coe, data processing and communications; Louis E. Wengert, information systems equipment; Harrison Van Aken, overseas operation; and Leonard C. Maier, advanced development and components.

■ Lt. Col. Sylvester P. Steffes has been chosen chief, Air Force Electronic Systems Div., Data Processing Equipment Office, Bedford, Mass. He replaces Col. Edward McCloy who will join CIT Corp., New York City.

■ J. Richard Sherman has been elected president, Data Systems Inc., Minneapolis, Minn. He was formerly with the Diebold Group.

■ K. H. Speierman has been named chief, software division, National Security Agency, Fort George G. Meade, Md. He was formerly with the Burroughs Defense & Space Group.

■ Lindon L. Griffin and M.A. Butterfield have joined the dp staff in the Center for Computer Sciences and Technology, National Bureau of Standards, Washington, D. C. They were formerly with the Navy and Farrington Manufacturing respectively.

■ Gordon A. Heup has been appointed manager, scientific computation, at Telecomputing Services Inc.'s newly-created Maryland division.

■ Kenneth W. Yarnold, formerly with Dunlap & Assoc., is director of research, System Development Corp., Santa Monica, Calif.

■ Omer C. Lunsford will manage American Oil Co.'s dp department, Chicago, Ill.

■ Edward G. Glowaty has been elected president, Honeywell 400/1400 Users Assn., Wellesley Hills, Mass.

■ Emmanuel J. Otis has been promoted to chief computer engineer, development division, Control Data Corp., Minneapolis, Minn.

■ Harry W. Schrimpf will serve as assistant to the vp, LFE Electronics Div., Laboratory For Electronics, Boston, Mass.

FERROXCUBE

Room to Grow . . . In a Stimulating Engineering Environment

Ferroxcube is a recognized and growing leader in the development and manufacture of commercial computer memory components and sub-systems. It is situated a short two hours from midtown, New York City—on the New York State Thruway—in the midst of the beautiful Catskill Mountain resort area.

We are engaged in a variety of interesting development and manufacturing programs. Move up professionally . . . financially . . . and socially . . . look us over. Challenging opportunities now available for:

MEMORY DEVELOPMENT ENGINEERS

Memory Systems Advanced Development

SENIOR & INTERMEDIATE LEVELS

To advance the state-of-the-art in system and circuit design. Projects include high speed memories, mass core memories, etc. Digital circuit experience required; knowledge of memory drive and sense circuitry, both discreet component and integrated, is desirable.

APPLICATIONS ENGINEERING

For Ferrite Memory Devices & Systems work with customer specifications with respect to core planes, stacks and systems design and specifications for computers & data processing. Opportunity for project responsibility. Familiarity with core memories and/or digital systems desirable.

Please send resume including salary requirements to:

J. PAUL STURTEVANT, DEPARTMENT 6

FERROXCUBE CORPORATION OF AMERICA

Corporation of America

SAUGERTIES, NEW YORK 12477

An Equal Opportunity Employer

CIRCLE 123 ON READER CARD

HARVARD UNIVERSITY
COMPUTING CENTER

Expansion of Computing Center Services has created permanent positions for senior programmers with 7094 experience in:

- **real time applications**
- **multiprogramming**
- **multivariate statistical analysis**
- **numerical analysis**

—

Opportunity to plan and execute major new systems and applications.

—

Resumes acknowledged and handled in confidence.

Mail to: Dr. Norman Zachary, Director
Harvard Computing Center
Harvard University
33 Oxford Street
Cambridge, Massachusetts 02138

An Equal Opportunity Employer

CIRCLE 122 ON READER CARD

Career Memo for Professional Achievement in '66

TO: ALL LEVELS OF

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**

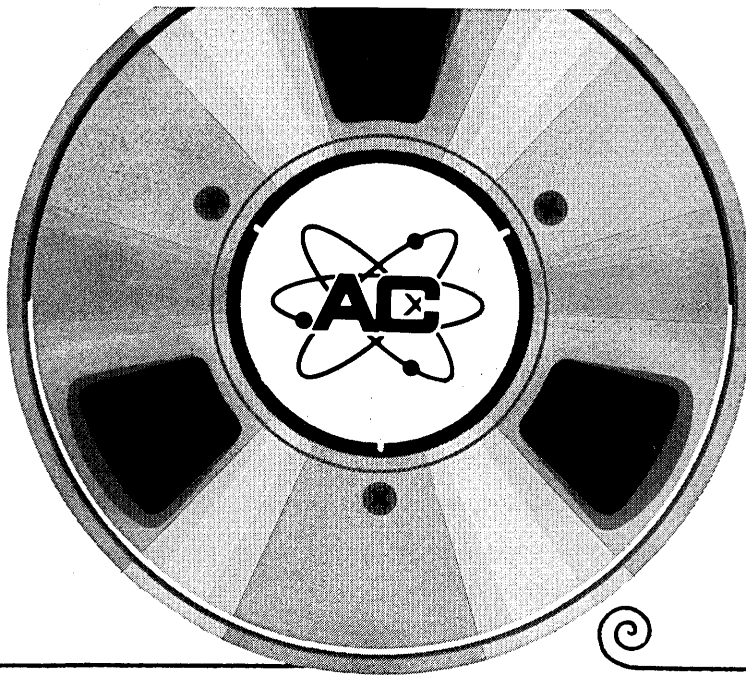
Starting salaries range to $25,000, according to your experience level; all fees and expenses are assumed by our client companies. Please forward your resume in strict confidence, including salary and geographic preference, DIRECTLY to Mr. R. L. Keilholtz or Mr. Donald Wayne.

EVERETT KELLEY ASSOCIATES

Consultants to the Computer Industry

121 So. Broad Street (Suite 1300)
Philadelphia, Pa. 19107

CIRCLE 121 ON READER CARD



SCIENTIFIC PROGRAMMERS

Reprogram your career in the aerospace field with AC Electronics Division of General Motors

Titan III, Apollo, Lunar Excursion Module (LEM). These are typical of the projects you may be working on as a member of the AC Electronics Division team. We're looking for qualified Programmers to fill immediate openings. If you meet the requirements for any of the positions listed below, send us your resumé today!

Sr. Scientific Programmers

Responsibilities include the development of large scale digital computer programs for orbit determination and simulation of highly complex space and missile guidance systems. BS or MA in Math or Physics plus experience on IBM 7000 series required. Location: Los Angeles.

Scientific Programmers

Analyze and prepare computer programs for solution of engineering and scientific problems utilizing the IBM System 360. Scientific applications include design automation, missile trajectory simulation and missile flight test data reductions. Degree in Math, Physics or Engineering required. Minimum of two years experience plus operation knowledge of large scale computers. Locations: Milwaukee, Los Angeles, Boston, Houston, New York and Cape Kennedy.

Programmer (Scientific/Real Time)

Analyze and develop digital computer programs for solution of engineering problems related to inertial navigation systems and components. BS in Math, Physics or EE required with experience in machine language and Fortran. Location: Boston.

Send resumé to:

Mr. R. O. Schroeder, Director of Scientific and Professional Employment, Dept. 5753, AC Electronics Division, General Motors Corporation, Milwaukee, Wisconsin 53201. Your resumé for one of the above positions will be reviewed immediately and a reply made to you within a matter of days.

AC ELECTRONICS

Division of General Motors, Milwaukee, Wisconsin 53201

An Equal Opportunity Employer

CIRCLE 117 ON READER CARD

varian

SENIOR SCIENTIFIC COMPUTATION ANALYST

Assignments include solution of difficult engineering and physics problems in a diversified and scientifically oriented company. For example, the interaction of electrons with electromagnetic fields. Requires advanced degree, preferably PhD. in engineering or physics, and background in scientific programming.

SCIENTIFIC PROGRAMMER

Positions available in Applied Mathematics Group and Management Informant Services. Requires degree in engineering, physics, or mathematics and two years scientific programming experience with large scale digital computers using an algorithmic language such as FORTRAN.

ENGINEER DIGITAL CIRCUIT

A challenging position is available for an engineer with knowledge and experience in design and build-up of transistor circuits. Must be familiar with digital computers and interfacing analog devices with digital computers. Knowledge of data handling helpful. BSEE or MSEE.

Send your resume in confidence to:

MR. J. T. GRAY

varian

611 Hansen Way
Palo Alto, California

— An Equal Opportunity Employer —

CIRCLE 118 ON READER CARD

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

USED EQUIPMENT

Before Selling or Returning IBM EAM or EDP Equipment, Contact us For Premium Prices. GMA LEASING 138 NEPPERHAN AVENUE, YONKERS, NEW YORK 10701. Phone 914 — YO 9-0807.

YES, WE HAVE those scarce 026 key punches and 056 verifiers available for lease immediately. But we won't have them long. Call or write: EDP LEASING CORP., 745 Fifth Avenue, New York, N. Y. 10022. Phone: (212) 421-9195.

BUSINESS OPPORTUNITIES

ASSOCIATE WANTED—Investor desires associate to establish and operate service bureau, NYC area. Heavy experience in D.P. sales or programming required. Investment $20K min. In reply please indicate experience, education and references. Box 2-1.

KEYPUNCH PERFORMANCE AIDS Increase production, reduce errors, and bring sub-standard operators up to par. Five easy-to-follow flow charts guide novice or experienced operators through preparation of the **program planning card,** and **alpha-numeric keypunching** and **error correction** with program control. Durable plastic sheets, 10 x 12 inches, fit workspace. Set of 5 charts: $15. Set of 5 35mm. training slides: $15. Quantity discounts. ENTELEK Inc., Dept. KP-1, Newburyport, Mass. 01950.

HELP WANTED—educational institutions

COMPUTER MAINTENANCE ENGINEERS: Openings available in the rapidly expanding Computer Technology Division of the Ottumwa Area Technical School established by the State of Iowa. The school presently has two computer systems and a full complement of I.B.M. unit record equipment for use in the student laboratories. Must have two years experience as a Computer Maintenance Engineer or other closely related areas to be certified by the State of Iowa for instructing in this technology. Instructing experience helpful but not required. Degree helpful but not required. Salary in the range of $8,000 depending on experience and education. Submit resume to: Bernard L. Terrill, Iowa Technical Education Center, Municipal Airport, Ottumwa, Iowa. 52501 Telephone 515-682-8351.

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.

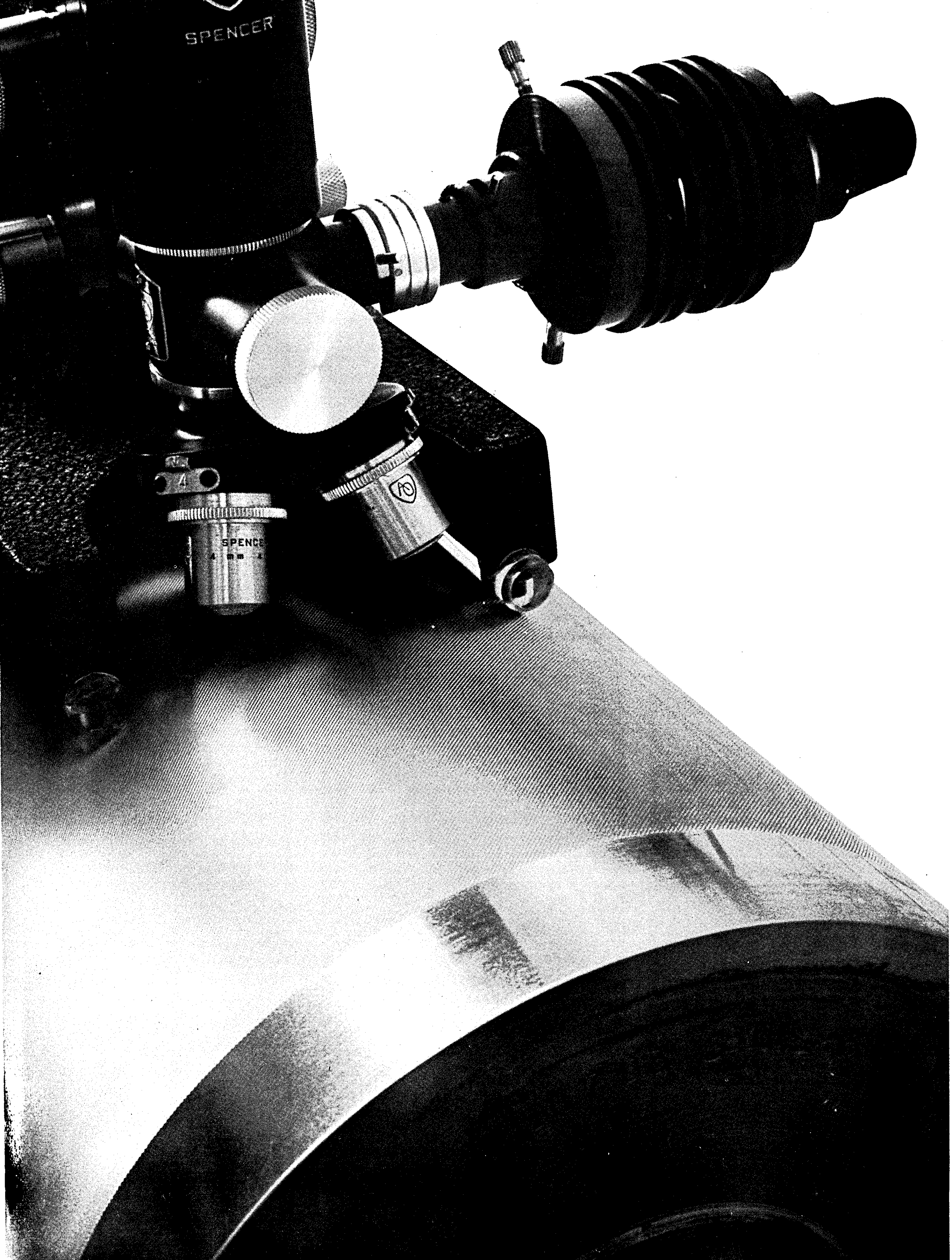
THE CLICHÉ EXPERT DISCUSSES COMPUTERS

with a bow to Frank Sullivan

Q. Good morning, Mr. Arbuthnot. I believe you're here to tell us about a management information system.
A. Yes, a total management information system.
Q. What kind of tools would this give to top management?
A. It would give top management the tools they need to make decisions based on up-to-the-minute information from every unit in your widespread organization so that they can manage effectively in spite of ever-changing conditions.
Q. And these decisions would be. . . ?
A. Real-time, of course.
Q. What kind of challenges would this help top management meet?
A. The challenges of a soaring economy, increased federal control, tougher competition, rapid technological change, product obsolescence and more sophisticated consumers.
Q. What kind of feasibility study do you make first?
A. An all-out feasibility study, of course.
Q. To determine. . . ?
A. If a total management information system is economically justifiable.
Q. Which means. . . ?
A. Are you funded?
Q. And after this. . . ?
A. We make an in-depth system analysis.
Q. What does this help you pinpoint?
A. This helps us pinpoint duplicated efforts, overlapping functions, rigidly structured organizational lines, divided responsibility, hamstrung authority and. . .
Q. And, Mr. Arbuthnot. . . ?
A. (Softly) . . . superfluous executive personnel.
Q. And they are. . . ?
A. Reoriented.
Q. What's the next step?
A. We flowchart the entire process. . .
Q. What sort of acronym does this help prevent?
A. GIGO.
Q. What kind of proposal do you make after this?
A. A firm proposal.
Q. And this involves what kind of hardware and software package?
A. A total hardware and software package.
Q. I understand your hardware is third generation.
A. It's truly third-generation, completely modular and enormously powerful, giving you the most performance per dollar of any hardware in its class or even. . .
Q. Or even of what?
A. Or even of hardware costing several times as much.
Q. Does it embody any advanced concepts?
A. It embodies several advanced concepts for total high performance and its significant, state-of-the-art characteristics are completely integrated.
Q. What sort of relationship is it designed to maximize?
A. The man-machine relationship.
Q. Does it have a full complement of anything to help this relationship?
A. Yes, a full complement of lights, bells and whistles.
Q. What kind of instruction repertoire does it have?
A. Extensive and powerful.
Q. What kind of access does the memory have?
A. Ultra-fast, random and expandable.
Q. How would you describe the line of peripheral equipment?
A. It's a complete line, with flexible and powerful input-output features.
Q. What kind of increments do we have to buy?
A. Only the exact increments you need.
Q. Would you say your system is fully expandable?
A. It's totally fully expandable to grow as you grow. You won't start out with hardware that's too big for the job or end up with hardware that's too small for the job.
Q. What kind of applications is the system suitable for?
A. It's designed for a wide range of applications for business, science and industry.
Q. What unique characteristics does your software have?
A. It's powerful. It's total. And it's fully compatible.
Q. Upward. . . ?
A. And downward.
Q. Is our programming investment protected?
A. Fully protected. With our exclusive INCEST concept, there's no costly reprogramming or retraining. It extends the usefulness of your present programming.
Q. Does the software come with the hardware?
A. It is fully documented and will be available shortly.
Q. What phase would you say it's in?
A. The debugging phase.
Q. What kind of program library do you make available to us?
A. An extensive program library that's being enlarged continuously.
Q. Will we be ready for tomorrow's problems?
A. Absolutely. Because our hardware and software are completely flexible, easily expandable and totally modular, you'll be ready for on-line time-shared multi-programmed solid-state batch processing from remote stations. With us, you have the years-ahead system.
Q. Is there some way you can characterize the unique and exclusive benefits of your system in a single sentence?
A. It provides the most throughput, lowest cost, greatest reliability and it defies obsolescence.
Q. When can I see one?
A. Our expert outside consultants and our top-flight engineering team are finalizing the first production prototypes preparatory to total systems checkout. Off the top of my head, I'd say our initial demo will be on the air sometime during the fourth quarter—seasonally adjusted, of course.
Q. How much for an adding machine, Mr. Arbuthnot?
A. Just sign right here, sir. I've got one in the car.

—B. W.

advertisers' index


SPENCER
4
SPENCER

when it comes to computer tape coating, MAC Panel lays it on thin

But, not too thin!

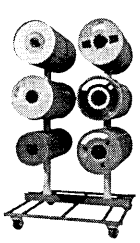
Just a uniform, .00041-inch coating thickness that assures uniform signal response . . . from edge to edge, from beginning to end.

This uniformity is the result of MAC's gravure coating method, and we microscopically inspect every gravure cylinder, to assure this precise control of oxide coating. MAC's coating thickness is held to a tolerance of one millionth of an inch. Even the polyester base material is ironed flat to a mirror smoothness—once prior to coating and then once again after coating. This super finish assures the best high frequency characteristics.

To mention a few more quality control measures that assure you of uniformly high standards of tape performance, we put our oxide blend through eighteen hours of milling in air tight, stainless steel vats. A minute less and we couldn't be sure of achieving uniform particle dispersion. To make doubly sure of uniform performance, the oxide blend is filtered to guarantee a uniform particle size of .000039 inches.

After coating, electronic temperature and drying controls in our multi-stage drying ovens scientifically maintain a delicate balance between bonding agents, oxide and other ingredients. It's a slow, inside-out drying process to assure thorough hardness. In addition, our chemists insist that the air in the drying ovens be as pure as humanly possible. So, three miles of filtering agents do the job in a highly specialized and efficient air purification system.

All of these quality control measures are routine at MAC. And they start in the receiving room, where base materials, oxide resins, and other materials are closely inspected for uniform quality by chemists and lab technicians. It all adds up to one thing: Only MAC Panel can guarantee uniformity of tape performance, because only MAC Panel guarantees uniformity of quality control at every step in the manufacturing process.



MAC

MAC PANEL COMPANY • High Point, North Carolina

MAC PANEL MANUFACTURES HEAVY-DUTY COMPUTER TAPE · FULL-WIDTH TESTED AND GUARANTEED AT DENSITIES THROUGH 1600 BPI

CIRCLE 2 ON READER CARD